Results and Discussion

Yield data are summarized in Table 1. No significant differences

Table 1. Performance of iron and zinc chelates on flax at Crookston, Minnesota in 1968

	Yield, bushels per acre					
	Check	Fe 10#	Fe 5#	Zn 5#	Zn 2.5#	Ave.
Nored	9.5	9.6	6.2	9.6	8.1	8.6
Bolley	7.7	7.3	6.4	9.1	8.1	7.7
B5128	13.1	10.8	9.3	14.8	10.3	11.7
Summit	12.2	10.8	9.7	14.4	16.7	12.8
Ave.	10.6	9.6	7.9	12.0	10.8	

Analysis of variance indicated treatments were not statistically different. Cultivars and treatment x cultivar mean squares were highly significantly different. The standard error (S.E.) for cultivarial means was 0.6 bu. The S.E. for the difference between cultivars within one treatment was 1.3 bu.

were noted between treatments. The cultivars reacted differently when averaged over the treatments. Further differences can be noted for the treatment x cultivar interaction. The cultivar Summit responded to both rates of zinc chelate and B5128 and Bolley responded to the high rate of zinc. The yield of B5128 and Summit was significantly depressed by iron chelate at both rates. Other differences were slight depressions of yield for certain treatments over the check.

Conclusions

These results alone do not lead to any definite conclusions. Some cultivars were found to respond to zinc and not to iron. The treatments were not significantly different. This study should be continued at least one more year.

The Effect of High Rates of Zinc Application to a Zinc Deficient Soil in Swift County on Corn Growth and Leaf Zinc Concentration in 1968

O. M. Gunderson and J. M. MacGregor

Since the effect of relatively heavy applications of zinc as granular $ZnSO_4 \cdot H_2O$ were not known, an experiment was initiated on a zinc deficient calcareous loam. Three four row plot replications were treated with granular $ZnSO_4 \cdot H_2O$ to supply 10, 40, 80 and 160 pounds of zinc per acre for continuous corn. The treatments were broadcast and plowed down.

Growth observations were periodically made and there were no apparent differences in either rate of growth, or appearance of the corn plants. Sixth leaves were sampled during early silking, and these were analyzed for both Zn and P content. The results are shown in the following table.

The Effect of Heavy Zinc Applications on Corn Leaf Zinc Concentrations to a Zinc Deficient Soil Near Benson, Swift County, Minnesota.

Rate of Zinc Application (lbs/A)	Replicate 1	Replicate 2	Replicate 3	Average
	Corn leaf zinc in parts per million			
10 as $ZnSO_4 \cdot H_2O$	14.5	12.3	17.0	14.6
40 as $ZnSO_4 \cdot H_2O$	17.0	19.7	18.8	18.8
80 as $ZnSO_4 \cdot H_2O$	21.5	18.2	29.0	22.9
160 as $ZnSO_4 \cdot H_2O$	40.5	31.4	32.8	34.9

Increasing the rate of zinc application to the soil from 10 to 40 pounds per acre increased average leaf zinc about 4 ppm, while the 80 pounds per acre rate produced a further increase. Increasing the zinc application rate to 160 pounds per acre more than doubled leaf zinc, but even this corn leaf zinc concentration is relatively common in corn leaves grown on many Minnesota soils where no presently recognized Zn deficiency occurs.

Since the heavier rates of Zn application had neither apparent beneficial nor detrimental effect on corn growth, and leaf zinc concentrations were not abnormally high, yield samples were not taken in this experiment.

The 1966-67-68 Experiments on Effect of Zinc Sources and Zinc Phosphate Interaction on Corn Leaf Composition and Grain Yield on a Calcareous Loam in Swift County

O. M. Gunderson, J. M. MacGregor, S. D. Evans & G. W. Randall

In the spring of 1966, a project was commenced to study:

1. The effect of several commercial zinc fertilizer materials, and
2. The effect of increasing amounts of phosphate fertilization on the zinc and phosphorus content of the sixth corn leaf and on the resulting ear corn yield.

Two randomized block experimental areas were established in mid-May of 1966 on the Richard Nikkelson farm some 2 to 3 miles north of Benson in Swift County. Each experiment consisted of 7 treatments replicated 4 times. All zinc treatments except one chelated zinc source (which was row applied each year) and all P treatments were broadcast and then plowed down. The farm operator also applied a total of 100 + 40 + 40 per acre as a blanket broadcast application before plowing. In 1966 the spring was late, so 90 day maturity corn was planted. Atrazine was applied on June 1st and leaf samples were taken in early September. In 1967, the planting season was earlier and a 100 day corn maturity was used. A mid-September frost materially decreased the 1967 ear corn yield. The 1968 growing season was more normal.

One of the problems in field experiments with zinc fertilization is the extreme variability of soils in their response to zinc applications. For this reason, large apparent differences may not be statistically significant.

The initial soil pH was 8.2, and soil P using Bray No. 1 extractant (1:10) varied from 3 to 50 pounds per acre.

Visual Zn Deficiency Symptom Rating and Zn Content of 6th Corn Leaf

In each of the three years of the study, visual estimates of severity of zinc deficiency symptoms have been made about silking time. A scale of 0 to 10 was used by two individuals making independent ratings with the lower value representing the most severe symptoms on the four replications of each treatment. The two ratings of the four plot averages were then averaged and 10 of the 6th corn leaves from the ground on each plot were then collected, washed, dried, ground and analyzed for zinc content. Both the visual ratings and leaf zinc concentrations for the three years are shown in Table 1.

It is obvious that a close relationship exists between the visual Zn deficiency symptoms exhibited by the corn plants and the zinc content present in the leaves at that (silking) time. It would appear that there is little additional value in determining leaf zinc content by chemical methods when visual deficiency symptoms are so well correlated.

The Effect of Zinc and Phosphate Applications on Corn Leaf Composition

Corn leaves were analyzed for both Zn and P during each of the three growing seasons and the values obtained are shown in Table 2.

In the zinc source study, increasing rates of Zn as granular $ZnSO_4 \cdot H_2O$ (36% Zn) have significantly increased zinc leaf content in each of the three years and depressed leaf phosphorus in 1966 and 1967, but not in 1968. The effect of ZnMNS on leaf zinc was intermediate, with the chelated zinc (Na_2Zn) showing the least increase in leaf zinc, with a variable but generally lesser effect on leaf phosphorus.

The addition of phosphate to the soil, especially at the higher rates, depressed leaf zinc in 1966 and 1967, but resulted in no significant depression in 1968. Higher phosphate applications increased leaf P, but

Table 1. Visual Ratings of Zinc Deficiency in Growing Corn Plants and Zinc Content of Sixth Corn Leaves.

1966 Treatment (lbs/A)	1966 Visual rating[a]	1966 Leaf Zn ppm	1967 Visual reting[a]	1967 Leaf Zn ppm	1968 Visual reting[a]	1968 Leaf Zn ppm
No zinc	5.1	7.2c	3.2	9.2d	3.0	14.8a
10 as $ZnSO_4$(P.D.1966)	7.9	11.7bc	7.1	13.8c	6.5	16.4ab
20 " "	8.7	14.0b	8.6	18.2b	8.7	23.4bc
40 " "	9.0	18.0a	8.5	26.5a	9.0	29.4c
10 as ZnMNS(")	8.7	9.3bc	8.0	12.8cd	7.5	15.3
0.5 Zn as Zn 45 (row annually)	2.6	8.6c	6.4	11.8cd	6.0	12.1a
2.5 Zn as Zn 45 (P.D. 1966)	6.0	8.3c	3.9	11.5cd	3.0	12.7a
Phosphate-Zinc Interaction						
40 P_2O_5 (P.D. in 1966)	7.0	10.0ab	7.5	10.2abc	7.0	13.3
80 " (")	7.0	10.2ab	7.0	12.5ab	5.7	16.1a
160 " (")	5.7	8.4bc	8.0	10.5abc	6.2	13.1a
320 " (")	3.9	7.5c	5.0	9.0bc	3.2	12.7a
640 " (")	2.7	7.3c	3.5	8.2c	2.5	9.3a
320 " + 10 Zn as SO_4 (P.D. in 1966)	8.5	12.4a	8.4	13.2a	8.7	15.4a
640 P_2O_5 + 10 Zn as SO_4 (P.D. in 1968)	7.9	11.0a	8.5	12.0ab	8.2	17.3a

[a] 0 = severe zinc deficiency symptoms, 10 = essentially normal corn growth

P.D. = plowed down

Table 2. The Effect of Zinc & Phosphate Treatments on the Zinc & Phosphorus Content of the Sixth Corn Leaf (1966-1968)

Treatment (lbs/A)	Ppm leaf zinc			% leaf phosphorus		
	1966	1967	1968	1966	1967	1968
No zinc	7.2c	9.2d	14.8c	0.400a	0.367a	0.410cd
10 as $ZnSO_4$(P.D.[a] 1966)	11.7bc	13.8c	16.4bc	0.297bc	0.304bc	0.338d
20 " "	14.0b	18.2b	23.4ab	0.259c	0.273c	0.462bc
40 " "	18.0a	26.5a	29.4a	0.259c	0.281bc	0.511b
10 as ZnMNS(P.D.1966)	9.3bc	12.8cd	15.3c	0.326abc	0.285bc	0.630a
0.5 Zn as Na_2Zn (row annually)	8.6c	11.8cd	12.1c	0.394a	0.331ab	0.351d
2.5 Zn as Na_2Zn (P.D. 1966)	8.3c	11.5cd	12.7c	0.372ab	0.323abc	0.458bc
Phosphate-Zinc Interaction						
40 P_2O_5 (P.D. in 1966)	10.0ab	10.2abc	13.3a	0.351bc	0.317c	0.410
80 " "	10.2ab	12.5ab	16.1a	0.313bc	0.312c	0.338
160 " "	8.4bc	10.5abc	13.1a	0.359bc	0.323c	0.462
320 " "	7.5c	9.0bc	12.7a	0.400b	0.436b	0.510
640 " "	7.3c	8.2c	9.3a	0.486a	0.570a	0.630
320 P_2O_5 + 10 Zn as SO_4 (P.D. in 1966)	12.4a	13.2a	15.4a	0.325bc	0.308c	0.351
640 P_2O_5 + 10 Zn as SO_4 (P.D. in 1966)	11.0a	12.0ab	17.3a	0.304c	0.310c	0.458

[a] P.D. = plowed down

the addition of 10 pounds of zinc per acre generally increased leaf zinc and lowered P levels. Since the effect of added Zn and P_2O_5 significantly affected leaf Zn and P in the first two years of this study and with no significant effect in the third year (1968), it is possible that these two element additions made early in 1966 are becoming less effective on the third corn crop.

The effects of the 1966 zinc and phosphate soil treatments on ear corn yields during the three years and amounts of available soil zinc as determined by the Institute of Agriculture Soil Testing Laboratory on 1968 samplings are shown in Table 3.

It is obvious that the zinc soil test is extracting the zinc applied to this calcareous loam more than two years earlier, with a general direct relationship to the amount of zinc applied.

The great variability in the severity of zinc deficiency exhibited by corn plants growing on this soil is well illustrated by the large differences in ear corn yield following fertilization with the different zinc sources, but these were not mathematically significant in either 1967 or in 1968. The general trend is shown by the three year yield averages.

Heavier P_2O_5 applications made in 1966 appeared to depress the amount of zinc extracted by test and significantly depressed corn yields in 1966 and in 1968. The 1966 addition of 10 lbs. of Zn/A increased the amount of zinc extracted from soils sampled in 1968 and also ear corn yields in the two more favorable growing seasons (1966 and 1968).

Table 3. The Effect of 1966 Zinc & Phosphate Fertilization on 1968 Available Soil Zinc, and on 1966, 1967 and 1968 Ear Corn Yield

Soil Treatment (lbs/A)	1968 Soil Test (lbs Zn/A) Rep. 1	Rep. 2	Rep. 3	Rep. 4	Avg.	Ear Corn @ 15.5% moisture (Bu/A) 1966	1967	1968	Avg.
No zinc	1.6	1.6	0.9	0.9	1.2	92.0bc	56.1a	71.3a	73.1
10 as $ZnSO_4$ (P.D.[a] 1966)	0.9	1.8	1.8	1.9	1.6	115.4a	77.5a	92.4a	95.1
20 " (")	3.6	2.9	4.6	2.5	3.4	111.8a	75.6a	94.8a	94.1
40 " (")	5.0	5.6	3.3	5.7	4.9	109.3a	81.7a	88.8a	93.3
10 as ZnMNS(")	2.2	2.0	2.4	1.6	2.1	103.8ab	79.2a	86.9a	90.0
0.5 as Na_2Zn (row annually)	1.5	1.1	1.1	2.0	1.4	85.5c	69.7a	93.4a	82.9
2.5 as Na_2Zn (P.D. in 1966)	4.1	1.9	1.1	1.4	2.1	93.3bc	58.4a	79.0a	76.9
Phosphate-Zinc Interaction									
40 P_2O_5 (P.D.[a] 1966)	0.8	1.7	1.6	1.3	1.3	98.4ab	68.5a	86.9abc	84.6
80 " "	1.0	1.1	3.8	2.1	2.0	96.9ab	65.8a	94.5bc	85.7
160 " "	1.0	1.6	1.0	1.5	1.3	96.3ab	60.8a	100.0c	85.7
320 " "	0.9	1.3	1.2	1.6	1.2	96.8ab	50.2a	81.4ab	76.1
640 " "	0.9	1.4	0.8	1.3	1.1	83.4b	34.3a	72.0a	63.2
320 " + 10 Zn as SO_4 (1966)	3.9	3.9	2.2	3.0	3.2	113.6a	74.8a	92.6bc	93.7
640 " "	4.5	2.6	7.7	2.6	4.3	107.6a	74.7a	100.6c	94.3

[a] P.D. = plowed down

The 1968 corn grain was analyzed for zinc concentrations, and the individual analyses for each plot are shown in Table 4. The average concentrations were then calculated and the actual zinc removed in the 1968 corn grain was determined on the dry grain basis, assuming 56 pounds of corn grain per bushel at zero moisture content.

Table 4. Zinc in 1968 Corn Grain at Benson. Mickelson-Swift County.

Soil Treatment (lbs/A)	Zinc in 1968 Corn Grain (ppm) 1	2	3	4	Average	1968 Yield Bu/A	Pounds of Zn removed per acre
No zinc	26.4	17.0	20.9	7.3	17.9	71.3	0.060
10 as $ZnSO_4 7H_2O$ (P.D.[a] 1966)	18.3	16.3	22.5	14.4	17.9	92.4	0.078
20 " (")	18.0	16.5	11.0	20.7	16.6	94.8	0.075
40 " (")	31.8	34.8	27.8	26.0	30.1	88.8	0.127
10 as ZnMNS (")	23.5	16.3	12.9	18.0	17.7	86.9	0.073
0.5 as Na_2Zn (row annually)	14.5	16.2	15.2	9.4	13.8	93.4	0.061
2.5 as Na_2Zn (P.D. in 1966)	21.3	16.2	16.4	14.8	17.2	79.0	0.064
Phosphate-Zinc Interaction							
40 P_2O_5 (P.D.[a] 1966)	15.4	13.5	12.4	14.8	14.0	86.9	0.058
80 " "	9.3	11.5	17.3	13.8	13.0	94.5	0.045
160 " "	11.5	10.4	13.5	12.0	11.9	100.0	0.056
320 " "	8.0	8.5	12.4	9.9	9.7	81.4	0.037
640 " "	7.0	11.4	9.9	7.9	9.1	72.0	0.031
320 "+ 10 Zn(")	19.4	15.2	13.5	15.5	15.9	92.6	0.070
640 "+ 10 Zn(")	11.7	15.8	12.0	14.4	13.5	100.6	0.064

[a] P.D. = plowed down

It is evident that only the 40 pound rate of zinc application (made in 1966) produced a marked increase in zinc present in the corn grain. Phosphate treatments produced a steady decrease in the zinc concentrations in the grain, but this was remedied by treating with 10 lbs of Zn/A.

It is evident that relatively small amounts of zinc per acre are being removed in the corn grain.

Effect of Micronutrient Additions to Soybeans on Seed Yield

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

The seed treatments outlined in Table 1 were applied to Chippewa 64 soybean seed before planting at Big Lake, Lamberton, Waseca, Morris and Rosemount. Foliar analyses indicated that the concentrations of nutrients added were normal or above normal on the check plots and the addition of these nutrients did not significantly affect the concentration of the element in the leaves.

Table 1. Effect on Soybean Seed Yield When Different Micronutrients were Added to Chippewa Soybeans in 1968

	Location					Average of all locations
	Big Lake bu/acre	Lamberton bu/acre	Morris bu/acre	Rosemount bu/acre	Waseca bu/acre	
Check	15.1	34.3	23.0	28.9	42.7	28.8
Mo 50gm/acre	13.4	35.4	27.2	28.7	44.1	29.8
Mo 100gm/acre	11.7	34.3	26.9	28.2	41.8	28.6
Co 30gm/acre	13.3	35.2	26.8	25.9	40.6	28.4
Co 30gm/acre	14.3	31.6	25.4	24.4	42.4	27.6
Fe 2 lbs/acre	16.3	36.5	26.9	25.6	41.5	29.4
Fe 4 lbs/acre	13.0	37.3	27.2	26.9	41.5	29.2
Zn 2 lbs/acre	14.5	38.7	27.1	29.4	43.0	30.5
Zn 4 lbs/acre	15.9	37.8	27.1	26.9	43.1	30.1
Mn 2 lbs/acre	16.2	37.5	25.1	26.4	44.6	29.9
Mn 4 lbs/acre	14.1	37.6	27.0	28.1	42.3	29.8
Molycofix [a]	14.9	33.0	26.1	24.4	41.7	28.0
Polyplex - 2	16.[illegible]	33.6	35.4	25.3	42.2	28.5
Polyplex - 4	14.4	31.4	23.9	22.9	42.9	27.1
Cu 1 lb/acre	15.6	31.4	25.0	24.8	45.1	28.4
Cu 2 lbs/acre	16.4	33.5	24.4	24.6	44.6	28.7
Molynoc [b]	13.9	34.7	26.9	29.2	43.1	29.6

[a] Obtained from W. R. Grace Co., Princeton, Illinois and added at recommended rate

[b] Obtained from Kolo Inoculant Co., Quincey, Illinois and added at recommended rate

The Effect of Zinc and Phosphate Applications on Zinc and Phosphorus Concentrations in Corn Leaves and Ear on Corn Yield of Two Farm Fields in Western Minnesota in 1968

Orville M. Gunderson and John M. MacGregor

Two western Minnesota corn fields were selected for Zn:P interaction investigations late in 1967. Three replications, each consisting of six 15' x 40' plots were treated in a randomized block; the treatments being; check, 60 lbs P_2O_5/A, 120 lbs P_2O_5/A, 240 lbs P_2O_5/A, 10 lbs Zn/A, and 240 lbs P_2O_5 + 10 lbs Zn/A. These were applied and plowed down in the fall and field corn was planted in 30" rows in the spring of 1968.

Hot and very dry weather occurred during tasselling and silking and this greatly reduced ear corn yields and the possibilities of zinc or phosphate effect. The two field results are best considered individually. Applied Zn was granular $ZnSO_4.H_2O$ and superphosphate was the P source.

The Eldren Lichtsinn Farm Experiment - Dumont, Traverse County

Corn had been grown on this Bearden silt loam in 1967. Soil pH averaged 7.4, available P was 10 lbs/A, K was 200 lbs/A, and available soil zinc test showed 2.2 lbs/A (high). Table 1 shows the 1968 corn leaf zinc and phosphorus concentrations at silking (under drowth conditions) and the eventual yield of ear corn.

Table 1. Fertilizer Treatment, Concentrations of Leaf Zinc, Phosphorus, and the Ear Corn Yield in 1968 on the Eldren Lichtsinn Field. (Bearden silt loam)

Treatment (lbs/A)	Leaf zn (ppm)	% Leaf P	Yield of ear corn (bu/A @ 15.5% moisture)
Check	21.0	0.289	102.9
60 P_2O_5	23.0	0.280	92.5
120 P_2O_5	26.8	0.286	111.0
240 P_2O_5	17.9	0.303	100.0
10 Zn	20.7	0.284	103.9
240 P_2O_5 + 10 Zn	19.4	0.283	106.4

The results show no consistent relationship in leaf Zn, P, or corn yields to the applied phosphate or zinc treatments. The low soil test value for soil P of 10 pounds per acre would indicate a probable phosphate yield response, but this did not occur. The relatively high test for available soil zinc is more consistent with the erratic yield results, but zinc applications to this soil failed to increase corn leaf zinc which might be normally expected.

The Charles Burmeister Farm Experiment - Chokio, Stevens County

This was a Hamerly clay loam having a pH of 7.4, extractable P was 13 lbs/A, an exchangeable K level of 370 (high), with a low available zinc test of only 1.2 ppm. Due to a drainage problem, only two replications of this field were harvested. The results are shown in Table 2.

Table 2. Fertilizer Treatment, Concentrations of Leaf Zinc, Phosphorus, and the Ear Corn Yield in 1968 on the Charles Burmeister Farm. (Hamerly clay loam)

Treatment (lbs/A)	Leaf Zn (ppm)	% Leaf P	Yield of ear corn (bu/A @ 15.5% moisture)
Check	19.5	0.239	66.6
60 P_2O_5	18.2	0.245	80.2
120 P_2O_5	14.3	0.266	71.3
240 P_2O_5	16.6	0.241	67.5
10 Zn	21.4	0.206	73.3
240 P_2O_5 + 10 Zn	34.0	0.241	73.9

With data from only two replications, and with all values being quite erratic, it is not possible to draw any valid conclusions from the results on this experimental field.

In conclusion, the extremely dry soil conditions at silking time when leaf sampling was done, may have seriously affected the leaf Zn:P balance and nullified the possibility of obtaining the usual Zn:P interaction previously observed in the corn growing on zinc deficient soils of western Minnesota. Corn yields were apparently independent of the applied mineral treatments.

A Survey of Micronutrient Additions to Corn In Southwest Minnesota

G. D. Holcomb and H. L. Meredith [1]

Situation Statement

During recent years there has been considerable concern of the need for the addition of micronutrients. As corn yields increase, it has frequently been suggested that the absence of one or more of the micronutrients may limit yield. Results in many areas of the nation have shown a profitable yield response to the application of a micronutrient. For clarity, N, P, and K, nutrients required in larger amounts, are referred to as the major nutrients or macronutrients. The nutrients required in trace amounts are referred to as minor or micronutrients.

There has been only limited research with micronutrients in southwest Minnesota. These results plus a general knowledge of micronutrients have served as the basis for recommendation of micronutrient needs in this part of the state.

Procedure for Demonstration Plots

To evaluate the need and to obtain leaf values for nutrients, demonstration plots were established in Cottonwood, Jackson, Nobles, and Rock Counties during May of 1968.[2] The indicator crop was corn. The micronutrients consisted of zinc, copper, manganese and iron. Plots were established in cooperation with the Tennessee Valley Authority, the

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[2]The cooperating county agricultural agents of these counties were respectively Paul Sandager, Ray Palmby, Robert Koehler, and Kent Ringkob and this investigation was made possible largely through their active participation.

Treatment (lbs. material per acre)	Yield, Bu/A at 15.5% Moisture
No starter	119.7
Starter only	118.3
2 lbs. zinc + starter	114.4
2 lbs. zinc, 2 lbs. manganese + starter	107.0
2 lbs. zinc, 2 lbs. manganese, 1 lb. copper + starter	107.3
4 lbs. zinc + starter	114.7
2 lbs. iron + starter	117.8
Starter only	112.0

Jackson County—Curtis Pietz farm. Planted May 3. Hybrid, Pioneer 3582. Insecticide, Thimet. Fertilizer: broadcase 0+97+65 per acre; preplant 160 pounds nitrogen per acre; with seed, 60 pounds 7-24-3 per acre. Harvested December 6. Stand, 21,500.

Treatment (lbs. material per acre)	Yield, Bu/A at 15.5% Moisture
1 lbs. zinc + starter	124.9
Starter only	127.3
1 lb. zinc, 1 lb. iron, 3/4 lb. manganese, 1/2 lb. copper + starter	127.4
Starter only	119.2
2 lbs. zinc + starter	124.5

Nobles County—Joel McCarvel farm. Planted May 10. Hybrid, Funks G18A. Fertilizer: 110 lbs. nitrogen per acre preplant; 96 pounds 7-21-7 per acre with planter. Harvested November 26. Stand, 18,000.

Treatment (lbs. material per acre)	Yield, Bu/A at 15.5% Moisture			
	I	II	III	Average
2 lbs. zinc + starter	89.7	84.6	--	87.1
Starter only	92.6	84.7	83.3	86.9
2 lbs. zinc, 1 lb. copper, 1.5 lbs. manganese, + starter	81.4	86.7	--	84.0
4 lbs. zinc + starter	86.4	78.6	--	82.5

Table 1. Analyses of corn plants at 15 to 24 inches height (leaves extended) from Jackson, Cottonwood, Nobles and Rock Counties, Minnesota, 1968.

	Percent				Parts Per Million				
	P	K	Ca	Mg	Zn	Cu	Mo	Mn	B
C. Pietz, 2 lbs. Zn	.47	3.5	.60	.30	30	12	1.8	53	12
Pieta, Zn,Fe,Mn,Cu	.49	3.23	.70	.33	27	14	1.9	61	13
Pietz, check #1 (W)	.44	3.6	.59	.29	24	13	1.5	54	11
Pietz, #1 Zn	.54	3.5	.66	.33	33	14	1.6	64	12
J.McCarvel, 2 Zn	.43	3.4	.49	.40	44	12	2.2	49	13
J.McCarvel, E. Ck.	.37	3.2	.46	.38	27	11	2.0	40	12
McCarvel, Zn,Mn,1 Cu	.39	3.8	.48	.36	39	15	1.4	45	10
McCarvel, W. Ck.	.34	3.6	.42	.36	35	12	1.4	35	10
McCarvel, 4 Zn	.43	3.2	.47	.36	40	11	2.3	39	14
R. O'Toole, 4 Zn	.40	3.1	.49	.37	32	12.9	2.1	51	9.9
R. O'Toole, Check	.39	3.0	.56	.47	33	12	1.8	58	9.4
R. O'Toole, Zn,Fe,Mn,Cu	.36	3.4	.46	.40	36	13	1.2	54	7.0
R. O'Toole, 2 Zn	.40	3.2	.58	.49	33	14	1.8	59	8.8
R. O'Toole, Starter	.40	3.2	.52	.47	34	14	1.6	53	7.5
W. Turner, Pop-up	.37	3.0	.56	.38	40	11	1.4	39	10
W. Turner, 2 Zn	.39	3.2	.66	.38	30	12	1.8	45	12
W. Turner, 2 Zn-Mn	.40	3.1	.68	.43	33	13	1.7	44	11
W. Turner, Zn,Mn,Cu	.42	2.8	.57	.34	31	12	1.9	41	13
W. Turner, 4 Zn	.40	3.3	.54	.39	38	11	1.4	35	10
W. Turner, Fe	.39	3.0	.53	.36	39	11	1.2	42	9.7
J. Hedquist, Zn	.42	3.6	.47	.27	37	8.2	1.1	45	9.1
J. Hedquist, Cu	.46	3.5	.50	.27	33	9.1	1.4	48	10
J. Hedquist, Check	.46	3.2	.46	.24	32	9.5	1.4	48	11
J. Hedquist, Mn	.47	3.5	.50	.30	30	8.5	1.4	51	10

No nutrient deficiency symptoms were observed throughout the growing season. There did not appear to be any yield response to starter fertilizer in these comparisons. None of the micronutrients added appeared to effect the final yield. The micronutrient solutions did not appear to consistently alter the composition of a particular micronutrient in the plant. Although these data are not conclusive, indications are that in 1968 yields were not increased by the micronutrient additions under the conditions studied on the farms represented in the southwest counties of Minnesota.

The above tissue data may be used as composition references for normal or near-normal corn plants in this part of the state at this stage of development. The comparison of tissue P and soil test P on yield appears in Table 2. The soil test results are shown in Table 3. Soil tests of the farm in Jackson and part of the samples from Cottonwood County are fairly high. Samples from Nobles, Rock and part of Cottonwood County reflected low phosphorus soil tests. The highest corn yields were made on the Hedquist farm in Cottonwood County (high soil tests - 127 bu/A) and the Pietz farm in Jackson County (high soil tests - 125 bu/A).

Table 2. Comparison of tissue P and soil test P with yield of corn, southwest Minnesota, 1968.

Farmer	County	Average Tissue P %	Average Soil Test P lbs/A	Average pH	Average Corn Yield Bu/A
Pietz	Jackson	.485	39.5	6.0	124.8
Turner	Cottonwood	.395	15.6	6.5	113.9
Hedquist	Cottonwood	.452	51.8	6.1	127.3
McCarvel	Nobles	.392	13.2	6.1	85.1
O'Toole	Rock	.390	10.4	6.6	109.2

Table 3. Soil tests of soils used in survey of micronutrient deficiencies in southwest Minnesota, 1968.

Sample Number	County	Farmer	pH	P[1]	K[2]	Treatment
S-25	Jackson	Pietz	6.0	37	300	1 lb. Zn
S-26	Jackson	Pietz	5.7	54	330	2 lb. Zn
S-27	Jackson	Pietz	6.1	40	300	Check
S-28	Jackson	Pietz	6.0	27	280	2 lb. Zn, 2 lb. Mn, 1 lb. Cu, 2 lb. Fe
S-29	Cottonwood	Turner	6.4	12	200	2 lb. Zn, 2 lb. Mn, 1 lb. Cu
S-30	Cottonwood	Turner	6.7	14	220	Pop-up
S-31	Cottonwood	Turner	6.6	12	230	2 lb. Zn, Mn
S-32	Cottonwood	Turner	6.5	15	230	2 lb. Zn
S-33	Cottonwood	Turner	6.3	23	210	2 lb. Fe
S-34	Cottonwood	Turner	6.0	17	200	4 lb. Zn
S-36	Cottonwood	Hedquist	5.9	58	390	Check
S-37	Cottonwood	Hedquist	6.2	48	360	1 lb. Cu
S-38	Cottonwood	Hedquist	6.2	62	400	2 lb. Zn
S-39	Cottonwood	Hedquist	6.1	45	330	2 lb. Mn
S-40	Cottonwood	Hedquist	6.3	46	300	Starter only
S-41	Nobles	McCarvel	6.6	12	300	Check
S-42	Nobles	McCarvel	6.4	20	360	4 lb. Zn
S-43	Nobles	McCarvel	6.4	8	280	2 lb. Zn
S-44	Nobles	McCarvel	6.6	9	270	2 lb. Zn, 1 lb. Cu, 1.5 lb. Mn
S-45	Nobles	McCarvel	6.6	17	410	Check
S-46	Rock	O'Toole	6.6	8	250	Starter only
S-47	Rock	O'Toole	6.7	8	210	2 lb. Zn
S-48	Rock	O'Toole	6.7	9	240	Check
S-49	Rock	O'Toole	6.6	12	300	2 lb. Zn, 2 lb. Fe, 1.5 lb. Mn, 1 lb. Cu
S-50	Rock	O'Toole	6.5	15	280	4 lb. Zn

[1]Bray No. 1 extracting solution, soil-solution ratio of 1:10.

[2]Neutral 1 N ammonium acetate extracting solution and Perkin-Elmer flame photometer.

Interpretation of phosphorus and potassium contents of Minnesota soils.

Relative Level	Extractable Phosphorus (P) Lbs. Per Acre	Exchangeable Potassium (K) Lbs. Per Acre
Low	0-10	0-100
Medium	11-20	101-200
High	21-30	201-300
Very high	Over 30	Over 300

Summary and Conclusions

A demonstration was conducted in southwest Minnesota to delineate the response of the addition of micronutrients on the growth of corn. No micronutrient deficiencies were noted throughout the growing season. No response to micronutrients was noted visually or reflected in corn yields. No leaf analyses were particularly low in any of the elements measured.

Tissue P and soil test P values corresponded to corn yields. The higher P values were grouped with the highest yield.

The results of this demonstration help to emphasize the need for maintaining soils at a desirable fertility level as determined by soil test.

Zinc deficiency typically occurs on soils with high pH and low organic matter levels. Since all of these soils were below 7.0 in pH, it is not surprising that a zinc response was not noted. Manganese and iron are seldom limiting except on soils with a pH above 7.5. Additions of copper to mineral soils have previously been observed to have little or no influence on tissue Cu or on yield when applied at the rate used in this study.

Cobalt Content of Minnesota Soils, Legumes, and Grasses

J. M. MacGregor and J. L. Keogh

In the mid-1940's, a cobalt deficiency in calves was reported near the town of Dundas, in Rice County, Minnesota. Feeding experiments conducted by the late Dr. Thor W. Gullickson of the then Department of Dairy Husbandry, established that the inclusion of cobalt in the diet of the unhealthy animal resulted in apparently normal health and subsequent growth. Since very little was known of the cobalt status of Minnesota soils or of the pasture or hay plants growing on different soils, a study was commenced in the late summer of 1948 on this problem.

Bulk soil samples were collected from 11 representative soil types at locations from Beltrami County in the north to Fillmore County in the southeast. Samples of the grasses growing in these soils were also collected for analysis. The soils were potted in the greenhouse in triplicate and seeded to meadow fescue in February, 1949. A solution of cobalt sulfate ($CoSO_4 \cdot 7H_2O$) was added to the potted soils to supply 0.0, 0.5, 1.0, and 5.0 pounds of cobalt per acre. To avoid contamination and maintain natural growth as much as possible, no other fertilizer materials were added. The grasses were harvested when heading out and analyzed for cobalt concentrations. The sampling location, soil type, pH, total soil cobalt, cobalt content of native grass and of the meadow fescue grown in the greenhouse with the cobalt-treated soils are shown in Table 1.

Table 1. Cobalt Content of Some Minnesota Soils, Native Grasses and of Meadow Fescue.

	County	Soil Type	Soil pH	Total soil Co. (ppm)	Co. in native grasses (ppm)	Meadow fescue grown in greenhouse Cobalt applied in lbs/A 0.0	0.5	1.0	5.0
						ppm cobalt at heading of meadow fescue			
9	Fillmore	Kenyon Si.L.	6.8	1.3	0.18	0.14	0.10	0.22	0.33
6	Renville	Nicollet L.	7.6	1.8	0.16	0.09	0.06	0.20	0.10
7	Fillmore	Tama Si.L.	5.7	2.1	0.18	0.12	0.20	0.16	0.18
5	Mille Lacs	Milaca VFSL	5.5	3.2	0.14	0.14	0.10	0.22	0.31
4	Sherburne	Zimmerman LFS	5.4	3.3	0.13	0.08	0.16	0.12	0.16
2	Stevens	Nutley Si. C.	6.3	4.4	0.12	0.08	0.09	0.10	0.36
3	Clay	Fargo Si. C.L.	6.2	5.3	0.15	0.08	0.10	0.11	0.33
8	Wabasha	Fayette Si.L	6.8	5.4	0.18	0.10	0.10	0.10	0.15
10	Martin	Clarion	7.5	5.8	0.15	0.05	0.10	0.10	0.19
1	Beltrami	Si.L.	5.9	6.5	0.20	0.14	0.29	0.18	0.86
11	Rice	Clarion L.	5.9	7.0	0.11	0.15	0.14	0.07	0.15

The lack of correlation between total soil cobalt, the cobalt concentration in the grasses growing on the sample sites, and the concentrations in the meadow fescue grown in the greenhouse where cobalt had been added at different rates was interesting but inconclusive, and since funds were not available to continue this study, the investigation was temporarily discontinued.

Precipitation in many areas of Minnesota during 1951 was exceptionally heavy, with a moisture excess of 10 to 12 inches on the annual basis being relatively common. At this time Dr. William Andberg, a veterinarian located at Anoka, observed several cases of what he considered to be cobalt deficiency in dairy cattle on some farms of the area. These farm soils are quite sandy in nature, the most common soil type being Zimmerman loamy sand. Dr. Andberg's observations (which continued into 1952) were reported to this department and it was decided to apply cobalt sulfate ($CoSO_4 \cdot 7H_2O$) spray at to pastures on several farms where possible cobalt nutritional deficiencies had been observed. The rates of cobalt application were to be the same as those used on the 11 soils of the 1948-49 greenhouse study at 0.0, 0.5, 1.0 and 5.0 pounds per acre.

Pastures on four Anoka County farms received cobalt sprays (in quadruplicate) early in May and a bluegrass and a legume pasture on the problem farm near Dundas in Rice County (Clarion loam) were also treated at the same time. None of the plot areas were fenced and these were grazed with the remainder of the pastures. Forage samples were harvested where possible from each plot, both in mid-June and again in early August for cobalt analysis. The forage samples were dried, ground and stored until late in 1968, at which time improved analytical equipment and methods were available for cobalt analyses.

The cobalt content of the two 1953 forage cuttings are shown in Table 2. In some instances, the pastures were grazed too closely and forage samples were not obtainable.

Table 2. The Cobalt Content of 1953 Pasture Forage on Five Minnesota Farms Following Soluble Cobalt Applications in Early May.

Soil type	County	Farm operator	Total Soil Co ppm	Forage type	Cutting	Rates of cobalt application to soil (lbs/A) 0.0	0.5	1.0	5.0
						Parts per million of Co in forage			
Zimmerman loamy sand	Anoka	Paul Paulson	1.19	alfalfa	First	----	----	----	2.09
" " "	"	" "		"	Second	0.15	0.18	0.38	0.88
" " "	"	" "		timothy	First	----	----	----	0.81
" " "	"	" "		"	Second	0.13	0.18	0.38	----
" " "	"	Peter Sortberg	0.56	alfalfa	First	0.30	0.98	0.78	1.88
" " "	"	" "		"	Second	0.15	0.23	0.38	1.38
" " "	"	" "		brome	First	0.15	0.53	0.17	0.31
" " "	"	George Giddings	1.65	brome	First	0.13	0.70	1.00	2.22
" " "	"	" "		"	Second	0.13	0.18	0.23	----
" " "	"	Peter Georges	0.72	alfalfa	Second	0.28	----	0.28	0.88
" " "	"	" "		brome	Second	----	----	----	1.63
" " "	"	" "		timothy	Second	0.23	0.13	0.18	0.75
Clarion loam	Rice	Don Fergason	2.26	legume mix.	First	0.28	1.50	2.50	7.13
" "	"	" "		" "	Second	0.15	0.23	0.38	0.18
" "	"	" "	2.49	bluegrass	First	0.08	----	----	9.50
" "	"	" "		"	Second	1.00	----	----	1.63

Dashes (--) indicate where close grazing eliminated sampling.

Although the cobalt concentrations of the different forage species are quite variable, it is apparent that applications of soluble cobalt to these soils results in some increase in Co concentration of the forage plants on these soils. There appears to be little difference between cuttings, and the legumes tend to be somewhat higher in cobalt content. However, it would seem to be more practical to supply cobalt directly in animal feeds rather than to soils of pasture or haylands.

1968 Soybean Inoculant Testing Program

G. E. Ham, Department of Soil Science and
V. B. Cardwell, Department of Agronomy and Plant Genetics

The plots were located at Rosemount, Waseca, Lamberton, Morris and Big Lake, Minnesota. The soil test results for soil samples taken at these locations are shown below:

Location	Soil pH	Soil texture	Extractable phosphorus pp2m	Exchangeable potassium pp2m	Sulfur pp2m	Zinc pp2m
Big Lake	5.9	loamy sand	200(VH)[a]	200(M)	5(L)	2.6(H)
Lamberton	6.0	silty clay loam	13(M)	210(H)	3(L)	1.3(M)
Morris	7.8	silt loam	13(M)	220(H)	7(M)	1.1(L)
Rosemount	6.1	loam	28(H)	250(H)	8(M)	2.1(H)
Waseca	5.8	loam	40(VH)	310(VH)	10(M)	2.9(H)

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

Materials and Methods

Inoculants applied by the inoculant companies and humus inoculants applied soon before planting to Chippewa 64 soybean seeds were evaluated for influence on soybean seed yield. The seed was supplied by the University of Minnesota and all seed was from one source. The planting dates were as follows: Big Lake, May 10; Lamberton, May 14; Morris, May 21; Rosemount, May 23; Waseca, May 25. The border rows of the three-row plots were planted with a tractor-mounted cone planter while the treatment or center row (including checks) was planted by opening a furrow with a wheel hoe, shaking the seeds from a coin envelope and covering with a garden rake. Seedling emergence was as good or better in the hand-planted rows as in the mechanically planted border rows.

Foliar analyses of leaf samples taken during the summer showed that the concentration of P, K, Ca, Sr, Na, Fe, Mg, Zn, Cu, Mo, Mn and B in the leaves was normal. The center row of each plot was harvested for seed yield. A 15-foot section of the center row was cut, threshed with a small plot thresher, cleaned and weighed. Yields for statistical analyses were based on bushels of soybeans per acre on the basis of 12.0% moisture. The yields are shown in Table 1. Yields from Grand Rapids and Crookston are not included due to the adverse growing season at these two locations which resulted in unsuitable testing conditions.

Results and Discussion

Inoculation of soybeans did not significantly affect soybean seed yields. The analysis of variance for all locations is shown in Table 2. The only significant effect was location. The reason for the significant location effect is obvious from the data since the average yield varied from about 15 bushels per acre at Big Lake to over 40 bushels per acre at Waseca. The analysis of variance for each location by itself showed no significant F values at the .10 level of significance.

The failure of inoculation to increase soybean seed yields confirms studies conducted by the University of Minnesota during 1967 and studies reported by other researchers in other states.

The samples of seed from the Morris and Waseca inoculation plots are being submitted to the U.S. Regional Soybean Laboratory at Urbana, Illinois for oil and protein analysis.

Summary and Future Plans

The 1968 soybean inoculation test results confirm the opinios expressed and the position taken in Soils Fact Sheet Number 9, "Inoculation Problems of Soybeans." The inoculation test will be discontinued unless the various companies wish to finance additional tests.

Table 1. Effect of Inoculation on Soybean Seed Yields (Bu/A) at Various Locations in Minnesota in 1968

Inoculant brand	Type inoculant	Location: Big Lake bu/acre	Morris bu/acre	Rosemount bu/acre	Waseca bu/acre	Lamberton bu/acre	Average of all locations bu/acre
A	Humus 1	15.8	24.1	27.1	42.7	37.4	29.4
A	Humus 2	15.9	25.2	26.8	41.6	35.0	28.9
B	Check	15.0	23.0	28.9	42.7	34.3	28.9
B	Research 1	15.6	25.7	27.1	42.9	38.0	29.9
B	Research 2	16.4	27.1	26.0	39.8	37.1	29.3
B	Humus 1	13.8	28.1	28.8	43.5	35.8	30.0
B	Humus 2	12.8	28.8	26.5	39.9	34.8	28.6
C	Check	17.1	25.4	26.4	43.9	36.4	29.8
C	Research A	15.4	25.2	24.6	44.0	32.3	28.4
C	Research B	12.2	26.0	26.8	42.5	37.1	28.9
C	Humus 1	13.6	25.7	27.3	41.3	30.8	27.7
C	Humus 2	13.6	26.0	26.0	43.9	40.5	30.0
C	Preinoc. Check	12.9	27.6	27.5	42.7	35.6	29.3
C	Preinoculated	16.5	27.0	27.0	42.1	39.2	30.4
D	Check	14.0	25.8	26.5	41.5	34.9	28.5
D	Research A	14.2	26.3	27.9	41.3	35.2	29.0
D	Research B	14.0	25.6	27.4	44.0	32.5	28.7
D	Humus 1	15.3	25.9	26.0	41.7	34.9	28.8
D	Humus 2	15.6	26.9	28.4	43.3	34.8	29.8

Table 1
Page 2 of 2

E	Check	15.9	24.3	26.1	40.0	38.7	29.0
E	Research 1	15.0	28.1	23.0	41.1	37.0	28.8
E	Research 2	16.2	24.8	24.7	43.3	33.1	28.4
E	Humus 1	15.6	26.1	24.5	41.7	33.0	28.2
E	Humus 2	16.3	25.1	25.3	43.3	33.2	28.6
F	Check	15.6	27.9	27.8	43.5	37.6	30.5
F	Research 1	16.0	27.6	27.0	41.6	38.2	30.1
F	Research 2	13.1	26.1	26.0	40.4	35.8	28.3
F	Humus 1	14.8	26.8	29.2	43.1	34.7	29.7
F	Humus 2	17.2	26.4	29.8	39.9	38.4	30.3
U of M	Check	15.4	24.9	27.8	43.2	39.2	30.1
U of M	Strain 1	15.5	25.2	26.5	43.0	38.0	29.9
U of M	Strain 2	13.4	26.2	27.3	42.7	37.8	29.5
U of M	Strain 3	14.4	27.2	26.9	42.3	38.0	29.8
Nodulating isoline		14.1	28.2	31.6	44.8	37.0	31.1
Nonnodulating isoline		8.8	17.7	18.6	33.5	29.3	21.7
Average of all checks		15.5	25.2	27.3	42.5	36.9	29.5
Average of all inoculants		14.9	26.3	26.7	42.2	37.1	29.4
Coefficient of variation		19.6%	9.7%	10.3%	6.5%	12.1%	10.7%

Table 2. Analysis of Variance for Soybean Seed Yield (bu./Acre) When Uninoculated and Inoculated Seeds Were Compared at Big Lake, Lamberton, Morris, Rosemount and Waseca, Minnesota in 1968.

Source of Variation	Degrees of Freedom	Mean Square	F Value[a]
Location (L)	4	14,372.50	419.39**
Replicates (R)	3	34.95	1.02 NS
R x L (error a)	12	34.27	
Inoculation (I)	32	10.30	1.06 NS
L x I	128	9.66	0.99 NS
R x I	96	7.94	0.82 NS
Error (error b)	384	9.72	0.82 NS

[a]**indicates significant at the .01 level of significance; NS indicates not significant at the .10 level of significance

Soybean Variety - *Rhizobium Japonicum* Interaction Studies

G. E. Ham, R. H. Anderson and J. R. Lofgren

Seven strains of *Rhizobium japonicum* (soybean rhizobid) obtained from the U.S.D.A. Beltsville collection were used to inoculate three different varieties of soybeans at Crookston and Grand Rapids in 1968. The peat-based inoculants were applied to the seed the night before planting and kept refrigerated until planted. The replications with three row plots in 24-inch rows were utilized with the center row of each plot inoculated. The growing season was cooler than normal at both locat'ons.

Few or no nodules were present on the roots of the uninoculated plants at both locations. Yields at Grand Rapids were increased by as much as 7.8 bushels per acre by inoculations while yields were increased by as much as 5.9 bushels per acre at Crookston (Tables 1 and 2). The effects of rhizobia strains and the strain x variety interaction were significant as indicated in Tables 3 and 4. This indicates that rhizobia strains increased yields significantly and the effect of a strain was not the same on all varieties. However, sorting out the best strain (s) for each variety is virtually impossible due to year variation and also due to location, i.e., the best strain on a variety may not be the best strain on this variety at another location or in another year.

Table 1. Effect on Soybean Seed Yield When Different Strains of *Rhizobium Japonicum* Were Applied to Soybean Seeds Planted at Crookston, Minnesota in 1968

Rhizobium Japonicum strain	Soybean Variety			Average of all varieties
	Altona bu/acre	Portage bu/acre	II-55-14 bu/acre	bu/acre
Check	15.4	16.7	16.1	16.1
38	21.3	20.2	17.5	19.7
110	17.7	21.8	19.5	19.7
122	16.3	19.1	20.7	18.9
123	16.8	20.6	17.0	18.1
126	19.9	20.8	17.6	19.4
135	16.3	17.8	16.8	17.0
138	18.4	20.0	21.4	19.9
Average of all strains	17.8	19.6	18.3	18.6

Table 2. Effect on Soybean Seed Yield When Different Strains of *Rhizobium Japonicum* Were Applied to Soybean Seeds Planted at Grand Rapids, Minnesota in 1968

Rhizobium Japonicum strain	Soybean Variety			Average of all varieties
	Altona bu/acre	Portage bu/acre	II-55-14 bu/acre	bu/acre
Check	27.6	30.0	29.8	29.2
38	31.2	34.2	37.0	34.1
110	32.5	32.1	35.6	33.4
122	33.3	34.3	32.0	33.2
123	30.8	31.7	31.3	31.3
126	35.3	34.1	34.4	34.6
135	30.6	32.8	32.3	31.9
138	32.3	36.4	37.6	35.4
Average of all strains	33.2	31.7	33.8	

Table 3. Analysis of Variance for Soybean Seed Yield When Soybean Seeds Were Inoculated at Planting Time at Crookston, Minnesota in 1968

Source of Variation	Degrees of Freedom	Mean Square	Calculated F Value
Replicates (R)	2	7.10	0.83 NS
Varieties (V)	2	6.75	0.79 NS
R x V	4	8.55	
Strain (S)	7	20.73	4.68**
V x S	14	9.24	2.09*
	42	4.43	

Table 4. Analysis of Variance for Soybean Seed Yield When Soybean Seeds Were Inoculated at Planting Time at Grand Rapids, Minnesota in 1968

Source of Variation	Degrees of Freedom	Mean Square	Calculated F Value
Replicates (R)	2	2.50	0.99 NS
Varieties (V)	2	26.34	10.48**
R x V	4	2.52	
Strain (S)	7	36.69	9.94**
V x S	14	6.75	1.83T
R x V x S	42	3.69	

Sugarbeet Rotation Study - 1968
Northwest Experiment Station, Crookston, Minnesota

Olaf C. Soine, Soil Scientist

This is the second year of this rotation study, but no definite trends are visible at this time. The yields of all crops were good. The sugarbeet yields are approximately 38 percent higher in 1968 than they were in the drought year of 1967. The beet plots follow the last crop in each rotation as given in table (e.g., Rotation 1, beets follow sw. cl. fallow; Rotation 2, beets follow the oats crop, etc.). The wheat yields in 1968 were similar to those in 1967. The barley yields were about 25% below last year's yields.

The crop yields for the 6 rotations for 1968 with 1967-68 averages are given in Table 1.

Table 2 gives the 1967 crop, yield, percent sugar, purity index, and sodium, potassium, and amino-N. in parts per million for the 6 rotations. The beets were harvested on September 23, and this early date may in part account for the low percentages of sugar and the high purity indexes. The percent sugar varied from 11.90 to 13.20 for the beets from Rotation 1 and 6, respectively. Rotation 1 beets had the highest purity index and sodium content, but the differences were not significant. The rotations did not show any significant differences in the potassium content of the beets. The beets that followed the sweet clover and the black fallow treatments contained the highest amount of amino nitrogen.

Table 1. Crop yields for 6 rotations for 1968 with 1967-68 averages.

	1968	1967-68	1968	1967-68	1968	1967-68	1968	1967-68
Rotation 1	Beets		Wheat		Barley		Sw. cl. fallow	
	21.44 T	17.28 T	54.4 bu.	55.1 bu.	65.0 bu.	83.1 bu.	-----	-----
Rotation 2	Beets		Wheat		Barley		Oats	
	18.76	16.24	53.6	54.6	77.9	89.4	114.0	125.4
Rotation 3	Beets		Potato*		Wheat		Barley	
	19.29	16.21	309	282.5	49.4	50.6	75.2	83.4
Rotation 4	Beets		Wheat		Barley		Alf. hay fallow**	
	20.19	16.11	56.1	52.9	73.6	89.6	2495 lb.	-----
Rotation 5	Beets		Wheat		Barley		Bl. fallow	
	22.23	17.78	57.3	58.7	75.2	87.8	-----	-----
Rotation 6	Beets		Wheat		Barley		Soybeans	
	20.36	16.88	57.8	57.7	75.3	83.2	21.4	27.5

* No. 1 Potato
** Moisture content 20%

Table 2. The 1967 crop, yield, percent sugar, purity index, and sodium, potassium and amino-nitrogen for the 6 rotations, 1968.

Rotation	1967	Yield	Sugar	Purity	Sodium	Potassium	Amino-N.
No.	Crop	T./A.	%	Index	P.P.M.		
1	S. cl. F.	21.44	11.90	1076	1034	1542	528
2	Oats	18.76	12.50	811	792	1543	351
3	Barley	19.29	13.03	763	705	1226	439
4	Alfalfa	20.19	12.86	911	792	1483	517
5	Bl. fallow	22.23	12.23	971	862	1323	552
6	Soybeans	20.36	13.20	787	592	1555	438
L.S.D.		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Alfalfa Removal vs Plow-Under for Sugarbeets in 1968
Northwest Experiment Station, Crookston, Minnesota

Olaf C. Soine, Soil Scientist

In this study, a 21-acre field of old alfalfa was used to evaluate the effect of removing the first crop versus plowing it under for sugarbeets the following year. This field had been in alfalfa for 3 crop years and the stand was medium. The treatments were randomized and laid out in 100 ft. strips across the field. The first crop of alfalfa was removed for hay from 4 strips and the remaining 4 strips were left and the field was plowed on June 28-29, 1967. It was fertilized with 250 lbs/acre of 0-46-0 in the fall and 100 lbs/acre of 5-42-0 at planting time.

The beets were mechanically thinned and no hand labor was used.

The beets were harvested September 20, 1968. Table 1 gives the field data.

Table 1. Yield of beets, percent sucrose, purity index and number of beets harvested.

Treatment	Yield	Sucrose	Sucrose	Purity	No. beets harvested
	tons/A	lbs/A	percent	index	/80 ft. row
Alfalfa removed	15.45	3930	12.72	766	64
Alfalfa plowed under	15.90	3892	12.24	864	70

Alfalfa Yields: Yields were taken from each plot and the average for all plots was 1858 lbs of dry matter per acre. This is equivalent to 1.1 tons of alfalfa hay at 15% moisture content. Figuring alfalfa hay at $16.50 per ton, the value of alfalfa would be $18.65 per acre.

Soil Fertility Experiments on Potatoes

C. J. Overdahl, G. W. Randall and C. P. Klint

The following tables are a summary of fertility trials on sandy soils with irrigated potatoes the past 3 years (1966, 1967 and 1968).

It is of interest to note a slight reduction in the K soil test from a 600+ to 435 lbs. on plots that were untreated with potassium for three years. There is an apparent corresponding yield response to potassium.

Reduction of magnesium levels in the potato petiole is directly related to the increase in potassium levels. Thus far no response has been measured in potato yield from magnesium treatments, either as dolomitic limestone, magnesium sulfate or magnesium chloride, even when petioles from untreated magnesium plots were as low as .15%.

With the Norland variety at the Gray farm, yields from 300 pounds of nitrogen were superior to those from 150 pounds N. At the Sand Plain farm, with the Russet Burbank variety, 150 pounds of nitrogen gave potato yields that were significantly higher than 75 pounds, but 300 pounds was not significantly higher than 150 pounds. The low total yield perhaps accounts for the lack of increase beyond 150 lbs. of N. The plan is to use a different variety in 1969.

Table 1. Effect of potassium on potato yield, % K and % Mg in petiole. Tessman Farm, Hennepin County, Minnesota.

	1966 CWT/A		1967 CWT/A		1968 CWT/A	
1						
200 + 150 + 0	332		206		178	
200 + 150 + 150	325		225		280	
200 + 150 + 500	277		222		271	
	% K	% Mg	% K	% Mg	% K	% Mg
2						
200 + 150 + 0	11.6	.14	8.0	.22	6.8	.35
200 + 150 + 150	12.7	.12	8.0	.20	7.6	.23
200 + 150 + 500	12.8	.14	7.9	.20	7.9	.14

K soil test = 600+ in spring of 1966, in fall of 1968 200+150+500 plot tested 600+ but 200+150+0 plots averaged 435 lbs. of exchangeable K.
Slightly lower N & P rates were used in 1966.
Variety - Norland

Table 2. Effect of dolomitic limestone on yield of potatoes (CWT) and % magnesium in tissue. Tessman Farm, Hennepin County, Minnesota.

Lime rate lbs/A	1966 Yield	1966 % Mg	1967 Yield	1967 % Mg	1968 Yield	1968 % Mg
0	344	.21	276	.20	322	.16
1000	368	.18	193	.17	323	.17
2000	377	.21	224	.17	326	.20
4000	354	.21	243	.23	328	.19
8000	-		227	.22	300	.23

Soil pH 5.4. Lime had no effect on soil pH or yield.

Table 3. Effect of magnesium ($MgSO_4$) on yield of potatoes and % Mg in petiole. Tessman Farm, Hennepin County, Minnesota.

Mg lbs/A	1967 Yield Cwt.	1967 Mg %	1968 Yield Cwt.	1968 Mg %
0	339	.22	371	.15
25	328	.23	362	.15
50	341	.26	370	.17
75	344	.25	373	.17
300	322	.23	346	.20**

Average of 5 reps. 200+150+500 applied on all plots both years, 75+150+150 in the row.

Magnesium applied in the row in 1967; same rates were broadcast in 1968.
Magnesium was significantly higher in petiole from 300 pound treatment in 1968.
There was no response to applications of magnesium.
Variety - Norland

Table 4. Effect of potassium on potato yield, % K and % Mg in petiole. Gray Farm, Sherburne County, Minnesota.

	1966 CWT/A	1967* CWT/A	1968 CWT/A
200 + 150 + 0	207	111	252
200 + 150 + 150	232	194	336
200 + 150 + 250	313	198	332
200 + 150 + 500	338	199	347
200 + 150 + 1000	341	203	329

	1966 % K	1966 % Mg	1967 % K	1967 % Mg	1968 % K	1968 % Mg
200 + 150 + 0	-	-	4.5	.49	4.9	.72
200 + 150 + 150	8.3	.55	7.6	.22	7.5	.32
200 + 150 + 250	10.0	.38	9.0	.15	7.8	.26
200 + 150 + 500	11.8	.31	9.0	.13	7.6	.20
200 + 150 + 1000	11.3	.37	9.0	.15	7.8	.17

* Yield reduced by severe hail damage.
Petiole analysis in 1966 at Ohio, 1967 & 1968 at U. of Minn.
Variety - Norland

Table 5. Effect of phosphorus on potato yield, % P in petiole. Gray Farm, Sherburne County, Minnesota.

	1966		1967		1968	
	CWT/A	% P	CWT/A	% P	CWT/A	% P
200 + 0 + 500	255	.29	145	.20	213	.21
200 + 150 + 500	325	.26	258	.51	318	.33

N & P treatments were slightly lower in 1966.
Variety - Norland

Table 6. Effect of nitrogen on potato yield. Gray Farm, Sherburne County, Minn.

1966	Yield Cwt.	1968	Yield Cwt.
50 + 100 + 500	228	75 + 150 + 500	317
100 + 100 + 500	307	150 + 150 + 500	331
200 + 100 + 500	346	300 + 150 + 500	368

No N yields taken 1967 due to hail and plot damage.
Variety - Norland

Table 7. Effect of nitrogen on potato yield. Sand Plain Experiment Farm, Sherburne County, Minnesota.

1968	Yield Cwt.
75 + 150 + 500	139a
150 + 150 + 500	204b
300 + 150 + 500	216b

4 replications
Variety - Russet Burbank

Table 8. Effect of potassium and magnesium treatments ($MgCl_2$) on yield of potatoes, % K and % Mg in petiole. Sand Plain Experiment Farm, Sherburne County, Minnesota 1968.

Treatment		Yield Cwt.		%	%
K_2O	Mg	A+B	A	K	Mg
0	0	158	81	5.8	.31
150	0	170	91	6.0	.26
500	0	189	126	6.7	.17
0	50	195	118	6.0	.36
150	50	199	115	6.2	.30
500	50	183	102	6.9	.19

$N + P_2O_5 + K_2O$ lbs/A	Potash Effect CWT/A	Mg lbs/A	Magnesium Effect CWT/A
200 + 150 + 0	176	0	172
200 + 150 + 150	185	50	192
200 + 150 + 500	186		

There were no significant differences in yield from either K or Mg. Yields were very low with many B size potatoes. 1968 soil test pH = 5.5, P = 200+, K = 190. Variety - Russet Burbank

Fertilizer Trials on Oil Crops
Northwest Experiment Station, Crookston, 1968

Olaf C. Soine, Soil Scientist

Tame Mustard: This completes a 3-year fertilizer study on tame mustard and the yield results are given in the following table.

The 1966 growing season was favorable with above normal precipitation during June, July, and August, and above normal temperatures during April and May. The summer drought of 1967 reduced the yielding potential of the crop. The excessive rainfall, cool and cloudy weather during the 1968 growing season were not too favorable for mustard.

The highest yields were obtained in 1966 but there were no significant differences between the treatments. The 20+40+0** (20 lb. N broadcast, 40 lb. P applied with drill) gave the highest yield response.

In 1967, 20+40+0* treatments produced the highest yields but the yield differences were not significant in this trial.

There were no significant yield differences in the 1968 trial. The 40+80+40 treatment gave the best yield differences in the 1968.

The 3-year average yields varied from a low of 855 to a high of 1071 lbs. per acre but the differences between the treatments were not significant. The 30+40+20* treatment gave the highest 3-year average yield, but it was not the highest yielder each year. The higher rates like 40+80+40 and 80+160+80 did not increase the yields when compared to the other rates.

Fertilizer Trial on Tame Mustard
Yield in lbs/acre, 1966-68

Treatment	1966	1967	1968	Avg. 1966-68
N-P-K-		lbs/acre		
0+0+0	1028	852	812	897
10+0+0*	1030	814	729	858
20+0+0**	1171	735	683	863
0+40+0	1095	860	703	886
10+40+0*	1228	918	727	958
20+40+0**	1363	820	748	977
10+40+0	1057	835	981	958
20+40+0*	988	1046	740	925
30+40+0**	1128	905	806	946
20+40+20	1119	861	895	958
30+40+20*	1200	1055	959	1071
40+40+20**	1097	840	786	908
40+80+40	--	852	1078	965
80+160+80	--	791	919	855
L.S.D.	N.S.	N.S.	N.S.	N.S.

10+0+0* and 20+0+0**, 10 and 20 lbs. N. respectively, broadcast prior to seeding.
10+40+0* and 20+40+0*, 10 and 20 lbs. N. broadcast, 0+40+0 applied in band with drill at seeding time.
Avg. date of seeding - May 2
Avg. date of harvest - August 7

Sunflowers: The following table gives the yield, bushel weight, and oil content of sunflowers for the past 3 years.

In general, the highest yields were obtained in 1967 and 1968. The fertilizer treatments varied from year to year and no single treatment gave a consistent high yield each year. The 40+80+0 treatment gave the highest average yield response for the 3-year period. The 0+0+40 treatment gave the lowest average yield for the 3-year period.

There was very little variance in the average bushel weights for the 3-year period.

The average oil content for 1966-67 varied from 40.2 to 45.8% for the 80+160+80 and 0+40+20 treatments, respectively, compared to 44.6% for the check plot.

Fertilizer Trial on Sunflowers

Treatment	Yield lbs/acre				Bu.wt.	Percent oil
N P K	1966	1967	1968	Avg.1966-68	Avg.1966-68	Avg.1966-67
40+80+0	1670	2094	1894	1886	29	44.2
20+40+0	1582	2205	1529	1772	28	45.0
80+160+80*	--	1390	2126	1758	28	40.2
40+80+40	1664	1711	1830	1735	29	44.7
0+0+20	1550	1791	1768	1703	28	45.2
20+0+0	1465	1626	2002	1698	28	45.5
20+40+20	1527	1971	1553	1684	29	44.8
0+40+20	1505	1754	1620	1626	29	45.8
40+0+0	1621	1319	1879	1606	29	44.4
0+0+0	1397	1578	1844	1606	29	44.6
0+80+40	1412	1638	1723	1591	28	45.1
0+80+0	1450	1680	1555	1562	29	45.3
0+40+0	1515	1393	1570	1493	29	45.1
0+0+40	1288	1290	1684	1421	28	44.0

* 2-year data
Avg. date of seeding - May 7
Avg. date of harvest - October 5

Summary of 1968 Soil Fertility Work on Sunflowers from the Department of Agronomy and Plant Genetics

R. G. Robinson[1]
Dept. of Agronomy and Plant Genetics

No fertilizer trials were conducted in 1968. However, within trials of row widths, plant populations, varieties, and crop sequence, comparisons were made of very high rates of N-P-K versus no fertilizer. The yield data in Table 1 are the grand averages of many treatments and represent the average response to fertilizer in these trials.

Table 1. Effect of fertilizer on soil test results and sunflower performance at four locations.

		Soil tests, July 1968, lb/A				Sunflower			
	Soil	Fertilizer		No fertilizer		Yields, lb/A		Date bloom	
Location	texture	P	K	P	K	Fert.	No fert.	Fert.	No fert.
Rosemount	silt loam	66	210	44	190	1249	1062	7-25	7-28
Rosemount	silt loam	48	290	26	230	1808	1488	7-26	7-29
Elk River	sandy loam	200	280	200	180	576	692	7-25	7-28
Grand Rapids	loamy sand	114	270	75	150	1614	1594	8-10	8-13

On the basis of these soil tests and previous experience with sunflowers, yield increases from P or K would not be expected even though the fertilizer applications greatly increased available P and K. All of the soil tests were rated high or very high in P and medium to very high in K.

In all tests, visual response to the N-P-K fertilizer was obvious--greener leaves, increased vigor, more rapid growth. This was probably due to the high rates of N--120 to 300 lb/A/.

Fertilizer decreased seed yield at both 30,000 and 60,000 populations and in 3 of 4 varieties at Elk River. The populations were too high but were chosen in expectation of irrigation which was not available when needed. Stalk and leaf growth were obviously greater on the fertilized plots, at least until bloom stage. One inch of irrigation water was applied to one replicate at bloom stage July 25 (too late). On this one replicate, irrigation alone increased yield to 851 lb/A and irrigation plus fertilizer to 1212 lb/A.

[1]Field work at Grand Rapids was conducted by Agronomist R. H. Anderson.

Yield Potentials on a Dorset Sandy Loam, Park Rapids, 1968

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

In order to determine the yield potential of the soils in the Park Rapids area with maximum fertility levels, yield production trials were carried out for corn, soybeans, potatoes, and sunflowers. The production trials for corn are reported separately. The yields for each crop are shown in Table 1.

Table 1. The Yield of Potatoes, Soybeans and Sunflowers From the Yield Potential Trials at Park Rapids 1968.

Crop	Variety	Yield
Potatoes	Norgold	554 bu./A
	Burbank	670 bu./A
Soybeans	Portage	23.9 bu./A
	Clay	36.0 bu./A
	Grant	34.8 bu./A
Sunflowers	Paradovich	1542 lb./A

Potatoes:

Both Norgold and Burbank russets were grown in this study. The seed pieces were planted approximately 1 foot apart in the row in 24 inch rows. The fertility program was: 500 lb. K/A as 0-0-60 and K_2SO_4, 50 lb. P/A as 0-46-0, 200 lb. N/A as 33-0-0 and 50 lb. S/A as K_2SO_4. In addition, 200 lb. N/A was sidedressed in 2 separate applications. Chlordane at 16 lb./A was applied at 50 lb./A to provide a systemic insect control. These two materials were disced in at planting time. The natural rainfall was supplemented with approximately 10 in. of water by weekly irrigation from July 13 to August 13. After each irrigation

the plants were sprayed with 1 1/2 lb./A of Polyram 80-W to prevent both early and late blight.

Soybeans:

The three varieties of soybeans were planted in 24 in. rows at a rate of approximately 90 lb./A. The fertilizer applications included: 200 lb. K/A as 0-0-60 and K_2SO_4, 50 lb. S/A as K_2SO_4, 30 lb. P/A as 0-46-0, and 100 lb. N/A as 33-0-0. These materials were disced in at planting time. Randox at 10 lb./A was also disced in to control the perennial grasses. The soybeans received approximately 12 inches of supplemental irrigation throughout the summer.

Sunflowers:

The sunflowers were planted in 24 inch rows with a spacing between the seeds in the row of approximately 6 inches. The fertilizers applied included: 300 lb. K/A as 0-0-60, 30 lb. P/A as 0-46-0, 50 lb. S/A as gypsum, 200 lb. N/A as 33-0-0 and 1 lb. B/A as fertilizer borate. Chlordane was applied at 16 lb./A to control soil insects. All of these materials were disced in at planting time. A sidedress application of 100 lb. N/A was made when the plants were approximately 2 feet tall. Approximately 12 inches of supplemental irrigation was supplied throughout the summer.

Discussion:

It should be pointed out that the yield of the Burbank russets was significantly greater than the yield of Norgold russets. With regard to the soybeans, the yields of the Clay and Grant varieties were not significantly different from each other but were significantly different from the yield of the Portage variety. However, at the time of frost the Grant variety was not mature and as a result the harvested soybeans were of poor quality.

The Effect of Variety and Population on Corn Yield at Park Rapids

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

As part of an overall production study, the effect of plant population on the yield of 7 corn varieties was studied during the summer of 1968. Both 65-68 and 75-85 day hybrids were included. The short season varieties were the Trojan TX-68 and Pioneer PXE-1 hybrids. The longer season varieties were Pioneer 3985, Trojan TX-80, Jacques JX-21, Northrup King PX-417 and Minnesota Hybrid 806. The short season varieties were planted to give approximately 30,50, and 100 thousand plants per acre. The longer season hybrids were planted to give approximately 20, 30, and 40 thousand plants per acre. All varieties were planted in 24 inch rows. All populations of each variety were replicated 5 times.

Fertilizer applications were constant for all populations of all varieties. The nutrients applied included: 300 lb. K/A as 0-0-60, 50 lb. P/A as 0-46-0, 50 lb. S/A as Na_2SO_4, 10 lb. Zn/A as $ZnSO_4.7\ H_2O$, 1 lb. B/A as fertilizer borate and 150 lb. N/A as 33-0-0. These materials were plowed down and worked in at planting time. In addition, 150 lb./A of a 5-15-10 liquid fertilizer were applied as a starter and 150 lb. N/A were sidedressed when the corn was approximately 24 inches high. Corn rootworms were controlled by applying 4 lb. actual chlordane per acre and perennial grasses were controlled by applying 10 lb. Randox/A. The corn was sprayed with 1.5 lb. Sevin per acre to control corn borer. The rainfall for the summer amounted to 12.68 inches with 9.98 inches falling during June. From July 13 to August 31, 14 inches of supplemental irrigation were applied.

The sixth leaf at silking was taken for nutrient analysis in the laboratory. The total S content was determined by wet digestion and subsequent turbidimetric analysis. The remainder of the elements reported here were determined by emission spectrographic analysis.

The yield data for the very short season hybrids are presented in Table 1. The values reported are averages of the 5 replications. In general, the yields were not as high as expected and there was no significant difference among the varieties or populations. It should be pointed out that in this table and all subsequent tables, treatment means followed by the same letter are not significantly different at the 5% level. Although yield differences were not significant, the average yields were higher for the lower plant populations. It is interesting to note the high precentage of barren stalks at the higher populations. This is probably a significant factor leading to the yield reductions.

Table 1. The Yield, Moisture Content, Shelling % and % Barren Stalks of Short Season Corn Hybrids Grown at Park Rapids in 1968

Variety	Population	Yield	Shelling	H_2O	Barren Stalks
	Plants/A.	Bu/A.	%	%	%
Trojan TX-68	30,000	72.1	74.4	32.9 b	14.7 b
Trojan TX-68	50,000	66.4	72.1	36.1 ab	27.4 ab
Trojan TX-68	100,000	63.7	72.1	38.4 a	26.7 ab
Pioneer PXE-1	50,000	62.2	77.1	33.0 b	32.5 ab
Pioneer PXE-1	100,000	53.6	77.8	32.6 b	43.1 a
		N.S.	N.S.		

The nutrient content of the short season hybrids at the various populations is given in Table 2. Although there are significant differences among varieties and populations for various elements, no general trend is evident from the data presented. In general, there is a reduction in the tissue content of several of the nutrients with an increase in the plant population.

Table 2. Nutrient Content of Short Season Corn Hybrids Grown at Park Rapids in 1968

Variety	Population	S	P	K	Mg	Ca	Sr	Fe	Zn	Cu	Mo	Mn	B
	Plants/A.	%					ppm						
Trojan TX-68	30,000	.244a	.420	2.07a	.402	.720	17.3	926.8	36.7a	8.18	6.8	49.5ab	8.3
Trojan TX-68	50,000	.221ab	.307a	1.90ab	.385	.654	16.1	748.5	30.8ab	8.09	9.3	38.6c	6.4
Trojan TX-68	100,000	.205b	.296a	1.42c	.471	.697	17.4	884.5	25.1bc	7.74	7.4	35.2c	7.2
Pioneer PXE-1	50,000	.221ab	.321a	1.92ab	.410	.720	17.3	787.3	24.6bc	7.02	9.4	54.8a	6.9
Pioneer PXE-1	100,000	.204b	.284a	1.63bc	.492	.717	17.6	835.4	20.3c	6.84	9.0	47.5b	6.1
					N S	N.S.	N.S.	N.S.		N.S.	N.S.		N.S.

The yield data for the 75-85 day hybrids are presented in Table 3. The highest average yield was produced by the Pioneer 3985 hybrid planted at 40,000 plants per acre. The smallest average yield was produced by the Trojan TX-80 variety planted at 20,000 plants per acre. The highest individual plot yield was 144.4 bu./A produced by the Pioneer 3985 variety at 40,000 plants per acre. The values reported in Table 3 are averages of 5 replications.

Table 3. The Yield, Moisture Content, Shelling Percentage and Percent Barren Stalks of 75-85 Day Corn Hybrids at Various Populations

Variety	Population	Yield	Moisture Content	Shelling Percentage	Barren Stalks
	Plants/A.	Bu/A.	%	%	%
Pioneer 3985	20,000	*103.5 bcd	45.3	82.6	13.4
Pioneer 3985	30,000	98.8 bcd	43.4	83.1	9.5
Pioneer 3985	40,000	122.3 a	43.3	82.4	4.7
Minnesota 806	20,000	108.5 abc	39.8	78.1	4.8
Minnesota 806	30,000	111.0 abc	41.4	76.5	9.7
Minnesota 806	40,000	106.6 abc	41.4	77.9	7.5
Jacques JX-21	20,000	112.9 ab	42.6	81.8	5.8
Jacques JX-21	30,000	110.7 abc	43.0	82.7	15.4
Jacques JX-21	40,000	113.9 ab	44.6	82.8	10.8
Northrup King PX-417	20,000	101.0 bcd	37.3	80.2	10.1
Northrup King PX-417	30,000	111.5 abc	37.0	79.8	5.4
Northrup King PX-417	40,000	122.2 a	35.4	79.6	5.3
Trojan TX-80	20,000	88.4 d	39.9	82.2	2.3
Trojan TX-80	30,000	100.3 bcd	41.2	82.7	6.2
Trojan TX-80	40,000	93.8 cd	41.8	82.3	13.8

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

The effects of variety as well as population can be separated and analyzed statistically. The effect of population on corn yield is shown in Table 4. The values reported are averages of all varieties at any one population. The yield at the 40 thousand population was significantly higher than the yield at the 20 thousand population but was not

significantly different from the average yield of all varieties planted at 30,000 plants per acre. There was no significant yield increase when the population was increased from 20 to 30 thousand plants per acre. In addition, population had no significant effect on the moisture content, shelling percentage or percent barren stalks of these 75-85 day hybrids.

Table 4. The Effect of Population on Yield, Moisture Content, Shelling Percentage and Percent Barren Stalks of 75-85 Day Corn

Population	Yield	Moisture Content	Shelling	Barren Stalks
Plants/A.	Bu/A.	%	%	%
20,000	102.9 a	41.0	81.0	7.3
30,000	106.5 ab	41.2	81.0	6.5
40,000	111.8 b	41.3	80.9	8.4
		N.S.	N.S.	N.S.

The effect of variety on corn yield is shown in Table 5. The values reported in this table are averages for all populations of any one variety. Considering all populations of each variety, the average yield of Trojan TX-80 was significantly lower than the average yields for the Jacques and Northrup King hybrids but was not significantly different from the average yield of either the Pioneer or Minnesota hybrids. Likewise, there were no significant differences among the yields for the Pioneer, Minnesota, Jacques, and Northrup King varieties when all populations were considered.

It should also be noted that the moisture content of the Northrup King variety was significantly lower than any of the other four varieties at all populations. There was no variety-population interaction for any of the variables listed in Table 5.

Table 5. The Effect of Corn Variety on the Yield, Moisture Content, Shelling Percentage and Percent Barren Stalks of 75-85 Day Corn

Variety	Yield	Moisture Content	Shelling Percentage	Barren Stalks
	Bu/A	%	%	%
Pioneer 3985	108.2 ab	44.0 a	82.7 a	9.2
Minnesota 806	108.7 ab	40.9 a	77.5 b	7.3
Jacques JX-21	112.5 a	43.4 a	82.2 a	6.0
Northrup King PX-417	111.6 a	36.6 b	79.9 b	7.0
Trojan TX-80	94.2 b	41.0 a	82.4 a	7.4
				N.S.

The effects of population and variety on the nutrient composition of corn plants are shown in Tables 6 and 7. The data in Table 6 show that plant population had no effect on the tissue content of any of the nutrients measured. The content of nutrients was, however, influenced by variety (Table 7). Again the results are variable and there is no distinct pattern. It is interesting that the Trojan variety has a distinctly lower sulfur content. This occurred even though 50 lb. of S/A was applied at planting time. Again there was no variety-population interaction for any of the nutrients studied. (See Tables 6 & 7 on following page.)

In general, the yield of the 75-85 day varieties increased with increasing population and some varieties proved to be superior to others. The yields of the 65 day hybrids were, however, much lower than expected. In addition, there was no consistent effect of either population or variety on the nutrient content of the corn tissue.

The results of this study show that very respectable, but not exceedingly high, corn yields can be obtained in the Park Rapids area. The data from the 65 and 68 day varieties points out the need for more study of these hybrids.

Table 6. The Effect of Population on the Nutrient Content of 75-85 Day Corn

Population	S	P	K	Ca	Mg	Sr	Fe	Zn	Cu	Mo	Mn	B
Plants/A.	%					ppm						
20,000	.260	.365	1.97	.667	.300	17.6	893.4	31.8	9.8	.89	61.6	8.4
30,000	.258	.369	2.24	.656	.254	16.8	865.0	32.3	9.6	.74	66.3	9.0
40,000	.249	.355	2.11	.644	.274	18.2	745.2	30.4	8.6	.75	63.	8.4
	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 7. The Effect of Variety on the Nutrient Content of 75-85 Day Corn

Variety	S	P	K	Ca	Mg	Sr	Fe	Zn	Cu	Mo	Mn	B
	%					ppm						
Pioneer 3985	.282 a	.397 b	2.14 ab	.657	.265 bc	17.1	811.0	30.6	9.1	.77	64.1 a	7.8
Minnesota 806	.273 a	.376 a	2.15 ab	.661	.304 ab	17.2	933.6	34.1	10.9	.92	73.3 a	9.7
Jacques JX-21	.257 b	.362 a	2.44 a	.640	.210 c	16.7	781.3	29.9	8.6	.67	64.4 a	8.7
Northrup King PX-417	.250 b	.351 a	1.86 b	.655	.339 a	17.4	812.4	28.8	9.2	.88	54.7 b	8.0
Trojan TX-80	.218 c	.330 a	1.94 b	.667	.262 bc	19.2	834.3	33.9	8.8	.73	61.6 a	8.6
				N.S.		N.S.	N.S.	N.S.	N.S.	N.S.		

The Effect of Salt Applications to an Ostrander Silt Loam at Rosemount and to a Webster Clay Loam at Lamberton on Soil Conductivity, Plant Population, and Yields of Hark and Chippewa 64 Soybeans in 1968

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

Since earlier studies of soybean chlorosis in Minnesota indicated that soluble salt concentrations in the soil were probably a contributing factor, it was decided to apply chemical salts to the soil at two locations in quantities sufficient to artificially increase saturation extract electrical conductivities of 2, 4, and 6 millimhos per centimeter in order to study the effect of such treatments on soybean growth and yield. Two varieties were to be grown - Hark, which has a low chlorosis tolerance and the more chlorosis tolerant variety Chippewa 64 using four replications in a randomized block, with each plot being fifteen feet wide and twenty feet in length.

Soil samples of the 0"-6" depth were collected at the two locations early in 1968 and these were studied in the laboratory to determine the approximate salt quantities required to induce the desired conductivities for the 6" soil depth. Two salt treatments were employed - $MgSO_4$ alone, and a mixture of $CaSO_4 \cdot 2H_2O$, $MgSO_4$, K_2SO_4 and Na_2SO_4, the relative proportions of the latter based on the cation distribution reported in the Profile 5 of the Soil Survey of the Southwest Experiment Station at Lamberton.

The calculated salt treatments were applied April 30 to May 3 and disked in before the two soybean varieties were planted. The Lamberton experiment soybean plants were severely damaged by hail in early May. This planting was then disked and replanted, but the new stand proved too variable and uneven, independent of the salt treatments applied. The yellowing which later developed in these soybeans showed no visual relation to soil salt treatment but followed the characteristic varietal

effect, being much more severe on the Hark than on the Chippewa 64 plants.

Soil of the surface 6 inches was sampled on half of the 72 plots of each field in early July and the electrical conductence of the saturated soil extract determined. Population counts were also made in early July. The Rosemount field was harvested by mowing two of the six 30-inch rows for 10 feet. Due to a saturated soil condition on the Lamberton field from September until snow in November, yield samples were not obtained. Soil samples of the first and second 6" depths on all plots were collected early in November, and these are being analyzed for electrical conductance for possible repetition of this study during the 1969 growing season.

The 1968 results are shown in Tables 1 and 2.

Table 1. Soil Treatment and Electrical Conductivity, Soybean Population, and 1968 Yield of Hark and Chippewa 64 Soybeans on an Ostrander Silt Loam at Rosemount.

	Treatment and desired conductivity	Sat. extract conductivity mmho/cm (actual)	Soybean population 1,000's/A		Yield (bu/a)	
			Hark	Chippewa 64	Hark	Chippewa 64
1	Check	0.72 a	133.8 b	114.5 b	28.8 a	20.3 a
2	2mmho $MgSO_4$	1.46 b	147.4 b	121.6 b	29.6 a	25.7 a
3	2mmho Salt Mix	1.38 b	135.4 b	113.4 b	33.2 a	25.5 a
4	4mmho $MgSO_4$	3.54 c	138.8 b	110.4 b	31.6 a	23.2 a
5	4mmho Salt Mix	2.93c	125.4 ab	119.4 b	28.4 a	26.6 a
6	6mmho $MgSO_4$	4.56 d	104.4 a	77.2 a	28.0 a	25.2 a
7	6 mmho Salt Mix	3.41 c	137.1 b	115.2 b	31.6 a	28.0 a
	F Value	42.6	5.11	6.60	0.91	2.46
	Significance	**	**	**	N.S.	N.S.
	CV	16.8	13.0	15.0	13.7	12.8

Table 2. Soil Treatment and Electrical Conductivity and Populations of Hark and Chippewa 64 Soybeans on a Calcareous Webster Clay Loam at Lemberton.

	Treatment and desired conductivity	Sat. extract conductivity mmho/cm (actual)	Plant population 1000's/A Hark	Chippewa 64	
1	Check	1.08 a	121.9 a	73.2 a	
2	2mmho $MgSO_4$	1.44 a	111.5 a	71.5 a	Too wet
3	2mmho Salt Mix	1.58 a	121.5 a	89.9 a	for
4	4mmho $MgSO_4$	2.96 b	99.4 a	95.1 a	yield
5	4mmho Salt Mix	3.02 b	120.5 a	63.4 a	sampling
6	6mmho $MgSO_4$	4.10 c	124.0 a	97.2 a	
7	6mmho Salt Mix	3.45 bc	113.5 a	98.9 a	
	F Value	17.4	0.51	0.94	
	Significance	**	N.S.	N.S.	
	CV	21.8	29.7	50.1	

Although there was a significant increase in the conductance of the soil of both fields with increasing salt treatments, the salt effect was not as large as that desired. Since the $MgSO_4$ was more soluble than the salt mixture, this salt produced the maximum conductivity of 4.56 mmhos/cm on the Rosemount field.

Plant populations of both varieties at Rosemount were significantly depressed by maximum conductivity with the highest rate of $MgSO_4$ application. There was no apparent characteristic chlorosis effect observed by the plants of either variety at any time on the Ostrander silt loam.

There was little difference in yield of the Hark variety on the various salt treated plots, and though the Chippewa 64 yields increased they were not significant, the untreated yield was considerably less than that on some of the salt treatments. It is possible that soybean

yields might be responsive to some component of one or more of the added salts.

It is apparent that factors other than high soluble salt concentrations in the soil such as temperature, moisture, aeration, etc., are probably important contributors to soybean chlorosis.

Trace Element Study with Kentucky Bluegrass and Timothy - 1968

John Grava, G. W. Randall, D. S. Fairchild,
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Four field experiments with Kentucky bluegrass and timothy were conducted to study the effects of trace element applications. All materials were top-dressed on established stands of grasses on growers' fields. General information on the experimental sites is given in Table 1.

Table 1. Location, soil type and other information concerning the experiments

Field No.	Location	Species, variety	Age of stand	Soil type
1.	E. Helmstetter Lake of the Woods County	K. bluegrass Park	1965 seeding	Rocksbury loam
2.	Ed. Baumgartner Roseau County	K. bluegrass Park	Renovated 1965	Bearden silty clay loam
3.	D. Habstritt Roseau County	K. bluegrass Park	Renovated 1966	Peat
4.	Al. Ravendalen Lake of the Woods County	Timothy Climax	1965 seeding	Unidentified loam

A Latin square design was used with six treatments replicated six times. Following amounts and sources of trace elements were used:

	Treatment	Rate
1.	None	—
2.	Boron (B)	2 lb./acre boron
3.	Copper (Cu)	50 lb./acre $CuSO_4 \cdot 5H_2O$
4.	Manganese (Mn)	25 lb./acre $MnSO_4$
5.	Zinc (Zn)	25 lb./acre $ZnSO_4 \cdot H_2O$
6.	B, Cu, Mn, Zn	Same as above

All treatments received a uniform application of N, P and K. All materials were applied on October 10, 1967.

The individual plots were 10 feet wide and 20 feet long. Plant tissue samples were collected at the beginning of heading out from fields 1, 2 and 4. No plant samples, at this stage of development, could be collected on the peat (field 3) because the field was inundated by flood. Nitrogen content was determined by the micro-Kjeldahl procedure. Contents of the other chemical elements were determined in the multielement emission spectrophotometer. A strip 17 feet long and 34 inches wide up the center of each plot was cut for seed yields.

Adjacent to each of the four main experiments with trace elements, six additional plots were established to measure the effects of fertilization with N, P and K on seed yields. Increases in seed yields, ranging from 120 to 460 pounds per acre, resulted from application of the three major nutrient elements (Table 2).

Trace element treatments did not increase seed yields of the two grasses (Table 3). Applications of boron and zinc resulted in significantly lower seed yields of Kentucky bluegrass on mineral soil (Field 1).

Effects of trace element treatments on the chemical composition of grass tissue on mineral soils are shown in Tables 4, 5 and 6. Increases in boron content of the tissue resulted from B applications on all fields. Manganese content in Kentucky bluegrass was increased only on field 1. Copper and zinc contents were not affected by trace element treatments.

Table 2. Effect of Fertilization on the Seed Yield of Park Kentucky Bluegrass and Climax Timothy, 1968.

Plant Nutrients Applied N P_2O_5 K_2O	Field 1 Bluegr. Rocksbury 1 (E.H.)	Field 2 Bluegr. Bearden sicl (E.B.)	Field 3 Timothy Unident. 1 (A.R.)	Field 4 Bluegr. Peat (D.H.)
Lbs./Acre	Yield of seed, lbs./acre			
None	232	171	43	422
60 + 30 + 30	591	387	270	-
90 + 45 + 45	693	500	368	-
20 + 40 + 40	-	-	-	583
30 + 40 + 40	-	-	-	543

Fertilizer treatments were made on October 10, 1967.

Table 3. Effect of Trace Element Applications on the Seed Yields of Kentucky Bluegrass and Timothy, 1968.

Treatments of Trace Elements	Field 1 Bluegr. Loam (E.H.)	Field 2 Bluegr Sicl (E.B.)	Field 3 Timothy Loam (A.R.)	Field 4 Bluegr. Peat (D.H.)
	Yield of seed, lbs./acre			
None	621 c	350	375	602
B (Boron)	524 a	367	353	600
Cu (Copper)	612 c	332	373	599
Mn (Manganese)	596 bc	316	370	597
Zn (Zinc)	550 ab	307	388	625
B, Cu, Mn, Zn	591 bc	387	368	583
Significance	**	N.S.	N.S.	N.S.
CV(%)	7	20	10	11

All plots received following amounts of plant nutrients: Field No. 1 and 2 60+30+30; field No. 3 90+45+45; field No. 4 20+40+40. All fertilizer materials were applied on October 10, 1967.

Table 4. Effect of Trace Element Applications on the Chemical Composition of Kentucky bluegrass tissue, 1968. Field 1. E.H. Lake of the Woods County, Rocksbury loam.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	5 a	10	30 b	28
B	8 b	10	20 ab	29
Cu	5 a	10	29 ab	28
Mn	5 a	11	33 c	30
Zn	5 a	9	27 a	34
B, Cu, Mn, Zn	7 b	11	31 bc	32
Significance	**	N.S.	**	N.S.
CV (%)	11	17	7	13

Table 5. Effect of Trace Element Application on the Chemical Composition of Kentucky bluegrass, 1968. Field 2. E.B., Roseau County, Bearden Sicl

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	5 a	13	25	23
B	7 b	9	26	20
Cu	5 a	11	23	21
Mn	5 a	12	25	22
Zn	5 a	17	24	27
B, Cu, Mn, Zn	7 b	17	27	27
Significance	**	N.S.	N.S.	N.S.
CV (%)	11	71	13	23

Table 6. Effect of Trace Element Applications on the Chemical Composition of Timothy Tissue, 1968.
Field 3. A.R., Lake of the Woods County, Unidentified loam.

Treatment	B	Cu	Mn	Zn
	Parts per million in dry matter			
None	9 a	11	32	39
B	12 b	12	26	39
Cu	8 a	11	30	37
Mn	8 a	11	30	37
Zn	8 a	12	35	42
B, Cu, Mn, Zn	12 b	12	30	41
Significance	**	N.S.	N.S.	N.S.
CV (%)	17	15	11	12

Soil Testing

John Grava

Soil testing entered a new phase on September 13, 1968, when the soil testing laboratory of the University of Minnesota started making fertilizer and lime recommendations with a computer. Computerized recommendations can be made for 72 different crops.

A complete updating of the soil testing laboratory has also taken place. The improvements include: (a) hiring of two full-time junior scientists, (b) introduction of tests for sulfur, zinc and soluble salts (conductivity), (c) adoption of the SMP buffer as a lime requirement test, and (d) speeded-up service.

The laboratory processed a total of 25,339 samples. The number of various types of samples analyzed during 1968 is shown by the following data:

Regular farm, garden and lawn samples	20,962
Specials (S 689, Zn 818, S.S. 372, L.R. 351)	2,230
Florist (Greenhouse) samples	1,438
Limestone	35
Departmental research samples	674
Total	25,339

Heavy rainfall and extremely wet soil conditions made sample collection most difficult. Because of that, the expected sample pick-up promoted by the improved service did not materialize. In fact, 7500 less soil samples were submitted for testing during the last four months of 1968 than during the same period in 1967. The monthly distribution of regular soil samples received by the laboratory is shown in Table 1.

Table 1. Monthly Distribution of Regular Soil Samples Received by the University of Minnesota Soil Testing Laboratory During 1968.

Month	Number of Samples
January	1585
February	1570
March	2952
April	2815
May	1012
June	369
July	462
August	1027
September	2432
October	3492
November	2248
December	1506