for yield as the 1st cutting was severely hit by drought. In 1965 and 1966 supplemental irrigations made it possible to obtain three cuttings. The 1966 yield data are reported in Table 5. Sulfur treatments increased alfalfa yields from 2.1 to 4.7 tons per acre for three cuttings in 1966. Plots which received sulfur plus trace elements showed no additional benefit beyond what could be attributed to the sulfur supplied.

The sulfur content of the alfalfa tissue is reported in Table 6. The data indicate that sulfur has reached a limiting level on all plots. Only the 100 lbs. per acre of elemental sulfur treatment has produced alfalfa with adequate levels of sulfur in the tissue for normal growth, (.254 to .287%). Even this is below the .3% level established by Alway and reconfirmed by our past experiments as being necessary for maximum yields. Despite the low levels of sulfur in the tissue yield increases were still obtained by some treatments. For example, the trace element + S treatment and the 25 lbs. of elemental sulfur per acre treatments have sulfur contents which do not differ significantly from the sulfur content of the checks, but the yields are significantly better than the check yields. We may assume therefore on the basis of the past history of the K_2SO_4, N-P-S treatments that next year there will be no significant effect of these two residual sulfur applications on the yield of the alfalfa.

Alfalfa-general

The alfalfa received a total of 15.76 inches of precipitation during the growing season and 10.25 inches of supplemental irrigation. Two inches of water were applied after each cutting to speed recovery and three other irrigations were made during periods of moisture stress. The total water received by the crop was therefore 26.01 inches.

Table 5. Effect of sulfur-bearing materials on the yield of alfalfa following corn. (1966)

Material	Rate lbs. S/acre	Date of Application	Yield (tons/acre) 1st cut	2nd cut	3rd cut	Total
None	0		.84	.66	.63	2.13
Sulfur	25	1962	1.08	1.12	1.08	3.28
Sulfur	50	1962	1.59	1.40	1.26	4.25
Sulfur	100	1962	1.46	1.71	1.48	4.65
Gypsum	60	10 lb. S. in 1962 50 lb. S. in 1963	1.54	1.58	1.23	4.35
K_2SO_4	10	1962	.89	.73	.71	2.33
16-20-0-S	10	1962	.84	.76	.81	2.41
Trace + S	25	10 lb. S/acre as Zn-Mn-N-S 1962 15 lbs. S/acre as trace element mixture in 1963	1.30	1.23	.96	3.49
lsd (.05)			.23	.25	.20	.56
(.01)			.31	.34	.27	.75
hsd (.05)			.37	.41	.32	.89
(.01)			.45	.49	.38	1.08

Table 6. Effect of sulfur-bearing materials on the sulfur content of alfalfa following corn (1966).

Material	Rate lbs. S/acre	Date of Application	Sulfur Content of Tissue (%) 1st cut	2nd cut	3rd cut
None	0		.176	.180	.212
Sulfur	25	1962	.172	.165	.209
Sulfur	50	1962	.174	.192	.236
Sulfur	100	1962	.287	.278	.254
Gypsum	60	10 lbs. S in 1962 50 lbs. S in 1963	.227	.198	.228
K_2SO_4	10	1962	.164	.160	.183
16-20-0-S	10	1962	.159	.170	.222
Trace + S	25	10 lbs. S/acre as Zn-Ma-N-S in 1962 15 lbs. S/acre as Trace Elem mix in 1963	.169	.162	.193
lsd (.05)			NS	.026	.051
(.01)			NS	.035	.069
hsd (.05)			NS	.041	.081
(.01)			NS	.050	.098

The alfalfa following corn was irrigated on a similar schedule. Precipitation equalled 15.76 inches and supplemental irrigation equalled 10.50 inches for a total amount of water supplied of 26.26 inches.

Small Grain

The study of the effect of sulfur treatments on the yield of small grain (barley, wheat and oats) was repeated in 1966. The nitrogen application was increased to 55# Nitrogen per acre in 1966 from 30# per acre in 1965. The additional N was supplied as ammonium nitrate and disked in before planting. Other basic treatments were as follows: 20# P per acre (as 20-52-0), and 249# of K (as 0-0-62) were broadcast and disked in before planting. The equivalent of a 12-32-16 starter was formulated from sulfur free materials and applied in the row at planting time at 100# per acre. Sulfur treatments consisting of 10# S per acre as gypsum, elemental sulfur or sodium sulfate were applied in the row at planting time. Planting date was May 7. Varieties used were Traill barley, Lodi oats and Chris wheat. The treatments were replicated five times for each crop.

The effects of the sulfur treatments on the grain yield and on the sulfur content of the whole plant at the time of heading are shown in Table 7 for barley, Table 8 for oats, and Table 9 for wheat.

During the growing season (from May 7 to August 9) the small grain received 12.09 inches of precipitation. This was supplemented by four irrigations which provided an additional 6.00 inches of moisture, for a total of 18.09 inches.

Table 7. Effect of sulfur-bearing materials on the yield and sulfur content of Barley (1966).

Material	Rate lbs. S/acre	Yield bu/A	Sulfur Content whole plant %
None	0	22.3	.195
El. Sulfur	10	29.2	.206
Gypsum	10	26.9	.233
Na_2SO_4	10	33.8	.253
lsd (.05)		6.9	.037
(.01)		NS	NS
hsd (.05)			
(.01)			

Table 8. Effect of sulfur-bearing materials on the yield and sulfur content of oats (1966).

Material	Rate lbs. S/acre	Yield bu/A	Sulfur Content whole plant %
None	0	54.2	.172
El. Sulfur	10	57.7	.191
Gypsum	10	58.0	.239
Na_2SO_4	10	62.7	.233
lsd (.05)		NS	.027
(.01)			.038
hsd (.05)			.037
(.01)			.049

Table 9. Effect of sulfur-bearing materials on the yield and sulfur content of wheat (1966).

Materials	Rate lbs/A	Yield bu/A	Sulfur Content whole plant %
None	0	16.2	.252
El. Sulfur	10	22.2	.281
Gypsum	10	18.6	.312
Na_2SO_4	10	17.9	.291
lsd (.05)		.3	.032
(.01)		.5	.045
hsd (.05)		.5	.043
(.01)		.6	.057

Yields of small grain were disappointing in 1966 despite an adequate supply of moisture, increased seeding rate, and higher nitrogen application. This is attributed largely to an adverse season. Despite the low yields, 10 lbs. of sulfur increased barley yields by 4 to 11 bushels and measurably increased the sulfur content of the tissue. Sodium sulfate was most effective in increasing yield and sulfur content, followed by elemental sulfur and gypsum.

Oat yields were increased by 4 to 8 bushels per acre by the sulfur treatment with corresponding increases in the sulfur content of the whole plant tissue.

Increases in wheat yields were smaller (1.7 to 6.0 bushels per acre) and did not show a consistent advantage for any particular sulfur material. The highest mean yield was produced by elemental sulfur (10 #S/acre). All sulfur treatments increased the sulfur content of the wheat tissue but it is interesting to note that the sulfur content of the control plants was greater than .2% (.251) which is much higher than the sulfur content of untreated oat and barley plants (.172 and .195% respectively).

Corn

The 1965 study of the effect of sulfur on the yield and sulfur content of corn was continued in 1966. Only one sulfur treatment was used (10 lbs. S per acre as Na_2SO_4) in addition to the control. Treatments were replicated six times. Minn hybrid 805 (85 day) was planted May 21 and thinned to a final population of 18,300 plants per acre. Supplemental irrigation was applied at four times during the growing season for a total of 6.25 inches of water applied. Natural precipitation during the growing period totaled 14.90 inches.

Basic fertilizer applications of 150#N/acre; 25# P/acre, and 200# K per acre were reapplied in 1966 and disked in before planting. Three hundred pounds per acre of 5-10-30 starter were applied at planting time and the corn was sidedressed with 90# of N/acre. All basic fertilizer materials were sulfur-free. Shortly after germination sulfur deficiency symptoms could be detected among the control plants. They were not as evident however as in 1965 possibly because this was 2nd year corn and possibly because, despite a late spring, the ground conditions after planting in 1966 were more favorable than in 1965. Deficiency symptoms disappeared by the time the corn was knee high, but a difference in height persisted until tasselling. The treated corn was in full tassell 4-5 days earlier than the controls.

The 1966 yield data are reported in table 10. Despite the early season advantage of the treated corn, the untreated corn had apparently caught up by harvest time. The treated corn averaged 4.3 bushels more corn per acre and was slightly drier but these differences were not significant at the 5% probability level.

Table 10. Effect of sulfur on the yield of 2nd year corn (1966).

Treatment	Rate lbs. S/acre	Ear Corn Moisture %	Shelling percentage %	Ear Corn yield Bu/acre
None	0	40.1	81.3	110.1
Sulfur (Na_2SO_4)	10	38.9	80.5	114.4
lsd (.10) (.05)		1.05	NS	NS

Potatoes

A study on the effect of sulfur on the yield of potatoes under irrigation was begun in 1965 and continued in 1966. Two sulfur-bearing materials (elemental sulfur and gypsum) at the rate of 50 lbs. of S/acre were compared with a control. Basic applications of 500# K/acre as 0-0-62, 200 #N/acre as 33-0-0 and 50# P/acre as 0-54-0 were applied before planting and disked in. Plots were replicated six times. In 1966 the variety planted was Russet Burbank. The plants were irrigated on a regular schedule and a vigorous program of disease and insect control was practiced. Plant petioles were sampled at midseason and analyzed for sulfur. Yields were recorded and the quality of the potatoes was checked by running specific gravity on representative samples from each plot. Yields, specific gravity and the per cent sulfur in the petioles are reported in Table 11.

The differences in yield are not significant. Potato quality as measured by specific gravity test and converted to total solids was also unaffected by the sulfur treatments. There were large differences in the sulfur content of the potato petioles taken at midseason.

Table 11. Effect of Elemental Sulfur and Gypsum on the Yield, Total Solids, and Sulfur Content of Irrigated potatoes. ("Russet Burbank")

Treatment	Rates lbs. S/acre	Yield bu/acre	Specific Gravity	Total Sulfur in petioles
None	0	539	1.143	.158
Sulfur	50	563	1.141	.219
Gypsum	50	529	1.144	.243
lsd (.05)		NS	NS	.007

Red Clover

An area which had been in small grain in 1964 was adapted to a Red Clover-Brome study in 1965. Basic applications of N, P, and K were broadcast before planting in 1964 and disked in. These basic applications supplied 35# N per acre as 20-52-0 and 249# K (300# K_2O) per acre as 0-0-62. An additional 100# of 12-32-16 was applied as starter on the small grain in 1964. The area had received 4 ton of dolomitic lime per acre in 1962.

The sulfur treatments were designed to study (1) the effects of reapplication of the same materials used on the 1964 grain crop at heavier rates (40# S/acre); (2) residual effects of sulfur treatments applied to small grain (oats and barley) in 1964; and (3) the effect of additional gypsum (40 # S per acre) plus trace elements. The exact treatments are listed in Table 12.

Table 12. Treatments on Red-Clover Brome Study.

Treatment No.	Sulfur-bearing Material	1964 lbs. S/acre	S applied 1965 lbs. S/acre	Total lbs. S/acre	Previous Crop 1964
1	None	0	0	0	Barley
2	Gypsum	10	40	50	"
3	El. Sulfur	10	40	50	"
4	Na_2SO_4	10	0	10	"
5	Gypsum	10	0	10	"
6	El. Sulfur	10	0	10	"
7	None	0	0	0	Oats
8	Gypsum + Trace	10	57*	67	"
9	El. Sulfur	10	0	10	"
10	Na_2SO_4	10	10	20	"

*Trace elements consisted of the sulfate salts of Zn, Cu, Mn and Fe and ammonium molybdate. Sulfur supplied by these salts was 17.4 lbs/acre.

Wegner Red Clover at 10#/acre and Lincoln Brome at 4# per acre were sown May 29, 1965. No yields were taken in 1965 but the field was clipped to 6.8 inches in late August to control weeds. Visible color differences were noted between checks and treated plots by the fall of 1965. In 1966 two cuttings were obtained and had the very favorable fall season been anticipated a third cutting would have been possible without damaging the stand. The plots were topdressed with 100# K/acre as 0-0-62 after the first cutting. Throughout the season on the untreated plots the red clover was a pale yellowish green color, was shorter and slower maturing. Treated clover was vigorous and dark-green in color.

The 1966 yield data are shown in Table 13. Sulfur treatments increased 1st cutting yields from 6 to 40%. Second cutting yields were even more strikingly effected by the sulfur treatments. As check plot yields began to decline with the depletion of natural soil sulfur, yield increases up to 109% were recorded.

Table 13. Effect of sulfur-bearing materials and residual sulfur treatments on the yield of red clover-brome. (1966)

Treatment No.	Yield		
	1st cutting tons/acre	2nd cutting tons/acre	Total tons/acre
1	1.24	.94	2.18
2	1.59	1.82	3.41
3	1.45	1.54	2.99
4	1.53	1.38	2.91
5	1.39	1.30	2.69
6	1.53	1.35	2.88
7	1.14	.87	2.01
8	1.34	1.53	2.87
9	1.27	1.15	2.42
10	1.36	1.45	2.81

Sulfur contents of the red clover and brome are reported in Table 14. The sulfur contents of the brome and the red-clover were essentially the same for similar sulfur treatments indicating that both species competed equally for the available sulfur supply. The sulfur contents are generally lower than might be expected for alfalfa grown under similar conditions. In no instance was the .3% sulfur level reached in the red clover. The question therefore remains as to whether additional sulfur applications will bring about further yield increases.

Table 14. Effect of sulfur-bearing materials and residual sulfur treatments on the sulfur content of red clover and brome (1966).

Treatment No.	1st cutting Red Clover % S	1st cutting Brome % S	2nd cutting Red Clover % S
1	.128	.120	.115
2	.208	.179	.135
3	.202	.162	.147
5	.173	.168	.129
5	.155	.158	.120
6	.163	.169	.131
7	.139	.157	.119
8	.208	.198	.147
9	.163	.175	.119
10	.186	.188	.138

The composition of the stand was unaffected by the treatment (Table 15). Apparently the red clover can compete and even choke out the brome when it is adequately supplied with nutrients.

Table 15. Effect of sulfur-bearing materials and residual sulfur treatments on the composition of red clover-brome hay. (1st cutting 1966)

Treatment No.	% Red Clover	% Brome
1	94.5	5.5
2	93.2	6.8
3	94.1	5.9
4	93.8	6.2
5	94.8	5.2
6	92.6	7.4
7	95.4	4.6
8	95.8	4.2
9	96.3	3.7
10	95.3	4.8

Soil Test Data for S-plot established in 1962.

In August a number of soil samples were taken to survey the pH, organic matter, extractable phosphorus and exchangeable potassium levels on the alfalfa plots established in 1962. Samples were taken by one inch increments to three inches and another increment from 3 to 6 inches. Each sample was a composite of two cores from each of six replicated plots. The survey of the effect of the sulfur treatments on pH is reported in Table 16. The data indicate that annual applications of 100# of sulfur in the elemental form have reduced the pH of the 0-1 and 1-2 inch depths to 4.7 and 5.2 respectively. The pH of the surface two inches of unsulfured plots is 6.8 and 6.2 respectively. As a result of this survey a more extensive sampling of the soil is planned.

Table 16. Survey of the effect of sulfur treatments on pH of soil under alfalfa.

Treatment	pH Depth (inches)			
	0-1	1-2	2-3	3-6
Check	6.8	6.2	6.1	6.3
100# S(1962)	6.0	5.5	5.8	6.0
100# S(annually)	4.7	5.2	5.7	6.0
1000# S(gypsum) 1962	6.4	5.8	6.0	6.1
50# S (gypsum) 1962	6.3	5.8	6.0	6.1
Check (Alf after corn)	6.8	6.7	6.7	6.7

Results of the other tests showed adequate levels of P and K in all soil increments. There apparently has not been any effect of sulfur on these nutrient elements.

1966 Zinc-Phosphate for Corn Study in Swift County

O. M. Gunderson, J. M. MacGregor,
G. W. Randall, S. D. Evans, R. I. Pietz

During the spring of 1966, a project was initiated to study 1) the effect of various zinc materials and rates on corn yield as well as the zinc and phosphorus content of the corn leaf tissue and 2) the effect of increasing amounts of phosphorus fertilizer on the uptake of zinc and phosphorus by the plant on the corn yield.

On May 16, two randomized block design experiments were established on the Richard Mickelson farm 2 miles north of Benson in Swift County. Each experiment consisted of seven treatments replicated four times. All zinc treatments except the chelate (Zn 45), which was row applied, and all phosphorus treatments were broadcast applications and then plowed down. The farmer also applied a total of 100+40+40 ($N+P_2O_5+K_2O$) per acre as a blanket broadcast application before plowing. Because of the late, wet spring, and the relatively low lying, poorly drained heavy soil, a 90 day maturity corn hybrid was planted on May 30. Atrazine was applied on June 1. Sixth leaf samples were taken at late silking stage in early September for zinc and phosphorus analyses. The results obtained are shown in the following tables.

Table 1. Zinc and Phosphorus Content of the Sixth Corn Leaf & Corn Yields following Zinc and Phosphate Fertilization in 1966.

Trt. No.	Treatment (lbs Zn)	Plant P (%)	Plant Zn (ppm)	Yield (bu/A)
1	NONE	0.400a[1]	7.2c	92.0bc
2	10# as $ZnSO_4$	0.297bc	11.7bc	115.4a
3	20# "	0.259c	14.0b	111.8a
4	40# "	0.259c	18.0a	109.3a
5	10# as ZnMnS	0.326abc	9.3bc	103.8ab
6	0.5# as Zn chelate	0.394a	8.6c	85.5c
7	2.5# as Zn chelate	0.372ab	8.3c	93.3bc

1.According to Duncan's Multiple Range Test, numerical values followed by the same letter are not significantly different at the .05 level.

Table 1 shows that significant differences occurred in the zinc and phosphorus content of the sixth corn leaves, as well as in corn yield from the different zinc treatments. Plant P content was highest in the check treatment and was much lower in leaves from the 10 pound Zn (as $ZnSO_4$) treatment. Increasing the rate to 20 and 40 pounds decreased the plant Zn only slightly. The ZnMnS and Zn chelate treatments did not reduce the plant P significantly.

Leaf Zn was lowest from the check treatment. The application of Zn as $ZnSO_4$ significantly increased the plant Zn content, with the 40 pound rate resulting in a significantly higher plant Zn content than any other treatment. Again, the ZnMnS and Zn chelate treatments failed to increase the uptake of zinc significantly.

Corn yields were highest on those treatments where Zn was applied as $ZnSO_4$. However, no significant differences in yield occurred among the 10, 20 and 40 pound rates. A small yield increase over the check was found with the ZnMnS treatment, but no increases in yield resulted from the Zn chelate treatments.

Table 2. The Effect of Seven Phosphate Treatments on the Uptake of P and Zn and on Corn Yield in Swift County in 1966.

Trt. No.	Treatment (lbs P_2O_5)*	Plant P (%)	Plant Zn (ppm)	Yield (bu/A)
1	40	.351bc[1]	10.0ab	98.4ab
2	80	.313bc	10.2ab	96.9ab
3	160	.359bc	8.4bc	96.3ab
4	320	.400b	7.5c	96.8ab
5	640	.486a	7.3c	83.4b
6	320+10#Zn as $ZnSO_4$	.325bc	12.4a	113.6a
7	640+ "	.304c	11.0a	107.6a

* includes the 40 lbs. applied by the farmer.

1. According to Duncan's Multiple Range Test, numerical values followed by the same letter are not significantly different at the 0.05 level.

Significant differences were resulted among the seven phosphate treatments for plant P, plant Zn and corn yield as shown in Table 2. Increasing phosphate fertilization rates resulted in raising the plant P from 0.351 to 0.486% and reducing the plant Zn content from 10.0 to 7.3 ppm. The plant P content of the 640 pound phosphate treatment was significantly higher than those from any other treatment. The addition of 10 pounds of Zn to the 320 and 640 pound phosphate treatments decreased the plant P content substantially. However, these zinc treatments resulted in significantly higher plant Zn contents.

Highest yields were produced on the 320 and 640 pound phosphate treatments <u>with</u> 10 pounds of zinc per acre as $ZnSO_4$. The 640 pound rate of phosphate <u>without</u> zinc produced the lowest yield.

<u>Initial conclusions of this study</u>

1. On some of these cold, wet, calcareous and heavy soils of western Minnesota, it is apparent that corn yield does respond to the application of zinc. This is apparently more evident at high rates of phosphate fertilization.

2. Significant responses in plant P, plant Zn and corn yield are clearly shown from the application of zinc as $ZnSO_4$, whereas, the application of ZnMnS did not clearly show these responses. Corn showed no yield response to zinc chelate (Na_2Zn) applications.

3. High rates of fertilizer phosphate increased the plant P, but apparently decreased the uptake of zinc. Zinc uptake at these high phosphate fertilization rates can apparently be increased with the addition of zinc sulfate at the rate of 10 pounds of zinc per acre (approximately 30 pounds of $ZnSO_4$ per acre).

Direct and Residual Effect of Zinc Fertilization of Corn on a Zinc Deficient Silty Clay Loam in Southern Kandiyohi County

J. M. MacGregor, O. M. Gunderson and R. Pietz

During the 1961 growing season, zinc deficiency was observed on some corn plants on the C. H. Litch farm at Lake Lillian. With the cooperation of the farm owner and Dr. R. R. Allmaras of the A.R.S. Soil and Water Research Station at Morris, a field experiment of zinc application for corn was initiated in May of 1962. Soybeans were seeded in 1963 but died out because of residue remaining from a 1962 application of atrazine. Corn was grown in 1964, 1965 and in 1966, usually being planted from late May until mid June, due to wet soil conditions. Late planting has usually resulted in comparatively low yields. Leaves were sampled (6th leaf from the ground) in each of the four years and were analyzed by the X-ray fluorescence procedure or by atomic adsorption procedures. The average zinc content of the leaves and yield of ear corn per acre for the four years are shown in the following table.

The Effect of 1962 Zinc Fertilization of a Zinc Deficient Silty Clay Loam in Southern Kandiyohi County on Zinc Concentrations in Corn Leaves and Corn Yields in 1962, 1964, 1965 and 1966

1962 Treatment (lbs./A	Leaf zinc in ppm				Yield of ear corn in bu./A			
	1962	1964	1965	1966	1962	1964	1965	1966
No zinc	9	19	8	10	43	40	38	41
Zinc broadcast and plowed under in spring								
15 zinc sulfate	13	19	12	10	69	58	59	54
30 " "	19	20	20	14	66	56	58	51
60 " "	27	27	25	15	76	56	69	56
120 " "	29	28	31	25	67	50	69	52
Zinc sulfate and/or nitrogen applied as a band starter								
20 nitrogen (N) alone	9	-	11	11	61	41	47	45
30 zinc sulfate	10	-	13	12	59	53	55	51
15 zinc sulfate + 20 N	10	-	14	11	63	58	56	61
30 " " " " "	11	-	13	16	64	65	65	60
60 " " " " "	12	-	20	12	63	62	59	51
Zinc chelate coated on seed corn (7 1/2 oz.Na ZnEDTA per bu.)								
Seed treatment alone	9	-	8	9	55	51	48	48
" " + 30 zinc sulfate plowed down	22	-	17	13	74	67	67	64

Comparatively good agreement was evident between the amounts of zinc applied in 1962 and subsequent concentrations in the corn leaves. Earlier investigators in other sections of the United States have shown that the critical level of leaf zinc for normal corn growth to be approximately 15 to 20 parts per million. In general, the band applied zinc appears to be much less available to the corn plants than equal amounts broadcast and plowed under in 1962, even in the fourth subsequent cropping season.

The zinc treatments produced substantial increases in corn yield with banding being only slightly less productive than plowing down, even though the corn leaves growing on the banded zinc plots contained considerably less zinc in each of the three growing seasons. With an extreme yield variation in 1966, corn yields were not significantly different with the different 1962 treatments.

Although zinc chelate coatings on the seed increased corn yield in each year, the zinc content of these leaves was extremely low, which might be expected from the amount of zinc initially applied (less than 1 oz. of the chelate per acre) and the corn yields were considerably less than any of the zinc sulfate treatments.

Nitrogen applications, either alone or in combination with zinc, had little appreciable effect on corn yields.

It is apparent that where zinc deficient soils do occur in Minnesota, the application of zinc sulfate, either plowed down or as a band application, will be an economic practice for corn production, especially with the apparent residual effect lasting over several crop years.

Zinc Fertilization of Continuous Corn
West Central Experiment Station
Samuel D. Evans

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

Treatment*		Yield Bu/A @ 15.5%		Leaf Analysis Zn, ppm		Leaf Analysis P, %	
1965	1966	1965	1966	1965	1966	1965	1966
Check	Check	97.80	101.85	15	16	.21	.24
5 lbs zinc as ZnS	None	98.93	104.01	17	18	.25	.26
10 lbs zinc as ZnS	None	96.63	102.14	17	24	.22	.29
10 lbs zinc as ZnS	10 lbs zinc as ZnS	96.67	100.62	17	23	.22	.27
20 lbs zinc as ZnS	None	98.93	104.70	22	23	.30	.26
0.5 lbs zinc as ZnCh	0.5 lbs zinc as ZnCh	97.47	98.30	19	20	.27	.24
45 lbs P Broadcast	45 lbs P Broadcast	99.54	96.39	16	13	.29	.26
45 lbs P Broadcast+ 10 lbs zinc as ZnS	45 lbs P Broadcast + No addt'l zinc	96.45	94.82	18	19	.22	.32

* ZnS - Zinc Sulfate, ZnCh - Zinc 45 Chelate, all zinc applied in the row at planting time, all plots received a uniform row application of 125 lbs of 8-32-16, 80 lbs of actual N was sidedressed each year.

The Effect of Boron, Phosphorus and Potassium on the Yield of Four Legume - Grass Hay Fields in Carlton County in 1965 and 1966

J. M. MacGregor, P. Borich and G. Randall

In July, 1964, following the removal of first cutting of hay, experimental plots were established on four Carlton County farms to determine the effect of boron alone and in addition to phosphorus - potassium on the yield and composition of the mixed legume-grass hays grown in the area. A 6x6 Latin square design was used. Symptoms of boron deficiency of legumes were evident on the second cutting of two of the four fields in August, 1964. While the boron applications at rates of 1 or 2 pounds per acre reduced the severity of the B deficiency symptoms, these treatments did not significantly increase 1964 second cutting hay yields. Boron with phosphorus - potassium improved growth, but there again was no significant increase in hay yield of the second cutting on any of the four fields in a relatively dry midsummer growing period.

In the spring of 1965, an additional 1 and 2 pounds of boron per acre were applied to the four 1964 fields, and a fifth field was added. First and second cuttings were harvested and the alfalfa plants of each field were analyzed for boron content. The first cutting of 1965 was very heavy and lodging on the PK plots was a problem, with no visible growth difference on any treatment. The second cutting growth was reasonably good and the yield was much heavier than in 1964, with untreated and PK treated plots on three of the five fields exhibiting boron deficiency. As in 1964, the boron treatments appeared to relieve the deficiency symptoms of the alfalfa to some extent, but even the plots receiving 4 pounds of boron (nearly 40 pounds of borax) per acre still showed some of the characteristic symptoms of boron deficiency.

In the fall of 1965, there was an excellent legume-grass stand on Field 4 (the Lauri Waisanen farm just west of Kettle River). In the spring of 1966, there was not a single legume plant surviving on any of the plots of the experiment - due to severe winterkilling. Since boron is primarily needed for alfalfa growth, and not for grasses, it was reluctantly decided to terminate the studies on this field. Extreme frost heaving appeared to be the cause of the severe alfalfa winterkill.

The remaining four fields were refertilized with 1 or 2 pounds of boron per acre early in 1966 and two cuttings of hay were removed, as in previous years. Soil samples were collected on three replicates of each of the five fields and available soil boron is now being determined. Two of the four fields (Field No. 2 on the Marvin Benson farm north of Mahtowa - and Field No. 5 of the Gerald Mowers farm at Cromwell) showed visible boron deficiency symptoms of the untreated alfalfa plants and also those receiving PK alone, whereas the remaining two fields showed no visible growth abnormalities.

1965 & 1966 Hay Yields on Boron - Phosphate & Potash Experiments
in Carlton County in Tons per acre

Cooperator	Treat.	1st Cut	2nd Cut	1966 Tot.	1965-66 Total
(1)					
Oraskovich (check)	1	2.26 a	0.80 a	3.06 a	5.64 a
0-60-180 + No B	2	2.50 a	0.83 a	3.33 a	5.78 a
0-60-180 + 1 lb.B/A	3	2.30 a	0.92 a	3.22 a	5.99 a
0-60-180 + 2 lb.B/A	4	2.35 a	0.75 a	3.10 a	5.77 a
0-60-180 + 1 lb.B/A (annually)	5	2.42 a	0.88 a	3.30 a	6.18 a
0-60-180 + 2 lb.B/A (annually)	6	2.43 a	0.90 a	3.33 a	6.00 a
(2)					
Benson #1 (check)	1	1.76 a	1.16 a	2.92 a	6.94 a
0-60-180 + No B	2	2.18 a	1.36 b	3.54 b	8.66 b
0-60-180 + 1 lb.B/A	3	2.18 a	1.50 b	3.68 b	8.90 b
0-60-180 + 2 lb.B/A	4	2.08 a	1.42 b	3.50 b	8.58 b
0-60-180 + 1 lb.B/A (annually)	5	2.17 a	1.38 b	3.55 b	8.38 b
0-60-180 + 2 lb.B/A (annually)	6	2.18 a	1.39 b	3.57 b	8.46 b
(3)					
Benson #2 (check)	1	3.01 a	1.56 a	4.57 a	8.34 a
0-60-180 + No B	2	3.01 a	1.68 a	4.69 a	8.46 a
0-60-180 + 1 lb.B/A	3	3.24 a	1.68 a	4.92 a	8.97 a
0-60-180 + 2 lb.B/A	4	3.14 a	1.63 a	4.77 a	8.57 a
0-60-180 + 1 lb.B/A (annually)	5	3.10 a	1.58 a	4.68 a	8.59 a
0-60-180 + 2 lb.B/A (annually)	6	3.04 a	1.66 a	4.70 a	8.43 a
(5)					
Mowers (check)	1	2.17 a	1.64 a	3.81 a	7.23 a
0-60-180 + No B	2	2.11 a	1.68 a	3.79 a	7.80 ab
0-60-180 + 1 lb.B/A	3	2.37 ab	1.66 a	4.03 ab	7.86 ab
0-60-180 + 2 lb.B/A	4	2.52 b	1.71 a	4.23 b	8.27 b
0-60-180 + 1 lb.B/A (annually)	5	2.48 b	1.79 a	4.27 b	8.40 b
0-60-180 + 2 lb.B/A (annually)	6	2.38 ab	1.64 a	4.02 ab	7.73 ab

a,b - Those yields with either a or b are significantly different whereas ab are not significant from a or b.

Significance of 1965-66 Legume Grass Hay Yields
following Boron-PK Treatments in Carlton County

		Treatment Totals	
1.	Oraskovich	First Cut	Not Significant
		Second Cut	" "
		1966 Total	" "
		1965 & 1966 Total	" "
2.	Benson #1	First Cut	Not Significant
		Second Cut	*
		1966 Total	*
		1965 & 1966 Total	**
3.	Benson #2	First Cut	Not Significant
		Second Cut	" "
		1966 Total	" "
		1965 & 1966 Total	" "
5.	Mowers	First Cut	*
		Second Cut	Not Significant
		1966 Total	*
		1965 & 1966 Total	**

* Significant at .05 level
** " " .01 level

It is apparent that the fertilizer produced yield increases on only two of the four fields (Fields 2 & 5). On Field 2, the significant yield increases evidently resulted from the phosphate-potash treatment, rather than from the applied boron. It is apparent that, even with visible boron deficiency symptoms developing on the alfalfa of the untreated plots, the application of boron improved the appearance of the plants but failed to significantly increase resulting hay yields.

On field No. 5, the heavier boron applications had a marked effect on the growing alfalfa, and this evidently resulted in a significant yield increase in 1966.

This experiment has demonstrated that the application of boron for alfalfa to the soils of this area may or may not result in significantly increased hay yields, even though alfalfa plants may show typical boron deficiency symptoms. The symptoms usually do not develop during the first year the hay crop is grown, being more likely to become evident with increasing age of the stand. It is also more likely to develop on the soils of coarser texture, which suffer more from a lack of moisture, and on these soils it may possibly become evident during the first cropping year.

While indiscriminate application of boron at the rate of 1 or 2 pounds per acre per year is not recommended, this is probably good insurance, especially on the sandier soils, since the cost of this treatment is relatively low. Liming of acid soils and fertilizing with ample amounts of phosphate-potash fertilizer is an essential practice on all soils of this region in north eastern Minnesota.

1966 Soybean Fertilization
Southwest Experiment Station

W. W. Nelson and G. W. Randall

In 1964 an experiment was designed to study the effect of N, P and K fertilizer treatments on the soybean yield and chemical composition of the soybean leaf. A randomized block design with seven treatments replicated five times was used. This experimental plot is moved each year to an area that has not been previously fertilized. The variety Chippewa was planted in 30" rows. Results of the 1966 experiment are as follows:

Table 1. The fertilizer treatments, yields and chemical composition of soybeans at the Southwest Experiment Station.

Trt. No.	Treatment (lbs $N-P_2O_5-K_2O$)	Yield (bu/A)	P	K	Ca	Mg	Mn	Fe
			%				ppm	ppm
1	0+0+0	25.5bc[1]	.325	1.84	1.10	.44	36	106
2	0+40+0	26.6ab	.325	1.88	1.20	.48	36	109
3	0+0+40	25.0c	.335	2.31	1.12	.43	38	109
4	0+40+40	26.5ab	.350	2.28	1.31	.49	50	115
5	20+0+0	26.2abc	.365	2.02	1.15	.48	45	114
6	20+40+0	27.3a	.370	2.00	1.16	.48	47	115
7	20+40+40	27.4a	.400	2.43	1.31	.52	68	128

1. According to Duncan's Multiple Range Test, the yields followed by the same letter are not significantly different at the .05 level.

There was a significant soybean yield response to fertilizer; although, it was quite small. The complete NPK treatment (No. 7) produced the highest yield. Individual N, P and K responses were +0.8, +1.3 and -0.2 bushels per acre, respectively. This would seem to indicate phosphate fertilizer to be the most beneficial fertilizer element in contributing to higher soybean yields at Lamberton.

Soybean leaf analyses show the P content to increase with nitrogen and phosphate fertilizer. The addition of potash fertilizer greatly increased the plant K content. Plant Ca and Mg contents were also higher when treatments contained phosphate fertilizer. The combined fertilizer treatment (NPK) resulted in greater plant Mn and plant Fe concentrations in the soybean leaf.

Sugar Beet Fertilization
West Central Experiment Station
Samuel D. Evans

A replicated 3 x 3 x 3 factorial NPK experiment was set out at the West Central Experiment Station in 1966. The work was set up on Hammerly clay loam with the following soil tests:

pH	7.7
Organic Matter	5.8 - 6.2%
Extractable phosphorus	3 - 5 lbs/acre
Exchangeable potassium	400 - 420 lbs/acre

Nitrogen, phosphorus, and potassium were used at 3 rates of each in all combinations. The rates were as follows:

Nitrogen	Phosphorus	Potassium
None	None	None
70 lbs N/acre	25 lbs P/acre	25 lbs K/acre
140 lbs N/acre	50 lbs P/acre	50 lbs K/acre

The fertilizer was applied on May 5, beets were planted on May 6, and harvest was carried out on October 25-26.

Statistical analyses were made for all variables and there were no interactions of the various nutrients. Therefore, only the averages for the various nutrients alone are presented in table 1. Averages for 6 nutrients are listed in table 2.

Table 1. Sugarbeet yield data, 1966.

	Yield tons/acre	Sucrose %	Sugar lbs/acre
No nitrogen	15.72 a	17.51 a	4492 a
70 lbs nitrogen	17.40 b	17.13 b	5967 b
140 lbs nitrogen	18.23 b	16.81 b	6127 b
No phosphorus	17.36	17.20	5973
25 lbs phosphorus	16.84	17.12	5758
50 lbs phosphorus	17.16	17.12	5872
No potassium	16.86	17.27	5825
25 lbs potassium	17.28	17.14	5913
50 lbs potassium	17.21	17.04	5865

* Values in the same column followed by different letters are significantly (P=0.05) different.

The yield data show that in 1966 at Morris only nitrogen had an effect on yield and % sucrose. With nitrogen only the first 70 lb. increment affected the variables significantly. Even though the second 70 lb. increment increased yield and sugar production per acre and decreased sucrose content, the changes were not significant.

Petiole samples were taken twice during the season and were analyzed at Ohio State. The analysis indicated that some plots were in the low range with respect to some nutrients according to the Ohio State standards (table 3).

Summary of Petiole Analyses of 6 Elements

Table 2. Fertility Treatments

Element	Sampling Date	0P	25P	50P	0K	25K	50K
Phosphorus, %	Early	.23	.17	.21	.20	.21	.22
Phosphorus, %	Late	.41	.37	.35	.34	.42	.36
Potassium, %	Early	5.33	4.27	5.31	5.19	4.66	5.06
Potassium, %	Late	5.41	5.12	5.18	5.33	5.44	4.95
Manganese, ppm	Early	28	20	23	25	20	27
Manganese, ppm	Late	23	23	20	21	21	23
Boron, ppm	Early	18	15	16	17	15	17
Boron, ppm	Late	23	22	19	22	21	21
Copper, ppm	Early	6	4	5	5	5	5
Copper, ppm	Late	8	8	6	7	7	8
Zinc, ppm	Early	14	12	13	13	12	13
Zinc, ppm	Late	15	12	14	13	14	15

* Early date - 7-22-66. Late date - 8-24-66; values underlined are in the low range by Ohio State standards.

Table 3. Deficient, low, and sufficient ranges for 6 elements.

	Deficient	Low	Sufficient
Phosphorus, %	0 - 0.13	0.14 - 0.25	0.26 - 1.30
Potassium, %	0 - 0.60	0.61 - 1.00	1.01 - 11.00
Manganese, ppm	0 - 10	11 - 25	26 - 200
Boron, ppm	0 - 8	9 - 15	16 - 200
Copper, ppm	0 - 2	3 - 5	6 - 100
Zinc, ppm	0 - 8	9 - 15	16 - 200

Evaluation of petiole analyses:

Phosphorus - The standard values appear to be too high at the early sampling date. At the later sampling date sufficient phosphorus was present in all treatments.

Potassium - Sufficient potassium was present in all treatments at both sampling dates.

Manganese - Two possibilities exist; (1) the standard values are too high or (2) most treatments were manganese deficient.

Boron - Levels of boron appear to be adequate in most treatments. The addition of phosphorus might possibly reduce the boron content.

Copper - At the early sampling date the plants are slightly low in copper or the range is too low. At the later date levels are adequate.

Zinc - Values in all treatments are at the high end of the low range. The addition of 10 lbs of zinc did not raise the zinc level in the petioles much so zinc is apparently not limiting.

Potato Fertilization Plot Results, 1966

Fertilizer plots on potatoes were established at the Eldon Tessman farm near Osseo and at the Howard Gray farm near Clear Lake in 1966.

The objective was to determine the need for fertilizer on soils that have been under an intensive phosphorus and potash buildup for nearly ten years and to observe fertilizer response through a similar experiment on a farm which had not had the benefit of this nutrient buildup. Included, was a lime rate study to observe magnesium differences in both plant tissue and in potato yield. Magnesium deficiency had previously been observed to be a problem where high potassium levels had been used. Four varieties were grown in order to observe lime effects on the buildup of scab organism on the tuber surfaces. All plots had two replications. Yields and related factors from nitrogen, phosphate and potash were as follows:

Eldon Tessman farm, Osseo. P test 200+, K test 600+, pH 5.4 sandy loam.

Nitrogen Response

	Norland			Russet Burbank		
	total yield cwt/A	over 2" size cwt/A	Specific Gravity	total yield cwt/A	Over 2" size cwt/A	Specific Gravity
50+100+500	228	187	1.050	240	209	1.056
100+100+500	307	261	1.052	174	139	1.059
200+100+500	346	311	1.054	192	165	1.065

Phosphate Response

		% P petiole			% P petiole	
100+ 0+500	319	.39	1.055	226	.34	1.052
100+100+500	304	.56	1.056	238	.52	1.063

Potash response

	Norland			Petiole Analysis	
	total yield cwt/A	over 2" size cwt/A	Specific Gravity	% K	% Mg
100+100+ 0	332	259	1.051	11.6	.14
100+100+ 50	315	268	1.053	12.0	.17
100+100+100	293	267	1.054	12.3	.09
100+100+250	356	319	1.050	13.0+	.15
100+100+500	277	241	1.050	12.8	.14

Potash response Continued. -Tessman Farm.

		Russet Burbank			
100+100+ 0	268	228	1.064	11.2	.22
100+100+ 50	199	177	1.060	11.2	.16
100+100+100	182	149	1.057	10.6	.19
100+100+250	245	213	1.056	9.5	.17
100+100+500	236	208	1.067	11.7	.16

Howard Gray farm, Clear Lake, P test 17 lbs., K test, 130 lbs., pH 5.4 sandy loam.

Nitrogen Response

	Norland			Russet Burbank		
	total yield cwt/A	over 2" size cwt/A	Specific gravity	total yield cwt/A	over 2" size cwt/A	Specific gravity
50+100+500	309	275	1.049	260	221	1.075
100+100+500	353	321	1.049	352	327	1.077
200+100+500	323	281	1.058	320	275	1.080

Phosphate response

		% P petiole			% P petiole	
100+ 0+500	255	.29	1.057	246	-	1.078
100+100+500	325	.26	1.053	308	.35	1.079

Potash Response

	Norland total yield cwt/A	over 2" size cwt/A	Specific gravity	Petiole Analysis % K	% Mg
100+100+ 0	207*	108	1.058	-	-
100+100+100	232	218	1.058	8.3	.55
100+100+250	313	269	1.052	10.0	.38
100+100+500	338	297	1.061	11.8	.31
100+100+1000	341	290	1.060	11.3	.37
	Russet Burbank				
100+100+ 0	172*	127	1.069	-	-
100+100+100	273	232	1.077	8.2	.42
100+100+250	304	274	1.077	11.4	.28
100+100+500	333	300	1.075	10.5	.27
100+100+1000	294	268	1.071	8.6	.34

* 1 rep only

Lime plot Tessman farm

lime treatment* lbs./acre	total yield cwt/A	% Mg	Al ppm
0	344	.21	180
1000	360	.18	167
2000	377	.21	153
4000	354	.21	140

Soil pH 5.4

SUMMARY

There appears to be no phosphorus or potassium response at the Tessman plot. The 200 pound nitrogen treatment appears to yield the best.

There is a response to N, P and K on the Gray plot. The Russet Burbank variety gave extremely variable results. The potatoes were very knobby and were generally a poor indicator as to which fertilizer treatments were most effective.

Perhaps the most striking difference between the two plot locations was the magnesium content. The very high potassium treatments have induced a low magnesium content in the petioles on the Tessman farm. Considerably higher magnesium content is shown on the petioles from Gray's farm.

There are little, if any, conclusions that can be drawn from the lime plot. Lime was broadcast and plowed 12 inches deep. Perhaps much of the lime is at too low a depth to have much effect.

Plot work conducted by-

C. J. Overdahl, C. P. Klint, O. C. Turnquist, G. W. Randall, R. D. Munson, George Roadfelt, and Enoch Bjuge.

Maximum Yield Study-Alfalfa
Rosemount Experiment Station

Dr. L. J. Elling of the Agronomy department established a maximum yield study with alfalfa at Rosemount in the spring of 1965. Members of the Soils Science Department assisted in the lime and fertilizer phase.

Since soils tested high in both P and K and quite acid, three rates of lime (0,3,10 tons) were used, but only two rates of fertilizer (800 pounds per acre of 4-12-24 vs. none). Half the fertilized area is top dressed annually with 800 pounds per acre of 4-12-24. Two varieties were used plus four replications.

Yields* tons/acre

fertilizer treatments	1965 seeding year	1966	2 years increase
none	2.77	5.02	-
800# 4-12-24 B. S.**	3.17	5.46	.84
800# 4-12-24 B. S. + 800 4-12-24 T.D.**	3.13	5.51	.85

*Average of 2 varieties, 2 cuttings 1965, 3 cuttings 1966. 15% moisture.
**B. S.=Before seeding, broadcast worked twice and plowed 10 inches deep.
T.D = top dressed fall 1965.
There was a significant difference between fertilized and unfertilized plots at the 5% level.

Yields* tons/acre

lime treatments tons/acre	1965 seeding year	1966	2 years increase
0	2.95	5.22	-
3	2.99	5.45	.27
10	3.13	5.32	.28

*Average of 2 varieties, 2 cuttings 1965, 3 cuttings 1966.
15% moisture. No significant yield differences due to lime treatments.

Lime and basic application of fertilizer were applied in the fall of 1964, worked twice with a field cultivator and plowed 10 inches deep.

Soil tests to a 6" depth in the fall of 1965 were as follows:

lime rate	pH Rep I	pH Rep II	O. M.% Rep I	O. M.% Rep II
none	5.8	5.4	4.8	4.3
3 ton	6.0	6.0	4.7	4.6
10 ton	6.1	6.3	4.7	4.3

fertilizer rate	P test Rep I	P test Rep II	K test Rep I	K test Rep II
none	40	45	180	200
800# 4-12-24	55	80	240	350
+top dressed	-	110	250	-

The lack of lime response and small change in pH due to liming suggested further sampling, this time in 2 inch increments, in the fall of 1965 to observe distribution to a 12 inch depth.

	pH according to lime treatments			P test by treatment		K test by treatment	
	tons per acre						
depth	0	3	10	none	192#P_2O_5	none	384#K_2O
0-2"	6.1	5.7	6.2	50	90	240	330
2-4"	5.9	5.9	6.6	55	55	220	230
4-6"	5.9	6.1	6.6	52	80	210	300
6-8"	5.8	-	6.4	40	75	200	330
8-10"	5.8	-	6.2	24	60	190	290
10-12"	5.8	-	5.8	13	11	160	190

Tissue analysis average from first cutting of alfalfa in 1965, according to treatment showed that K_0 = 1.84%, K_{384} = 2.21%, P_0 = .25%, P_{192} = .25%. Calcium and magnesium levels reflected no effect of lime treatments. Boron levels were slightly below the threshhold levels of "sufficient". Tissue analysis is being made of all three cuttings in 1966.

L. J. Elling, Jim Justin, R. D. Munson, prepared by C. J. Overdahl.

Fertilizer Trials on Oil Crops
Northwest Experiment Station
Crookston, Minnesota - 1966
Olaf C. Soine, Soil Scientist

Sunflowers: There is considerable interest in sunflower production in the Red River Valley, and in 1966 an estimated 27,000 acres were planted. The yield per acre was 920 lbs. as given by the Minnesota Crop and Livestock Reporting Service. The price per pound is approximately 4 1/2 cents.

Three fertilizer trials were conducted this year, two on the Station, and one at Gonvick. Plots were laid out consisting of four replicates and 13 treatments at the Experiment Station and 10 treatments at Gonvick.

The yield and bushel weights for the 2 fields on the Station are given in table 1. Field 16, which was in flax in 1965, gave the best yields. Every treatment except the 20 lbs. of potash gave an increase yield when compared to the check plot.

Field 42 was in sugarbeets in 1965 and the soil on this field was Bearden silt loam. The yields of sunflowers were much lower when compared to field 16. The treatments, 40-80-0 and 40-80-40 gave the largest yield increase.

There was no significant difference in the bushel weights for fields 16 and 42.

The oil content for fields 16 and 42 is given in table 2 with an average for both fields. All the plots on field 42 were higher in oil content when compared to field 16. The differences between treatments on either field were not large. No single treatment produced a very large increase in percentage of oil when compared to the check.

Table 3 gives the yield, bushel weight, and oil content for the trial at Gonvick. Nitrogen - 40-0-0 - gave the best yield increase. The bushel weights were similar for all treatments.

(continued)

Fertilizer Trials on Oil Crops -
(continued)

Table 1.

THE EFFECT OF FERTILIZER ON THE YIELD
AND
BUSHEL WEIGHT OF SUNFLOWERS
NORTHWEST EXPERIMENT STATION - 1966

Treatment lbs./acre	Yield lbs./acre			Bus. wt.
$N-P_2O_5-K_2O$	Field 16*	Field 42**	av. 2 fields	av. 2 fields
0-0-0	1840	953	1397	29
20-0-0	1873	1057	1465	28
0-40-0	1980	1050	1515	29
0-0-20	2037	1062	1550	29
20-40-0	1999	1165	1582	28
0-40-20	2094	916	1505	29
20-40-20	1896	1158	1527	29
40-0-0	2015	1227	1621	29
0-80-0	1960	939	1450	29
0-0-40	1644	932	1288	29
40-80-0	2031	1348	1670	30
0-80-40	1857	966	1412	29
40-80-40	1945	1383	1664	29

* Field 16: Bearden silty clay loam, 1965 crop - flax
** Field 42: Bearden silt loam, 1965 crop - sugarbeets

Sunflowers planted in 22 inch rows at 20,000 plants per acre.
Fertilizer applied as a band treatment.
Amiben at 3 lbs/acre gave 99% weed control.

Variety: Peredovik
Date of planting: May 25, 1966

(continued)

Fertilizer Trials on Oil Crops
(continued)

Table 2.

THE EFFECT OF FERTILIZER
ON THE
OIL CONTENT OF SUNFLOWERS
NORTHWEST EXPERIMENT STATION - 1966

Treatment lbs./acre $N-P_2O_5-K_2O$	Percent Oil Field 16	Field 42	Average
0-0-0	46.3%	47.1%	46.7%
20-0-0	46.8	48.2	47.5
0-40-0	45.3	48.0	46.6
0-0-20	44.8	48.2	46.5
20-40-0	44.5	47.7	46.1
0-40-20	45.7	47.8	46.7
20-40-20	44.9	48.1	46.5
40-0-0	45.1	47.3	46.2
0-80-0	44.6	48.6	46.6
0-0-40	44.4	48.6	46.5
40-80-0	43.5	47.6	45.5
0-80-40	44.7	48.3	46.5
40-80-40	45.0	47.7	46.3

Variety: Peredovik

Table 3.

THE EFFECT OF FERTILIZER ON THE YIELD, BUSHEL WEIGHT
AND
OIL CONTENT OF SUNFLOWERS
GONVICK - 1966

Treatment* lbs./acre $N-P_2O_5-K_2O$	Yield lbs/acre	Bu. Weight lbs/bus.	Oil Content percent
0-0-0	1285	28	50.2
40-0-0	1447	28	50.1
0-40-0	1195	29	50.8
0-0-40	1122	28	49.5
40-40-0	1418	28	49.5
0-40-40	1178	28	50.6
40-40-40	1259	27	48.7
40-80-40	1193	28	50.1
40-80-80	1301	28	49.0
80-80-80	1413	28	48.1

*Fertilizer broadcast prior to planting
Date of planting: May 23, 1966
Row width: 40 inches

Variety: Peredovik

(continued)

Fertilizer Trials on Oil Crops
(continued)

The oil content for the sunflowers on the field at Gonvick was higher than the two fields on the Experiment Station. No single fertilizer treatment produced an increased percentage of oil when compared to the check plot on the Gonvick field.

Tame Mustard: Considerable acreage of tame mustard is grown each year in the Red River Valley, and questions about the fertilization of this crop have been asked. An experiment consisting of 12 different treatments with 3 replicates was laid out on a Bearden silt loam soil. A combination of broadcast and band treatments were used; for example, **20-0-0 broadcast and 0-40-0 applied in a band at seeding time.

The field data is given in table 4. There was no significant difference in yield. The treatment, **20-40-0, (**20-0-0 broadcast + 0-40-0 band applied) gave the best yield increase - 335 lbs. The treatment *20-40-0, (*10-0-0 broadcast + 10-40-0 band applied) was the only treatment that was below the check plot in yield.

Mustard tends to shatter when the crop nears maturity and the plants are dry. This may account for the high L.S.D. figure in this trial.

Crambe: This crop produces an oil that is used in industry where high temperatures are attained. There is no acreage of this crop being grown at the present time.

An experiment with 12 treatments and 3 replications was laid out on a Bearden silt loam soil in 1966. A combination of broadcast and band treatments was used, similar to the tame mustard trial.

Table 5 gives the yield of Crambe in lbs. per acre. Treatments **20-0-0 (broadcast) and x 30-40-20 (*10-0-0 broadcast plus 20-40-20 band application) gave significant increases when compared to the check plot.

(continued)

Table 4. YIELD RESPONSE OF TAME MUSTARD TO COMMERCIAL FERTILIZER NORTHWEST EXPERIMENT STATION - 1966

Treatment lbs./acre $N-P_2O_5-K_2O$	Yield lbs./acre	Duncan's Range
**20-40-0	1363	
**60-80-40	1266	
*10-40-0	1228	
*30-40-20	1200	
**20-0-0	1171	
**30-40-0	1128	
20-40-20	1119	
0-40-0	1095	
10-40-0	1057	
*10-0-0	1030	
0-0-0	1028	
*20-40-0	988	
L.S.D. 5%	393	
L.S.D. 1%	534	

Mustard sown @ 10#/acre in 7 inch rows.
Treatments *10-0-0 and **20-0-0 broadcast before seeding.
Remaining treatments applied alone and in combination with broadcast treatments in a band at seeding time.
Sown May 7, 1966 - harvested August 11, 1966.

Table 5. YIELD RESPONSE OF CRAMBE TO COMMERCIAL FERTILIZER NORTHWEST EXPERIMENT STATION - 1966

Treatment lbs./acre $N-P_2O_5-K_2O$	Yield lbs./acre	Duncan's Range
**20-0-0	1374	
*30-40-20	1318	
40-80-40	1200	
**20-40-0	1191	
*10-40-0	1172	
20-40-20	1091	
*20-40-0	1081	
10-40-0	1045	
0-0-0	1040	
*10-0-0	1027	
0-40-0	988	
**30-40-0	981	
L.S.D. 5%	209	
L.S.D. 1%	284	

Crambe sown @ 15#/acre in 7 inch rows.
Treatments *10-0-0 and **20-0-0 broadcast before seeding.
Remaining treatments applied alone and in combinations with broadcast treatments in a band at seeding time.
Plots sown May 9 - harvested August 18, 1966

Effects of Fertilization on Seed Yield and Chemical Composition of Tissue of Park Kentucky Bluegrass

John Grava, D.M. Larsen, G.W. Randall, R.S. Farnham, W.P. Martin, and J.M. MacGregor

Ten field experiments were conducted on growers' fields in northwestern Minnesota to study effects of fertilization on seed production of Park Kentucky Bluegrass and Timothy. The investigations consisted of: (a) Date of fertilization, 5 trials (3 trials with K. Bluegrass and 2 trials with Timothy); (b) Fertilization of 5 to 8 year old Timothy stands, three 5x2x2 factorial experiments; (c) Two potassium rate trials with K. Bluegrass. The determinations involved the measurement of seed yield, determination of 16 chemical elements in grass tissue, and climatological measurements at the experimental sites.

Since the investigations on Timothy will be used by D.M. Larsen for his M.S. thesis problem, data from K. Bluegrass plots only is given in this report.

Cool season grasses, such as K. Bluegrass and Timothy prefer somewhat cool and moist weather. The 1965-66 season, as shown in table 1, was characterized by wet and cool fall, rather heavy snowfall and extremely cold January and February. Normal rainfall was received at Roseau in the spring but the temperature was rather low during April and May. The rainfall in June and July was slightly above normal. The average temperatures in June and July were about 1°F. Above normal. However, there were 15 days in July when the maximum air temperature exceeded 79°F. (4 days in July of 1965). K. Bluegrass was harvested on July 7-9, and Timothy on August 2-4. Thus, due to a later harvest, Timothy was more exposed to high temperatures than K. Bluegrass.

Table 1. Climatological Data As Measured at Roseau U.S. Weather Station.

Period	Precipitation (inches)		Temperature (°F.)		GDD T_b = 40°F.
	Total	Departure From Normal	Ave.	Departure From Normal	
1965/66					
Aug-Oct.	7.24	0.32	51.4	-3.5	1052
Nov.-Mar.	5.33	2.01	10.5	-2.0	
Apr.-July	11.19	1.72	54.0	-1.6	1858
Total	23.76	+4.05			2910
Average			35.2	-2.3	

A. Date of Fertilization Trials

Of the three experiments with K. Bluegrass only one could be used for seed harvest. Two other experiments had to be discontinued because the cooperators inadvertently had applied additional fertilizer in the spring.

Table 2 shows soil test results of an alkaline Colvin sicl in Roseau County

Table 2. Soil Test Results, Colvin Silty Clay Loam, G. Kveen, Roseau County.

Sampling Depth, Inches	ph.	Extractable P pp 2 m	Exchangeable K pp 2 m
0-1	7.7	55	150
1-2	7.9	16	90
2-3	7.9	12	80
3-6	8.1	55	90
6-12	8.5	8	80
12-18	8.4	8	50
18-24	8.8	10	30

The seed yields obtained in this experiment are shown in table 3.

The chemical composition of K. Bluegrass is given in table 4. Nitrogen content was determined at the Department of Soil Science by the Micro-Kjeldahl Method. The other elements were determined with a emission spectrograph by the Ohio State University Plant Analysis laboratory.

Plant tissue samples were collected from another "Date of Fertilization" trial on a peat soil. The results are given in table 5. Seed yields could not be obtained on this experiment because of excessive lodging.

Table 3. Effect of date of fertilizer application on the seed yield of Park Kentucky Bluegrass-1966. Colvin Silty Clay Loam, G. Kveen, Roseau County.

Date of Fertilization	Seed Yield LB./Acre
Aug. 25, 1965	421
Sept. 15, 1965	495
Oct. 15, 1965	590
May 26, 1966	329
June 15, 1966	189
Split (1/2 Sept. 15 & 1/2 May 26)	435

All plots received: 60+46+46

Seeded: May 1959; Renovated: 1962

Fertilization in 1965: None.

Flooded for 6 weeks during spring 1966.

Table 4. Effect of date of fertilization on chemical composition of Kentucky Bluegrass tissue, Colvin sicl, G. Kveen, Roseau County - 1966

Date of Fertilization*	N	P	K	Ca	Mg	B	Cu	Zn	Mn	Mo	Al	Fe
	Per Cent					Parts Per Million						
Check (June 15, 66)	1.64	.32	1.89	.39	.24	5	10	27	77	.73	199	254
August 25, 65	1.62	.30	2.13	.36	.22	4	9	21	52	.68	151	169
September 15, 65	1.93	.32	2.26	.42	.24	4	11	23	63	.93	166	236
October 15, 65	2.03	.31	2.21	.36	.23	4	9	21	57	.59	68	91
May 26, 66	3.39	.37	2.75	.39	.25	4	10	26	63	.77	68	131
Split (1/2 Sep. 15 & 1/2 May 26)	2.56	.33	2.32	.39	.24	4	9	22	56	.79	109	151

* All plots received: 60+46+46 (N, P_2O_5, K_2O) treatment; fertilizer was applied on "June 15" plots after the collection of plant tissue samples.

Table 5. Effect of date of fertilization on chemical composition of Kentucky Bluegrass tissue, deep peat, L. Miller, Roseau County - 1966

Date of Fertilization*	N	P	K	Ca	Mg	B	Cu	Zn	Mn	Mo	Al	Fe
	Per Cent					Parts Per Million						
August 25, 65	2.99	.33	1.81	.48	.36	6	5	35	50	1.23	13	55
September 15, 65	3.02	.33	2.05	.44	.34	5	6	37	49	1.05	12	53
October 15, 65	3.20	.34	1.99	.46	.35	5	7	39	45	.96	13	61
May 1, 66	3.29	.35	2.38	.45	.34	5	5	37	48	.83	13	61
May 20, 66	3.23	.36	2.29	.40	.33	5	5	37	51	1.02	12	60
Split (1/2 Sept. 15 & 1/2 May 1)	3.18	.34	1.96	.44	.34	5	5	36	47	.97	11	53

* All plots received: 30+46+46 (N, P_2O_5, K_2O) treatment.

B. Potassium Rate Study

Burson et al. (1959-1963) found that K topdress applications had little or no effect on seed yields of K. Bluegrass in Roseau County, even on soils (peat, sandy loam, silt loam) with low exchangeable K content. The potassium rate most often used was 80 lbs. K_2O per acre. However, some growers had observed less lodging and obtained increased seed yields with the use of relatively high K application.

To investigate effects of K application on K. Bluegrass seed production two field experiments were established in northwestern Minnesota. Fertilizer topdress applications were made on established stands on a Rocksbury loam and a deep peat on September 15, 1965. A randomized block design was used with the treatments replicated four times. Plant tissue samples were collected prior to the heading-out time. Seed yields were obtained from only one experiment on the loam soil. The grass had severely lodged on the peat.

Soil test results of samples obtained prior to fertilizer application from the experiment on loam soil are given in table 6.

Table 6 Soil test results·Rocksbury loam, E. Helmstetter, Lake of the Woods County.

Sampling Depth, Inches	ph	Extractable P pp2m	Exchangeable K pp2m
0-1	8.4	40	100
1-2	8.3	18	70
2-3	8.3	22	60
3-6	8.0	12	50
6-12	8.4	4	40
12-18	8.3	3	50
18-24	8.5	3	60

As shown in table 7 K. Bluegrass seed yields were increased by the application of nitrogen and phosphorus. However, no yield increases were obtained with the addition of potassium, even at the higher rates.

The chemical composition of K. Bluegrass tissue from the two experimental sites are given in tables 8 and 10.

As shown in Fig. 1 the K content in grass tissue was affected quite differently by potassium topdress application to the two soils. On the peat there appears to be a curvilinear relationship with the greatest increases in K content taking place up to the 140 lbs. K per acre rate. On the loam soil, the first increment of 35 lb. K/acre increased the K content in grass tissue by 0.19%, but no increases are shown beyond that point. One gets the impression that, for some unknown reason, the potassium applied to this mineral soil was not absorbed by the plants.

Table 7. Effect of potassium application on the seed yield of Park Kentucky Bluegrass - 1966.Rocksbury loam, E. Helmstetter, Lake of the Woods County.

Treatment	Seed Yield lb./acre
None	93
60+46+0	305
60+46+42	232
60+46+84	308
60+46+126	283
60+46+168	317
60+46+336	298

Fertilizer applied: Sept. 15, 1965

Seeded: 1962

Fertilizer used in 1965: 75+75+0

Table 9. Soil test results.Deep peat, L. Miller, Roseau County.

Sampling Depth, Inches	ph	Extractable P pp2m	Exchangeable K pp2m
0-1	6.6	23	160
1-2	6.6	13	90
2-3	6.6	8	50

Table 8. Effect of Potassium treatments on chemical composition of Kentucky Bluegrass tissue, Rocksbury loam, E. Helmstetter, Lake of the Woods County - 1966

Treat No.	Treatment* N	P_2O_5	K_2O	N	P	K	Ca	Mg	B	Cu	Zn	Mn	Mo	Al	Fe
	lb./acre			Per Cent					Parts Per Million						
7	None			1.75	.29	1.92	.33	.19	6	9	20	38	.24	6	22
1	60	46	0	1.98	.29	1.99	.39	.21	6	12	20	38	.35	7	29
2	60	46	42	2.01	.29	2.18	.38	.20	5	10	20	34	.25	8	29
3	60	46	84	2.06	.30	2.13	.36	.20	5	9	20	37	.30	7	27
4	60	46	126	2.03	.29	2.13	.38	.20	5	15	21	37	.35	8	31
5	60	46	168	2.06	.30	2.21	.38	.19	5	11	20	34	.27	7	29
6	60	46	336	2.07	.30	2.24	.37	.20	6	10	21	35	.30	7	38

* Fertilizer applied on Sep. 15, 1965.

Table 10. Effect of potassium treatments on chemical composition of Kentucky Bluegrass tissue, deep peat, L. Miller, Roseau County - 1966

Treat No.	Treatment* N	P_2O_5	K_2O	N	P	K	Ca	Mg	B	Cu	Zn	Mn	Mo	Al	Fe
	lb./acre			Per Cent					Parts Per Million						
7	None			3.04	.31	1.67	.45	.36	7	4	36	43	.97	12	49
1	30	46	0	3.21	.34	1.77	.47	.38	7	5	36	47	1.13	12	54
2	30	46	42	3.18	.35	1.97	.47	.36	7	4	37	46	1.04	12	60
3	30	46	84	3.15	.34	2.16	.46	.34	6	4	36	49	.81	13	54
4	30	46	126	3.09	.34	2.36	.43	.32	6	4	35	43	.72	12	49
5	30	46	168	3.27	.35	2.61	.36	.31	5	4	34	42	.66	11	51
6	30	46	336	3.19	.35	3.00	.33	.25	5	4	33	45	.50	12	51

* Fertilizer applied on Sep. 15, 1965.

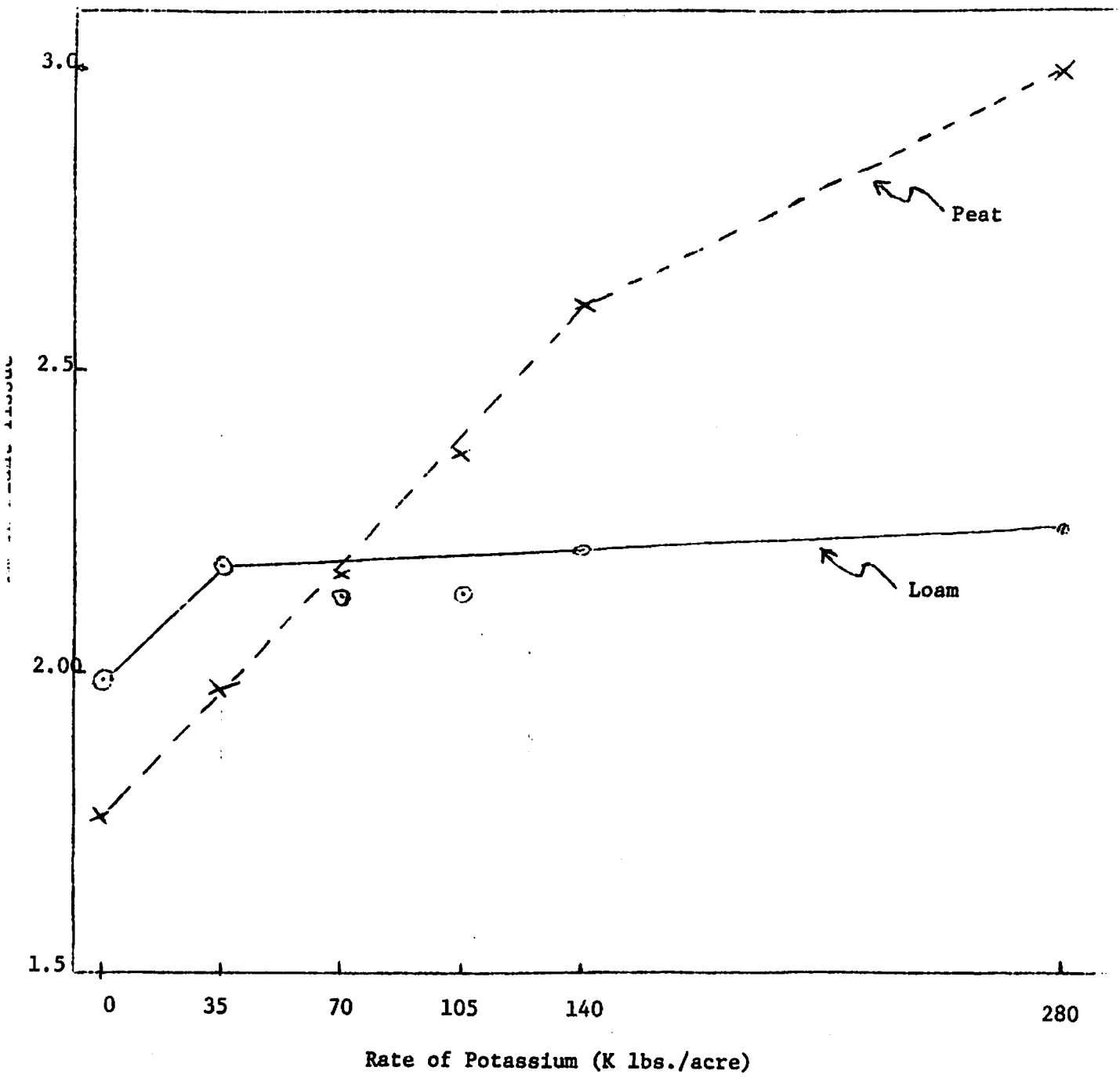

Figure 1 Effect of Potassium topdress applications to mineral and peat soils on the K content of K. Bluegrass tissue.

Improvement of Forested Soils

R. H. Rust

In 1965 a 25 acre field was selected in Wadena County for investigation of soil properties which affect productivity. The site is located on drumlin topography (about 2 - 4 percent slopes) which covers some 500,000 acres in parts of Wadena, East Ottertail and Todd counties. At this site the associated soils with a range in natural drainage conditions are the Rockwood, Blowers, and Paddock series - all of which have a fragipan, to a greater or lesser extent, at 2 to 3 feet below the surface.

In 1966 the field was limed (2 T/A) and fertilized with phosphate (100 lbs/A 0-45-0), potash (500 lbs/A 0-0-60), and gypsum (300 lbs/A), then seeded to a mixture of Vernal alfalfa and Lincoln bromegrass.

Fifteen legume and legume-grass mixtures were seeded in replicate plots on 3 different soil conditions to assess adaptability.

Five plots (200 x 150 feet) were marked out on a uniform 4 percent slope for future hydrologic studies. Water stage recorders (4) and observation wells (12) were installed at upper and lower ends of the plots about July 1 and observation of the water table made for the remainder of the season.

Approximately 18 inches of rainfall were recorded during the period May 15 through October 15. No appreciable perched water tables were observed after July 1 (when the observation wells were installed).

A good to excellent stand of alfalfa was established.

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This project is being conducted in cooperation with the Agricultural Research Service.

Land Forming
at
Northwest Experiment Station - 1966

Olaf C. Soine, Scientist

This experiment was laid out in the fall of 1965 to study the effect of 5 different methods of land forming on the yield of crops in a rotation of corn, wheat, barley and alfalfa. A fertilizer trial was included in the experiment.

The plots and treatments were randomized and the crops and fertilizer treatments were replicated 4 times. The soil type is Bearden silt loam. Wheat and barley were seeded on May 24, and this late date of seeding may account for the low yields of these 2 crops. The corn was planted on May 25.

The 5 methods of land forming are:

1. Check, no treatment
2. .02% grade in one direction
3. .01% grade in one direction
4. Level grade
5. Land smoothing - pulling soil from high spots to low with no attempt to grade.

The yields of barley were low on all plots and there was no significant effect on the yields by either land forming or fertilizer treatments.

The yields of wheat on the "no treatment" plots were slightly lower than on the other 4 land forming plots. The results of the fertilizer treatments were variable and no single rate gave a consistent increase in yield.

All the corn yields were good. The yields of corn on the "no treatment" plots were lower than the yields on the other 4 treatments. The 0-40-0 and the 40-40-20 rates produced the most consistent yield increases of corn.

Effect of 5 Different Methods of Land Forming
on
The Yield of Corn, Wheat and Barley

Land forming treatments	Fertilizer lbs./acre N	P_2O_5	K_2O	Corn* bushels	Wheat per	Barley acre
No treatment	0	0	0	80.0	17.2	35.0
	0	40	0	81.4	20.3	39.9
	0	40	20	71.5	14.6	31.5
	40	40	20	85.2	18.6	38.5
.02% grade	0	0	0	80.4	26.6	27.8
	0	40	0	84.2	25.1	34.0
	0	40	20	69.9	28.7	33.8
	40	40	20	91.5	25.0	39.4
.01% grade	0	0	0	78.6	20.2	23.4
	0	40	0	86.8	18.4	21.7
	0	40	20	86.3	20.2	26.9
	40	40	20	91.2	26.7	38.8
Level grade	0	0	0	85.4	22.6	36.4
	0	40	0	88.8	23.3	35.6
	0	40	20	72.5	24.9	36.2
	40	40	20	92.3	24.7	40.0
Land smoothing	0	0	0	93.1	22.5	33.8
	0	40	0	88.5	22.1	32.0
	0	40	20	89.7	20.3	36.6
	40	40	20	86.5	22.6	36.3

*Corn planted in 22 inch rows, 20,000 population.
Bushels per acre at 15.5% moisture.

Soil Testing in Minnesota During 1966

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes nearly forty thousand samples annually. The following data show the number of various types of samples analyzed in 1966:

Regular farm, garden and lawn samples	35,721
Florist (Greenhouse) samples	1,867
Limestone	37
Departmental research samples	913
Total	38,538

The monthly distribution of regular soil samples received by the laboratory is s in table 1.

Table 1. Monthly distribution of soil samples received by the University of Minnesot Soil Testing Laboratory during 1966.

Month	Number of Samples
January	3016
February	2388
March	3747
April	4549
May	1300
June	885
July	881
August	2035
September	3464
October	4900
November	5469
December	3087