These results confirm earlier findings in regard to use of fertilizers in the production of grass hay or pasture. The following conclusions have been interpreted from the data and are further supported by observations and data accumulated by previous research in Minnesota.

1. Pastures with mixed grasses, particularly those containing considerable timothy and quack grass species, produced higher average yields with or without fertilizer use than those pastures which were predominantly Kentucky bluegrass.

2. Fertilizer applications containing an equivalent of 150 pounds of nitrogen, 50 pounds of P_2O_5 and 50 pounds of K_2O resulted in increases in yield of hay of more than 2 tons per acre in two cuttings.

   Yields with the above fertilizer applications were nearly 3 times those obtained from no fertilizer application.

3. The application of 30 pounds of nitrogen per acre in combination with 15 pounds of P_2O_5 and 15 pounds of K_2O resulted in significant increases in yield in the first cuttings, but did not significantly increase yields in subsequent cuttings.

4. Nitrogen applied at the rate of 100 pounds of N per acre in the absence of additions of phosphorus and potassium fertilizer resulted in significant increases in yields. These increases, however, were not of the magnitude obtained when the equivalent quantity of nitrogen was applied in combination with phosphorus and potassium fertilizer. Future work in this area should include specific trials to determine phosphorus and/or potassium needs. It is likely that the response to additions of phosphorus and potassium fertilizer was largely due to the presence of additional phosphorus.

   Soil tests below 10 pounds per acre of P indicate low available phosphorus. A soil test of less than 100 pounds per acre of K indicates a low potassium level.

5. Under conditions of these trials, no significant increases in yields were obtained from the application of weed control materials.

   Data from these trials show that the application of 2-4-D effectively controlled most of the broad leaf weeds. Under the relatively good moisture and growing conditions experienced during this season, grass yields from plots not receiving weed control materials were similar to those in which weeds were controlled. Normally, weed control is an essential part of good pasture management and often can be as effective in increasing yields as fertilizer treatment.

These trials will be conducted for several more years in order to more fully study the influence of weed control and fertilizer treatment on the change of species.

6. Samples of hay obtained from the check plots, weed control plots, and those plots receiving 100 pounds of nitrogen plus 50 pounds each of P_2O_5 and K_2O per acre were analyzed for protein content. These data are shown in Table 3. Increases in protein content, as influenced by nitrogen fertilizer applications, often exceeded 5 percent. There was little difference in the protein content of the mixed grasses as compared with the stands which were predominantly Kentucky bluegrass. In the first cutting, those plots receiving applications of 2-4-D for weed control were generally lower in protein. This was likely due to the reduction in the population of legume plants in the weed control plots.

7. The average protein yield per acre obtained from the two cuttings on both the mixed grass and predominantly Kentucky bluegrass pasture sites was significantly increased by fertilizer applications, as shown in Table 4. The yield of protein per acre on the fertilized plots was more than 3 times that obtained on non-fertilized areas.

Less than 15 percent of the hay and pasture land in Minnesota is fertilized. Farmers as yet have not been motivated to try to shoot for high levels of forage production. While there are many reasons, perhaps one of the most important in northern Minnesota is that farmers feel they do not need additional forage because they keep only sufficient livestock to utilize the forages they normally produce. To be profitable, forages must be fed to livestock. Forages are not easily marketed and, during years of surplus production, the market price is often quite low. There were many instances of under utilization of hay and pastures in Minnesota this past growing season.

Farmers must have sufficient livestock to utilize the additional forages produced as a result of increased fertilization. If forages are not fed or grazed, forage fertilization may not be a paying proposition.

When one compares the production of T.D.N. and protein from grasses with that of corn, we realize that forages properly fertilized and harvested either as forage or pasture can be valuable. Table 5 shows a

Comparison of the production obtained in the trials with an equivalent production of corn.

The possibility of producing 77 bushels of corn per acre in northern Minnesota on land now being used for pasture and hayland is rather unlikely. However, a yield of 3.5 tons of hay per acre from this land is a reality when proper fertilizer weed control and management is employed.

Table 1. Hay yields - pasture fertilizer - weed control trials. Red River Basin - Minnesota - 1971

Treatment ($N + P_2O_5 + K_2O$)	Hay Yields tons/acre *Mixed Grasses 1st Cut	*Mixed Grasses 2nd Cut	K. Bluegrass 1st Cut	K. Bluegrass 2nd Cut
0 + 0 + 0	.55	.83	.39	.40
0 + 0 + 0 + weed control	.43	.71	.35	.35
30 + 15 + 15	.70	1.10	.49	.43
30 + 15 + 15 + weed control	.73	.84	.57	.43
100 + 50 + 50**	1.75	1.81	1.08	.96
100 + 50 + 50** + weed control	1.75	1.71	1.21	.92
100 + 0 + 0	1.02	1.06	.61	.50
100 + 0 + 0 + weed control	1.13	.90	.69	.52
	5 sites	5 sites	6 sites	4 sites

* Mixed grasses - includes quack, timothy, orchard, brome and Kentucky bluegrass

** Received 50 pounds nitrogen after first cutting

Table 2. Phosphorus and potassium soil test levels - pasture fertilizer - weed control trials.
Red River Basin - Minnesota - 1971.

Location County	Soil Test Level P	K
	lbs/A	
Marshall	5	170
Red Lake	8	600
Pennington	5	200
West Polk	7	160
West Polk	6	170
East Polk	5	160
East Polk	13	140
Roseau	27	340
Norman	18	170
Norman	45	470
Mahnomen	35	560

Table 3. Protein percent - pasture fertilizer - weed control trials.
Red River Basin - Minnesota - 1971.

Treatment ($N + P_2O_5$)	% Protein *Mixed Grasses 1st Cut	2nd Cut	K. Bluegrass 1st Cut	2nd Cut
0 + 0 + 0	11.7	11.3	11.9	10.3
0 + 0 + 0 + weed control	10.7	10.9	11.5	10.3
150 + 50 + 50** + weed control	16.8	15.0	15.2	15.5

* Mixed grasses - includes quack, timothy, brome, orchard, Kentucky bluegrass mixtures

** 50 pounds nitrogen applied after first cutting

Table 4. Protein pounds per acre - pasture fertilizer - weed control trials. Red River Basin - Minnesota - 1971.

Treatment ($N + P_2O_5 + K_2O$)	Protein pounds per acre					
	*Mixed Grasses			K Bluegrass		
	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	Total
0 + 0 + 0	151	187	338	93	82	175
0 + 0 + 0 + weed control	92	155	247	80	72	152
150 + 50 + 50** + weed control	588	513	1001	367	285	652

* Mixed grasses - includes quack, timothy, orchard, brome and Kentucky bluegrass

** Received 50 pounds nitrogen after first cutting

Table 5. Production of T.D.N. and protein from grass pasture compared to corn.

	Ton Hay/Acre	Pounds T.D.N./Acre	Pounds Protein/Acre
Permanent Bluegrass no fertilizer	.8	800	160
Permanent Bluegrass + fertilizer	2.0	2000	600
Mixed Grasses + fertilizer	3.5	3500	1000
Corn (bu.)	18	800	90*
Corn (bu.)	45	2000	227*
Corn (bu.)	78	3500	393*

* Based on 9 percent protein in corn.

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THE NUTRIENT STATUS OF KENNEBEC POTATOES AS INFLUENCED BY VARIOUS FERTILIZER TREATMENTS GRAND FORKS, MINNESOTA 1971

Charles Simkins, Edwin Plissey and Paul Groneberg

The nutrient content of the potato leaf and its petiole has been used by a number of investigators to determine the nutrient status of the potato plant. As the means and methods for tissue analysis become more efficient, rapid and reliable, critical values for the nutrient content of plant tissue can be established and correlated with nutrient supplies in the soil, crop growth and yield and quality of harvested crop.

In order to help establish critical levels for the potato crop, leaf and petiole samples were taken for a field of Kennebec potatoes which had been previously fertilized at various N, P and K rates. The 4th or 5th leaf from the top was sampled, along with the leaf petiole. Samples were taken on July 15, 1971 about 50 days after emergence of the potato plants. The potato plants were in full bloom stage. Nitrogen determinations were made by a modified Kjeldahl method. Other nutrients, as shown in Tables 1 and 2, were determined by means of emission spectrography.

Discussion of Results

Nitrogen - Levels of nitrogen in the plant tissue were increased by N fertilizer applications. Fifty pounds of nitrogen per acre produced a level in the plant tissue which was equal to that obtained by other rates (100, 150 and 200 lbs. per acre). The level of approximately 5.5% nitrogen produced yield levels which were significantly higher than the non treated plots and equal to those plots treated with higher rates of nitrogen.

Phosphorus - Phosphorus levels in the plant tissue were not significantly altered by phosphorus, nitrogen or potassium fertilizer doses. On the average, those plots receiving phosphorus fertilizer produced leaf samples which were slightly higher in phosphorus. Plots receiving no phosphorus averaged .47 percent phosphorus in the leaf while plots receiving phosphorus applications equal to 200 pounds of P_2O_5 per acre averaged .51 percent P_2O_5. Although the values were not significant, the phosphorus content of the leaves increased with increasing rate of P_2O_5 in the phosphorus rate trial (.484 for control to .597 for 400 lbs. P_2O_5/acre).

Potassium - Significant increases in potassium in the leaf tissue were observed only in the potassium trial where rates of potassium application exceeded 100 pounds K_2O per acre.

Although the percent K increased from 2.2 to 2.8 percent in the tissue, there was no significant increase in yield at harvest time.

Calcium and Magnesium - The quantity of these two cations was not significantly changed as a result of the various fertilizer treatments. The high amount of exchangeable calcium and magnesium in this alkaline soil should furnish ample calcium and magnesium for crop growth.

Aluminum - It was surprising to find that the leaf tissue of the potato grown on these alkaline soils (pH 7.8 to 8.0) contained aluminum in some instances as high as 900 ppm. The author, to date, has found little reference to the possibility of toxicity of aluminum to the potato plant on alkaline soils. It should be interesting to determine where the quantity of soluble aluminum in this soil is high. The content of aluminum in the leaf tissue was significantly decreased by increasing rates of phosphorus. It was noted that the highest levels of aluminum in the plant tissue was observed coming from those plots where

the soil test indicated a low level of available phosphorus. A level of more than 400 ppm in the plant tissue is considered to be excessive to many plants, including alfalfa and sugar beets. Perhaps the high soluble aluminum content of the soil and the accompanying high level of aluminum in the plant tissue is responsible for the response obtained from high levels of phosphorus application in the work of A. C. Caldwell et al.

In these trials, the yield increases due to increasing phosphorus application were not significant. The low plant population, however, could be responsible for this.

Iron, Manganese and Boron - The effect of the various fertilizer treatment on quantity of iron, manganese and boron in the plant tissue was similar to the quantity of aluminum found in the tissue. Iron and manganese and boron in the plant tissue decreased with increasing phosphorus applications. This phenomena is not new since it has been well established that phosphorus fertilizer additions can result in a decrease of plant uptake of several micro-nutrients.

Copper - The quantity of copper in the plant tissue was also reduced with increasing phosphorus additions. The quantity of copper in the plants, however, was considerably above the critical level established by several investigators.

Zinc - Zinc levels in the plant tissue were not significantly influenced by fertilizer treatments. Samples from all plots displayed zinc levels well above the 16 ppm considered to be critical for good potato growth.

Table 1. Nutrient content of leaf and petiole of Kennebec potatoes as influenced by nitrogen, phosphorus and potassium fertilizer treatment. Grand Forks - 1971. Average of 4 replications.

Treatment	N %	P %	K %	Ca %	Mg %
0+0+0	4.78 a	.471	2.57	.901	.765
0+200+100	4.63 a	.477	2.58	.816	.695
50+200+100	5.47 b	.511	2.60	.759	.695
100+200+100	5.37 b	.493	2.78	.844	.755
150+200+100	5.70 b	.581	2.85	.725	.637
200+200+100	5.64 b	.548	2.88	.837	.714
Treat. Sig.	**	N.S.	N.S.	N.S.	N.S.
0+0+0	4.82	.484	2.53	.919	.645
150+0+100	5.17	.488	2.85	.914	.744
150+100+100	5.82	.514	2.67	.685	.579
150+200+100	5.56	.504	2.83	.871	.683
150+300+100	5.79	.593	2.56	.674	.572
150+400+100	5.85	.597	2.68	.732	.594
Treat. Sig.	*	N.S.	N.S.	N.S.	N.S.
0+0+0	4.55 a	.460	2.36 ab	.983	.752
150+200+0	5.75 b	.563	2.20 a	.814	.686
150+200+100	5.57 b	.488	2.57 abc	.849	.713
150+200+200	5.43 b	.483	2.84 bc	.858	.702
150+200+300	5.73 b	.529	2.82 bc	.745	.612
Treat. Sig.	**	N.S.	**	N.S.	N.S.

* Denotes 1% level of significance
** Denotes 5% level of significance

Table 2. Nutrient content of leaf and petiole of Kennebec potatoes as influenced by nitrogen, phosphorus and potassium fertilizer treatments. Grand Forks, 1971. (Averages of 4 replications.)

Treatment	Al ppm	Fe ppm	Zn ppm	Cu ppm	Mn ppm	B ppm
0+0+0	450 b	593	29.3	12.5	48.1	25.5 b
0+200+100	308 a	567	29.8	14.8	48.1	27.2 b
50+200+100	230 a	478	32.3	9.2	45.0	22.6 a
100+200+100	171 a	365	29.9	9.2	43.0	21.3 a
150+200+100	282 a	537	41.3	10.5	45.9	21.7 a
200+200+100	234 a	454	34.4	9.2	44.7	20.8 a
Treat. Sig.	**	N.S.	N.S.	N.S.	N.S.	**
0+0+0	584 b	966 c	31.9	13.9	58.2 b	23.6 b
150+0+100	520 b	860 bc	33.8	12.1	56.4 b	23.7 b
150+100+100	291 a	537 ab	41.0	12.4	44.5 a	20.5 a
150+200+100	303 a	546 ab	29.8	8.4	47.3 a	21.5 ab
150+300+100	213 a	428 a	40.8	9.4	43.8 a	19.9 a
150+400+100	210 a	434 a	33.0	7.9	44.7 a	20.7 a
Treat. Sig.	**	*	N.S.	N.S.	**	*
0+0+0	571 b	930 b	29.7	14.1 b	58.3 b	24.1 b
150+200+0	300 a	559 a	36.4	11.3 ab	48.7 a	20.1 a
150+200+100	279 a	519 a	28.2	8.4 a	45.9 a	20.5 a
150+200+200	354 a	620 a	30.6	8.2 a	48.4 a	21.2 a
150+200+300	299 a	635 a	32.4	7.9 a	44.4 a	20.4 a
Treat. Sig.	**	**	N.S.	*	**	**

* Denotes 1% level of significance
** Denotes 5% level of significance

YIELDS AND SPECIFIC GRAVITY OF KENNEBEC POTATOES AS INFLUENCED BY FERTILIZER TREATMENTS GRAND FORKS POTATO RESEARCH CENTER-1971

Charles Simkins, Edward Plissey and Paul Groneberg

Numerous investigations during the past 25 years have shown the need for additions of fertilizer for high potato yields in the Red River Basin of Minnesota. Most recently, the work of A. C. Caldwell and colleagues has indicated that on certain soils of the Red River Valley the application of high rates of phosphorus fertilizer (400 to 600 lbs. P_2O_5 per acre) may be important in obtaining highest yields of marketable potatoes. As management practices change, and more disease resistant varieties are available, a reevaluation of plant food needs are necessary. The goal of researchers and extension workers is to obtain sufficient information regarding fertilizer use by the potato crop to allow for recommendation of concise, economical quantities of fertilizer for a given situation.

This requires the development of a method to determine the present nutrient supplying power of the soil. It also requires that we learn on a given soil type the efficiency with which added plant food nutrients are absorbed by the potato crop. Furthermore, we must establish a realistic and economical yield potential which is consistently attainable under good management practices. Thus a fertilizer experiment should be much more than just a trial where fertilizer rates are applied to a crop and yields are taken. Unless one is relatively certain that the yields obtained from a fertilizer trial were <u>not limited</u> by management factors which could have been controlled by a good farmer, the data is of little value in projecting fertilizer needs.

Methods and Materials

In order to study the influence of various rates of N, P and K fertilizer on the yield and specific gravity of Kennebec potatoes, a site was selected on the Potato Research Center, Grand Forks, North Dakota. The soil was a Bearden silt loam and had previously been cropped to small grain (wheat).

A composite soil sample taken before planting indicated a medium phosphorus level (16 lbs. P per acre), a high potassium level (400 lbs. K per acre), and a medium NO_3N level (60 lbs. per acre). At planting time, additional composite soil samples were taken at 3 locations in the experimental site. The soil samples were analyzed at the soil testing laboratories at the Universities of Minnesota and North Dakota. While the soil testing methods are somewhat different in the two laboratories, the results on the basis of rating of available nutrients was nearly the same. A comparison of the soil test results were as follows:

Place of Sampling in Field

	Minnesota	Rating	North Dakota	Rating
East				
Nitrogen	86 lbs/acre	M	76 lbs/acre	M
Phosphorus (P)	20 lbs/acre	M	20 lbs/acre	M
Potassium	410 lbs/acre	H	220 lbs/acre	H
Center pH				
Nitrogen	122lbs/acre	VH	136 lbs/acre	VH
Phosphorus (P)	39 lbs/acre	VH	61 lbs/acre	VH
Potassium	470 lbs/acre	H	280 lbs/acre	H
West				
Nitrogen	53 lbs/acre	L	41 lbs/acre	L
Phosphorus (P)	3 lbs/acre	L	14 lbs/acre	L
Potassium	360 lbs/acre	M	180 lbs/acre	M

L=Low - M=Medium - H=High

Obviously, with this large variation in original plant nutrient content, one would expect a great variation in yield, crop growth and fertilizer response. This was borne out in observations during the growing season, as well as yields obtained at harvest time. The first

impulse when such a variation in soil variation and plant growth are observed is to discard the trial and expend efforts elsewhere. After more careful observation, however, it was found that the soil variation and difference in crop growth corresponded with different replications. With this apparent variation, it was interesting to continue investigations and determine the differences in responses at the various fertility levels.

The trial consists of 3 incomplete factorials involving:

5 N rates	5 P_2O_5 rates	4 K_2O rates
0	0	0
50	100	100
100	200	200
150	300	300
200	400	

In the N trial, an application of 200 lbs. P_2O_5 and 100 lbs. K_2O per acre was applied to all plots including the zero N plots. In addition, in each replication, there was a plot receiving no fertilizer application.

The P trial received a uniform application of N and K_2O at the rates of 150 lbs. and 100 lbs. per acre, respectively.

The K_2O trial received a uniform application of N and P_2O_5 at the rate of 150 and 200 lbs. per acre, respectively.

The potatoes were planted in 40 inch rows. Seed pieces were spaced in the row at 12 inches. Each plot consisted of 4 rows, 24 feet long.

Ammonium nitrate, treble superphosphate and potassium chloride were employed as nitrogen, phosphorus and potassium sources. The fertilizer materials were applied at planting time, approximately 2 inches to side and 2 inches below the potato seed pieces. The potatoes were planted on May 26, 1971. The vines were killed on August 26 and the potatoes were harvested on September 2, 1971 The 4th and 5th

leaf, including leaf petioles, were collected from each plot on July 15. These samples were analyzed for N,P,K,Cu,B,Al,Mg,Mn,Mo,Ca,Fe and Zn. (These results are discussed in another paper.) A sample from each plot was taken at harvest time for specific gravity and chipping quality determinations.

Weather and moisture conditions during the growing period were nearly ideal. More than 14.0 inches of precipitation was received during the growing period. The distribution was so favorable that it is likely that the crop was well supplied with moisture at all times.

Discussion of Results

Yields

The yields in general were quite high considering the number of plants per acre. A spacing of 12" x 40" will result in a plant population of approximately 13,000 plants per acre. Under conditions of these trials, it is quite likely that a plant population of 17,000 to 18,000 would have been more desirable. Based on previous research, a production potential of 500 bushels per acre is realistic under good management conditions in the Red River Basin. There were approximately 90 days between the time of planting and harvesting, yet many of the tubers harvested were over sized and too large for good chipping quality. A larger plant population would, no doubt, reduce the size of tubers and increase total yield and chipping quality.

Yields obtained from various fertilizer treatments are shown in Table 1.

Table 1. Yield, specific gravity and chipping quality of Kennebec potatoes as influenced by various fertilizer treatments - Grand Forks, 1971.

Lbs/acre $N-P_2O_5-K_2O$	Yield No. 1's bu/acre	Specific Gravity	Chipping Quality
0 + 0 + 0	338 a	1.083 b	52
0 + 200 +	348 a	1.083 b	49
50 + 200 + 100	417 b	1.083 b	53
100 + 200 + 100	432 b	1.074 a	46
150 + 200 + 100	391 b	1.077 a	45
200 + 200 + 100	346 a	1.073 a	50
Sig. Treatment	***	*	N.S.
0 + 0 + 0	281	1.088 b	48
150 + 0 + 100	310	1.082 ab	45
150 + 100 + 100	348	1.076 a	41
150 + 200 + 100	369	1.079 a	47
150 + 300 + 100	379	1.078 a	48
150 + 400 + 100	363	1.077 a	48
Sig. Treatment	N.S.	*	N.S.
0 + 0 + 0	251 a	1.089 b	49
150 + 200 + 0	337 b	1.081 a	44
150 + 200 + 100	346 b	1.081 a	44
150 + 200 + 200	340 b	1.079 a	47
150 + 200 + 300	378 b	1.081 a	45
Sig. Treatment	**	**	N.S.

* 1% level
** 5% level
***10% level

Although there was considerable variation in fertilizer response due to the differences in soil fertility, the overall response to nitrogen and phosphorus fertilizer application was quite significant.

In the nitrogen trials, the application of 50 lbs. N in combination with 200 lbs. P_2O_5 and 100 lbs. K_2O produced the highest significant increase in average yield.

In the phosphorus trials, statistical significance of fertilizer treatments on yield was not obtained at the 1, 5 or 10 percent levels. Average yields, however, indicate an increase in yield up to the 300 pound P_2O_5 rate.

The addition of potassium fertilizer did not significantly increase yields when used in combination with nitrogen and phosphorus fertilizer materials.

Included in the trials were 12 plots which received no fertilizer applications. Similarly, there were 12 plots which received an application of 150 lbs. N, 200 lbs. P_2O_5 and 100 lbs. K_2O per acre. The average yield for all the check plots was 290 bushels per acre. The above mentioned fertilized plots produced an average yield of 369 bushels per acre, or approximately an 80 bushel per acre increase.

Specific Gravity

As indicated in Table 1, the specific gravities of the potatoes examined from these trials were significantly altered by fertilizer applications. Nitrogen rates of more than 50 pounds of N per acre resulted in a significant decrease in specific gravity. Phosphorus fertilizer applications also contributed to the lowering of specific gravity of the potatoes. The 100 pound rate of P_2O_5 application was

as effective in lowering specific gravity as the 200, 300 or 400 pound rates.

The inclusion of potassium fertilizer in combination with nitrogen and phosphorus did not result in additional lowering of the specific gravity of the potatoes when used at 100, 200 and 300 pounds of K_2O per acre.

Chipping Quality

Data obtained from chipping tests did not show significant differences in chipping quality which could be attributed to fertilizer application. It is important to note that the average of 12 no fertilized plots produced a chipping value of 50, while those potatoes examined from the 12 plots receiving 150 pounds of N, 200 pounds of P_2O_5 and 100 pounds of K_2O produced an average chipping value of 44.

FERTILIZER EFFECT ON 1971 SMALL GRAIN YIELDS IN NORTHWESTERN MINNESOTA

by

J. M. MacGregor*

Small grains are grown extensively in northwestern Minnesota and rising farming costs have emphasized lowering unit production cost. The use of commercial fertilizers is well recognized as one way of increasing yields by applying the needed nutrient elements at adequate rates and proportions as an important part of a soil management system.

The use of such essential elements as fertilizer nitrogen and phosphorus has long been appreciated to be of value on these soils. More recently there has been increasing interest of possibly increasing small grain yields by the inclusion of potassium, sulfur, or of one or several of the micronutrient elements such as manganese, zinc, copper, or boron. A three year study on the effects of applying elements to northwestern Minnesota soils for small grain production was commenced in 1970 on 12 fields (2 of barley, 5 of oats, and 5 of wheat). Only one field (barley) responded to a 40 pound per acre rate of N, P_2O_5 and K_2O (40+40+40), there being no significant yield increase to heavy applications of potassium, or to moderate treatment rates of sulfur or of the four micronutrient elements, either alone or combined.

In 1971, nine fertility treatments were broadcast on plowed land, worked into the surface soil and planted on 17 fields scattered over seven northwestern Minnesota counties. The treatments applied corresponded to those of 1970, but with an additional 40+40+0 (N + P_2O_5)

*This study is possible only through the active interest of county extension personnel and cooperating farm operators in several northwestern Minnesota counties. Their contribution is duly acknowledged.

treatment added to study the relative effectiveness of the potash included in the basic treatment (40+40+40). Each of the nine fertilizer treatments was randomly broadcast with an untreated plot in five replications, making a total of 50 individual plots (10' x 15') in each of the 17 fields. Overall dimensions of each experimental area were 75' x 100', or less than one-fifth acre of each of the 17 fields.

A second treatment difference from the 1970 study was the use of "Sol-U-Sul" as a source of sulfur, rather than the "flowers of sulfur" broadcast in 1970. Sulfur from the former product is largely available to plants as soon as it is dissolved in soil water, whereas the "flowers of sulfur" may require several weeks for oxidation to sulfates by soil microorganism to become completely available.

A third change from the 1970 study was that the 40+40+40 broadcast treatment was applied to all of the sulfur and micronutrient plots as a standard fertility application -- irrespective of the starter fertilizer to be applied by the farm operator, or to fertilizer applied earlier for the 1971 crop. In 1970, amounts of each starter fertilizer were subtracted from the 40+40+40 broadcast treatment, resulting in a total (starter + broadcast) fertilizer rate to supply 40+40+40. This 1970 practice was found to be too time consuming, and placed a severe limitation on the number of experimental fields which could be included in the study.

As in 1970, zinc, manganese, and copper were applied as sulfates, which are relatively soluble in water. Boron was also added in a soluble form.

Fields were staked in mid-April as soon as workable, and the fertilizer treatments were broadcast. All stakes were then removed, with the farm operator working and seeding the entire field by the

usual procedures. The experimental plot areas were then re-staked in late June after weed spraying operations were completed.

The 1971 growing season was ideal for small grain production in most areas of northwestern Minnesota, although some farms experienced minor drouth or hail damage. Yield samples were harvested in late July or early August by cutting and bagging grain from a 3' x 8' swath from the central part of each plot. This was done just prior to the harvest of the entire field by the farm operator with the exception of two oat fields which were somewhat immature when sampled. (Prestebak and Sperling) (Due to a weed problem, only three replications were harvested on the Jameson wheat field). The grain was dried, threshed, weighed, and the respective yields calculated from the 5 replications of each field. Yields were statistically analyzed -- 13 of the 17 fields showed no significant yield differences. These are reported in the 3 following tables with soil analyses and other pertinent data.

Table 1 shows that the soil texture of the 9 oat fields varied, (with one organic (muck) soil) from a sandy loam to silty clay loam, having a pH range of 5.4 to 8.0 Organic matter in all fields was high, with extractable P varying from 8 to 75 lbs per acre. Nitrate-N ranged from 66 to 395 lbs per acre. Minimum soluble Zn was 0.8 lbs per acre and minimum sulfur was 7 lbs/A Both of these values are in the low range of availability and application of these two elements might prove beneficial to some crop species.

Yields of only 2 of the 9 oat fields responded significantly to the 1971 broadcast fertilizer treatments, and both of these responding fields were damaged by hail after they headed out. It is evident that nitrogen and phosphate fertilization was primarily

responsible for the yield increases on these two fields. None of the 9 oat fields produced a significant yield effect from the heavy potash, sulfur, zinc, manganese, boron, or copper applications, either with the 40+40+40, or as a combination "shotgun" treatment and the 40+40+40.

Table 2 shows the soil analyses and yields obtained on the 5 barley fields. These soils were all fine textured, with the greatest variation in nutrient availability shown in the K and NO_3-N analyses. Fertilizer treatment significantly increased barley yields on only 1 of the 5 fields. Apparently the N + P_2O_5 (40+40+0), were responsible for the barley yield increase.

Table 3 data show that all 3 wheat field soils were fine textured, with the main soil differences occurring in the levels of soluble P and NO_3-N. Starter fertilizer had been purposely omitted from the Northwest Experimental Station wheat field at Crookston, and the 40+40+40 broadcast treatment produced significantly larger wheat yields. Since the 40+40+40 broadcast treatment resulted in yields approximately equivalent to the N + P_2O_5 (40+40+0), and extractable soil P was very high, it may be assumed that N was the most effective fertilizer element for increasing wheat yield on this field. It is obvious that heavy rates of K_2O application, or of moderate broadcast rates of sulfur, zinc, copper, manganese or boron (either alone or combined) have failed to significantly increase 1971 yields of wheat on the three 1971 experimental wheat fields.

Table 1. County, Farm Operator, Location, Soil Test, Fertilizer Treatment and 1971 Yields of Nine Northwestern Minnesota Oat Fields.

County	Ottertail	Ottertail	Ottertail	Wilkin	Clay	Norman	Pennington	Pennington	Becker
Operator	M.Erlandson	R.Roehl	G.Bradow	I.Bellmore	P.Brantner	H.Barkve	N.Peterson	C.Prestebak	W.Sperling
Address	F.Falls	F.Falls	F.Falls	Kent	Felton	Ada	T.R.Falls	T.R.Falls	Ponsford
Soil texture	SiCL	L	SL	L	SiCL	SiCL	SL	Muck	L
Soil pH	7.1	6.7	7.3	7.7	8.0	8.0	7.1	5.4	6.8
Soil OM	H.	H.	H.	H.	H.	H.	H.	V.H.	H.
Soil P	8	23	20	75	8	10	65	9	11
Soil K	420	380	240	600+	560	580	200	120	90
Soil NO_3-N	170	197	122	133	395	232	176	116	66
Soil Zn	1.5	12.8	4.2	3.4	0.8	1.6	5.3	3.1	2.5
Soil S	15	11	11	12	13	16	8	40+	7
1970 crop	flax	barley	oats	barley	wheat	wheat	oats	oats	corn
1970 fertilizer (lbs/A)	None	8+27+9	64+57+15	19+48+13	12+57+14	40+29+0	50+18+18	14+14+14	23+8+45
1971 variety	Lodi	Sioux	Sioux	Harmon	Lodi	Lodi	Kelsey	Lodi	Portal
1971 starter (lbs/A)	15+38+10	47+38+10	20+50+13	19+48+13	None	10+29+0	14+14+14	14+14+14	23+8+25
1971 broadcast (lbs/A)	1971 oat yields in bushels per acre								
None	56.4a	91.4	90.7	79.4	102.3	68.9	55.9	61.4	60.8abc
40+40+0	62.4b	87.9	83.3	78.7	104.6	77.0	53.2	61.3	69.9cd
40+40+40	63.1b	85.1	84.8	78.5	93.7	77.9	56.1	59.1	59.0a
40+40+200	65.8b	89.7	85.5	91.6	99.5	71.3	57.8	58.0	59.6ab
40+40+40+10Zn	62.4b	91.2	85.7	81.8	92.6	72.4	48.1	65.0	64.0abcd
40+40+40+10Mn	63.6b	91.0	85.4	80.1	105.4	73.9	60.0	66.7	68.3bcd
40+40+40+2B	66.0b	86.5	85.4	78.5	101.2	77.6	54.9	57.1	67.3abcd
40+40+40+10Cu	65.5b	89.4	90.1	80.0	112.8	69.1	59.1	56.9	63.8abcd
40+40+40+20S	65.4b	90.8	86.4	89.5	105.3	70.0	56.7	66.6	70.0d
40+40+40+10Zn+10Mn +2B+10Cu+20S	65.7b	92.6	87.0	71.1	111.3	76.5	53.3	57.4	66.3abcd
Comments	(hailed)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	(hailed)

N.S. -- Not Significant

Numbers followed by the same letter are not significantly different at the 5.0% level (Duncan's New Multiple Range Test)

Table 2. County, Farm Operator, Location, Soil Test, Fertilizer Treatment and 1971 Yields of Five Northwestern Minnesota Barley Fields.

County	Wilkin	Wilkin	Clay	Norman	Pennington
Operator	R.Fried-ericks	R.Hove-land	C.Brende-muhl	J.Tobin	F.&B.Wald
Address	Foxhome	Lawndale	Kragnes	Flom	T.R.Falls
Soil Texture	SiCL	CL	SiCL	CL	SiCL
Soil pH	7.9	7.6	7.6	7.4	7.0
Soil OM	H	H	H	H	H
Soil P	30	9	33	25	65
Soil K	410	460	600+	190	600+
Soil NO_3-N	210	265	117	65	455
Soil Zn	2.3	0.7	1.0	1.7	1.8
Soil S	20	18	10	12	33
1970 crop	barley	wheat	durum	oats	wheat
1970 Fertilizer (lbs/A)	35+89+24	18+46+0	29+74+0	16+16+10	14+29+29 (+S+T.E.)
1971 Variety	Larker	barley	Larker	Larker	Larker
1971 starter (lbs/A)	23+57+15	51+46+0	37+37+0	22+22+20	18+36+36
1971 broadcast (lbs/A)	1971 barley yields in bushels per acre				
none	38.6	34.3	64.6	45.8a	65.0
40+40+0	36.4	37.2	60.4	58.8bc	62.9
40+40+40	37.3	38.5	60.8	55.8bc	58.9
40+40+200	35.3	33.5	65.0	61.8c	63.2
40+40+40+10Zn	37.8	33.7	64.7	56.4bc	62.8
40+40+40+10Mn	38.2	38.2	58.8	57.3bc	64.6
40+40+40+2B	36.0	40.0	70.0	56.4bc	67.1
40+40+40+10Cu	33.9	42.8	66.0	53.3b	65.1
40+40+40+20S	37.8	38.6	68.6	57.9bc	66.7
40+40+40+10Zn+10Mn+2B=10Cu+20S	35.7	29.7	64.1	59.1bc	66.3
Comments	N.S.	N.S. (dry)	N.S.		N.S.

N.S. + Not Significant

Numbers followed by the same letter are not significantly different at the 5.0% level Duncan's New Multiple Range Test).

Table 3. County, Farm Operator, Location, Soil Test, Fertilizer Treatment and 1971 Yields of Three Northwestern Minnesota Wheat Fields.

County	Clay	Norman	Polk
Operator	F.Kreps	R.Jameson	N.W.Station
Address	Borup	Ada	Crookston
Soil texture	SiCL	SiCL	SiCL
Soil pH	7.8	7.8	8.3
Soil OM	H	H	H
Soil P	57	60	160
Soil K	520	520	600+
Soil NO_3-N	290	186	192
Soil Zn	1.3	2.1	1.5
Soil S	40+	9	40+
1970 crop	oats	S.Fallow	sugar beets
1970 fertilizer (lbs/A)	54+20+20	--	6+157+0
1971 variety	Waldron	R.River 68	Chadron
1971 starter (lbs/A)	none	24+72+0	none
1971 broadcast (lbs/A)	1971 wheat yields in bushels per acre		
none	40.7	41.4	34.1a
40+40+0	46.0	41.5	46.5c
40+40+40	44.3	39.1	44.3bc
40+40+200	44.4	38.9	46.3bc
40+40+40+10Zn	43.7	38.9	46.5c
40+40+40+10Mn	47.9	41.9	47.0c
40+40+40+2B	44.5	36.4	40.8b
40+40+40+10Cu	48.6	43.5	44.5bc
40+40+40+20S	44.0	42.5	44.1bc
40+40+40+10Zn+ 10Mn+2B+10Cu+20S	46.3	39.5	45.2bc
Comments	N.S.	N.S.	

N.S. + Not Significant

Numbers followed by the same letter are not significantly different at the 5.0% level (Duncan's New Multiple Range Test).

Conclusions

It is apparent that broadcast applications of sulfur, zinc, manganese, boron, and copper, either alone or combined, as well as light or heavy applications of potash have not significantly increased the experimental yields of 17 small grain fields in northwestern Minnesota in 1971. Significant yield increases resulted on four fields from broadcast applications of 40 lbs of N and P_2O_5 per acre (40+40+0). The results obtained are essentially the same as those reported on 12 fields of small grain grown in northwestern Minnesota during the 1970 growing season.

NITROGEN RATE STUDIES ON SEMI-DWARF WHEAT VARIETIES WEST POLK COUNTY - 1971

Charles Simkins - Samuel Bigger - Richard Arnston

The recent introduction of semi-dwarf wheat varieties in Minnesota has stimulated an increase in wheat production among farmers in the Red River Basin of Minnesota.

During the 1971 harvest season, it was not uncommon to encounter farmers who had produced more than 80 bushels (4,800 lbs.) of wheat per acre. The favorable spring planting season and the good distribution of moisture during the spring and summer growing season, no doubt, contributed considerably to these record yields. However, without adequate fertilizer use,many farmers were obtaining yields of less than 40 bushels per acre.

In the past, largely because of the high organic matter level of soils and the practices of legume fallow and black fallow, nitrogen fertilizer use on small grains produced inconsistent results. In general, phosphorus fertilization of small grains was the key to good fertilizer management for small grain production. Nitrogen use was restricted to 30 to 50 pounds of N per acre if the field had been in a nitrogen depleting crop such as sugarbeets, sunflowers, or potatoes. In most cases, the inherent potassium levels in the soil supplied most crops with sufficient potassium. The wheat varieties available to the farmers did not have a potential of more than 50 bushels per acre. An application of nitrogen fertilizer exceeding 50 pounds per acre often resulted in excessive lodging and poor quality grain.

New short-statured wheat varieties which resist lodging have yield potentials of 100 bushels (6,000 lbs.) of grain per acre. This potential increases the requirement for plant food nutrients and requires continuing research to assure that yields are not limited by an insufficient supply

of plant nutrients.

In addition, it is important to study the influence of nitrogen fertilizer applications on wheat milling and baking quality. Most semi-dwarf wheat varieties are relatively low in protein and may exhibit low baking absorption and loaf volume values.

Methods and Materials

Field sites were selected at two locations in West Polk County, one near East Grand Forks, Minnesota (Gulbranson farm), the other near Angus, Minnesota (Miski farm). The soils were classified as Bearden silty clay loam and had been cropped to sugar beets during the 1970 crop season. Soil test results indicated a medium to high phosphorus level; high potassium level and medium nitrate nitrogen level. Sulfur levels as indicated by soil tests were high, above 30 ppm S.

Era wheat was seeded by grain drill at the rate of 90 lbs. per acre. Fertilizer materials were applied at seeding time at the rate of 20 lbs. nitrogen and 50 pounds of P_2O_5 per acre. Additional nitrogen at the rates of 60, 120, and 180 pounds per acre was applied on May 19, June 11, and June 30. Four replications of each treatment were applied broadcast on plots 1/200 of an acre in size. Ammonium nitrate (33.5% N) was used as the nitrogen source. At harvest time, an area 4 feet by 15.5 feet was harvested by hand and threshed by means of Vogel thresher.

Nitrogen content of grain was obtained by modified Kjeldahl method. Samples for yield determinations were taken twice at the Gulbranson location on August 11 and August 16. Yield determinations at the Miski location were taken at the August 16 date.

Results - Yields of Wheat

Yields of Era wheat obtained from the various nitrogen treatments are shown in Table 1.

At the Miski location, nitrogen applied at the rate of 60 pounds N per acre at seeding time (in addition to the 20 pounds of N applied by the farmer) resulted in yield increases of more than 20 bushels per acre, The increases at this level of application (60 pounds N per acre) were equal to those obtained at higher levels of application (120 and 180 pounds N per acre). Field observations indicated some delay in maturity due to the application of 120 and 180 pounds of N per acre. Some lodging also occurred in these plots.

To study the influence of this delayed maturity on the yield of wheat grain, the Gulbranson location was harvested at two dates. At the August 11 harvest date, the wheat kernels at the Gulbranson location were in the hard dough stage. Wheat is often cut at this stage and allowed to remain in the swath for further maturing and reduction in moisture content to accommodate threshing. The wheat kernels at the August 16 date were fully matured and relatively low in moisture content. As indicated by the data obtained from the two harvests, considerable yield increase was obtained by harvesting at a more mature date. Yield differences were greatest at the 120 and 180 pound N rates.

It is interesting to note that data obtained at the August 11 harvest date showned no statistical significance in grain yields as a result of nitrogen applications. This was likely due to the immaturity of the grain. Care should be exercised by farmers as well as researchers to make sure the grain is physiologically mature before harvesting. Yields obtained at the August 16 harvest date showed similar results as those obtained at the Miski location. Sixty pounds N applied at seeding time resulted in the highest significant increase in yield of wheat grain. The results obtained are consistent with those we might expect on soils which, as shown by soil tests, already contained more than 80 pounds of NO_3N per acre.

Results - Protein Content of Wheat

Investigations have shown that soil application of nitrogen can result in increased protein content of grain.

On soils low in available nitrogen, small applications of nitrogen will normally result in yield increases with little or no change in grain protein content, whereas large applications increase grain protein.

Experiments have also shown that late soil applications (flowering time) have resulted in higher protein percentages in the grain than those applications applied at or near seeding time.

The protein content of the harvested wheat at both the Miski and Gulbranson locations was significantly increased by nitrogen fertilizer applications.

In general, the nitrogen fertilizer applied at the time of stooling (June 11) or at flowering stage (June 30) resulted in the highest protein content of grain. Based on the data obtained in these trials, an application of 60 pounds N per acre resulted in the highest significant increase in yield and approximately 1 percent increase in protein content. The 120 and 180 pound rates of nitrogen increased the protein content 2-3 percent, but did not consistently increase yields over the 60 pound rate.

Based on the present premiums for protein in wheat (January 1972) (5¢ for 14% protein) (15¢ for 15% protein) the application of more than 60 pounds N per acre on soils testing 80 pounds NO_3N per acre would be uneconomical.

Table 1. Era wheat yields - West Polk County - 1971

Treatments (lbs. N/acre)	Miski	Gulbranson August 11	Gulbranson August 16
	bu/acre		
CHECK	52 a#	60a	65a
Seeding - May 19			
60	73 b	73a	79 cd
120	71 b	65a	81 d
180	65 b	64a	82 d
Stooling stage - June 11			
60	70 b	63a	69 ab
120	67 b	68a	76 bcd
180	71 b	70a	73 abcd
Flowering stage - June 30			
60	75 b	69a	70 abc
120	64 b	67a	75 bcd
180	65 b	71a	78 bcd
Significance			
Rep	NS	NS	NS
Treatment	**	NS	**
C.V.	10.73	8.77	7.94

Soil Test		
NO_3N	87 lbs/acre	80 lbs/acre
P	13 lbs/acre	38 lbs/acre
K	390 lb /acre	600 lbs/acre
S	40 lbs/acre	33 lbs/acre

Treatment means followed by the same letter are not significantly different at the 5.0% level. (Duncan's New Multiple Range Test)

Table 2. Protein content of Era wheat - West Polk County - 1971 .

Treatments (lbs. N/acre)	Miski	Gulbranson August 11	Gulbranson August 16
		% protein	
Check	12.0 a #	12.0 a	10.8 a
Seeding - May 19			
60	12.7 ab	12.8 b	13.1 b
120	13.6 bcd	14.1 def	13.3 bc
180	14.1 cd	14.3 ef	13.7 bcd
Stooling stage June 11			
60	13.4 bc	13.0 bc	10.8 a
120	14.0 cd	13.7 cde	14.8 de
180	14.1 cd	13.7 cde	14.8 de
Flowering stage - June 30			
60	13.6 cd	13.4 bcd	12.7 b
120	13.7 cd	14.5 f	14.3 cde
180	14.4 d	14.0 def	15.0 e
Significance			
Rep	NS	NS	NS
Treatment	**	**	**
C.V.	4.14	3.58	5.83

Treatment means followed by the same letter are not significantly different at the 5.0% level.(Duncan's New Multiple Range Test).

THE EFFECT OF NITROGEN RATES ON CHRIS AND ERA WHEAT UNDER IRRIGATION

A.C. Caldwell and D. Fairchild, Department of Soil Science

Five rates of N, (0, 25, 50, 75 and 100 lb/A) were applied broadcast just after planting time to plots of Chris and Era wheat on an irrigated Hubbard sandy loam near Park Rapids, Minnesota. A basic starter fertilizer of 8-16-32 + 2 1/2 S was applied at 150 lb/A. Yield data are given in the table.

There were no effects of N rates on Era, but 50 lb/A and heavier rates of N increased yields of Chris significantly. Era out yielded Chris on the average about 10 bushels per acre, but yields of both varieties were quite low.

There were several contributing factors to the unsatisfactory yields. Rainfall was sparse, and below normal in May (before irrigation was started), and there was some hail damage. Temperatures, also, were below normal for the growing period.

It is hoped to repeat this experiment in 1972.

Yields of Era and Chris as affected by nitrogen rates under irrigation.

	Variety	
	Era	Chris
*N rates lb/A	Yield	bu/A
0	27a**	19a
25	31a	18a
50	29a	23b
75	32a	24b
100	30a	24b

* N applied broadcast as ammonium nitrate.

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

SOYBEAN FERTILIZER PLACEMENT STUDY

G. E. Ham, S. D. Evans, W. W. Nelson and V. L. Ferch

Different N fertilizer rates and P and K fertilizer placement were studied at Lamberton, Morris, and Waseca. Main plots were broadcast P and K which were split into three nitrogen rates (0, 50 and 100 lbs per acre). Each nitrogen rates was divided into row fertilizer treatments (check, seed placement, 2 x 2 band and a combination of band and seed placement). Treatments, fertilizer rates, soybean variety and seed yields are shown in Tables 1, 2 and 3. The response to N fertilizer without P and K was not significant at any location. N fertilizer did increase yields significantly when used with P and K fertilizer at all locations. Broadcast P and K alone did not increase yields compared to row fertilizer alone.

Table 1.

EFFECT ON SOYBEAN SEED YIELD WHEN DIFFERENT FERTILIZER PLACEMENTS WERE APPLIED TO CORSOY SOYBEANS GROWN AT WASECA, MINNESOTA IN 1971.

Starter Fertilizer	0		50		100	
	No Bdcst	Bdcst-	No Bdcst	Bdcst	No Bdcst	Bdcst
	bu/acre					
Check	34 a*	36 a-c	34 a	38 b-e	37 a-d	36 a-c
Seed Placement	34 a	36 a-c	39 c-f	43 gh	37 a-d	40 d-g
Band	35 ab	34 a	37 a-d	37 a-d	38 b-e	36 a-c
Band + Seed Placement	35 ab	38 b-e	39 c-f	41 e-h	44 h	42 f-h

FERTILIZER RATES: Band 14 + 35 + 45
Seed Placement 4 + 10 + 14
Broadcast 0 + 100 + 150

SOIL TEST VALUES: pH 6.8
P 40 lbs/acre (very high)
K 265 lbs/acre (high)

* Yields followed by the same letter or letters are not significantly different at the .05 level. Yields followed by 2 letters with a hyphen are included in all groupings between the two letters.

Table 2.

EFFECT ON SOYBEAN SEED YIELD WHEN DIFFERENT FERTILIZER PLACEMENTS WERE APPLIED TO CLAY SOYBEANS GROWN AT MORRIS, MINNESOTA IN 1971.

Starter Fertilizer	0		50		100	
	No Bdcst	Bdcst	No Bdcst	Bdcst	No Bdcst	Bdcst
	bu/acre					
Check	24 a*	27 bcd	26 abc	31 ef	26 abc	25 ab
Seed Placement	26 abc	27 bcd	29 de	28 cde	31 ef	28 cde
Band	26 abc	27 bcd	28 cde	33 f	29 de	27 bcd
Band + ZN	25 ab	28 cde	29 de	29 de	33 f	29 de

Fertilizer rates:	Band	10 + 20 + 10
	Seed placement	4 + 8 + 4
	Broadcast	0 + 60 + 30
	$ZnSo_4$ (Zn)	10

Soil test values:	pH	7.7	
	P	7	lbs/acre (low)
	K	300	lbs/acre (high)

*See Waseca Table .

Table 3.

EFFECT ON SOYBEAN SEED YIELD WHEN DIFFERENT FERTILIZER PLACEMENTS WERE APPLIED TO CORSOY SOYBEANS GROWN AT LAMBERTON, MINNESOTA IN 1971.

Starter Fertilizer	0		50		100	
	No Bdcst	Bdcst	No Bdcst	Bdcst	No Bdcst	Bdcst
	bu/acre					
Check	25 a*	27 a-c	26 ab	30 d-f	26 ab	31 ef
Seed Placement	28 b-d	28 b-d	29 c-e	30 d-f	28 b-d	31 ef
Band	28 b-d	28 b-d	30 d-f	29 c-e	32 f	30 d-f
Band + Seed Placement	29 c-e	29 c-e	31 ef	30 d-f	31 ef	31 ef

Fertilizer rates:

Band	15 + 20 + 18
Seed placement	5 + 7 + 6
Broadcast	0 + 60 + 30

Soil test values:

pH	5.7
P	10 lbs/acre (low)
K	290 lbs/acre (high)

* See Waseca Table

SOYBEAN NITROGEN FERTILIZER STUDIES

G. E. Ham, W. W. Nelson, S. D. Evans and V. L. Ferch

Ammonium nitrate at the rate of 0, 5, 10 and 15 pounds N per acre was applied with the seed and 25 and 50 pounds N per acre was banded 2 inches to the side and 2 inches below the seed at Lamberton, Morris and Waseca. Soybean varieties and seed yields are shown in Table 1. N increased the seed yield of Merit at Morris, and Corsoy at Waseca. At Waseca, 15 pounds N per acre with the seed decreased seed yield. N did not affect seed yield at Lamberton.

Table 1.

EFFECT OF SEED ZONE OR BANDED NITROGEN FERTILIZER ON SOYBEAN SEED YIELDS IN 1971.

Row Fertilizer Nitrogen	Morris		Lamberton		Waseca	
	Soybean variety					
	Merit	Clay	Merit	Corsoy	Merit	Corsoy
	bu./acre					
0	26 a+	33	36	37	31 b	35 a
5	29 bc	30	34	38	31 b	34 a
10	27 ab	32	37	38	32 b	34 a
15	29 bc	30	35	38	27 a	36 ab
25*	29 bc	32	36	38	32 b	37 ab
50*	30 c	32	36	37	33 b	39 b

*25 and 50 lbs. N were banded, other rates placed with seed.

+ Yields under a given variety having the same letters are not significantly different at the .05 level.

SULFUR FERTILIZATION OF CORN AND ALFALFA IN SOUTHERN AND WESTERN MINNESOTA

D. S. Fairchild, W. E. Fenster,[1]
O. M. Gunderson, W. W. Nelson

Ten field experiments were established in 1971 to study the effects of sulfur rates and forms on corn and alfalfa production. All sulfur treatments were applied in the spring of 1971 with the exception being the Lamberton site which was fertilized in 1970.

Continued sulfur research is needed in Minnesota Agriculture as a result of increased use of high-analysis fertilizers that are low in sulfur, increased crop yields, decreased gains of atmospheric sulfur and decreased use of sulfur as a pesticide.

General information on the experimental sites is given in Table 1. Soil test results are shown in Table 2. Sites were selected that had previously tested medium to low in available sulfur. The final sulfur soil test values given in Table 2 were higher than originally anticipated. This may have been due to accidental incubation and subsequent sulfofication which resulted after collection of the samples.

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(1) Efforts of Bobby McCaslin and Paul Graneberg on plot work and statistical analysis are greatfully acknowledged.

Table 1. Location and Soil Type of Experimental Site

Location	Soil Type
Southwest Experiment Station Redwood Co.	Webster Clay Loam
J. Welti Wabasha Co.	Port Bryon Silt Loam
M. Voth Goodhue Co.	Undetermined
J. McCormick Houston Co.	Fayette Silt Loam
L. Kulberg Renville Co.	Nicollet Loam
C. Phillips Chippewa	Borup Loam
Weispfinnig Pope Co.	Esterville Loam
A. Hauge Pope Co.	Osakis Loam
F. Loquai Dodge Co.	Kenyon Silt Loam
G. Von Ruden Steele Co.	Undetermined

Table 2. Soil Test Levels of Experiment Sites.

Location	P	K	S	pH	O.M
	---lbs/A---		p.p.m.		
Redwood Co.	27	235	11	5.9	H
Wabasha Co.	68	390	16	6.8	M
Goodhue Co.	34	350	23	5.9	M
Houston Co.	65	190	16	6.6	M
Renville Co.	45	440	30	6.8	H
Chippewa Co.	52	500	19	7.9	H
Pope Co. (Corn site)	141	280	15	6.4	M
Pope Co. (Small Grain)	18	140	20	5.9	M
Dodge Co.	58	310	19	6.0	M
Steele Co.	28	240	10	6.1	M

A randomized complete block design was used with five treatments replicated six times. The fertilizer treatments were as follows:

Corn Sites	Form of Sulfur	Alfalfa Sites
0 lbs S/A		0 lbs S/A
25 lbs S/A	K_2SO_4	50 lbs S/A
25 lbs S/A	elemental S	50 lbs S/A
50 lbs S/A	K_2SO_4	100 lbs S/A
50 lbs S/A	elemental S	100 lbs S/A

The study at Lamberton included residual sulfur rates of 0, 20, and 100 lbs/A of elemental Sulfur replicated nine times.

All cooperators used optimun rates of N, P and K with good weed and insect control.

Plant tissue samples were collected at the following stages of growth:

1. Corn - whole plants at 10 inches in height and the 6th leave at silking,
2. Alfalfa - Top 1/3 of plant at harvest, and
3. Small grain - Flag leaf at dough stage.

Total nitrogen in tissue was determined by the Micro-Kjeldahl method, and other elements were determined in a multi-element emission spectrophotometer. Sulfate-sulfur in plant tissue was determined by digestion with nitric and perchloric acids. Analysis of sulfur in plant tissue has not been completed as yet. No consistent or significant sulfur interaction with the following elements were noted: N, P, K, Ca, Mg, AL, Fe, Zn, Cu, Mo, Mn and B.

Crude protein determination on the grains showed no significant increase with varying rates of sulfur.

Yields of grain and forage are reported in Tables 3, 4, 5 and 6. Corn yields ranged from 89 - 196 bu/A between experimental sites, but no significant differences were noted within any experiment at the 5.0 or 10.0% level. Only two cuttings of alfalfa were taken in 1971 due to a lack of moisture in late summer.

Table 3. Sulfur treatments and Corresponding 1970 and 1971 Corn Yields at Lamberton.

Fertilizer Treatment lbs/S/A	1970	1971
	----------bu/A----------	
0	155	113
20	157	114
100	154	109
Significance	N.S.#	N.S.

#Not significantly different at the 5% level.

TABLE 4

1971 Corn Yields on Sulfur Fertilization Trials

Treatments	Pope County	Houston County	Wabasha County	Goodhue County	Renville County	Chippewa County
	----------Bu/A Shelled Corn (15.5%)----------					
0 lbs. S/A	98	193	145	142	111	90
25 lbs S/A (K_2SO_4)	101	190	144##	144	119	89
25 lbs S/A (Sol-U-Sul)	102	192	157	145	118	90
50 lbs S/A (K_2SO_4)	98	196	157	146	113	90
50 lbs S/A (Sol-U-Sul)	101	184	151	143	114	100
	N.S.#	N.S.	N.S.	N.S.	N.S.	N.S.

N.S. - Not Significantly different at the 5.0% level.
- Yield increases of 0 - 13 Bu/A are indicated in Table 1, but are not statistically different because of variation within plots. Yield increases are the result of chance and not treatment effect.

TABLE 5

1971 Oat Yields on Sulfur Fertilization Trials

Treatments	Pope County	Dodge County
	----------Bu/A----------	
0 lbs S/A	63	51
50 lbs S/A (K_2SO_4)	65	47
50 lbs S/A (Sol-U-Sul)	64	47
100 lbs S/A (K_2SO_4)	65	50
100 lbs S/A (Sol-U-Sul)	67	49
	N.S.#	N.S.

#N.S. -- Not significantly different at the 5.0% level.

TABLE 6

1971 Alfalfa Yields on Sulfur Fertilization Trials

Treatments	Steele County 1st Cutting	2nd Cutting	Total
	Tons/A		
0 lbs S/A	2.2	2.0	4.2
50 lbs S/A (K_2SO_4)	2.2	1.9	4.1
50 lbs S/A (Sol-U-Sul)	2.2	2.0	4.2
100 lbs S/A (K_2SO_4)	2.2	1.8	4.0
100 lbs S/A (Sol-U-Sul)	2.1	2.0	4.1
	N.S.#	N.S.	N.S.

N.S. - Not significantly different at the 5.0% level.

1972 EXPERIMENTS

The present plots, with the exception of the Lamberton site, will be continued to study residual effects of sulfur. One additional site at the Waseca experiment station will include use of varying rates of sulfur to determine if starter sulfur responses may be realized.

SOIL TESTING

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes over twenty-eight thousand samples annually. The following data show the number of various types of samples analyzed in 1971.

Regular farm, garden and lawn samples		20,438
Florist (greenhouse) samples		1,821
Specials:	Nitrate	1,538
	Sulfur	1,264
	Zinc	702
	Soluble Salts	292
	pH	448
Limestone		16
Departmental research samples		1,994
	TOTAL	28,513

The monthly distribution of regular soil samples received by the laboratory is shown in Table 1.

Table 1. Monthly distribution of soil samples received by the University of Minnesota Soil Testing Laboratory during 1971.

MONTH	NUMBER OF SAMPLES
January	414
February	435
March	859
April	4,665
May	1,907
June	836
July	896
August	2,174
September	2,995
October	2,922
November	1,683
December	651

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