A Report on Field Research in Soils

(A compilation of recent experimental results by personnel of the Department of Soils and Extension Specialists and Agronomists at the Branch Stations at Crookston, Duluth, Grand Rapids, Lamberton, Morris, Rosemount, and Waseca).

Department of Soils
University of Minnesota

February, 1963

Some of the results herein reported are from experiments carried on during 1962 only, and should not be regarded as the results obtained over a number of years. The investigations are those of a more practical nature, and do not include some of the more theoretical problems presently under study in greenhouse and in the laboratory. Because these are largely one year results they should not be considered as conclusive and the results are not for publication.

TABLE OF CONTENTS

Summary of 1962 Minnesota Weather and the St. Paul Experimental Plot Data.

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The 1962 Growing Season Weather

The growing season weather proved to be generally unsatisfactory except for hay and pastures. The exceptionally great precipitation of May, in some places amounting to more than 200% of normal, while of doubtful benefit to the water resources of the state greatly delayed planting and adversely affected small grains. In July and August, critical months for the growth and maturation of corn, precipitation remained high. Although in some areas of coarse textured or "droughty" soils the excessive precipitation was beneficial. By the end of the season almost all areas, except perhaps the southeast, were well above normal (table 1). And, as might be expected, air temperatures (table 2) and soil temperatures were lower than normal.

Table 1. Total departure of precipitation from the long term normal, April 1-October 21, 1962. (U.S. Weather Bureau data).

Duluth	+2.94 in.	Rochester	+1.50 in.
Fargo	+7.82	St. Cloud	+6.36
International Falls	+5.52	Sioux Falls	+3.88
Minneapolis-St. Paul	+4.06		

Table 2. Departure of air temperature from long term normal. April-September, 1962 (U. S. Wea. Bur. data).

Station	April	May	June	July	August	September	Ave.
Crookston	-2.1	-0.1	+1.5	-2.5	+1.4	-0.9	-0.4
Duluth	-3.3	+0.3	-2.5	-5.2	-2.4	-2.8	-2.6
Fairmont	-2.2	+4.7	-0.7	-4.2	-1.2	-3.0	-1.1
Grand Rapids	-1.8	+2.5	-0.8	-4.0	-0.2	-1.6	-1.0
International Falls	-3.0	+1.5	+1.7	-2.7	-0.1	-1.0	-0.6
Minneapolis	-2.5	+3.0	-1.1	-5.5	-2.2	-4.1	-2.1
Morris	-3.5	+1.4	-1.4	-4.6	-0.3	-3.4	-2.0
Rochester	-3.0	+4.6	-0.6	-4.4	-1.7	-4.1	-1.5
St. Cloud	-2.8	+3.3	-0.3	-4.0	-0.6	-2.7	-1.2
Waseca	-3.4	+2.8	-2.4	-5.3	-2.3	-5.6	-2.7
Worthington	-2.8	+4.2	-1.4	-4.2	-1.6	-3.8	-1.6

Table 3. Percent of possible sunshine received compared with the long term normals, April-September, 1962 (U.S. Wea. Bur. data).

Station	May	June	July	August	September
Duluth	35	59	50	59	56
(normal)	58	63	69	62	51
Minneapolis	39	55	49	67	55
(normal)	58	61	69	66	61

Of equal or greater importance was the increased cloudiness which resulted in greatly decreased sunshine as shown in table 3.

In addition to the excessive precipitation, greatly reduced sunshine and lower air and soil temperatures, there was an early and severe cold wave which crossed Minnesota in the third week of September. The lowest temperature recorded was 17°F. at Cotton in St. Louis County. This cold wave effectively terminated the season in many areas. Although minimum temperatures of around 32°F. are to be expected in September, temperatures in the 20s are not. This severe cold wave occurred about three to four weeks earlier than normal in the south and one to two weeks earlier in the north.

Soil Moisture Survey

The generally above normal precipitation during the 1962 season is reflected in the survey results (table 4). Perhaps the most important feature of table 4 is that all stations, where a comparison was possible, have greater soil moisture reserves this fall than last fall. It is interesting to note that the crops apparently use about 20-25 inches of water.

The Polk County, Crookston, soil moisture data indicate that water use by the crops in decreasing order are alfalfa, soybeans and sugar beets. However, a major portion of the difference is believed to be due to the difference in sampling dates, and that the real difference, between the three crops is far less than indicated.

Weather Station Plot Data, St. Paul.

A summary of the above and below ground meteorological information obtained at the experimental plot on the St. Paul campus is shown in tables 5 and 6.

The soil temperature data, table 5, show the influence that a cover has upon temperature. The sod cover, with the grass at no time being longer than about four inches, exerted an influence upon soil temperatures to a depth of about 80 cm. Under the sod the summer temperatures were cooler and in the winter were warmer than under the bare soil. In winter the sod acted as an insulator, and in the summer the temperature difference was due to the insulating effect as well as the cooling effect of the transpiring surface and, to a minor degree, the color difference.

The previous winter, 1960-61, was quite open and comparison with last winter shows an obvious influence that the snow cover had. For example, in January, 1961, snow cover averaged less than 0.5 inches, and in January, 1962, it averaged about 3-4 inches deep. As a result the January, 1962, soil temperates at 1 cm. averaged 6 and 7 degrees F. higher than the previous year.

The maximum soil temperature this last summer was not observed on the bare plot, as might be expected, but rather in the soybean plot. The temperature recorded was +122°F. at 1 cm. depth. The reason for this is that the plants had not yet grown enough to shade the soil surface completely but were tall enough to effectively decrease wind movement and reduce heat losses by convection.

The average soil temperature at each depth for the period October, 1961-September, 1962 (table 5) gives the impression that there is a big difference between depths. It is true that the shallow depths will show a slightly higher average of perhaps a degree or less, in this area at least, however the main reason for the large difference is the time when the observations were made. These data were obtained from only the 5 p.m. observation and are not hourly averages. Thus it is believed that the diurnal heat wave is largely responsible for the rather larger differences.

Table 4. 1962 soil moisture survey

County & nearby town	Soil	Crop	Sampling dates	Available water present[1]	% of maximum avail. water	Water use by crop [2]	Increase (+) or decrease (-) in water content of Fall 1962 over Fall 1961.
Chippewa,	Rothsay	Corn	May 1	7.4 in.	54.0%	--	
Milan	si. l.		Nov. 8	8.2	59.9	21.85 in.	Not sampled in 1961
Chippewa,	Aastad	Corn	April 27	12.1	92.4	--	
Montevideo	si. c. l.		Nov. 12	9.3	71.0	24.36	Not sampled in 1961
Dodge,	Kasson	Alfalfa	April 20	8.0	76.9	--	
Dodge Center	si.l.		Sept. 24	5.1	49.0	22.23	+ 2.5 in.
LacQuiParle	Aastad	Corn	April 27	9.5	59.7	--	
Bellingham	si. c. l.		Nov. 9	11.5	72.3	20.60	Not sampled in 1961.
LacQuiParle	Rothsay	Flax	May 1	6.3	48.1	--	
Marietta	si. l.		Nov. 9	8.3	63.3	24.00	Not sampled in 1961
Lyon	Rothsay	Corn	April 30	8.1	86.2	--	
Minneota	si. l.		Oct. 31	6.8	72.3	23.99	Not sampled in 1961
Mille Lacs	Mora	Hay	May 21	11.0	114.6	--	
Milaca	si. l.		Sept. 25	8.3	86.5	21.94	+ 5.2 in.
Polk	Hegne	Alfalfa	May 7	8.4	49.4	--	
Crookston	si. c.		Oct. 31	5.1	30.0	22.61	+ 2.1 in.
Polk	Fargo	Soybeans	April 25	7.9	46.5	--	
Crookston	si. c.		Oct. 31	8.1	47.6	19.54	+0.8 in.
Polk	Fargo	Sugar beets	June 1	11.5	67.6	--	
Crookston	si. c.		Nov. 2	6.6	38.8	18.68	Not sampled in 1961

Table 4. Continued

County & nearby town	Soil	Crop	Sampling dates	Available water present[1]	% of maximum avail. water	Water use by crop[2]	Increase (+) or decrease (-) in water content of Fall 1962 over Fall 1961.
Ramsey	Waukegan	Soybeans	May 25	8.7	103.6	--	
St. Paul	si. l.		Dec. 1	10.1	120.2	21.21	+5.9 in.
Redwood	Nicollet	Corn	April 30	8.3	58.0	--	
Belview	c. l.		Oct. 26	6.7	46.8	24.34	Not sampled in 1961
Redwood	Webster	Corn	May 1	8.7	85.3	--	
Lamberton	si. c. l.		Oct. 31	7.3	71.6	23.09	+1.2 in.
Sibley	Nicollet	Corn	May 3	9.2	78.6	--	
Gaylord	c. l.		Oct. 31	9.2	78.6	22.01	+0.7 in.
Wabasha	Fayette	Corn	May 31	10.4	67.5	--	
Kellogg	si. l.		Sept. 26	11.5	74.7	25.19	+4.0 in.
Watonwan	Nicollet	Corn	May 28	12.7	91.4	--	
Butterfield	c.l.		Oct. 25	8.8	63.3	22.28	+3.3 in.

Soil moisture samples obtained through courtesy of E. C. Dragemuller, A. N. Fischer, W. M. Kalton, P. N. Kennedy, G. F. Sickeler, Soil Conservation Service, USDA; W. W. Nelson, S.W. Expt. Sta.; O. C. Soine, N.W. Expt. Sta.; O. Gunderson, L. Hanson, G. Holcomb, Minn. Agric. Ext. Service

[1]Plant available water in a five foot column of soil.

[2]Based upon difference between first and last soil samplings plus precipitation. No attempt has been made to account for water runoff or percolation through the soil.

Table 5. Summary of soil temperatures (°F.) at experimental plot, Dept. of Soil Science, Univ. of Minn., St. Paul, Oct. 1961-Sept. 1962. (Observation time 5 P.M., C.S.T. daily; Waukegan silt loam soil.)

Depth (cm.)	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Ave.
						Bare Plot							
1	55	34	30	23	25	30	48	71	83	82	87	68	53.0
5	56	35	31	24	25	30	47	69	81	81	85	69	52.7
10	56	35	31	25	25	30	44	65	76	78	80	67	51.0
20	53	36	32	26	25	30	39	60	70	73	75	63	48.5
40	53	39	34	29	26	30	35	56	65	70	72	62	47.6
80	55	43	38	34	29	31	33	50	60	67	69	63	47.7
						Soybean Plot							
1	-	-	-	-	-	-	-	-	-	79	80	60	--
5	-	-	-	-	-	-	-	-	-	78	78	60	--
10	-	-	-	-	-	-	-	-	-	75	75	60	--
20	-	-	-	-	-	-	-	-	-	71	71	59	--
40	-	-	-	-	-	-	-	-	-	67	68	59	--
80	-	-	-	-	-	-	-	-	-	65	65	60	--
						Sod Plot							
1	53	36	32	29	28	31	44	63	74	75	74	65	50.3
5	54	37	32	29	28	31	42	62	73	75	74	65	50.2
10	54	37	33	30	28	31	40	60	70	73	72	64	49.3
20	53	38	35	31	29	31	36	57	66	70	70	63	48.3
40	53	41	35	33	31	31	34	53	62	66	68	63	47.5
80	55	45	38	35	33	32	32	48	58	64	65	63	47.3
120	57	48	41	38	35	34	35	45	54	61	63	62	47.7
160	57	50	43	39	37	35	35	43	52	59	61	61	47.7
320	57	54	49	46	43	41	40	41	46	51	55	57	48.3
640	-	-	-	-	-	-	-	-	-	45	48	49	--

Next year the plans are to have a complete set of soil temperature data from the soybean plot.

Table 6 is a summary of the above ground metecrological data obtained at the experimental plot.

Perhaps the most interesting feature in this table is the difference between the extreme minimum temperatures of the ambient (air) temperature, as measured in the standard weather shelter, and at 1 cm. above the sod, the bare soil and within the soybean plot. During the growing season the extreme minimum temperature at 1 cm. above the sod ranged from 4 to 15°F. colder than the extreme minimum measured in the temperature shelter. It should be noted, too, that lower minimum temperatures were observed over the sod than over the bare plot.

During the winter the difference between minimum temperatures over the sod and bare plot disappear due to the snow cover. While snow cover was present the minimum temperatures were measured, as nearly as possible, at 1 cm. above the snow surface. It can be very cold at or just above the snow surface as shown by the extreme minimum of -37°F. recorded in March, while the extreme minimum in the temperature shelter was but -24°F.

Table 6. Summary of atmospheric conditions, experimental plot, Dept. of Soil Science, Univ. of Minn., St. Paul, October, 1961-September, 1962.

Ambient Temp. (5 1/2 ft. above ground	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Average or Extreme
Ave. Max.	63	41	24	18	21	34	54	71	76	78	80	68	52
Ave. Min.	40	26	9	1	7	19	32	51	56	58	59	49	34
Average	52	34	17	9	14	27	43	61	66	68	69	58	43
Departure**	+2	+1	+2	-6	-4	-4	-3	+2	0	-6	-2	-4	-3
Extreme Max.	83	63	53	36	39	50	88	87	90	87	90	80	90
Extreme Min.	26	14	-12	-24	-23	-24	9	39	42	47	53	33	-24
Minimum Temp. (°F.) 1 cm. above sod													
Ave.	34	22	8	-2	3	14*	31	47	51	52	53	43	30*
Extreme	14	4	-22	-25	-25	-37	5	27	31	33	38	27	-37
Minimum Temp. (°F.) 1 cm. above bare soil													
Ave.	37	25	8	-2	3	14*	32	49	53*	54*	55	45	31*
Extreme	21	11	-22	-25	-25	-37	5	34	40	36*	43	30	-37
Minimum Temp (°F.) 1 cm. above soil in soybean plot													
Ave.	-	-	-	-	-	-	32	48	M	M	57	48	-
Extreme	-	-	-	-	-	-	5	33	36	M	44	35	-
Precipitation (in.)													
Total	3.58	1.18	1.50	0.43	1.77	2.20	1.36	8.12	4.74	6.04	4.54	3.57	39.03
Departure**	+1.93	-0.26	+.65	-.37	+.88	+.72	-.55	+5.00	+.48	+3.37	+1.75	+.72	+14.32
Greatest Day	1.40	1.00	0.86	0.09	0.50	0.85	0.41	1.73	1.56	2.17	1.13	1.30	2.17
Days with prec.	11	7	21	14	16	9	13	22	11	20	15	17	176***
Wind													
Total miles	3864	4022	4515	4567	3713	3078#	4900	4871	2847	2674	2559	2607	3685
Ave. mi/day	125	134	146	147	133	106	163	157	95	86	83	87	122
Ave. mph/day	5.2	5.6	6.1	6.1	5.5	4.4	6.8	6.5	3.9	3.6	3.4	3.6	5.1
Prevailing direction##	SE	NW, S	NW	NW, NNW	NW	W	NW	SW	NE	NW	S	S	NW
% Frequency**	15	17	20	16	25	13	20	16	13	23	19	17	14
Relative Humidity													
Ave. Max	93	94	92	87	86	86	83	85	88	91	91	95	89
Ave. Min.	50	63	76	69	67	61	38	46	45	43	40	43	53
Ave.	71	77	83	78	77	74	61	65	66	67	65	69	71

*Estimated values
**Departure from long term mean of U.S.W.B. Minneapolis Station
***Total days with recorded precipitation; average precipitation days per month = 15
#Two days missing; anemometer buried in snow.
##at 5 p.m.

SOIL TESTING IN MINNESOTA DURING 1962

John Grava

Unusually high precipitation in the early part of the year made sample collection extremely difficult. Consequently, fewer soil samples were received by the Soil Testing Laboratory in 1962 than during previous years (42,350 in 1961). The following data show the number of samples analyzed in 1962:

Regular farm, garden and lawn samples	30,832
Florist (greenhouse) samples	1,312
Limestone	116
Departmental research samples	2,206
TOTAL	34,466

Norman County won the Minnesota Fall Soil Sampling Roundup. A plaque was presented by "The Farmer" magazine to Norman County Extension Agents during the annual Soils and Fertilizer Shortcourse. The purpose of this recognition is to call attention to excellent cooperation among fertilizer dealers, extension agents and other agricultural leaders in promoting soil testing. The plaque was awarded for the highest number of soil samples per commercial farm received from a county by the University of Minnesota Soil Testing Laboratory from July 1 to November 30.

Table 1. List of top ranking counties with outstanding soil testing programs in the fall of 1962.

County	Samples Per 100 Farms Number	Samples Per 100 Farms Rank	Total Number of Samples Number	Total Number of Samples Rank	Number of Farms*
Norman	49	I	575	II	1177
Swift	42	II - III	625	I	1481
Big Stone	42	II - III	346		818
Watonwan	41		529	III	1275

* Adjusted by excluding (1) cropland acreage not harvested or pastured in 1959, and (2) excluding non-commercial farms (less than 50 acres).

Figure 1 shows monthly distribution of samples received by the laboratory during 1962.

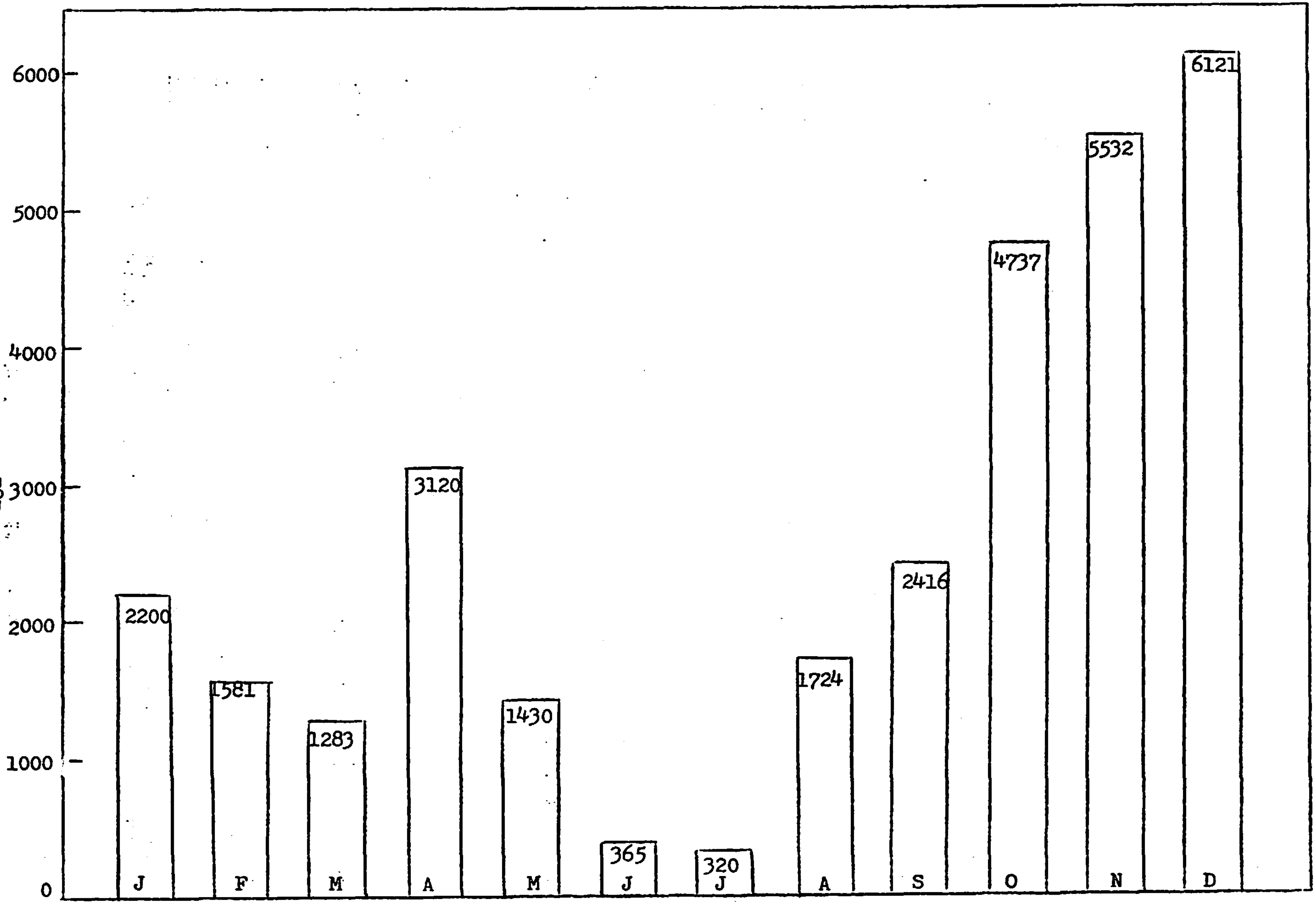

Figure 1. Monthly distribution of soil samples received by the University of Minnesota Soil Testing Laboratory during 1962. (TOTAL = 30,832).

Soil Productivity Study

R. H. Rust

The soil productivity study which began in 1956 is an attempt to gain reliable estimates of the productivity of major soil types in Minnesota. This productivity is estimated for the major crops under several generally specified soil management programs. The estimates are incorporated in the soil survey reports published for the individual counties by the Soil Conservation Service, USDA, and The Experiment Station, cooperatively.

Since the project began 487 farm cooperators have furnished crop and soil management data on some 98 extensive soil types in the state. Currently 372 cooperators are enrolled in the project. The following kinds of data are recorded: date and rate of seeding; stand estimate; kind and amount of soil amendments used; moisture and temperature conditions during the growing season; weed and insect control measures; yields and losses of yield from harvesting or abnormal conditions; soil tests of pH, available P and K, organic matter.

Since it is planned that productivity estimates be based on multiple regression analysis and since there are a number of factors to be studied, a relatively large number of observations (generally more than 30) of each crop on each soil is necessary in order to establish reliability. In addition, the evaluation of yield variation associated with weather observations (chiefly rainfall and temperature) necessitates collection of data over sev eral years.

In the following table the various soils included in the study are listed together with (1) number of fields, and (2) number of yields. Where 2 or more yields of a crop have been recorded, the crops, number of fields, and the average yields are given. The reader may establish the location of the listed soils by reference to Soils of Minnesota, Ext. Bul. 278, or to the appropriate county soil report.

It should be noted that the average yields listed do not necessarily reflect the relative productivity of the soils listed. They serve only to indicate the nature of yield levels attained in the last one to five years by farmers who are in general using above average management. Many of the yields also reflect very favorable weather patterns as well as very unfavorable seasons. For those personnel concerned the data may serve to indicate where additional effort is needed.

Table 1. Soil series, number of fields, and number of yields included in soil productivity study to date. Average yields of selected crops given where two or more yields received.

*Number of fields on this series
**Number of yields on all crops

Soil series / crop	*	**
Aastad	(11)*	(32)**
Corn	10	49
Flax	5	14
Oats	4	57
Spring Wheat	2	32
Barley	3	49
Hay (other)	2	4.6
Alfalfa-brome-past.	3	136
Anoka	(1)	(1)
Arlington	(1)	(1)
Barnes	(15)	(65)
Corn	21	54
Flax	6	8
Soybeans	5	24
Spring wheat	4	31
Corn silage	2	6.0
Oats	11	61
Alf-Brome	5	1.6
Alfalfa	5	1.9
Barley	4	48
Beardon	(6)	(11)
Spring wheat	2	36
Sugar beets	3	11.6j
Barley	2	62
Beltrami	(4)	(9)
Corn	2	66
Oats	2	66
Alfalfa	2	2.1
Alf-Brome-Past.	2	76s
Blue Earth	(2)	(10)
Oats	2	25
Soybeans	2	16
Corn	3	48
Alf-Brome	2	3.0
Braham	(1)	(1)
Brainerd	(3)	(7)
Corn	2	52
Oats	2	42
Brickton	(2)	(2)

Soil series / crop	*	**
Buse-Barnes	(2)	(10)
Alf-Brome	3	1.6
Flax	2	9
Soybeans	2	13
Central	(3)	(3)
Chilgren	(5)	(17)
Alfalfa	2	2.3
Hay (other)	3	2.4
Oats	2	35
Barley	3	47
Flax	2	10
Spring wheat	2	25
Clarion	(34)	(208)
Corn	40	76
Oats	21	69
Alfalfa	9	2.6
Mix. Leg-grass	3	5.0
Soybeans	10	29
Spring wheat	6	32
Alf-brome	10	2.9
Alf-brome-past.	2	175
Corn silage	2	12.3
Colvin	(5)	(12)
Alfalfa	3	3.4
Corn	5	61
Comfrey	(1)	(6)
Corn	2	60
Sorghum	2	8.5
Cormant	(4)	(9)
Alf-brome	2	3.8
Oats	4	49
Downs	(3)	(10)
Corn	5	112
Alfalfa	3	3.4
Dubuque	(1)	(1)
Dundas	(4)	(11)
Alf-brome	3	4.5
Alfalfa	2	1.7

Enstrom	(1)	(4)
Alf-brome Pasture	2	222
Estelline	(1)	(2)
Esterville	(13)	(40)
Corn	13	57
Oats	10	42
Corn Silage	5	7.8
Alf-brome	8	2.2
Alfalfa	2	3.1
Fairhaven	(4)	(12)
Corn	6	62
Oats	4	63
Fargo	(19)	(46)
Barley	4	22
Soybeans	3	23
Spring wheat	11	31
Alfalfa	2	3.1
Flax	5	11
Sugar beets	5	12.8
Oats	7	42
Alf-brome	3	1.6
Fayette	(7)	(30)
Oats	5	50
Corn	14	92
Alfalfa	2	2.9
Alf-brome	5	6.4
Flom	(8)	(22)
Oats	6	56
Soybean	2	24
Flax	2	18
Corn	7	73
Corn silage	2	14.5
Floyd	(5)	(14)
Corn	8	85
Oats	2	80
Soybeans	2	28
Fossum	(2)	(2)
Foxhome	(1)	(2)
Freer	(3)	(11)
Oats	4	59
Corn silage	2	6.7
HHy (other)	3	2.3
Freon	(3)	(6)
Oats	4	56

Glencoe	(1)	(1)
Greenbush	(2)	(5)
Corn silage	2	12.5
Hay (other)	2	1.5
Grimstad	(5)	(18)
Barley	4	44
Flax	3	10
Soybeans	3	15
Spring wheat	3	27
Oats	3	75
Grygla	(3)	(6)
Oats	3	35
Hammerly	(1)	(2)
Harpster	(1)	(2)
Oats	2	34
Hayden	(22)	(70)
Alfalfa	13	3.4
Corn	21	74
Oats	15	55
Alf-brome	12	3.8
Alf-brome-past.	5	269
Hegne	(5)	(10)
Spring wheat	3	36
Alfalfa	2	1.2
Barley	3	47
Hibbing	(2)	(2)
Hubbard	(14)	(52)
Alfalfa	5	2.4
Corn	21	63
Soybeans	11	21
Alf-brome	2	2.0
Potatoes	4	392
Oats	6	43
Corn silage	2	15.4
Kasson	(2)	(4)
Oats	2	65
Kato	(1)	(4)
Kenyon	(2)	(7)
Corn	3	88
Hay (other)	2	4.0

Kingston	(3)	(11)
Corn	8	78
Soybeans	2	27
Kittson	(2)	(8)
Corn silage	2	4.9
Kranzberg	(2)	(6)
Alfalfa	2	2.3
Alf-brome	2	1.9
Lamoure	(2)	(10)
Corn	4	56
Sweet corn	3	7.0
Soybeans	2	34
Lerdal	(1)	(5)
Corn	3	82
Lester	(9)	(29)
Oats	6	58
Corn	8	71
Alf-brome	4	3.1
Alfalfa	9	3.8
LeSaeur	(9)	(25)
Corn	15	79
Soybeans	4	24
Oats	3	53
Barley	2	49
Litchfield	(1)	(6)
Corn	2	83
Marcus	(1)	(1)
Marna	(5)	(13)
Corn	8	95
Soybeans	2	38
Mavie	(1)	(1)
McDonaldsville	(1)	(1)
McIntosh	(3)	(13)
Corn	2	70
Oats	3	61
Spring wheat	4	35
Barley	2	56
Menahga	(3)	(9)

Milaca	(6)	(20)
Corn	3	54
Corn silage	3	10.8
Oats	2	36
Mixed leg.-grass	4	2.0
Hay (other)	4	2.0
Moody	(2)	(6)
Corn	4	70
Mora	(3)	(10)
Corn	3	55
Oats	2	75
Mixed leg.-grass	2	1.9
Nebish	(7)	(24)
Oats	9	48
Alfalfa	5	1.4
Alf.-brome	4	2.0
Alf.-brome-past.	3	58
Nicollet	(19)	(79)
Corn	34	75
Soybeans	9	28
Oats	12	57
Barley	2	94
Spring wheat	3	32
Corn silage	3	9.1
Alfalfa	9	3.7
Alf-brome	4	4.0
Nokay	(3)	(7)
Corn	4	65
Onamia	(3)	(15)
Corn	4	68
Oats	4	64
Alfalfa	3	2.1
Alf-brome	2	1.8
Ostrander	(4)	(12)
Corn	4	97
Soybeans	2	26
Alfalfa	2	4.8
Parnell	(1)	(6)
Corn	3	44
Oats	2	75
Deep Peat	(6)	(16)
Mix. Leg.-grasspast.	2	242
Timothy (seed)	2	330
Corn	3	77
Corn silage	2	6.5

Shallow Peat	(5)	(7)
Soybeans	3	24
Barley	2	56
Pierce	(1)	(1)
Racine	(1)	(1)
Redby	(3)	(5)
Mix. Leg.-grass	2	1.0
Mix. Leg.-grass-past.	2	68
Rocksbury	(12)	(24)
Oats	8	66
Flax	3	9
Alfalfa	2	2.3
Hay (other)	4	1.6
Hay (Other)past	3	117
Sweet clover-brome	2	1.7
Rockwell	(5)	(10)
Corn silage	2	12.9
Oats	3	52
Barley	2	27
Alfalfa	2	1.7
Sioux	(2)	(5)
Oats	2	21
Alfalfa	2	.8
Shooks	(2)	(4)
Skyberg	(3)	(7)
Corn	2	91
Mix. Leg.-grass-past.	2	154
Sletten	(1)	(2)
Soybeans	2	30
Storden-Clarion	(1)	(5)
Oats	2	80
Alfalfa	3	2.5
Tama	(8)	(27)
Corn	5	99
Corn silage	2	15.3
Oats	8	62
Alfalfa	2	4.3
Alf-brome	2	4.8
Alf-brome-past.	3	178
Mix. Leg.-grass	3	3.0
Taylor	(1)	(2)
Terril	(1)	(2)

Todd	(2)	(4)
Alf-brome	3	2.2
Truman	(3)	(8)
Corn	3	100
Ulen	(3)	(17)
Corn	5	56
Corn silage	2	15.5
Oats	5	45
Alfalfa	2	2.6
Vallers	(3)	(14)
Corn	4	55
Soybeans	5	20
Oats	2	63
Varco	(1)	(5)
Corn	3	88
Alf-brome	2	2.8
Vienna	(2)	(5)
Corn	3	63
Wabash	(1)	(4)
Corn	3	109
Wadena	(4)	(12)
Corn	5	76
Soybeans	2	21
Oats	3	80
Wakegan	(8)	(28)
Corn	13	82
Oats	6	79
Alf-brome	3	3.1
Waukon	(9)	(28)
Corn	6	62
Oats	5	55
Barley	3	43
Spring wheat	2	30
Alfalfa	9	2.1
Mix. Leg.-grass	2	3.2
Webster	(35)	(116)
Corn	58	89
Corn silage	5	10.1
Soybeans	12	19
Oats	16	61
Alfalfa	11	4.1
Alf-brome	8	2.9
Alf-brome-past.	2	75

Webster Calc. Var.	(8)	(28)
Corn	10	89
Soybean	9	34
Oats	2	87
Alfalfa	3	32
Wildwood	(2)	(5)
Oats	2	33
Winger	(4)	(15)
Barley	3	46
Oats	5	74
Spring wheat	2	31
Alfalfa	3	1.6
Zimmerman	(3)	(11)
Corn	2	71
Oats	2	57
Corn silage	3	11.0
Hay (other)	2	10.9

Grand Total as of December 20, 1962	No. Fields	No. Yields
	(469)	(1581)

The Effect of Nitrogen Source, Placement and Time of Application on the Yield and Composition of Continuous Corn on Webster clay loam at Lamberton

J. M. MacGregor, W. W. Nelson, and R. G. Hanson

The long time effect of urea or of ammonium nitrate nitrogen applied at three different rates and times using two placements on the yield and the composition of field corn where grown every year is the object of an investigation commenced on the Southwest Experiment Station at Lamberton early in 1960.

Four replicates of 18 different treatments are established on corn plots six rows in width and 77.5 feet in length. Ample phosphorus and potassium are applied in the starter fertilizer. A plant population of 18,000 stalks per acre is grown and all crop residues are plowed under after harvest in the late fall. The primary objective is to find an answer to four important questions:

1. The relative effectiveness of equal amounts of nitrogen as urea or as ammonium nitrate when applied to this soil at different rates per aare.

2. The relative efficiency of such nitrogen forms when they are applied in the late fall, in the spring at time of planting, or as a sidedressing in late June or in early July.

3. The relative values of fall plowing down two nitrogen sources in comparison to overwintering of the nitrogen fertilizer on the surface of the fall plowed soil.

4. To find if there was any possible fertilizer nitrogen accumulation in the soil, the relative amounts removed by the corn crop and losses sustained through leaching, losses to the air, or losses by soil erosion.

For the first few years, all data is to be obtained by harvesting and chemically analyzing the corn plants, and computing nitrogen removal and relative efficiency based on amounts actually present in the corn plants. Later in the experiment, possible nitrogen accumulations in the soil will be measured directly.

It was not possible to fall plow and fertilize late in 1959, and the area was spring plowed early in 1960 and the first fertilizer treatments were applied at planting time. Fall plowing and fertilizing was carried out both in 1960 and in 1961. The 1961 nitrogen sidedressing with urea or with ammonium nitrate was applied on June 23rd, and the following visual observations were made on July 27th:

1. 40# of applied N/A or less - the corn leaves of all plants were "firing".

2. 80# of applied N/A - fall nitrogen - leaves fired
spring nitrogen - some firing
sidedressed - leaves green

3. 160# of N/A - corn leaves of all treatments were a deep green.

4. Nitrogen source, whether from urea or from ammonium nitrate had no visual effect on severity of leaf "firing".

The yield and composition of the 1960 and the 1961 corn grain and fodder are shown in the following tables.

The Effect of Nitrogen Source, Rates & Time of Application on the Yield and Nitrogen Content of 1960 & of 1961 Field Corn at Lamberton, and the Percentage N Uptake by the Corn
Webster silty clay loam
(Average of four replicates)

Treatment (lbs. N per acre)[1]	Ear Corn bu./A 1960	Ear Corn bu./A 1961	Ear Corn % N 1960	Ear Corn % N 1961	Fodder Tons/A 1960	Fodder Tons/A 1961	Fodder % N 1960	Fodder % N 1961	Percentage uptake of fertilizer nitrogen 1960	1961	2-yr. average
None	49.5	88.2	1.17	1.20	1.82	3.03	0.74	0.41	--	--	
40 as NH_4NO_3--fall plowed under	42.3	87.5	1.15	1.19	1.79	3.00	0.84	0.50	8	- 9	0
40 as urea --- " " "	55.1	78.2	1.09	1.22	1.57	3.87	0.61	0.50	-28	90	31
40 as NH_4NO_3--left on plowed surface	49.0	96.7	1.26	1.15	1.87	4.03	0.84	0.48	16	86	51
40 as urea --- " " " "	62.3	101.3	1.20	1.37	1.87	3.89	0.76	0.57	13	74	44
80 as NH_4NO_3--fall plowed under	67.4	97.9	1.22	1.24	1.85	3.30	0.78	0.67	5	43	24
80 as urea --- " " "	61.7	76.9	1.25	1.20	1.87	3.46	0.88	0.50	7	27	17
160 as NH_4NO_3- " " "	69.8	97.9	1.31	1.34	2.23	4.50	0.91	0.70	17	58	38
160 as urea -- " " "	79.4	112.5	1.22	1.46	2.18	4.37	0.85	0.86	12	71	42
40 as NH_4NO_3-- at planting	66.2	92.0	1.28	1.21	1.85	3.55	0.87	0.54	21	67	44
40 as urea --- " "	45.4	91.1	1.22	1.19	2.12	3.60	0.85	0.61	47	27	37
80 as NH_4NO_3-- " "	59.3	90.0	1.20	1.17	2.07	3.63	0.79	0.60	12	43	28
80 as urea --- " "	57.7	99.1	1.26	1.32	2.26	4.03	0.82	0.60	21	40	31
40 as NH_4NO_3-- as late sidedressing	63.6	92.6	1.23	1.19	2.01	3.66	0.89	0.57	27	80	54
40 as urea --- " " "	57.7	95.6	1.12	1.33	1.90	3.51	0.77	0.54	9	107	58
80 as NH_4NO_3-- " " "	50.4	98.4	1.22	1.24	1.76	2.96	0.89	0.63	15	34	25
80 as urea --- " " "	76.9	86.4	1.14	1.37	1.51	3.92	0.81	0.70	-11	95	42
160 as NH_4NO_3- " " "	40.7	97.4	1.23	1.50	1.65	3.58	0.88	0.97	0	54	27

[1] The entire area received 0-30-15 at the rate 125#/A as band applied starter + 150#/A broadcast before plowing.

The growing season of 1962 at the South West Experiment Station was much wetter than normal. Frequent heavy rains kept the soil essentially saturated until mid-July. The corn was planted early but developed very slowly during the cool, wet summer. A killing frost terminated growth in mid-September.

Nitrogen deficiency of the corn leaves was evident in many of the treatments during much of the growing season, the only treatments appearing to have adequate available nitrogen being the three rates of side dressed nitrogen. The fall and spring applied nitrogen apparently was not available to the growing corn in adequate quantities. The 1962 results are shown as follows:

The Effect of Nitrogen Source, Rates & Time of Application
on the Yield and Nitrogen Content of 1962 Field Corn at Lamberton, and
the Percentage N Uptake by the Corn
Webster silty clay loam
(Average of four replicates)

Treatments (lbs. N per acre)[1]	Ear Corn		Fodder		lbs. N	% uptake	
	bu/A	% N	Tons/A	% N	removed /A.	fert. 1961&62	Nit. 62
None	26.1	1.32	1.13	0.80	44.1	-	-
40 as NH_4NO_3--fall plowed under	30.9	1.45	1.82	0.75	58.1	0	35
40 as urea -- " " "	29.1	1.38	1.39	0.70	48.7	31	11
40 as NH_4NO_3--Left on plowed surface	29.6	1.51	1.24	0.80	49.6	51	14
40 as urea -- " " " "	37.0**	1.48	1.76	0.76	63.6	44	49
80 as NH_4NO_3--fall plowed under	43.6**	1.31	1.67	0.84	71.6	24	34
80 as urea -- " " "	36.7**	1.31	1.53	0.60	55.1	17	14
160 as NH_4NO_3-- " " "	46.7**	1.33	1.91	0.85	79.3	38	22
160 as urea -- " " "	43.5**	1.24	1.66	0.78	69.4	42	16
40 as NH_4NO_3-- at planting	45.4**	1.36	1.52	0.77	68.7	44	62
40 as urea -- " "	31.4	1.55	1.39	0.76	52.5	37	21
80 as NH_4NO_3-- " "	32.7*	1.47	1.53	0.60	51.0	28	9
80 as urea -- " "	40.5**	1.39	1.35	0.59	56.4	50	15
40 as NH_4NO_3--as late sidedressing	39.5**	1.41	2.04	0.65	66.2	54	55
40 as urea -- " " "	24.9	1.25	1.56	0.70	46.9	58	7
80 as NH_4NO_3-- " " "	46.7**	1.46	1.79	0.81	75.6	25	39
80 as urea -- " " "	48.2**	1.38	2.10	0.62	74.1	42	38
160 as NH_4NO_3- " " "	77.7**	1.42	2.69	1.11	137.6	27	58

* L.S.D. (5%) 6.3 bu.
** L.S.D. (1%) 8.0 bu.

Comments

The yields of corn grain grown on the different nitrogen treatments were variable in all three years of the experiment, and it is hoped that these will tend to be more uniform as the experiment is continued. Such variability prevents any meaningful conclusions at present on the relative effectiveness of the two nitrogen sources or as to the most efficient time of applying such forms of nitrogen. In the wet summer of 1962, early and late spring application of nitrogen produced the higher yields.

The relative proportions of additional nitrogen taken up by the corn growing on the nitrogen fertilized plots is of interest. So far, fall plowing and the turning under of broadcast fertilizer nitrogen on the cornstalks was not advantageous from considerations of corn yield or efficiency of nitrogen uptake by the corn. The efficiency of nitrogen uptake varies greatly and at least five years of results should be obtained before even preliminary conclusions can be made.

The Effect of Nitrogen Fertilization On Yield and Composition of Wheat at Crookston in 1960, 1961, and 1962

J. M. MacGregor, H. W. Kramer, & O. C. Soine

Ammonium nitrate has been the most popular form of solid nitrogen fertilizer in Minnesota for some fifteen years. Urea manufacture and sale has been gradually increasing during the last several years, since it contains 45% N in comparison to the 33% N of the ammonium nitrate, urea manufacturing costs have been reduced, and urea storage (both as to space and possible explosiveness) is simpler than with ammonium nitrate. On being moistened, urea hydrolyzes to ammonium carbonate with the nitrogen being utilized either as the ammonium ion, or after gradual oxidation to the nitrate form. As the urea hydrolyzes, there is a sharp, but localized increase in soil pH - a condition favoring ammonia losses to the atmosphere. Many laboratory and a few field experiments have shown some losses of urea nitrogen as ammonia, but the magnitude of such losses under field conditions and the comparative effectiveness of urea nitrogen to other fertilizer nitrogen sources have not been well established.

The present experiment was designed to study the effect of urea and of ammonium nitrogen on the yield and nitrogen composition of wheat, in order to establish the relative proportions of nitrogen from the two sources actually taken up by wheat. Since laboratory experiments have demonstrated that calcareous soils are subject to greater volatilization of ammonia nitrogen from urea than are acid soils, and immediate covering of the applied urea may reduce such losses, the calcareous Hegne clay loam at Crookston was selected for this trial.

Urea or ammonium nitrate nitrogen was applied in quadruplicate treatments at the rate of 20 or 40 pounds of nitrogen per acre with three basic differences:

1. The nitrogen fertilizers were disked in at time of seeding.

2. The nitrogen fertilizers were broadcast and left on the soil surface immediately following seeding.

3. The nitrogen fertilizers were broadcast when the wheat was in the boot stage and left on the soil surface.

Both wheat grain and straw samples were analyzed for yield and N content, and the additional nitrogen present in the nitrogen-fertilized plants was considered to be due to the addition of nitrogen fertilizer and this was computed as percentage recovery of the applied fertilizer nitrogen. The results are shown in the following tables.

The 1962 growing season at Crookston was excessively wet and relatively cool-for example, the field corn was planted so late and grew so slowly that it was not sufficiently mature to harvest as grain. Three of the wheat plots were drowned out and results were quite variable.

Anhydrous ammonia treatments to supply 40 and 80 pounds of N per acre were applied just before seeding, the first time this nitrogen source was included. The 1962 wheat yields are shown in the following table.

The effect of nitrogen source, time and depth of covering on nitrogen content of 1962 wheat on Hegne clay loam at Crookston and percentage uptake of the applied fertilizer nitrogen. (Average of four replicates)

NITROGEN TREATMENT (lbs/A)[1]	Grain bu/A	Grain % N	Pounds of N in grain/A
None	7.7	1.94	
20 as NH_4NO_3 - disked in at seeding	7.7	1.96	9.1
20 as urea - " " " "	12.6	2.02	15.3
40 as NH_4NO_3 - " " " "	18.4*	2.17	22.7
40 as urea - " " " "	17.3*	2.05	20.7
20 as NH_4NO_3 - left on surface at seeding	15.0	2.08	17.9
20 as urea - " " " " "	15.1	2.07	18.7
40 as NH_4NO_3 - " " " " "	15.0	2.03	18.4
40 as urea - " " " " "	11.9	2.07	14.8
20 as NH_4NO_3 - broadcast at boot stage	11.2	2.06	13.6
20 as urea - " " " "	13.8	2.06	16.2
40 as NH_4NO_3 - " " " "	17.4*	2.08	21.7
40 as urea - " " " "	18.8*	2.07	23.2
40 as anhydrous NH_3 at seeding	37.4**	2.31	51.8
80 " " " " "	28.1**	2.54	42.7

* LSD (5%) 8.3 bu.
** LSD (1%) 11.1 bu.

The results of three years (1960-62) of wheat fertilization on yields at Crookston are shown in the following table.

Table 2. The effect of nitrogen source, time and depth of covering of nitrogen fertilizer on the yield and nitrogen content of 1960, 1961 and 1962 wheat on Hegne clay loam at Crookston. (Average of four replicates)

	Wheat yield in bushels per acre				Percentage nitrogen			
Nitrogen Treatment (lbs/A)[1]	1960	1961	1962	3 year average	1960	1961	1962	3 year average
None	8.2	12.4	7.7	9.4	2.08	2.30	1.94	2.11
20 as NH_4NO_3- disked in at seeding	11.7	15.5	7.7	11.6	2.00	2.40	1.96	2.12
20 as urea -- " " " "	15.9*	20.7*	12.6	16.4	2.00	2.53	2.02	2.18
40 as NH_4NO_3- " " " "	22.7*	17.9*	18.4*	19.7	2.11	2.52	2.17	2.27
40 as urea -- " " " "	19.6*	20.5**	17.3*	19.1	1.47	2.55	2.05	2.02
20 as NH_4NO_3- left on surface at seeding	16.7*	15.4	15.0	15.7	2.05	2.35	2.08	2.16
20 as urea -- " " " " "	16.1*	17.2	15.1	16.1	2.05	2.60	2.07	2.24
40 as NH_4NO_3- " " " " "	21.3*	19.9**	15.0	18.7	2.10	2.63	2.03	2.25
40 as urea -- " " " " "	19.7*	21.3**	11.9	17.6	2.02	2.65	2.07	2.25
20 as NH_4NO_3- broadcast at boot stage	12.6	15.9	11.2	13.2	2.10	2.59	2.06	2.25
20 as urea--- " " " "	6.7	14.6	13.8	11.7	2.16	2.60	2.06	2.27
40 as NH_4NO_3- " " " "	7.9	16.8*	17.4*	14.0	2.40	2.80	2.08	2.43
40 as urea -- " " " "	11.9	12.7	18.8	14.5	2.19	2.74	2.07	2.33
* Significant at the 5% level	5.9	5.2	8.3					
** " " " 1% "	8.1	6.9	11.1					

Tentative Conclusions (on three years of results)

1. Urea or ammonium nitrate nitrogen broadcast at the time of wheat seeding, and either disked in or left on the surface, was much more effective for increasing wheat yield and nitrogen recovery, than were similar applications made some weeks later when the wheat plants were in tha boot stage.

2. Urea was equal in effectiveness to ammonium nitrate nitrogen, both for increasing wheat yields and for increasing the nitrogen content of the wheat.

3. Anhydrous ammonia was used only in 1962, but it was a very effective source of nitrogen for both increasing wheat yield and nitrogen content of the grain.

Comparison of phosphorus sources

A. C. Caldwell

A phosphorus source experiment was established at Rosemount in 1951. Twelve treatments of various phosphate materials were replicated 4 times across a regular rotation of corn, wehat and 2 years of alfalfa. Potassium was applied according to soil test, Lime was applied to 2 replicates in the fall of 1961. In 1959 the rotation was changed to corn, soybeans, wheat and alfalfa.

In general, yields of corn and soybeans were not influenced by the various phosphorus sources. Wheat did respond, particularly to the more available materials. As in past years large increases in yield of alfalfa resulted from almost all sources whether the phosphorus was readily available or not.

Effect of various phosphate fertilizers on yield of corn, soybeans, wheat and alfalfa (Rosemount, 1962).

Treatments	P_2O_5/A/Yr lbs	Corn bu/A	Soybeans bu/A	Wheat bu/A	Alfalfa bu/A
None	--	144.8	22.2	20.9	1.55
Ord. Super.	40	143.6	19.8	26.4	2.50
Conc. Super.	40	141.2	21.4	22.6	2.76
CalMeta	40	139.2	20.7	27.6	3.08
Phos. Acid	40	149.6	16.7	30.6	2.43
Fused Trical. Phos.	40	160.6	21.4	28.3	2.71
Fl. Rock + Ord. Super	20 + 20	147.9	24.2	27.7	3.21
Fl. Rock	100	146.8	19.5	22.1	2.97
	P_2O_5/A/4 yrs.				
Fl. Rock	1000	144.3	24.4	24.6	2.69
Western Rock	1000	153.2	22.5	21.7	2.88
Cal. Clay Rock	1000	147.1	24.5	22.6	2.03
Tunis. Rock	1000	141.1	21.5	25.6	3.07

The effect of lime and molybdenum on the yield of alfalfa, oats, corn and soybeans.

A. C. Caldwell

To study the long time effects of lime on the yields of some common crops and on the physical and chemical properties of the soil, an experiment with lime rates was started in the fall of 1951. Treatments were 0, 3, 6, 12 and 24 tons of dolomitic lime per acre, replicated 4 times. A rotation of oats, 2 years of alfalfa and corn was set up. Each year corn and oats have received 200 pounds of 5-20-20 per acre. Alfalfa has received P and K as needed according to soil test.

In 1959 soybeans were substituted as a crop for one of the years of alfalfa. Soybeans get 100 pounds of 5-20-20 per acre as a starter fertilizer.

In 1960 an application of 8.7 ounces of Mo per acre, (as $(NH_4)_2MoO_4$), was made to one of the check plots in each replicate to determine the effect of this nutrient.

Effects of the different treatments on yields are shown in the table. Alfalfa yields have been mostly affected by lime, as has been the case in the past. 3 tons of lime have been as effective as higher rates. Molybdenum has also been rather surprisingly effective in increasing yields above the untreated.

The results on oats are quite at variance with what was found in other years when increases (sometimes substantial) resulted from lime applications. In 1962 yields were lower than usual with a lot of variation from plot to plot. Consequently no significance can be attached to the increases or decreases shown.

All treatments resulted in increases in corn yields. This is in general agreement with results in other years.

There were no major effects of lime on soybeans.

Effect of lime and molybdenum on yields of alfalfa, oats, corn and soybeans (Rosemount 1962).

Lime treatment tons/acre	Alfalfa bu/a	Alfalfa diff.	Oats bu/a	Oats diff.	Corn bu/a	Corn diff.	Soybeans bu/a	Soybeans diff.
0	2.01		48.5		139.4		24.9	
3	3.16	1.15	50.0	1.5	152.1	12.7	26.6	1.7
6	2.99	0.98	41.2	-7.3	149.4	10.0	24.7	-0.2
12 2	2.62	0.61	54.8	6.3	152.9	13.5	24.9	--
24	3.01	1.00	46.9	-1.6	152.2	12.8	23.4	-1.5
0 + 8.7 oz. Mo/a	2.99	0.98	50.0	1.5	151.9	12.5	25.4	0.5

Effect of sulfur-bearing materials on alfalfa (Park Rapids, 1962)

In the spring a sulfur experimental field was established on a Todd sandy loam near Park Rapids. To plots planted to alfalfa was applied elemental sulfur at rates of 25, 50 and 100 pounds and gypsum at 50 and 100 pounds S per acre. The table shows the yield of hay obtained and the % S in young alfalfa plants from the various treatments.

Both sources of sulfur and all rates resulted in yield increases. These were not large in terms of pounds, but do nevertheless represent a 20+% increase in forage obtained. This was the year of establishment of the alfalfa so full growth had not been obtained. Yields do include some grass and weeds.

Sulfur analysis was on pure alfalfa sorted out from other plants. All treatments resulted in an increase in sulfur in the plant. Increase in plant sulfur went up with larger application rates of elemental sulfur. The young plants took up more sulfur from gypsum than from elemental sulfur.

Effect of sulfur-bearing materials on alfalfa yields (Park Rapids, 1962)

Treatment	S lbs/A	Alfalfa Yield lbs/A	Diff.	S in Tissue % S	Diff.
None	-	1795		.117	
Sulfur	25	2118	323	.139	.022
Sulfur	50	2277	482	.160	.043
Sulfur	100	2299	504	.189	.072
Gypsum	50	2293	498	.228	.111
Gypsum	1000	2022	227	.263	.146

FIELD EXPERIMENTS WITH ZINC ON CORN

Orville Gunderson and John Mac Gregor*

Minnesota soils, considered about average in zinc content in comparison with other soils of the United States, may not supply enough zinc for some crops. As the natural lime content of the soil increases, crop plants generally find it increasingly difficult to take up sufficient zinc for normal growth. This problem is naturally more serious in the relatively short-lived, high production plants such as corn.

Zinc deficiencies of corn have been observed for some years on the high lime soils of many western states, especially under irrigation. Irrigation indirectly tends to induce such microelement deficiencies since high crop yield removes more nutrient elements.

Zinc deficiency is especially noticeable under irrigation agriculture because of the associated land forming that exposes subsoil layers-and perhaps because of the use of high analysis fertilizers in greater quantity, although nitrogen fertilizer placed near the seed has frequently resulted in normal plant growth.

This indirect effect of fertilizer nitrogen has two possible explanations. When nitrogen is placed with zinc or alongside seed in the soil, the supply of native available zinc is increased due to the acidic residue of the nitrogen fertilizer. Ammonium sulfate is especially effective in this way. The increased effectiveness of band applied zinc sulfate ($ZnSO_4$) when mixed with a small amount of nitrogen could be due to the above mechanism, or to some other mechanism that diminishes toxicity produced by high zinc concentrations of the bands.

Zinc deficiency of corn was first reported from central Minnesota during the 1961 growing season, and limited field studies were made at that time. The deficiency on corn is characterized by initial stunting, followed by the later development of a longitudinal striping of the leaves. The veins remain green and interveinal tissue yellows and, in serious cases, dies. The younger leaves may be almost white. Corn grown on high lime peat or on mineral soil may be affected, especially on low lying, recently drained areas.

Field experiments in 1962 consisted of trials on (1) a recently pumped calcareious clay loam on the Litch farm north and west of Lake Lillian (Kandiyoki County),(2) a slightly higher lying clay loam on the Larson farm 2 to 3 miles fabther north, and (3) a pumped area of peat soil a mile south of Lake Koronis, on the Behr farm in western Meeker County.

Each field was spring plowed shortly after the plowdown zinc sulfabe treatments were broadcast. A two-row tractor attached corn planted with fertilizer band placement equipment especially build by the Morris ARS Station, was used to plant corn and to apply the banded zinc and nitrogen about an inch to the side and below the seed.

A third type of treatment consisted of coating corn seed with a zinc chelate (Na_2Zn chelate) at the rate of 8 ounces per bushel.

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* The active cooperation of Dr. Raymond Allmaras and the use of specialized equipment from the Soil and Water Conservation Research Station, ARS, Morris, is hereby acknowledged.

Phosphorus and potassium fertilizers were broadcast before plowing to supply 100 pounds of phosphate per acre and 50 pounds of potash. Urea nitrogen at 100 pounds of nitrogen per acre was broadcast in early June.

The two mineral soil fields were seeded in mid-May; planting on the colder peat soil was delayed until June 5. Herbicides were used to control weed growth. Plant populations approximated 18,000 plants per acre.

The no-zinc corn plants on the Litch field and on the Behr peat were more seriously affected by zinc deficiency whereas the Larson field showed little vegetative deficiency during the growing season. The Litch corn showed some stunting but no distinct leaf symptons, until July 10, 11, and 12, when severe leaf striping developed rapidly. Since the peat soil of the Behr field was planted late, leaf striping commenced relatively late in July.

An early frost the morning of September 5 killed corn leaves on the low lying peat field, but ears filled to some degree after this damage and all three fields were harvested and sampled in mid-October.

Results

Broadcasing fertilizer at the rate of 100-100-50 over the three entire experimental areas should have insured an ample supply of the three major nutrients. Plant populations of 18,000 per acre, with ample rainfall, should have allowed for maximum zinc effect.

Wet corn on the early frosted peat field lowered yield averages substantially, the no-zinc treatments of the three fields averaging only 47 bushels ear corn per acre. Where zinc as zinc sulfate (about 30 percent zinc) was plowed under at rates of 5, 10, 20, or 40 pounds per acre, average yield increases varied from 13 to 15 bushels per acre, with the 10-pound zinc treatment increasing yields very well.

Banding ammonium nitrate at the rate of 20 pounds of nitrogen per acre (no zinc) about 1 inch to the side and below the seed showed an average yield increase of some 10 bushels per acre. This effect has usually been observed by other investigators and the increase has been attributed to nitrogen stimulation of the plants and to a greater extraction of native zinc from the soil.

Banding both nitrogen and the zinc as the sulfate at the rate of 10 pounds of zinc per acre increased average corn yields only about 8 bushels per acre.

Banding both 20 pounds of nitrogen (as NH_4NO_3) and zinc sulfate at rates of 5, 10, or 20 pounds of zinc per acre increased yields an average of 8 to 13 bushels per acre.

Zinc chelate treated seed was only slightly effective for increasing corn yield, possibly because of the limited amount of zinc chelate adhering to the seed. Since only 1 year's results are available, no definite conclusions can be mad e as to optimum rate and placement of the zinc. However, it appears that heavier rates were not beneficial and may have been somewhat detrimental.

Conclusions

Although much more reaearch is essential before definite recommendations can be made, it appears that plowing down zinc sulfate at a cost of \$2 or \$3 per acre may be practically effective. Further research may show that (1) granulation of either zinc sulfate of of an effective low cost zinc chelate in the fertilizer manufadturing process, and (2) either plowing such materials under or banding near the seed may be done at relatively low cost, and may supply sufficient zinc for maximum corn production.

Application of zinc to soil is not recommended unless there is a known need for including this element with the fertilizer treatment.

Zinc analysis of the corn leaves has shown that much more zinc is present where the zinc sulfate was plowed down, and the increase is greater with the higher rates of application. Banding zinc sulfate adjacent to the seed was not as effective for increasing zinc uptake by corn as the plowed down application. Zinc chelate treated seed had little effect on increasing the zinc content of the leaves. Banding of nitrogen near the seed increased corn yield, but did not increase zinc concentrations in the leaves.

1962 Studies of Boron and FTE Fertilization for Corn

J.R. Peterson and J.M. MacGregor

Leaf Sampling and analysis: Leaf samples of corn were taken on all treatments to determine time of boron uptake and critical level of boron in the plants. The July and September leaf samples were taken from the upper part of the plant. The August sampling included leaves from the upper, middle, and lower part of the plants. The samples were dried, ground in a Wiley Mill, and stored in polyethylene bags. Leaf sampling dates are given in Tables 1, 2 and 3.

The curcumin-oxalic acid method was used for the analysis of total boron in the leaves. The results are given in Tables 1, 2 and 3.

Table 1. Boron Content of Corn Leaves on Milaca Very Fine Sandy Loam - 1962.

Time of Sampling	Leaves Sampled	Treatments (Lbs./A.)*				
		Check	1B	2B In Row	15 FTE504	2B Broadcast
		(ug. B/gm. Tissue, oven dry basis)**				
July 20	Upper	21.2	40.9	55.3	19.4	32.6
August 20	Upper	34.3	71.2	93.8	37.2	43.6
August 20	Middle	18.0	47.2	54.7	12.6	22.0
August 20	Lower	13.4	42.4	72.2	14.1	22.5
September 18	Upper	39.9	46.5	63.3	34.2	39.2

* All treatments received 122# N, 73# P_2O_5, and 169# K_2O per acre.
** Average of 6 replications.

Table 2. Boron Contents of Corn Leaves on Onamia Very Fine Sandy Loam - 1962.

Time of Sampling	Leaves Sampled	Treatments (Lbs./A.)*				
		Check	1B	2B In Row	15 FTE504	2B Broadcast
		(ug.B/gm. Tissue, oven dry basis)**				
July 13	Upper	9.7	28.0	64.9	17.6	22.2
August 14	Upper	14.8	19.4	26.1	16.3	25.9
August 14	Middle	9.7	12.4	18.6	11.0	12.6
August 14	Lower	10.1	16.9	15.2	11.0	14.1
September 18	Upper	26.9	30.4	38.4	31.3	36.4

* All treatments received 124# N, 64# P_2O_5, and 160# K_2O per acre.
** Average of 6 replications.

Table 3. Boron Content of Corn Leaves on Fayette Silt Loam - 1962.

Time of Sampling	Leaves Sampled	Treatment (Lbs./A.)* Check	1B	2B In Row	15 FTE504	2B Broadcast
		(ug. B/gm. Tissue, oven dry basis)**				
July 15	Upper	13.0	23.1	23.1	14.5	19.2
August 16	Upper	24.6	34.6	36.1	24.2	28.1
August 16	Middle	14.9	20.3	26.0	14.6	19.2
August 16	Lower	15.5	21.2	27.1	15.2	20.2
September 15	Upper	15.6	19.6	17.2	13.0	15.2

* All treatments received 123# N, 77# P_2O_5, and 173# K_2O per acre.
** Average of 6 replications.

Soil pH and water soluble boron level: The pH was determined on a saturated soil paste using a Beckman zeromatic pH meter. The native water soluble boron was determined by adding 40 ml. of distilled water to 20 gm. airdried soil and boiling this solution five minutes. A reflex condensor was used to contain the volatile boron during the boiling process. After cooling, the solution was filtered and an aliquot was analyzed by the curcumin-oxalic acid method. The results are given in Table 4.

Table 4. Soil pH and Water Soluble Boron Content of Three Soil Series Used in the 1962 Boron-Corn Experiments.

Soil Series	pH	Water Soluble Boron (ug./gm. air dry soil)
Milaca very fine sandy loam	5.8	0.92
Onamia fine sandy loam	5.7	0.72
Fayette silt loam	6.5	0.64

Harvest: The Milaca fine sandy loam field was severely damaged by hail on July 21. This storm resulted in a near loss of the plants and as a result very few ears developed. We did not harvest this field.

The other two plots were harvested in October. Forty-five feet of the two center rows of the four row plots were hand picked and weighed. A moisture sample was taken and dried to determine the yield on a 15.5% moisture level. Yields are given in Table 5. None of the treatments gave a significant yield increase at the five percent level.

Table 5. The Effect of Boron and Fritted Trace Element Fertilization on the Yield of 1962 Corn: Fayette Silt Loam, Tony Wallrich - Wabasha.

Fertilizer Treatments*	I	II	III	IV	V	VI	Mean	Increase over check
Check	117.8	85.9	130.5	113.8	117.0	98.7	111	--
1# B/A. in row	104.6	108.3	124.6	110.5	112.4	109.1	112	1
2# B/A. in row	103.6	120.4	105.2	127.6	102.9	119.8	113	2
2# B/A. broadcast	130.6	113.9	131.3	103.2	116.3	118.8	119	8
10# FTE504/A. in row	127.6	126.9	122.2	126.1	106.4	116.1	121	10

* All treatments received 123# N, 77# P_2O_5, and 173# K_2O per acre.

Fertilizer Treatments*	Onamia very fine sandy loam, Carl Erickson - Mora.							
Check	88.7	79.0	72.3	81.7	65.0	67.3	76.	--
1# B/A. in row	76.6	69.6	75.1	70.6	65.8	73.6	72	-4
2# B/A. in row	88.2	66.8	77.9	74.5	70.5	73.3	75	-1
2# B/A. broadcast	78.4	73.2	66.1	81.5	69.9	68.6	73	-3
10# FTE504/A. in row	75.2	78.7	70.0	84.5	75.7	79.9	77	1

* All treatments received 124# N, 64# P_2O_5, and 160# K_2O per acre.

It is evident that the boron fertilization increased the boron content of the corn leaves, but did not increase corn yield.

Boron and FTE Fertilization Studies on Alfalfa-Grass Stands in Wabasha County on Fayette Silt Loam

J.R. Peterson, J.M. MacGregor and Henning Swanson

Three established hay fields were top dressed as growth commenced in the spring of 1962 and two cuttings were made of the hay crop.

Plant Tissue sampling and analysis: Tissue samples of two of the four replicates were taken at harvest times. These samples were dried, ground, and analyzed for total boron using the same method as was used with the corn leaves. These samples included alfalfa and brome, or orchard grass. A summary of the boron content of the two hay cuttings on the three farms is given in Table 1.

Table 1. Boron Content of Alfalfa-Grass Mixture on Fayette Silt Loam in Wabasha County - 1962.

Fertilizer Treatment*	ug.B/gm. oven dry hay **	
(#/A.)	1 st crop	2 nd crop
Bremer Farm:		
Check	28.5	30.6
1 B	40.6	29.4
2 B	40.4	41.2
15 FTE502	36.2	31.4
Walter Danchwart:		
Check	19.6	17.6
1 B	24.8	19.6
2 B	25.4	23.7
15 FTE502	20.0	17.2
Edwin Freiheit:		
Check	32.2	24.4
1 B	33.2	28.3
2 B	47.0	34.2
15 FTE502	30.9	18.8

* All treatments received 500# of 0-20-20 per acre.

** Average of two replications.

Soil pH and water soluble boron level: The same analytical procedure was used as stated earlier in this report. The results are given in Table 2.

Table 2. Soil pH and Water Soluble Boron Content of Fayette Silt Loam at the Three Locations in Wabasha County Used in the 1962 Boron-Alfalfa Experiment.

Farm	pH	Water Soluble Boron (ug/gm. air dry soil)
Bremer	6.7	0.79
W. Danchwart	6.9	0.96
E. Freiheit	6.3	0.65

Harvest: From each 16' x 16' plot, $7.27 \cdot 10^{-4}$ acre were cut with a power mower. This hay was weighed. A moisture sample was taken and dried todetermine the yield in tons per acre at 15 percent moisture. The yields of the first crop, second crop, and total for the season are given in Table 3. None of the yields are significantly different at the five percent level.

Table 3. The Effect of Boron and Fritted Trace Elements on the Yield of 1962 Alfalfa-Grass Mixture on Fayette Silt Loam in Wabasha County.

Fertilizer Treatment* (Lb./A.)	Tons/Acre at 15% Moisture** 1st Crop	2nd Crop	Total	Increased over check
Bremer Farm:				
Check	2.14	1.53	3.67	-
1 B	2.15	1.52	3.67	0
2 B	2.22	1.54	3.76	0.08
15 FTE502	2.08	1.63	3.71	0.04
Walter Danckwart:				
Check	2.18	1.82	4.00	-
1 B	2.17	1.94	4.11	0.11
2 B	2.12	1.70	3.82	-0.18
15 FTE502	2.08	1.87	3.95	-0.05
Erwin Freiheit				
Check	1.92	1.56	3.48	-
1 B	1.93	1.47	3.40	-0.08
2 B	1.92	1.43	3.35	-0.13
15 FTE502	1.90	1.48	3.38	-0.10

* All treatments received 500# of 0-20-20 per acre.

** Average of 4 replications.

Conclusions: Boron top dressing increased the levels of boron in the hay to some extent but did not excrease hay yields.

THE NICOLLET COUNTY PLOTS
Soil Fertility and Crop Production Studies on the Webster Soils of Southern Minnesota

W. P. Martin, Fred Wetherill and H. W. Kramer

Yield Results - 1962

Re: 1959 results, "A Report on Soils and Soil Fertility", p. 74, Dept. Soils, Mimeo, April 1960; ibid 1960 results, p. 44, Feb. 1961, ibid 1961 results, p. 61, Feb. 1962.

Soils: Webster and closely related Nicollet silty clay loams; level topography, minimum erosion, adequate tile drainage.

Cropping systems: (established 1948) (1) corn-oats, (2) corn-oats with clover green manure, (3) 4-yr. rotation of oats-hay-corn-corn extended to five years in 1958 with soybeans between two corn years, and (4) continuous corn included beginning in 1954.

Fertilizer treatments: Multiple rates and materials including barnyard manure at regular and "extra" heavy levels; see tables for treatments and 1959 report for details on materials, rates and methods of applications. There are four replications.

CONTINUOUS CORN: RATE AND TIME OF APPLICATION

Nitrogen:		Yield Results:	
Rate	Time*	Starter only**	+PK broadcast***
None	0-0-0	42 bu.	44 bu.
40 lbs	1-0-0	52	68
80 "	1-1-0	58	63
120 "	1-1-1	55	64
80 "	1-0-1	54	65
80 "	0-1-1	59	61
40 "	0-0-1	59	61
40 "	0-1-0	56	64
80 "	2-0-0	59	67
120 "	3-0-0	62	61

* 0-0-0 refers to time of application, i.e. planting time-first cultivation-second cultivation.
** 175 lbs. 6-24-12 starter in row at planting time.
*** Starter plus 200 lbs. 0-20-20 broadcast.

CORN-OATS WITH AND WITHOUT LEGUME GREEN MANURE: (three replications)

	Corn:	(with legume)	Oats:	(with legume)
1. Check	36	40	40	42
2. N on oats	35	41	75	72
3. NP on oats	40	48 4	79	84
4. NPK on oats	45	53	72	92
5. P plowdown	40	4949	44	53
6. NPK in hill	52	62	43	47
7. N plowdown	47*	41*	64*	49*
8. N sidedress	39*	40*	43*	54*

*One replication only

CORN -SOYBEANS-CORN-OATS-HAY (WITH REGULAR AND EXTRA-HEAVY FERTILIZATION LEVELS): (four replications)

Treatments (regular)	Corn (1) Reg.	Corn (1) Extra*	Soybeans Reg.	Soybeans Extra*	Corn (2) Reg.	Corn (2) Extra*	Oats Reg.	Oats Extra*	Hay Reg.	Hay Extra*
6. Check	52 bu.	68 bu.	22 bu.	31 bu.	45 bu.	75 bu.	48 bu.	82 bu.	3.2 t.	5.1 t.
1. P for oats	66	68	24	26	47	59	48	51	4.4	5.0
2. Pkfor oats	68	70	23	27	48	60	51	57	4.7	4.9
7. NP for oats	78	69	24	28	46	56	83	82	4.2	4.4
3. NPK for oats	74	71	26	28	50	63	87	70	4.5	5.4
10. P for oats & corn	64	66	27	27	51	57	54	63	4.2	5.1
4. Manure for corn	70	71	29	30	62	82	62	86	4.0	5.4
8. Manure & P for corn	75	76	30	30	62	82	56	75	4.7	5.1
5. " & NPK for corn	70	72	28	30	65	81	60	86	4.8	5.4

*Refers to extra-heavy fertilization treatments in addition to regular treatments outlined.

Profit Possibility Plots
(Results of NPK rates on corn demonstrations in 1962)

C. J. Overdahl, John Grava, L.D. Hanson, M. V. Halverson, J.L. App

Rainfall was considerably above normal in most areas and fertilizer responses appeared more profitable than in 1961.

In the western half of Minnesota a total of 25 fields averaged 26 bushels increase over the check plot from the most profitable treatment used. This was 200# of 5-20-20 in the row and 70# of supplemental nitrogen. Profits beyond fertilizer costs were increased $9.60 per acre for this treatment. There were 4 fields with high phosphorus tests and 10 with high tests in potassium. Forty pounds of P_2O_5 in the row averaged a 9 bushel increase while 40 pounds P_2O_5 broadcast averaged an increase of 6 bushels.

Results are shown in Table 1 from the 15 fields in the area testing low in phosphorus and medium in potassium. Profits are slightly higher on these lower testing fields.

In the eastern half of Minnesota the 19 fields harvested averaged a 19 bushel yield increase from the best treatment. This was again as in the western part of the state 200# of 5-20-20 in the row plus 70 pounds of supplemental nitrogen. Soil tests were considerably higher on the plot sites in the eastern area. Sixteen fields had medium or above phosphorus tests and 11 medium or higher potassium tests. Profits from fertilizer were only $2.90 above fertilizer costs. Forty pounds of K_2O in the row showed an average yield increase of 4.3 bushels while 80 pounds broadcast averaged 4.6 bushels increase. There appeared to be higher efficiency by placing potassium near the seed than by broadcasting on the majority of the fields.

Table 2 shows results from the eastern half of the state from only the plots having tests with low potassium or medium phosphorus. The sandy textured soils are excluded from these averages. Profits from fertilizer are about $10 per acre higher than the overall averages of all fields in this area. Note that the highest trestment of potash (120# K_2O) was the most profitable. Also note that 40# K_2O in the row averaged about the same as 80# K_2O broadcast.

There are 5 plots located on sandy loam soils. The best treatment of those used was 80+0+80. These plots showed an average increase of 14 bushels from 70 pounds of supplemental nitrogen, no apparent phosphorus response and 80 pounds of K_2O broadcast increased yields an average of 9 bushels. The average profits from the best treatment was $8.60 beyond fertilizer costs.

A complete summary will be in Soil Series 67 entitled "Profit Possibilities with Fertilizer on Corn". This booklet includes individual summaries of all 53 plots harvested. The demonstrations were established and tended by county agents and vo-ag teachers. There were 12 treatments and 2 replications as follows:

East and West	Western Minn.	Eastern Minn.
1. 0+0+0	1B. 80+40*+0	1B. 0+0+80**
2. 10+40+40	2B. 10+80*+40	2B. 10+40+120**
3. 80+40+40	3B. 80+80*+40	3B. 80+40+120**
4. 80+40+0	4B. 80+80*+0	4B. 80+40+80**
5. 80+0+0	5B. 80+40*+0	5B. 80+0+80**
6. 80+0+40	6B. 80+40*+40	6B. 80+0+120**

* has 40# P_2O_5 broadcast

** has 80# K_2O broadcast

Table 1. Western half of Minnesota, averages for fields with low P and medium K (15 fields)

MOST PROFITABLE PLOT COMPARED TO CHECK

Plant nutrients/A.	Yield	Labor & Mgt. Returns/A.*	Fertilizer net profit	Cost/bu.	Acres to net $1000	Bu. to net $1000
1. 0 + 0 + 0	66	$ 21.00	--	$0.68	48	3140
3. 80 + 40 + 0	94	32.60	$ 11.60	0.65	31	2880

INDIVIDUAL BENEFITS FROM NITROGEN, PHOSPHORUS AND POTASSIUM

Nitrogen Effect Treatment	Yield	inc.	Phosphorus Effect** Treatment	Yield	inc.	Potassium Effect** Treatment	Yield	inc.
2 10 + 40 + 40	83		6 80 + 0 + 40	84		4 80 + 40 + 0	87	
3 80 + 40 + 40	94	+11	3 80 + 40 + 40	94	+10	3 80 + 40 + 40	94	+7
			3B 80 + 80 + 40	96	+12			

Average soil test	pH	P	K
	7.05	6.8	149

* production cost other than fertilizer estimated at $ 45 per acre. CORN VALUED AT $1/BU.

** all treatments of 40# are in row, 80# P_2O_5 has 40# broadcast plus 40# in row

Remarks - Average starter profits $ 9.70
Average 40# P_2O_5 row 10 bu.
Average 40# P_2O_5 best 8 bu.

Table 2. Eastern half of Minnesota, averages for fields with low K and medium P (excluding sady textured soils).

MOST PROFITABLE PLOT COMPARED TO CHECK

	Plant nutrients/A.	Yield	Labor & Mgt. Returns/A.*	Fertilizer net profit	Cost/bu.	Acres to net $1000	Bu. to net $1000
1.	0 + 0 + 0	73	$ 23.00	--	$0.69	43	3170
3B	80 + 40 + 120	106	35.60	$ 12.60	0.66	28	2980

INDIVIDUAL BENEFITS FROM NITROGEN, PHOSPHORUS AND POTASSIUM

Nitrogen Effect

	Treatment	Yield	inc.
2B	10+40+120	95	
3B	80+40+120	106	+11

Phosphorus Effect **

	Treatment	Yield	inc.
6B	80 + 0 + 120	99	
3B	80 + 40 + 120	106	+7

Potassium Effect **

	Treatment	Yield	inc.
4	80 + 40 + 0	91	
3	80 + 40 + 40	101	+10
4B	80 + 40 + 80	100	+9
3B	80 + 40 + 120	106	+15

Average soil test	pH	P	K
	6.5	15.1	76.0

* Production and fixed cost other than fertilizer estimated at $ 50 per acre. CORN VALUED AT $1/BU.

** all treatments of 40# are in row, 80# K_2O is best, 120# has 80# broadcast plus 40# in row

Remarks - Average starter profits $9.70
Average increase from 40# K_2O row 10 bu.
Average increase from 80# K_2) best 9 bu.

The Effect of Very High Fertilizer Rates and Ratio on Stand of Corn

Rosemount Agricultural Experiment Station - U. of M.
1961

Paul M. Burson
Department of Soils

This trial was not designed to study the economics of high rates of fertilizer on the yield of corn. The primary purpose was to determine whether or not starter fertilizer at very high rates placed in a band 2 inches to the side and 2 inches below the corn kernels would injure germination and thereby reduce stand or adversely affect the growth of the crop during the growing season. The effect on yield was purely accidental.

In this trial the fertilizer band placement was used so that the fertilizer could be precisely controlled. The planter was equipped with the new extra high speed type of auger and a special high speed sproket in the fertilizer attachment so that much higher than normal rates per acre could be applied.

The fertilizer used was made up by blending three fertilizer material s. The three included ammonium nitrate (33 + 0 + 0), 46 percent superphosphate (0 + 46 + 0) and 60 percent muriate of potash (0 + 0 + 60). There was one additional fertilizer which was a manufactured grade of 6 + 12 + 24.

In all cases the planter was set to deliver the maximum amount permitted by the gauging mechanism. In other words, the fertilizer distributor was wide open.

Corn stand vs. high fertilizer rates and ratios

N	P_2O_5	K_2O	Ratio	Total lbs. of fert./acre[1]	Plant population	Percent lodging	Yield bu./acre
0	0	0	-----	-------	14,000	0	38.5
230	115	115	2:1:1	1290	16,000	40 +	100.3
365	122	122	3:1:1	1370	16,000	40+	102.4
365	73	73	5:1:1	1400	16,000	40 +	105.7
95	188	376	1:2:4	1570	16,000	Trace	98.6

Soil type: Port Byron silt loam

It is to be noted in the table that as the three fertilizer ingredients were varied in the ratio the rate of flow also varied and that the same amounts were not applied with the same machine adjustment. This suggests that as blends and fertilizer grades vary in composition the fertilizer distributor should be calabrated each time for each blend or grade if a specific rate per acre is desired.

A planting rate of 18,000 kernels per acre was used on all plots. It is ordinarily assumed that the mortality rate between planting and harvest time may range from 10 to 15 percent. If 15 percent is used the plant population or final stand at harvest time when 18,000 kernels are paanted would be about 15,300. In this trial where the final stand was 16,000 the mortality was 12.2 percent. On the check plots with final stands at 14,000 the mortality rate was 22.2 percent.

This trial further indicates that when starter fertilizer is placed in a band there is little or no danger for "so called burning" or injury to germination. This means that when the fertilizer band attachment is used the farmer could make whatever rate of application he may desire without fear of injury to germination.

It is to be noted that while very high rates of nitrogen did not affect germination it did promote lodging. With the use of 95 pounds of nitrogen in the starter there was no lodging. As much as 120 poungs of nitrogen in starter was used in other trials with little or no lodging. When nitrogen rates in the starter reached beyond 200 pounds per acre there was a higher rate of lodging.

Field and laboratory studies with corn

A. C. Caldwell and R. W. Blanchar

The effects of nitrogen, phosphorus and potassium on corn yield and nutrient composition were studied. No broadcast applications were made. All materials were applied as starter materials at planting time. These experiments were carried out at Red Wing, Waseca, Lamberton, and Morris.

Lamberton location (Nicollet soil)

The effects of nitrogen, phosphorus, and potassium alone and in combination are shown in Table 1. Results indicate that the most striking effect was the interaction between nitrogen and phosphorus.

Table 1. Effects of nitrogen, phosphorus and potassium on nutrient content and yield of corn at Lamberton.

Treatment*	Stage of Growth: Young plants (12 to 18 inch height)				Tasseling	Yield Shelled corn
	Weight gm/pl.	N %	P %	P-Yield mgP/pl.	P %	bu/A
0+0+0	.7	2.4	.28	2	.18	34
90+0+60	.7	3.8	.23	2	.21	55
90+60+60	4.4	4.0	.45	20	.21	93
00+60+60	1.2	2.3	.38	5	.24	43
90+60+0	4.5		.47	22	.21	107
L.S.D. (.05)	1.6	.5	.06	8	.04	11

*Fertilizer sources were: nitrogen (33-0-0), phosphorus (0-46-0), and potassium (0-0-60).

Yield was increased only slightly by phosphorus or nitrogen alone, however when applied together striking increase in yield occurred. (Table 1) There was also a significant increase in percent phosphorus and phosphorus-yield due to the application of nitrogen and phosphorus together over phosphorus alone. Percent nitrogen was not affected by the addition of phosphorus, however nitrogen uptake was increased due to phosphorus application.

Thinning samples (young plants 12-18" high) appeared to reflect more accurately the phosphorus effects on yield than did 6th leaf samples at tasseling time.

Waseca location (Nicollet soil)

An experiment identical to the one reported at Lamberton was carried out at the South Central ExperimentaStation at Waseca.

The most striking effect at Waseca was the influence of starter nitrogen and phosphorus together on early corn growth. This effect, however, was not apparent later in the season and was not reflected in either analysis of samples at tasseling time or corn yield (Table 2). The only significant effect on corn yield at Waseca was due to nitrogen. The analysis of young plants does indicate early effects of the starter materials and is of interest from that stand point.

The effect of nitrogen, phosphorus, potassium and the nitrogen-phosphorus interaction is shown in Table 2.

Table 2. Effects of starter nitrogen, phosphorus and potassium on the nutrient content and yield of corn at Waseca.

Treatment*	Stage of Growth							Yield
	Young plants (12 to 18 inch height)					Tasseling		
	Weight gm/pl	P %	K %	P-Yield mg/pl	K-Yield gm/pl	P %	K %	Shelled corn bu/A
0+0+0	5.6	.31		18		.28		114
90+0+60	5.7	.29		16		.29		135
90+60+60	11.7	.38	4.3	45	.53	.29	2.0	133
0+60+60	8.3	.25		21		.26		123
90+60+0	11.6	.37	2.6	43	.33	.30	1.5	132
L.S.D. (.05)	2.8	.04	.5	12	.13	.02	.3	9

*Fertilizer materials used were: nitrogen (33-0-0), phosphorus (0-46-0) and potassium (0-0-60).

About a 20 bushel yield increase resulted from nitrogen application. Phosphorus and potassium also significantly increased yield over no treatment. However, yield was not increased by either phosphorus or potassium on plots which had received nitrogen.

Analysis of young plants revealed that application of either phosphorus or nitrogen alone did not increase percent phosphorus in the tissue or phosphorus uptake by the corn plants. When nitrogen and phosphorus were applied together both percent phosphorus and phosphorus yield were significantly increased (Table 2).

Red Wing location (Fayette soil)

This experiment was carried out on a Fayette soil of relatively high fertility.

The effects of nitrogen, phosphorus, and potassium are shown in the following table. In this experiment application of starter fertilizers did not increase corn yield (Table 3). The application of phosphorus significantly increased phosphorus content of the plant tissue. No significant increasee in potassium content of corn was found due to the application of potash (Table 3).

There were no significant increases in phosphorus content due to the nitrogen phosphorus interaction as was shown at Lamberton and Waseca. Percent phosphorus in young plants was decreased by the addition of nitrogen without phosphorus (Table 3).

Table 3. The effect of nitrogen, phosphorus and potassium on nutrient content and corn yield at Red Wing.

Treatments*	Stage of Growth: Young plants (12 to 18 inch height)			Tasseling		Yield
	Weight gm/pl	P %	K %	P %	K %	Shelled corn bu/A
0+0+0	2.4	.51		.35		114
0+60+60	3.1	.53		.38		115
90+0+60	2.4	.37		.35		119
90+60+60	3.0	.51	5.8	.41	2.5	123
90+60+0	2.9	.53	5.5	.43	2.3	125
L.S.D. (.05)	.7	.06	1.0	.05	.3	13

*Fertilizers were: nitrogen (33-0-0), phosphorus (0-46-0), and potassium (0-0-60).

Morris location (Barnes soil)

Results of this field trial with corn using 27-14-0 supplemented with ammonium nitrate when necessary are shown in Table 4.

Data presented in Table 4 indicate that neither nitrogen, phosphorus or zinc applied as starter materials affected the yield of corn significantly.

Table 4. 27-14-0 as a starter fertilizer for corn at Morris.

Treatment	Young plants (12 to 18 inch height): Weight gm/pl	P %	P-Yield mg P/pl	Yield: Shelled corn bu/A
0+0+0	1.4	.40	5.8	76
90+0+0	1.2	.33	4.0	79
90+15+0	1.7	.41	7.3	81
90+30+0	2.3	.48	11.1	80
90+45+0	1.7	.43	7.6	85
90+45+0 plus zinc 12#/A	2.0	.48	9.7	77
L.S.D. (.05)	.8	.08	4.1	11

Phosphorus content of young corn plants was significantly increased by the first 15#/A of phosphorus added, but further increments did not significantly increase phosphorus content.

Summary

Nitrogen applied with phosphorus as starter fertilizers on Nicollet soils at Lamberton and Waseca had a very significant effect on the phosphorus nutrition of corn. At both these locations, phosphorus content of young corn treated with both nitrogen and phosphorus was much greater than that from phosphorus without nitrogen. This effect resulted in about a 50 bushel per acre increase in corn yield at Lamberton, but no yield differences were found at Waseca. No nitrogen-phosphorus interactions were found on a Fayette soil at Red Wing, however this soil is an extremely fertile one as indicated by soil test and analysis of plant tissue.

Tissue analysis was carried out on both young corn plants and corn leaves at tasseling time. In general it appears that phosphorus effects manifest themselves more greatly early in the development of the plant, and also that differences in phosphorus levels are at a maximum at this time. When small differences between fertilizer materials are to be detected they can most easily be determined from the tissue analysis of young plants.

The addition of K to the soil increased the K content of plant tissues, particularly the young plant. Nitrogen content of plants was increased substantially by the application of ammonium nitrate.

Results of Six Years of Continuous Corn Fertilization at Morris
Barnes Loam - Stevens County

J. M. Mac Gregor, R. G. Hanson, G. R. Blake and R. Thompson

In 1957, a continuous corn experiment was initiated to study the effect of fertilizing annually with differing rates of nitrogen with constant rates of phosphate and of potash, and the effect of different tillage methods on corn yield and soil structure.

The following table shows the corn yields for the 1957-62 period.

The Effect of Annual Fertilization of Corn on Barnes Loam, Applied in Spring or Fall With Minerals on the Yield of Ear Corn.

Annual Nutrients applied (lbs/A)	Time of Fertilization	1957	1958	1959	1960	1961	1962	Six Year Average
		bushels of ear corn per acre @ 15.5% moisture						
0+40+40	spring	65.2	73.2	36.1	53.3	32.3	26.7	47.8
40+40+40	fall	71.0	81.5	40.9	48.2	48.3	41.2	55.2
40+40+40	spring	69.4	81.0	41.5	55.0	47.6	44.1	56.4
80+40+40	"	72.1	82.4	39.7	53.7	45.0	45.7	56.4
240+40+40	"	71.3	80.3	36.8	52.5	46.1	47.8	55.8

Plant populations have been maintained at about 18,000 plants per acre each year.

Yields during the first two years of the experiment were considerable higher than durigg the succeeding four yeabs of the study. It was very dry in 1961 and very cool and wet during the summer of 1962.

It is evident that the annual application of nitrogen at the rate of 40 pounds per acre increased corn yields to the same extent as twice to six times (80 to 240 lbs N/A) the 40 pound per acre rate, even though the heavier rates produced much healthier appearing corn plants. It appears that some factor other than soil nitrogen supply is limiting the corn yields on this experimental field.

Continuous Corn - High Fertility Experiment
Rosemount Experiment Station
Soils

W. F. Martin and H. W. Kramer

Yield Results - 1962

Re: 1959 results, page 97, Department of Soils Mimeo, April, 1960: 1960 results, page 82, *ibid*, February, 1961, 1961 results, p. 79, *ibid*, February, 1962.

Soil Type: Port Byron silty clay loam

Object: To determine profitable rates of fertilization for continuous corn.

Site: Fairly level with minimum erosion hazard; protected from hill pastures with terrace; tile drained.

Past results: Yields have varied from 45 bu./ac. to 133 bu. as an average of all treatments, 1953-1961. Highest yields were obtained in 1954 and lowest in 1957 (because of excess ppc. and weediness). Yields have consistently reflected fertilizer responses.

		16,000 plants	20,000 plants
1.	Check	74 bu.	93
2.	H*	86	110
3.	HS_1	91	110
4.	HS_2	90	114
5.	B_1H	97	114
6.	B_1HS_1	95	117
7.	B_1HS_2	94	117
8.	B_2H	94	118
9.	B_2HS_1	95	119
10.	B_2HS_2	96	118

*H = 200 lbs. 10-20-20 hill drop
S_1 = 100 lbs. 33-0-0 sidedress
S_2 = 200 lbs. 33-0-0 sidedress
B_1 = 400 lbs. 6-12-24 broadcast
B_2 = 800 lbs. 6-12-24 broadcast

Continuous Corn - High Fertility Experiment
Rosemount Experiment Station
Soils

John Grava

I. Soil test results* 1958 and 1960

Treatment No.	Manual application of N P$_2$O$_5$ K$_2$O (lbs./acre)	Soil pH	Extractable Phosphorus (P) (lbs./acre)	Exchangeable Potassium (K) (lbs./acre)
	1. Sampling Date: July 18, 1958			
1	0 + 0 + 0	5.8	17 M	105 M
4	82 + 32 + 32	5.8	27 H	135 M
6	69 + 112 + 112	5.7	91 VH	218 M
9	89 + 192 + 192	5.4	143 VH	278 VH
	2. Sampling date: August 1, 1962			
1	0 + 0 + 0	5.9	17 M	130 M
4	86 + 40 + 40	6.0	26 H	155 M
6	77 + 88 + 136	5.7	78 VH	208 M
9	101 + 136 + 236	5.3	150 VH	340 VH

* average of four replications

II. Effect of fertilization on N, P and K contents** in 6th corn leaf at tasseling time - 1962

Treatment No.	Nitrogen %	Phosphorus %	Potassium %
1	3.02	0.233	1.36
4	3.20	0.290	2.30
6	2.87	0.302	2.55
9	3.16	0.340	2.80

Critical levels (according to Tyner): 2.9% N, 0.295 % P, and 1.3%K.

**Average of four replications.

NPK - Rate and Placement Studies with Corn on Fayette Soils-1962

John Grava and Lowell Hanson

Most farmers who get their soils tested are beyond the stage where the question whether or not to use fertilizer is being asked. A fertilizer recommendation now has to provide information on what grade, how much of it, and how to apply it. To provide such information rather complicated field experiments are needed. With these questions in mind an NPK-rate and placement study with corn was initiated on Fayette and related soils in southeastern Minnesota in 1961. Results of that study were reported in a report on field research in soils, February 1962.

The study was continued on three corn fields in Goodhue and Wabasha counties in 1962. Following is a brief description of the location, soil type, cropping pattern, fertilization and soil management.

FIELD 1 Nygren Brothers, Red Wing, Minnesota, Goodhue County
Soil Type: Fayette-Seaton silt loam

Year	Crop	Fertilizer	Manure
1961	Corn	100 lbs./A. 5-20-20	---
1960	Alfalfa	---	10 To/A. in fall
1959	Oats & Alfalfa	---	---

Limed: 1957 2 To./A.
Plowed: Spring, 1962
Weed Control: Cultivated 1x; weeds not eliminated

FIELD 2 Dale Flueger, Red Wing, Minnesota, Goodhue County
Soil Type: Fayette silt loam

Year	Crop	Fertilizer	Manuer
1961	Corn	125 lbs./A. 5-20-20 Row	8 To/A.
1960	Corn	125 lbs./A. 5-20-20 Row	8 To/A.
1959	Pasture (Brome Grass & Alfalfa)	---	---

Plowed: Spring, 1962
Weed Control: Atrazine (post-emergence); weeds not eliminated

FIELD 3 Edwin Freeze, Kellogg, Minnesota, Wabasha County
Soil Type: Fayette silt loam

Year	Crop	Fertilizer	Manure
1961	Sweet corn	275 lbs./A. 4-12-36 + 80 lbs./A. of N	----
1960	Sweet corn	200 lbs./A. 6-24-24	----
1959	Sweet corn	200 lbs./A. 6-24-24	----

Limed: 1957 or 1958, 3 To./A.
Plowed: Fall, 1961
Weed Control: Atrazine (post-emergence); cultivated 1x; weeds eliminated

In 1961 the experiments were conducted on soils testing medium to high in phosphorus and low to medium in potassium. The three fields used for experiments in 1962 showed much higher P and K fertility levels, as shown in Table 1.

Table 1. SOIL TEST RESULTS

Location	pH	Organic Matter %	Extractable Phosphorus lbs./A	Exchangeable Potassium lbs./A	Soil Texture
Nygren Brothers, Goodhue County	6.7	2.8L	58 VH	220M	Silt Loam
Flueger, Goodhue County	7.4	2.8L	18 M	225H	Silt Loam
Freeze, Wabasha County	7.1	2.6L	64VH	185M	Silt Loam

These fertility levels are reflected also in the check yields:

Nygren Brothers	129 Bu./Acre
Flueger	99 Bu./Acre
Freeze	121 Bu./Acre

Surface and subsoil samples were collected during the first week of May for moisture determinations and routine chemical analysis. Each field experiment consisted of 15 treatments, replicated five times, for a total of 75 plots. Individual plots were 25 feet long and 13.3 feet wide. A part of the fertilizer was broadcasted, plowed down on fields No. 1 and2, and disced-in on field No. 3.

Pioneer 376 (108-112 day) corn variety was planted (May 16, 17 and 18) at all locations. Corn was thinned to a uniform stand of 20,000 plants per acre (2 plants per hill, 15 inches apart in 40-inch rows). The farmer cooperators were provided with rain gauges and asked to keep rainfall records. Corn leaf samples were collected at the tasselling time for N, P and K determinations.

Finally, corn yields were determined by harvesting and weighing ears from 20-two stalk hills from each plot. Moisture content was determined on five representative ears from each treatment.

Subsoil moisture was sufficient at the planting time. All locations received about 18.5 inches of rainfall from May 15 to September 30. Corn developm ent was delayed, particularly in the early stages of growth.

Corn yield response to nitrogen fertilization is shown in Table 2.

Table 2. CORN YIELD RESPONSE TO NITROGEN FERTILIZATION

Rate of Nitrogen N lbs./Acre	Location					
	Nygren Brothers		Flueger		Freeze	
	Yield of shelled corn (15.5 % moisture) Bu./Acre					
10	140		134		133	
60	164	+24	146	+12	140	+7
120	164	+24	155	+21	136	+3

Note: All treatments received 0+0+80 broadcast and 10+40+40 row treatment.

The 60 pound rate of nitrogen was sufficient in producing profitable yield increases on two fields. At one location the highest yield was realized with the application of 120 pounds of nitrogen. However, one of the most significant conclusions that can be derived from this study is the ability of the Fayette soils to release nitrogen to corn. An average corn yield of 132 bushels per acre was produced with only 10 pounds per acre of row-placed nitrogen (Ave. 110 Bu./A at 4 locations in 1961).

A comparison of three phosphorus rates and two types of placement is given in Table 3.

Table 3. CORN YIELD RESPONSE TO PHOSPHORUS FERTILIZATION

Rate of Phosphorus P_2O_5 lbs./A.	Location					
	Nygren Brothers		Flueger		Freeze	
	Soil Test = 58		Soil Test =18		Soil Test=64	
	Yield of shelled corn (15.5% moisture) Bu./Acre					
0	151		139		135	
40 Bcst.	156	+5	140	+1	143	+8
40 Row	157	+6	156	+17	136	+1
80 (40 Bcst. + 40 Row)	170	+19	155	+16	144	+9

Note: All treatments received 110+0+80 broadcast and 10+0+40 row treatment.

It should be pointed out that in 1961 on similar soils phosphorus applications resulted in decreased yields at three out of four locations. Furthermore, broadcast application of 40 lbs. P_2O_5/A. resulted in lower yields (average of 14 Bu./A.) than the same amount of phosphorus applied in a row.

Corn responses to phosphorus applications were observed on all fields in 1962. On Flueger's field with a medium P test, row placement was more effective than broadcast. Both types of placement were equally effective on a soil with very high P test (Nygren Brothers).

Corn yield responses to five potassium rates and two types of placement are given in Table 4.

The potassium test values on these fields are approaching the high level, generally higher than most Fayette soils. On two fields the 80 lbs. of K_2O per acre rate was most efficient, resulting in 6 to 12 more bushels of corn than the 0 K treatment. At one location the 120 pound rate of K_2O increased the yield by 25 bushels per acre. While corn leaves collected from row placed potassium treatments showed higher K content than those from broadcast treatments, no such clear cut differences due to placement were observed in corn yields.

The recommenced rates and placement of N, P and K, based on the reported experimental data, are indicated in Table 5.

Table 4. CORN YIELD RESPONSE TO POTASSIUM FERTILIZATION

Total K_2O lbs./A.	Broadcast K_2O lbs./A.	Row K_2O lbs./A.	Location: Nygren Brothers Soil Test: 220	Flueger Soil test: 225	Freeze Soil Test: 185
			Yield of shelled corn (15.5% Moisture)		Bu./ Acre
0	---	---	146	145	141
40	40	---	166 +20	150 +5	131 -10
40	---	40	161 +15	148 +3	132 -9
80	80	---	156 +10	157 +12	137 -4
80	---	80	169 +14	154 +9	133 -8
80	40	40	154 +8	152 +7	147 +6
120	80	40	171 +25	153 +8	136 -5
120	40	80	157 +13	159 +14	145 +4
160	80	80	162 +16	156 +11	147 +6

Note: All treatments received 110+0+0 broadcast and 10+40+0 row treatment.

Table 5. MOST EFFICIENT FERTILIZER TREATMENTS - 1962

Location	N		P_2O_5		K_2O
			lbs./Acre		
Nygren Brothers	60	+	80[1]	+	120[2]
Flueger	120	+	40[3]	+	80[4]
Freeze	60	+	40[5]	+	80[6]

1) P_2O_5 40 lbs./A. Broadcast + 40 lbs./A. Row

2) K_2O 80 lbs./A. Broadcast + 40 lbs./A. Row

3) Row

4) Broadcast

5) Broadcast

6) K_2O 40 lbs./A. Broadcast + 40 lbs./A. Row

Acknowledgements

The authors are indebted to the National Plant Food Institute for financial assistance, and to members of the Minnesota Fertilizer Industry Association for contribution of fertilizer materials. Appreciation is expressed to Extension agents: Messrs. Arnold Wiebusch and Mat Metz for their assistance and to Messrs. Dale Flueger, Edwin Freeze, Neil and Normal Nygren for their cooperation in conduction the experiments.

PROPER FERTILIZER PLACEMENT CAN IMPROVE STAND AND YIELD OF CORN

Rosemount Agricultural Experiment Station - U. of M.
1961
Paul M. Burson
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Two types of fertilizer attachments on the corn planted were tested on four fields. The planters were the splitboot type and the band placement type. All the fertilizer was applied as starter and consisted of several different grades.

The fertilizer placement with the splitboot is intended to be at seed level and at the side of the seed. However, the actual placement varies with the make of the machine, the condition of the seedbed, soil conditions and the physical condition of the fertilizer to mention a few. It may be placed as intended but the fertilizer may be above or with the seed. With the band type the placement is definitely determined by the mechanical adjustments. In these trials the placement was 2 inches to the side and 2 inches below the seed placing the fertilizer in an exact position to the seed. Both planters had been previously calibrated for both seed and fertilizer rates.

The trials consisted of 4 rows of corn in paired plots which were replicated two or four times. The data shown in the table below are averages of the results from four fields. Two of the fields were on Clyde silty clay loam and two on Port Byron silt loam.

Split boot vs. band placement

	Splitboot	Band	Increase
Yield all fertilizers	79.8 bu.	99.9 bu.	20.1 bu.
Final stand - plants/ac	10,000	15,900	5,100

4 fields

Planting rate - 18,000 kernels per acre

With the splitboot attachment some of the fertilizer comes in direct contact with the seed and appears to have seriously injured germination. In these trials the average final stand at harvest time was 5100 plants per acre less with the split boot than when the band type attachment was used. The lower plant population is reflected in a lower yield, of 20.1 bushels per acre.

Both nitrogen and potash will injure germination when any considerable amounts come into direct contact with the seed. Phosphorus is less harmful. However, the splitboot attachments limit the amount of starter fertilizer that should be applied. If the rate of a mixed fertilizer should exceed 150 pounds per acre there is the probability that germination may be injured. Moisture supply and weather conditions can make considerable difference.

The Effect of Potash Placement in Starter Fertilizer on the Yield of Corn

Rosemount Agricultural Experiment Station
U. of Minn., 1961
Paul M. Burson
Department of Soils

Two types of fertilizer placement attachments on the corn planter were used. They were the splitboot and the side band. The splitboot attachment is designed to place the fertilizer at seed level but to the side of the seed. However, this is not the case. It may place the fertilizer above the seed or with the seed depending on the condition of the soil, the condition of the fertilizer, particle size, weight of ingredients, the design of the attachment and the way the planter is operated.

The band fertilizer attachment places the fertilizer positively in relation to the seed by using a separate opener which may be set for a predetermined rate and placement. In these trials the fertilizer band was 2 inches to the side and 2 inches below the seed. With this placement there was no chance for seed and fertilizer contact.

Splitboot vs. band placement

Method	40 lbs. K_2O	No potash	Increase or decrease
Splitboot	72.2 bu.	76.0 bu.	- 3.8
Band	111.9	97.4	+ 14.5

The fertilizers compared, as shown in the table above, were 40-40-40 with 40-40-40 and 80-40-40 with 80-40-0. The planting rate was 18,000 kernels per acre.

Using the splitboot type the inclusion of potash in the starter reduced the yield by 3.8 bushels per acre. This indicates that in all probability some fertilizer came in direct contact with the seed with a consequent reduction in stand due to injury at germination.

The inclusion of potash in the starter and placed in a band to the side and below the seed increased the corn yield 14.5 bushels per acre. This increase is nearly the same as obtained in 1960 for including potash in the starter which was 12.0 bushels per acre. In 1962 the increase was 14.0 bushels per acre. The results from the trials in 1960, 1961 and 1962 are similar to those conducted in other parts of Minnesota in 1961 and indicate that some potash should be included in starter for corn. All trials have shown that placement of the fertilizer is becoming most important to successful and profitable corn production.

Comparative Effects of Deep Tillage Versus Plowing on Soil & Water Losses and Corn Yield over Four Years (1959-62) on Port Byron Silt Loam at Rosemount

J. M. Mac Gregor

In 1953, a seed-bed preparation experiment was initiated on a 9% slope of the Port Byron silt loam at Rosemount to determine the relative effect of deep tillage seed-bed preparation versus conventional plowing, on losses of soil and water and of corn, oat, and hay yields where a four year rotation of corn, oats, followed by two years of alfalfa was practiced.

Six years of experimental results (1953-1958) indicated that the four year rotation in use was adequately maintaining soil tilth, and with no treatment replication there was no significant difference in soil or water loss with the two methods of soil preparation of in the yields of corn, oats, or of alfalfa hay.

Therefore, in 1959, the four-year rotation was changed to a continuous cornj sequence on each of the eight plots. After harvest each fall, a stalk cutter was used on all plots, after which four were plowed and the remianing four adjacent plots were deeply cultivated (to approximately an eighth inch deep) and then reworked to a slightly shallower depth in the spring. Corn was planted to obtain approximately 16,000 plants per acre, using 5-20-20 as starter fertilizer each year at the rate of 200 pounds per acre. A nitrogen sidedressing of 80 pounds of ammonium nitrate nitrogen per acre was broadcast annually in late June or in early July.

Results

The growing season of 1959 was abnormally wet, followed by two comparatively dry summers of 1960 and 1961 and about normal rainfall in 1962. This variation in growing season moisture has produced considerable difference in all of the results obtained, as shown in the following table:

Table 1. The effect of seed-bed preparation by plowing or by deep cultivation on soil and water losses and resulting corn yield on a 9% slope of Port Byron silt loam at Rosemount (1959-62) (Averages of four replicates).

	Year			
	1959	1960	1961	1962
Total precipitation (April-Oct. inc.)	32.5"	21.8"	19.3"	20.4"
Water runoff on plowed plots	6.3"	0.7"	None	None
Runoff as % of 7 month pptn.	19	3	None	None
Runoff on cultivated plots	5.6"	0.3"	None	None
Runoff as % of 7 month pptn.	17	1	None	None
Tons of soil erodded/A on plowed plots	2.4	None	None	None
Tons of soil eroded/A on cultivated plots	1.3	None	None	NONe
Yield of ear corn per acre on plowed plots	119	88	99	71
Yield of ear corn per acre on cultivated plots	122	74	81	60

Discussion

Precipitation - the total amount, the distribution and the relative intensities of each rain, has a great effect on soil erosion and water runoff - and also materially affects subsequent corn yields on the two different methods of seedbed preparation. The heavier than normal rainfall of 1959 was more effectively controlled and conserved by deep tillage rather than by the plowing, and this method of soil preparation reduced both soil and water losses and also resulted in a 122 bushel yield of ear corn per acre. The plowed plots (all plots of the experiment are worked on the contour) had a greater runoff and soil loss under the heavy rains of that summer, and yielded 118 bushels of corn per acre.

The growing seasons of 1960, 1961 and 1962 were drier than normal, and although there were some rains resulting in runoff water in 1959, no measured soil loss occurred in any one of these three later years. The drier soil conditions apparently lowered corn yields substantially in comparison to those produced in 1959, and the deeply cultivated plots were less productive where the seed-bed was prepared by plowing. A yield difference of either 14 18 or 11 bushels per acre would be of primary concern to a farmer following such conservation practices. In addition, the corn population on the deeply cultivated plots was generally unsatisfactory, although this effect was largely corrected when the corn yields er acre were calculated.

Conclusion

While nothing definite can be concluded from the results from four years data, it is evident that there was better control of soil moisture under higher rainfall where deep cultivation was used rather than plowing. This better moisture control may have been improved by increasing the water infiltration into the subsoil by working at deeper levels than by normal plowing. Under dry conditions, this may have been detrimental in allowing greater losses of soil moisture to the air under prolonged periods of drier soil conditions. It is possible that cutting the corn stalks in a field chopper rather than with a stalk cutter will allow preparation of a suitable seed-bed by cultivation to a maximum depth of six inches. This may allow a greater retention of subsoil moisture, which is apparently a critical factor in drier growing seasons.

Comparison of fertilizer materials on spring wheat

A. C. Caldwell and H. W. Kramer

Comparisons of fertilizer materials on wheat were made on three experimental fields in the spring of 1962. All 3 fields were on Fargo-Bearden type soils in the Minnesota Red River Valley. Farms were located near Crookston and East Grand Forks. Fertilizer materials tried included 0-46-0, 27-14-0, and 30-10-0. They were applied on the basis of 30 pounds of P_2O_5 per acre with the wheat at planting time through a fertilizer attachment on the drill. Yields of wheat were secured.

The effects of the different materials are shown in the table. On field 3 there were essentially no effects from fertilizers. The small positive and negative effects are probably not significant. On the other two fields there were yield increases brought about by fertilizer usage, particularly the nitrogen-phosphorus combinations. 30-10-0 might appear to be a bushel or so better than 27-14-0, but this is likely due to the extra nitrogen in 30-10-0, 90 pounds vs. 58. (Fertilizers were applied on the basis of 30 pounds P_2O_5 per acre).

Effect of fertilizer materials on yields of spring wheat (1962).

Treatment[1]	Field 1	Field 2 Yield of wheat, bu/ac	Field 3
None	18.7	23.9	28.4
0-46-0	19.1	27.4	26.7
27-14-0	27.6	28.3	29.4
30-10-0	29.4	31.9	26.4

[1]Fertilizers applied on the basis of 30 lbs. P_2O_5 per acre.

CLAY COUNTY BARLEY DEMONSTRATIONS - 1961

O. A. Dællenbach, Curtis Johnson and Merle Halverson

Soil Type: Fargo silty clay loam
pH: 6.8
%).M.: 6.7
Avail. P: 33 (Very High)
Exch. K: 600+ (Very High)

Variety: Traill
Sample size: 12' x 181.5' = 0.05A
(Combine harvested)

	Early	Late
Seeded	4-21-61	5-4-61
Swathed	7-23-61	7-29-61
Combined	8-1-61	8-1-61

(Each measurement is an average of 3 separately harvested samples)

Fertilizer Treatment	Yield, Bu./A. Early	Yield, Bu./A. Late	% Plump Kernels Early	% Plump Kernels Late	% Thin Kernels Early	% Thin Kernels Late	Bu.Wt.,Lbs./Bu. Early	Bu.Wt.,Lbs./Bu. Late
0+0+0	56.0	55.0	67.7	71.0	2.0	1.3	46.2	46.7
0+30+0	66.5	61.8	39.0	69.3	6.7	2.7	44.7	47.0
0+30+15	56.3	61.8	81.3	75.7	1.0	2.0	47.2	47.0
30+30+0	72.0	77.0	44.6	63.3	4.7	2.0	45.5	47.5
30+30+15	72.8	73.6	71.0	69.3	1.0	2.0	46.8	47.2

The apparent effect of phosphorus was to drastically reduce kernel plumpness on an early seeding, but not on a later seeding. Potassium applied with the phosphorus apparently increased kernel plumpness to its original high level on the early seeding, but showed no substantial effect on the later seeding. These effects are noted both in the absence and presence of fertilizer nitrogen.

These data suggest a possibility that soil conditions peculiar to time of seeding may influence quality responses of barley to row-placed potassium fertilizers, irrespective of soil potassium status.

KITTSON COUNTY BARLEY DEMONSTRATIONS - 1962

Winton Fuglie and Merle Halverson

Soil Type: Fargo clay
% O.M.: 5.5
Avail. P: 19 (Medium)
Exch. K: 600+ (Very High)
Cropping history: 1960 Durum, 50 Bu./A.
1961 Durum, 15 Bu./A.

Variety: Parkland
Seeded: May 27, soil wet and cold
Sample size: 12' x 503' = 0.138A
(Combine harvested)

(Each measurement is an average of 2 separately harvested samples)

Fertilizer Treatment	Yield Bu./A.	% Plump Kernels	% Thin Kernels	Bu. Wt. Lb./Bu.	% Protein in Grain
0+0+0	49.0	41	13.5	42	9.5
0+30+0	45.1	38	13.5	42	10.8
0+30+15	49.6	47	10.5	42	9.9
30+30+0	64.8	49	8.5	44	10.3
30+30+15	57.5	61	6.5	44	10.0

Nitrogen treatments advanced maturity 4 days to one week, apparently increased yield, kernel weight and kernel plumpness, and reduced percentage of thin kernels without affecting bushel weight.

The apparent effect of potassium treatment was to increase percent plump kernels and decrease percent thin kernels without affecting kernel weight. The real effect of potassium upon yield is not clear in this work.

These data are consistent with those obtained in previous demonstration work with respect to effect of potassium on kernel plumpness when barley is seeded early on cold, wet soils. They are indicative only, and constitute no basis for generally recommending the use of potassium on soils testing high in this mineral nutrient. Under many conditions on such soils, however, the addition of 15 lb. K_2O may provide sufficient increases in yield and/or kernel plumpness to more than pay for the relatively small investment .

65
49
16 bu
30# N

Residual Effect of Fertilizer on First Year Yield of Vernal Alfalfa Following a Decade of Fertilized Alfalfa Production

J. M. MacGregor and R. G. Hanson

Ranger alfalfa was seeded in the spring of 1950 on the Port Byron silt loam of the Soils Unit of the Rosemount Experiment Station, with fertilizer treatments commencing in the fall of 1949. The initial object of the study was to determine the optimum kind, rate, and time of fertilization most effective on the yield, composition and longevity of alfalfa.

Three crops of hay (commencing in 1951) were removed annually from the differentially fertilized plots. In the eleventh year, with thinning alfalfa stands and increasing invasion of grasses and of weeds, after the first cutting of hay was removed, the plots were worked to about an eight inch depth with a spring harrow to kill all vegetation. They were reworked in late August, packed and seeded to Vernal alfalfa (August, 1961) with additional fertilizer.

Two cuttings of alfalfa were removed in 1962 with the residual effect of the ten year fertilizer program being evident on the alfalfa growth during the entire growing season. The following table shows the initial 1951 yields of Ranger alfalfa, the 1962 yields of Vernal alfalfa, and the total hay yields over the twelve year period consisting of 33 cuttings.

The most effective fertilizer treatment (48, 48 tons of hay per acre)over the twelve year cropping period was with initial phosphorus-potassium followed by annual applications. The highest yield of 1962 alfalfa (3.31 tons per acre) occurred where phosphorus alone had been applied and this treatment yielded some ten tons of hay less than the most effective treatment. The greater 1962 yield was the result of more limited alfalfa production over the 1951-61 period due to lack of stand, but when the stand was restored in 1962, the residual effect of the fertilizer phosphorus was evident. The three highest yielding fertilizer treatments over the twelve year period yielded considerably less alfalfa in 1962 than the more productive plots of the previous years.

It is evident that the higher yields obtained over the initial eleven year period was at least partially the result of a better maintenance of the initial Ranger alfalfa stand. As the alfalfa stand became depleted on some treatments over the years, yields decreased. With the establishment of a new alfalfa stand late in 1961, the residual fertility of some of these lower yielding plots resulted in a much greater hay production.

Total Yields - Rosemount Alfalfa - 1951-62

Average of Seven Replications

12 year yield rank	Treatment		1951	1962	(Tons/acre at 15% moisture) 12 year total yield	Increase
29	Check		3.10	2.12	32.31	----
1	300# 0-20-20	SBS + 200# AS	3.96	2.95	48.48	16.17
2	300# 0-20-20	FBS + 200# AF	3.89	2.96	47.71	15.40
3	300# 5-20-20	SBS + 200# AS	4.03	2.92	47.42	15.10
4	1000# 0-20-20	SBS + 200# AS	4.42	3.09	47.10	14.79
5	1000# 0-20-0	SBS + 100# KCl AFC	4.26	3.10	46.82	14.51
6	200# 0-20-20	AS	3.25	3.29	46.59	14.28
7	1000# 0-20-20	SBS + 200# 5-20-20 BS	4.34	2.78	46.20	13.89
8	1000# 0-20-0	SBS + 200# 0-20-20 AS	4.14	2.96	45.52	13.21
9	300# 0-20-20	FBS + 200# BF	3.51	3.28	44.51	12.20
10	200# 0-20-20	AF	3.60	3.06	44.29	11.98
11	1000# 0-20-20	SBS + 200# BS	4.30	2.59	41.64	9.33
12	300# 0-20-20	SBS + 200# BS	3.79	2.81	41.31	9.00
13	1000# 0-20-0	SBS + 200# 0-20-20 BS	3.95	2.58	39.70	7.39
14	300# 0-20-0	SBS + 200# AS	3.77	2.44	39.01	6.70
15	300# 0-20-20	SBS	3.90	2.47	38.11	5.80
16	1000# 0-20-0	SBS + 200# AS	4.04	3.31	38.02	5.71
17	200# 0-20-0	AF	3.83	3.18	37.62	5.31
18	1000# 0-20-20	SBS	4.09	2.37	37.59	5.28
19	200# 0-20-0	AS	3.64	2.86	37.55	5.24
20	300# 0-20-0	FBS + 200# BF	3.68	2.96	36.82	4.51
21	300# 0-20-0	FBS + 200# AF	3.77	2.92	36.59	4.28
22	300# 0-20-20	+ Trace elements SBS	3.88	2.52	35.85	3.54
23	300# 5-20-20	SBS + 20# N AS	3.75	2.34	34.96	2.65
24	300# 0-20-0	SBS + 200# BS	3.64	2.05	34.69	2.38
25	300# 0-20-0	FBS	3.61	2.24	34.26	1.95
26	300# 0-20-20	+ 20# Boron SBS	3.84	2.41	33.48	1.17
27	1000# 0-20-0	SBS	4.01	2.37	33.05	0.74
28	300# 0-20-20	FBS	3.78	2.34	32.49	0.18
30	300# 5-20-20	SBS	3.82	2.17	32.30	-0.01
31	300# 0-20-0	SBS	3.59	1.81	31.23	-1.08

SBS - Spring before seeding
FBS - Fall before seeding
AFC - Annual first cutting
AS - Annual spring
BS - Biennial spring
AF - Annual fall
BF - Biennial fall

Trace elements - $CuSO_4$ 25#/A; $ZnSO_4$ 25#/A; $MnSO_4$; $FeSO_4$ 25#/A
Borax 20#/A.

1. Only 1 cutting taken in 1961, reseeded to Vernal alfalfa in August of 1961.
2. 2 Cuttings taken in 1962.
3. 3 Cuttings taken in all years 1951-60.

Residual effects of fertilizer on soybeans grown continuously

A. C. Caldwell

An experiment was set up in 1957 to study the effects of P, K and barnyard manure on the yields and plant composition of soybeans. Fifteen treatments were applied with 4 replications. In 1958 through 1962 no fertilizer was applied in order to study the residual effects of the fertilizer applied in 1957.

Yield results are shown in the accompanying table. All treatments with the exception of P and K applied alone at the minimum rate, gave small to moderate increases in yield. Statistical analyses have not been run on these data yet, but at this yield level it is doubtful if a yield difference of less than 2 bushels per acre would be significant.

Yields are lower than in past years. There was evidence of some disease (unidentified), that may be partly responsible for this.

Effect of residual fertilizer on yield of continuous soybeans (Rosemount, 1962).

Treatment $N-P_2O_5-K_2O$ lbs/A	Yield Bu/A	Diff.
0-0-0	12.4	
0-0-20	11.9	-0.5
0-0-80	15.4	3.0
0-0-400	16.7	4.3
0-20-20	18.8	6.4
0-40-40	14.3	1.9
0-60-60	14.3	1.9
0-80-80	16.4	4.0
0-400-400	19.5	7.1
0-400-400 + 6 T* Man.	15.3	2.9
0-20-0	10.7	-1.7
0-80-0	15.9	3.5
0-400-0	14.2	1.8
0-20-0 + 6 T* Man.	13.2	0.8
6 T* Man.	14.8	2.4

*6 T = 6 tons manure/A.

THE EFFECT OF PASTURE FERTILITY AND MANAGEMENT ON BEEF PRODUCTION
Rosemount 1962

P. M. Burson, Soils; A. R. Schmid, Agronomy;
A. L. Harvey and O. E. Kolari, Animal Husbandry

On May 22, 1962, "medium" to "good" grade steers were lotted and turned onto pasture. Prior to 1962 one-half of each pasture was fertilized and the other one-half unfertilized. Beginning in 1962 all of the pasture area was fertilized except for a one rod strip adjacent to the center fence in the original unfertilized area. On this area a basic treatment of 500 lbs. per acre of 0-20-20 is applied at the time of renovation. No other treatment of phosphate and potash will be made until again renovated. On the original fertilized area the usual annual application of 200 lbs. per acre of 0-20-20- was made. Since pastures B and C have not been renovated for several years no treatments of phosphate and potash were made on the old unfertilized areas. On the areas only 120 lbs. of actual N were applied in 1962. On the original fertilized areas the regular 200 lbs. of 0-20-20 was applied with the nitrogen. In all cases the nitrogen was applied as a topdressing at two different times as follows: (1) all in early spring, (2) all in early June, (3) 1/2 early spring and 1/2 in July, and (4) 1/2 early June and 1/2 in July.

The total production of beef per acre ranged from 271 lbs. on the pastures B and C (south) to 301 lbs. on pastures B and C (north) to the maximum on pasture E (renovated) where 396 lbs. of beef was produced per acre.

The carrying capacity as shown by steer-days per acre ranged from 153 on the B and C (north) pasture to 190 on the renovated E pasture. It should be noted that there is a big difference in pastures B and C (north) and B and C (south) in fertility levels, type of soil, the need for lime, the steepness of slopes, the extent to which erosion has previously occurred and the depth of topsoil. On the basis of these soil characteristics pasture B and C (north) could be classes as "fair to good", pasture B and C (south) "poor to fair" while pasture E could be classed as "good to very good".

The production of beef per acre for 1962 seems to reflect these soil differences even though the grazing-management practices were the same on all pastures. Pasture B and C (south) with 120 lbs. of N per acre, produced 271 lbs. of beef per acre as compared to pasture B and C (north) with only 60 lbs. of N produced 301 lbs. of beef to 396 lbs. of beef per acre on pasture E.

These data seem to bear out the principle that more beef per acre, the same as any other agricultural crop, can be produced on those soils that are higher in fertility, even though they are too steep and erosive to use in the production of tillable agricultural crops.

Table 1. Beef produced with yearling steers on fertilized pastures grazed in rotation May 22 to September 5, 1962 (106 days).

Pasture	B & C south 120 # N	B & C north 60# N	E
No. acres	7.2	7.4	7.8
No. steers - started[a]	12	12	16
Ave. initial wt., lbs.	598	604	598
No. steers - finish[b]	4	4	8
Ave. final wt., lbs.	844	812	819
Ave. daily gain, lbs.	1.71	1.97	2.08
Steer-days/acre	159	153	190
Beef produced/acre	271	301	396
Value of beef produced per acre @$23.50 cwt.	$63.69	$70.74	$93.06
Tillage and seed cost/acre			$6.64
Fertilizer and lime cost/acre	$11.05	$6.01	$5.25
Return over lime, fertilizer, seed and tillage costs	$52.64	$64.73	$81.17

[a] All steers implanted with 24 mg. stilbesterol May 22, 1962.
[b] Steers were removed as carrying capacity decreased.
Grade: "medium" to "good" yearling steers.
Fertilizer and lime treatments: 0-40-40 (P, $.09/lb., 20% carry-over; K, $.07/lb., 50% carry-over), nitrogen, 30% carry-over; Lime, all pastures @ 3 tons per acre, cost $.97 per acre per year over a 10 year period.
E pasture: Renovated in 1960-61.

Acknowledgement is due Ed Bonnell, Earl Stevermer and David Kill for field assistance on the project.

Fertilizer Experiments on Park Kentucky Bluegrass Seed Production in Roseau County

P. M. Burson, J. M. MacGregor, & H. W. Kramer

Park Kentucky Bluegrass seed is produced on both organic and mineral soils of Roseau County. The effect of fertilizer on seed production on such soils has now been studied for three years.

A. Fertilization of organic (peat) soils.

Two experimental fields were selected during the summer of 1959, and the first fertilizer treatments were made in that autumn and comparable treatments were applied in the spring of 1960. No later treatments were made with the seed yields being taken for 1960, 1961 and 1962. These and the total yield on each treatment for the three year period 1960-62 are shown in the two following tables.

Table 1. The effect of different fertilizer treatments on the 1960-62 yields of Park Kentucky Bluegrass seed on two peat soils of Roseau County.

Charles Habstritt Farm-Roseau (deep peat - seeded 1959)

Nutrients applied (lbs/A.)	1960	1961	1962	Total '60-'62	1960	1961	1962	Total '60-'62
	Pounds of harvested grass seed per acre							
None	54	133	141	328	54	113	141	308
	Fertilized-fall of 1959				Fertilized-spring of 1960			
0+80+0	167	327	164	658	237**	371	262	870
0+80+80	196*	255	200	651	242**	259	313	814
30+80+0	164	247	329	740	218*	272	306	796
30+80+80	197*	265	364	826	146	370	279	795
60+80+80	128	268	305	701	255**	257	249	761
90+80+80	250**	248	350	848	221*	247	261	729
40+20+80	186*	220	354	760	179	220	191	590
33+33+33 (winter)	173	203	----	----	173	203	----	----

The last treatment was a farm operator application of 12+12+12 at the rate of 275#/A.

* L.S.D. (5%) = 128#/A.
** " (1%) = 170#/A.

Table 2. The effect of different fertilizer treatments on the 1960-62 yields of Park Kentucky Bluegrass seed on two peat soils of Roseau County.

Stanley Roadfeldt Farm-Badger (shallow peat - 1957 seeding)

Nutrients applied (lbs./A.)	1960	1961	1962	Total '60-'62	1960	1961	1962	Total '60-'62
	Pounds of harvested grass seed per acre							
None	205	113	212	530	205	113	212	530
	Fertilized-fall of 1959				Fertilized-spring 1960			
0+80+0	382**	192	383	957	300	195	291	786
0+80+80	349**	229	207	785	334*	229	170	733
30+80+0	327*	202	417	946	387**	179	266	832
30+80+80	306	140	375	821	372**	216	450	1038
60+80+80	377**	177	184	738	409**	173	583	1165
90+80+80	331*	223	330	884	365**	144	292	801

It is evident that all of the fertilizer treatments have increased grass seed yields in each year, resulting in a substantial increase for the three year period. The comparative of the fall and of the spring treatments are variable.

* L.S.D. (5%) = 128#/A.
** L.S.D. (1%) = 170#/A.

It was desirable to determine the effect of fall and spring fertilization on a comparatively older stand of Park Kentucky Bluegrass on peat soil which had a sod-bound condition. The experiment was simplified, nitrogen alone and a complete fertilizer being applied in the fall of 1961 and in the spring of 1962 on the same peat field as that reported in the preceding table (Stanley Roadfeldt of Badger).

The 1962 grass seed yield was the fourth harvest and the brief results are shown in Table 3.

Table 3. Yield of Park Kentucky Bluegrass Seed in 1962 on a fourth year harvest on peat soil fertilized after three harvesting years - Stanley Roadfeldt-Badger.

Nutrients applied (lbs./A.)	1962 Grass seed yield in pounds per acre	
None	314	314
	Fertilized-fall 1961	Fertilized-spring 1962
60+0+0	654	447
60+80+80	714	616

The fall fertilization of this fourth year stand on peat readily doubled the grass seed yields, with complete fertilzation being more effective than nitrogen alone. Spring fertilization was not so effective, especially where nitrogen alone was applied.

B. Fertilization of Park Kentucky Bluegrass on Mineral Soils

Several mineral soils were fertilized with different treatments in different years.

A Park Kentucky bluegrass stand on mineral soil was fertilized at the end of the second year - in the fall of 1961 and in the spring of 1962- on the Clifford Foss farm of Badger. The 1962 seed yields are shown in the following table.

Table 4. The effect of fall or of spring fertilization (1961-62) of Park Kentucky Bluegrass on a mineral soil on the 1962 grass seed yield. (Clifford Foss farm - Badger)

Nutrients applied (lbs./A.)	Pounds of grass seed harvested per acre.	
None	130	
	Fertilized-fall 1961	Fertilized-spring 1962
0 +80+ 0	154	207
0 +80+80	176	178
30+80+ 0	323**	299**
30+80+80	368**	256**
60+80+80	429**	344**
90+80+80	377**	413**
90+ 0+ 0	301**	315**
surrounding farm field	265	

L.S.D. (5%) = 95
" (1%) = 114

Nitrogen is the most effective nutrient element, but the inclusion of the two minerals produced additional yield increases. There is little or no yield difference between the fall or the spring fertilization treatments.

A second mineral soil at Pine Creek was fertilied in May of 1962 on the Ray Rice farm with the resulës shown in table 5.

Table 5. The 1962 first year yield of Park Kentucky bluegrass seed on a mineral soil fertilized in May, 1962. (Roy Rice farm-Pine Creek)

Nutrients applied (lbs./A.)	Pounds of grass seed per acre
None	180
30+ 0+ 0	148
30+40+ 0	400**
30+40+40	409**
30+80+ 0	223
30+80+80	300*
30+80+40	354*
60+ 0+ 0	208
60+40+ 0	433**
60+40+40	502**
60+80+ 0	547**
60+80+80	507**
60+80+40	247
farm field	376**

* L.S.D. (5%) = 115
** " (1%) = 155

Phosphorus and nitrogen were the two effective elements for increasing grass seed on this farm-with potassium having very little response.

Winter Versus Spring Fertilization on Park Bluegrass-Mineral Soil

Nitrogen fertilizer alone and a complete fertilizer were spread on the snow lying on two Park Kentucky bluegrass mineral soil fields in February and in April of 1961. Yields were obtained on both fields in 1961, after which one was plowed up. The 1962 yield of grass seed was then obtained on the Magnuson field. Results of both years are shown in table 6.

Table 6. The effect of winter versus spring fertilization of Pakk Kentucky bluegrass seed on two mineral soils.

Nutrients applied (lbs./A.)	Fertilized in Feb., 1961				Fertilized in April, 1962			
	Wold.	Magnuson		Total	Wold	Magnuson		Total
	1961	1961	1962	1961&62	1961	1961	1962	1961&62
	Grass seed yield in pounds per acre							
None	53	39	135	174	53	39	176	215
60+ 0+ 0	60	43	363	406	115	66	310	376
60+80+80	77	97	300	407	113	52	318	370

In the first growing season after fertilization, the grass seed yield on both fields was substantially better on the April fertilization, indicating a probable loss of fertility in the February fertilizer application. However, when the two years yield (of 1961 and 1962) are totalled, the fertilizer applied on the surface of the deep snow in February of 1961 produced a two year grass seed yield at least equivalent to the fertilization applied on bare soil some forty days later. This suggests that over a period of two years or more, fertilizer application on snow can produce satisfactory yield increases.

The Effect of Fertilizer on Yield of Climax Timothy Seed on Mineral Soils in Roseau County

1960-62

Paul M. Burson, J. M. MacGregor, & H.W. Kramer

Roseau County is fast becoming a grass seed producing area which includes both Park bluegrass and Climax timothy. This northern area of Minnesota is well adapted for the production of these graas seed crops. Grass such as timothy is is a basic part of a permanent agriculture for this area. Timothy fits into a forage program. It is an excellent grass crop in mixtures with alfalfa, medium red clover and alsike clover for hay or for pasture. It has a wide range of soil and fertility adaptation and is very palatable for livestock as either hay or pasture. About 5,000 acres of timothy are now being grown in Roseau County for seed production.

In the Fall of 1959 three fields were selected to study the effect of fertilizer on timothy seed production. The two fields selected in Roseau County were on the Clifford Foss and the B.J. Borgen farms while the third was the Andrew Skaar farm in Pennington County. The fertilizer treatments included 80 lbs. of P_2O_5 alone and in combination with 80 lbs. of K_2O with 30, 60 and 90 lbs. of actual nitrogen per acre. On the Borgen and Skaar fields the treatments were applied in the spring of 1960. On the Foss fields the same treatments were applied in the fall of 1959 and on adjacent plots in the spring of 1960. The purpose here was to determine if there was any difference between fall and spring application. The Skaat field was plowed up in 1961, half of the plots on the Foss field were refertilized in the fall of 1961, and a new experiment was applied on the same field in 1961.

The following tables gives the seed yields from the various fertilizer treatment combinations for the years 1960,1961 and 1962. The year 1961 should not be considered as a representative year because of the severe drought from April to September, with the rainfall being 5.75 inches below normal during this period. Timothy is not a productive crop during extreme dry periods, and is better adapted to cool moist conditions typical of the usual growing conditions of northern Minnesota. The yield results for 1960 might be considered as quite representative of what could be expected from the fertilization of timothy for seed production. The growing season of 1962 was one of ample precipitation.

In 1960 the seed yields ranged from 159 lbs. on the unfertilized soil to almost 900 lbs. with a 90 + 80 + 80 treatment. Spring fertilizer applications gave the greater increase in seed production with an average yield of 531 lbs. in comparison to 431 pounds when fertilized in the fall.

Timothy is not subject to as much lodging as some other grasses or grain crops. Some lodging did occur on the 90 lbs. rate of nitrogen plots, however.

On the basis of the present information 60 lbs. of N appears to be adequate in seed production with little or no danger of lodging. For phosphate and potash needs, the soil test should be the basis for this determination, the same as for any other crop.

Table 1. Climax Timothy Seed Yields in 1960-61-62 on Three Mineral Soild in Roseau County.

Nutrients applied (lbs/A.)	1960 Skaar[1]	1960 Foss[2]	1961 Skaar[1]	1961 Foss[2]	1961 Borgen[1]	1962 Foss[2]	1962 Borgen[1]
	Seed yield in pounds per acre						
None	225	159	63	56	76	195	173
0+80+ 0	235	177	141	102	119	180	187
0+80+80	226	173	111	105	104	166	176
30+80+ 0	568	494	134	70	139	442	415
30+80+80	634	505	121	68	113	410	438
60+80+80	815	710	100	80	144	537	470
90+80+80	892	823	103	62	145	522	526
Average fall yield	--	431	--	80	--	368	--
Average spring yield	--	531	--	88	--	401	--

1. Fertilized spring of 1960
2. Fertilized fall of 1959 or spring of 1960 (average yields of spring or fall treatments). 1961 very dry.

It is evident from the results shown on Table 1 that the most substantial increases in timothy seed yields were where NP or NPK fertilizers were applied to these mineral soils. The 1960 increases were somewhat better when fall fertilized, but this was not true in the two following years.

The results shown in Table 2 comprise the total of the two or the three year yields of the fields reported in the preceding table.

Table 2. Cumulative two-or three-year yields of Climax timothy seed in the years 1960-'61-'62 on three Roseau County mineral fields with one
b fertilization.

Nutrients applied (lbs/A.)	Skaar 1960+61 (Fert. spring of '60)	Borgen 1961+62 (Fert. spring of '60)	Foss 1960+61+62 (FERT. fall and spring '59 or '60)
	Total pounds of timothy seed per acre over 2 or 3 yrs.		
None	288	249	410
0+80+ 0	376	306	459
0+80+80	337	280	444
30+80+ 0	702	554	1006
30+80+80	755	551	983
60+80+80	915	614	1327
90+80+80	995	671	1407
Total average-fall	----	----	879
Total avdrage-spring	----	----	1014

The cumulative timothy seed yields of the three fields shown in Table 2 indicate what results a grower might expect for fertilization over a two year or longer period. Increasing amounts of nitrogen were increasingly effective with the inclusion of the two mineral elements. The grower can reasonable expect fertilizer effect for two years or more.

The three year averages on the Foss field indicate that spring fertilization on this mineral soil produced more effective results.

The Foss experimental timothy field of the two previous tables was first fertilized in the fall of 1959 and in the spring of 1960. The 1960 and 1961 seed harvests were removed fromlthese treatments, and it was then decided to refertilize half of these treatments in the fall of 1961 to determine if periodic fertilization would be profitable compared to the initial fertilization alone. The effect of this additional fertilization treatment of late 1961 in comparison to the initial treatment results obtained with the 1959-1960 fertilization only in the 1962 seed yield are shown in Table 3.

Table 3. The 1962 Yield of Climax Timothy Seed Fertilized in 1959-60 in Comparison to Yields Fertilized in 1959-60 and Refertilized in the Fall of 1961-Mineral Soil.

(Clifford Foss Farm-Badger)

Nutrients(lbs/A.) in 1959-60		1962 Yield (lbs/A.)	Additional nutrients (lbs/A) Fall, 1961	1962 Yields (lbs/A.)	Increase for 1961, Fert. (lbs/A.)
None		195	None	262	67
0+80+0	Fall '59	193	40+0 +0	230	37
"	spring '60	166	80+0 +0	454	288
0+80+80	fall '59	174	40+40+0	635	461
"	spring '60	157	80+40+0	596	439
30+80+0	fall '59	385	40+40+40	585	200
"	spring '60	498	40+ 0+40	458	-40
30+80+80	fall '59	397	40+40+20	422	25
"	spring '60	423	80+40+40	589	166
60+80+80	fall '59	436	80+ 0+40	330	-106
"	spring '60	638	30+ 0+0	351	-287
90+80+80	fall '59	521	60+ 0+0	359	Θ162
"	spring '60	523	90+ 0+0	429	-94

The results shown on Table 3 are important, since the second fertilization late in 1961 emphasizes the value of phosphorus fertilization. Good yield increases were obtained where this element was included with nitrogen on this mineral soil. Nitrogen or nitrogen-potash resulted in decreased 1962 seed yields.

Effect of Fertilizers on Timothy Seed Yields in Clearwater County

Harley Shurson, Arnold Heikkala, Curtis Klint and Merle Halverson

A demonstration was laid out on an established stand of timothy growing on an organic soil of low phosphorus and potassium status. The pu pose was to measure the effects of time and rate-of-application of nitrogen, phosphorus, and potassium fertilizers on seed yield. A complete factorial design including two application times (fall vs. spring), two rates of nitrogen (0 and 33 lbs/A as ammonium nitrate), three rates of phosphorus,(35, 70 and 105 lb. P_2O_5 as triple superphosphate) and two rates of potassium (23 and 92 lbs. K_2O/acre as muriate of potash)was used. The design was repliated 3 times. Individual plot dimension was 15' x 15'.

Seed yields were harvested in the fall of 1961, yields per acre calculated and the data subjected to statistical analysis.

Results

Table 1. Effect of time of application and rate of nitrogen on yield of timothy seed. (each yield is the average of 18 plots receiving the indicated treatment)

N rate, lb/A	Seed yields, lb/A N applied fall, 1960	N applied spring 1961
0	248	248
33	327	407

A highly significant interaction between application time and nitrogen response was found. Yield increases due to 33lb/A spring applied nitrogen were essentially double those obtained with fall application of the identical nitrogen rate.

Though high in total nitrogen, raw sedge peats of this type may decompose slowly and provide little nitrogen in a form available to plants. This is because their wide carbon: nitrogen ratio is unsuited to the dietary needs of soil microorganisms. In the present case, it is possible that the small amount of added fertilizer nitrogen may have hastened decomposition with an increase in production of available nitrogen from the soil source.

Table 2. Effect of phosphorus and potassium on yield of timothy seed (each yield is an average of 12 plots receiving the indicated treatment).

K_2O rate lb/A	Seed yield, lb/A P_2O_5 rate lb/A		
	35	70	140
23	334	268	299
92	283	341	324

A highly significant interaction between phosphorus rates and potassium rates was noted. Increasing the potassium rate from 23 to 92 lbs/A at the 35 lb/A P_2O_5 rate produced a significant yield decrease. At the 70 and 140 lbs/A P_2O_5 rates, however, significant yield increases occurred when the K_2O rate was increased from 23 to 92 lb/A. These findings serve to emphasize that phosphorus and potassium were both in critical short supply on this soil in terms of the needs of the timothy crop for seed production.

The following additional findings are of interest.

- Phosphorus and potasssium were as effective in fall as in spring application.

- The effects of phosphorus and potassium upon yield occurred both in the presence and absence of added nitrogen.

Woodchip (sawdust)- Nitrogen Experiment on Potatoes
Grand Rapids Experiment Station

W. P. Martin, A. C. Caldwell, M. V. Halverson

Yield Results - 1962

Object: To determine how woodchips or sawdust used as a soil conditioner will influence potato yields with and without supplementary nitrogen and also to measure residual effects.

Soil type: Unnamed fine sandy loam soil related to the Nebish gray-wooded soils.

Crops: Potatoes first year: small-grain second without furthur treatment to check on residuals.

Woodchips (or sawdust): W_o = none: W_1 = 5 tons/ac.; and W_2 = 15 tons/Ac. placed on surface and disked in.

Fertilization:

250 lbs 0-0-60 applied preplant and plowed down throughout.
335 lbs 12-24-12 band placed at planting time throughout.
N_0 = no additional nitrogen; N_1 = 360 lbs/ac. 33.3-0-0 applied preplant and plowed down; and N_2 = 540 lbs/ac. 33.3-0-0 plowed down and 540 lbs./ac. also applied side-dress 3 wks. after emergence.

There are nine combination treatments and five replications (45 plots) in the experiment.

	N_o	N_1	N_2	Ave.
W_o	214 bu.	188 bu.	178 bu.	193 bu.
W_1	211	151	158	173
W_2	176	148	163	162
Ave.:	200	162	166	176

FERTILITY STUDIES ON ORGANIC SOILS AT HOLLANDALE, 1962

R. S. Farnham

The fertility studies on organic soils in the Hollandale area commenced in 1960 were continued in 1962 with emphasis on placement of straight materials.

The pH of this partly decomposed organic soil was 7.0 to 7.2; extractable P (Bray's No. 1) was very high; and extractable K was very high. The plot area was tiled and is located about ½ mile west of the 1961 site on the same type of organic soil.

The plot design was a randomized block using 12 treatments replicated four times. All fertilizer was applied below and to the side (row placed) of the potato tubers at planting time. Plots were harvested October 18 and total yield of potatoes and specific gravity data are shown in Table 1.

Table 1. Yield and specific gravity of cobbler potatoes, 1962.

Number		Treatment N P K	Total Yield Cwt./Acre	Yield Increase Cwt./Acre	Specific Gravity	Total Solids %
1	CHECK	0-0-0	273	--	1.062	16.0
2		0-50-0	288	15	1.064	16.5
3		0-100-0	280	7	1.064	16.5
4		0-200-0	286	13	1.065	16.6
5		0-0-100	262	-11	1.062	16.0
6		0-50-100	314	41	1.064	16.5
7		0-100-100	319	46	1.065	16.6
8		0-200-100	306	33	1.066	16.8
9		0-0-300	304	31	1.065	16.6
10		0-50-300	316	43	1.060	15.7
11		0-100-300	259	-14	1.062	16.0
12		0-200-300	299	26	1.065	16.6

Yield increases from 40 to 46 hundred weight were obtained where phosphorus and potassium were applied in the proper combinations. Potassium alone at the 300 lb. K_2O rate was more effective than phosphorus alone. Apparently there is a PK interaction effect.

Specific gravity does not appear to be affected by any of the treatments, although a slight increase was noted where the P and K were in the best combinations.

This is the second year in succession that highly significant yield increases have been obtained despite very high soil test values before fertilizing. Also the high yield increases were obtained this year despite unfavorable weather conditions - high rainfall and very cool growing season. This is probably due to the placement of fertilizer instead of broadcasting.

Fertilizer Experiments with Cucumbers - 1962

R. S. Farnham and John Grava

Location: M. A. Gedney Co's. Research Farm, Silver Lake (McLeod Co) Minnesota

Materials and Methods:

Soil Type: Lester loam
Percent O.M.: 6.4 (very high)
pH: 7.0 (neutral)
Extractable phosphorus: 16 lbs/A (medium)
Exchangeable potassium: 170 lbs/A (medium)

Variety: SMR 15

Plot Design:

Two separate experiments, one a nitrogen placement study and the other a phosphorus and potassium study to determine the most economical fertilizer application for pickling cucumbers.

Spacing between hill planted cucumbers was 42" x 42". Each plot contained 9 hills and there were 4 replications.

It was calculated that 5,762 plants (hills) constitute an acre and these figures were used to determine fertilizer needs per hill. Fertilizer was hill placed in a 6 inch circle around the germinating plants at a depth of about 2 inches below seed. This was approximately one week after planting.

Some nitrogen was hill placed at time of planting and the remainder side dressed after appearance of first female bloom (approximately July 10th).

All plots were harvested by hand at least every three days and pickles were sorted and sized into the 5 pickle grades - 1A, 1B, 2, 3, 4.

Rainfall Data:

	1962	1961
July	2.8"	.7"
August	5.5	2.4
Sept. 15	3.5	3.4
	11.8"	6.5"

Temperature:

Ave. High for 1962 growing season 76.7° F.
Ave. Low for 1962 growing season 57.3° F.

Results and Discussion:

Table 1 shows the results of the fertilizer trials on cucumbers in 1962 at Silver Lake, Minnesota.

The nitrogen placement studies show that hill applied nitrogen shortly after planting gave the best results. Side dress applications alone after the first bloom were not as effective as the hill applied and even caused a decrease in yield in one case.

Nitrogen, phosphorus and potassium in combination gave the biggest yield increases varying from 254 to 321 bushels above the 30-0-0 treatment. The 30-120-120 application produced the biggest yield-632 bushels.

Table 2 gives the percent and value by pickle grades (sizes) and total return in gross dollar value per acre for the various combinations of N-P-K. The treatment which produced the highest dollar value per acre was the 30-120-60 which totaled $ 903.30 gross return. This was due to the highest percent 1A and 1B grades which are worth more per pound.

No. 1A size is worth $7\frac{1}{4}$ ¢ per pound
No. 1B " " " 4.5 ¢ " "
No. 2 " " " 2.9 ¢ " "
No. 3 " " " 1.5 ¢ " "
No. 4 " " " 1.0 ¢ " "

Fertilizers producing the highest dollar value of the more expensive sizes are the most economical to use on pickling cucumbers.

Potassium alone with blanket nitrogen was more effective than phosphorus alone.

It is concluded that highly significant yield increases can be obtained on this soil with a relatively small investment in fertilizer. In fact the most profitable rate (30-60-120) produced a groww return of $ 903.30 per acre with a fertilizer investment of less than $ 25.00 per acre. This is about double the return where no P and K were applied.

1962 Cucumber Fertility Plots
Silver Lake, Minn.

Treatments

No.	Experiment I	NITROGEN PLACEMENT
1	0-60-60	All plots received 60# P_2O_5
2	30H-60-60	all 60# K_2O
3	60H-60-60	
4	30SD-60-60	SD-Side Dress N after first
5	30SD, 30H-60-60	female bloom. H-Hill
6	30SD, 60H-60-60	application of N at regular
7	60SD-60-60	fertilizer time.
8	60SD, 30H-60-60	
9	60SD, 60H-6060	

No.	Experiment II N - P - K	PHOSPHORUS AND POTASSIUM EXPERIMENT
10	30-0-0	Nitrogen applied at 30# N rate
11	30-60-0	on all plots.
12	30-120-0	
13	30-0-60	P and K variable.
14	30-60-60	
15	30-120-60	
16	30-0-120	
17	30-60-120	
18	30-120-120	

Table 1. Results of fertilizer trials on cucumbers - 1962

1962 Silver Lake Fertilizer Trials

NITROGEN PLACEMENT

Plot No.	Treatment	1A	1B	No.2	No.3	No.4	Total lbs.	Lbs. per Acre	Bushels per Acre
1	0-60-60	16.3	28.8	42.	50.	9.4	146.5	25,862	517
2	30H-60-60	18.7	27.3	48.3	52.6	11.3	158.3	28,137	563
3	60H-60-60	15.8	23.1	49.8	60.5	12.9	153.1	27,213	544
4	30SD-60-60	15.3	24.4	46.4	43.3	11.9	141.1	25,080	501
5	30SD-30H-60-60	15.6	25.6	43.	45.7	21.1	151.1	26,858	537
6	30SD, 60H-60-60	17.1	24.1	42.2	51.1	9.8	144.3	25,649	513
7	60SD-60-60	14.4	25.6	42.	56.4	12.9	151.3	26,893	537
8	60SD, 30H-60-60	18.4	29.	45.3	48.7	13.4	155.	27,551	551
9	60SD, 60H-60-60	16.1	23.6	42.3	56.	15.9	153.8	27,337	547

SD=Side Dressing
All plots received 60# P_2O_5 and 60# K_2O.
N after first female bloom. H-Hill. Application of N at regular fertilizer time.

PHOSPHORUS AND POTASSIUM EXPERIMENT

Plot No.	Treatment	1A	1B	No.2	No.3	No.4	Total #	# per Acre	Bu. per Acre
10	30-0-0	7.4	15.8	30.9	25.9	7.7	87.6	15,570	311
11	30-60-0	9.5	14.8	26.3	32.3	12.7	95.6	16,992	339
12	30-120-0	10.4	19.1	26.9	32.	12.5	100.9	17,934	359
13	30-0-60	9.7	17.7	30.5	37.4	7.4	102.7	18,254	365
14	30-60-60	16.4	29.	45.6	49.9	18.	159.1	28,280	565
15	30-120-60	18.2	27.7	46.8	65.2	18.1	176.	31,284	625
16	30-0-120	12.5	16.7	32.	38.7	15.9	115.7	20,565	411
17	30-60-120	16.8	28.6	45.8	62.1	14.2	167.4	29,755	595
18	30-120-120	14.2	26.5	54.6	65.1	17.5	177.9	31,620	632

Nitrogen applied at 30# N rate on all plots.

P and K variable.

Table 2. PHOSPHORUS AND POTASSIUM EXPERIMENT - PERCENT AND VALUE BY PICKLE GRADES AND TOTAL VALUE OF PICKLING CUCUMBERS

	Treatment	1 A		1 B		2		3		4		Total
		%	Value	%	Value	%	Value	%	Value	%	Value	Value
10.	30-0-0	8.45	$95.38	18.04	$126.40	35.27	$159.25	29.57	$69.06	8.79	$13.69	$463.78
11.	30-60-0	9.94	122.45	15.48	118.37	27.51	135.56	33.79	86.12	13.28	22.56	485.06
12.	30-120-0	10.31	134.05	18.93	152.77	26.66	138.65	31.71	85.30	12.39	22.22	532.99
13.	30-0-60	9.44	124.93	17.23	141.53	29.70	157.22	36.42	99.72	7.20	13.14	536.54
14.	30-60-60	10.31	211.38	18.23	231.99	28.66	235.05	31.36	133.03	11.31	31.98	843.43
15.	30-120-60	10.34	234.52	15.04	221.58	26.59	241.23	37.04	173.81	10.28	32.16	903.30
16.	30-0-120	10.80	101.02	14.43	133.54	27.66	164.96	33.45	103.18	13.74	28.26	590.96
17.	30-60-120	10.04	216.59	17.08	228.70	27.36	236.09	37.10	165.59	8.48	25.23	872.20
18.	30-120-120	7.98	182.94	14.90	212.01	30.69	281.42	36.59	173.55	9.84	31.11	881.03

Nitrogen Fertilization Studies on Turf - 1962

R. S. Farnham

Nitrogen fertilization studies on bluegrass turf were continued in 1962 and a greenhouse study on turf was added. Objectives of these studies were as follows:

1. Compare the effectiveness of several slow-release nitrogen fertilizers on yield and color of Kentucky bluegrass turf.

2. To determine the optimum nitrogen rate needed when applied as a single application in late spring.

3. To evaluate the effectiveness of several new coated nitrogen materials, slow-release chemicals, and organic nitrogen forms in supplying nitrogen to grass during the growing season.

Materials and Methods

Nitrogen fertilizer materials included in the study were ammonium nitrate, urea, law grades of fertilizer such as 20-10-5, 16-8-8, 10-10-10, organics and several experimental products supplied by Spencer Chemical Co. The inorganic nitrogen forms were both coated and uncoated. The coated fertilizers were supplied by Archer-Daniels-Midland Co.

Nitrogen was applied at 4 and 8 pounds of N per 1000 sq. ft. rates. Phosphorus and potassium were applied on all plots in amounts equivalent to 8 lbs. of P_2O_5 and K_2O per 1000 sq. ft. All materials were applied in May on dry turf and thoroughly wet immediately after application. Notes on burning were kept for first month.

Plots were located west of the Farm Shop on the campus and the size of each was 5' x 10'. Thirty-two treatments were applied and clippings were made at two week intervals from June 1st to October 15th. Color comparisons were made periodically during the season.

Greenhouse plots were 18" x 18" cut sods obtained from a commercial sod grower. Optimum soil moisture was maintained by adding water as needed and temperature was kept relatively warm.

Results and Discussion

Total clipping yields and color ratings are shown in Table1, for the outside turf study and greenhouse results shown in Table 2.

1. Coated nitrogen materials for the third year in succession were superior to any of the other fertilizers as shown by highest yield of clippings and high color rating. Eight pounds of nitrogen/ 1000 sq. ft. in one application appears to be significant to maintain good growth and high quality for an entire season. Coated 10-10-10 and 20-10-5 were the highest yielding materials although this year milorganite was third. This is probably due to the above average rainfall which would favor the organics and slow-release types over the highly soluble and readily leached nitrogen materials.

2. Burning of grass shortly after applying was evident on several of the uncoated highly soluble materials at the 8 lbs. of N/1000 sq. ft. rate. The organics, coated fertilizers, and slow-release chemicals did not burn.

3. The coated 10-10-10 at the 4 lb. N/1000[2] rate was the highest yielder in the greenhouse tests. One of the organics developed fm m peat also produced high yields. Some of the urea and urea-form materials performed better in the greenhouse than in the field although only the lower rate (4lb. N/1000) was used in the greenhouse.

No burning was noticed in the greenhouse study which is probably due to the high organic sod used.

Table 1. 1962 Turf Plots total clipping yields and color ratings

No	Treatment	Rate lb. N/1000ft.^{2}	Total clippings Gms/1000 ft.^{2}	Rank	Ave Color rating	Early burn damage
7	10-10-10 coated (ADM)	8	62,938	1	6.5	none
9	20-10-5 coated (ADM)	8	61,144	2	8.0	"
19	Milorganite	8	57,922	3	7.0	"
6	10-10-10 uncoated	4	57,689	4	4.5	"
5	10-10-10 coated (ADM)	4	56,516	5	7.0	"
13	NH_4NO_3 coated (ADM)	8	56,478	6	8.0	"
27	16-8-8 1/2 coated 1/2 uncoated (ADM)	8	56,111	7	6.0	"
1	16-8-8 coated (ADM)	4	53,217	8	6.0	"
24	Spencer 30-10-0 coated	8	52,822	9	7.0	Slight
29	NH_4NO_3 1/2 coated 1/2 uncoated (ADM)	8	52,756	10	8.0	None
23	Spencer 34-0-0 S 4383	8	52,578	11	7.5	Slight
28	Spencer 34-0-0 1/2 30-10-0 1/2	8	52,467	12	7.5	None
10	20-10-5 uncoated	8	52,428	13	7.5	Slight
8	10-10-10 uncoated	8	52,406	14	7.0	None
18	Milorganite	4	52,322	15	6.0	"
3	16-8-8 coated	8	52,250	16	6.5	"
26	16-8-8 1/3 coated 1/3 uncoated 1/3 NH_4NO_3 (C)	8	51,878	17	6.5	"
21	Spencer 32-0-0 S 4238	8	51,562	18	6.5	Slight
11	NH_4NO_3 coated	4	51,162	19	5.5	"
2	k6-8-8 uncoated	4	49,784	20	6.0	"
32	20-10-5 1/2 coated 1/2 uncoated	8	49,484	21	6.5	Non e
12	NH_4NO_3 uncoated	4	48,712	22	7.0	None
22	Spencer 34-0-0 S 4383	4	47,001	23	7.0	Slight

Table 1. Con't.

16	Urea heavy coated	8	44,751	24	7.0	Slight
17	Ca Anthraxillate (Belgium)	8	44,751	25	6.5	"
25	Spencer 30-10-0 coated	8	44,634	26	6.0	None
15	Urea med. coated	8	44,118	27	5.5	Slight
14	NH_4NO_3 uncoated 32-0-0	8	43,540	28	5.0	Severe
20	Spencer 32-0-0 S 4238	4	42,574	29	7.5	Slight
31	Check	0	42,435	30	5.5	None
30	Check	0	42,285	31	4.5	"
4	16-8-8 uncoated	8	42,096	32	6.5	Severe

Table 2. 1962 Greenhouse Turf Fertilization Studies

No	Treatment	Rate lbs. N/1000 ft.^{2}	Rep I gms.	Rep II gms.	Total Reps gms.	Rank
2	10-10-10 coated	4	106.88	108.18	215.16	1
9	Spencer 34-0-0 S 4383	4	96.19	96.27	192.46	2
11	Organic (85) 1/4" rate	4	97.28	94.88	192.16	3
7	Urea uncoated	4	86.11	96.06	182.17	4
6	NH_4NO_3 coated	4	81.99	99.95	181.94	5
13	Nitroform	4	102.29	76.26	178.55	6
1	10-10-10 uncoated	4	72.96	100.23	173.19	7
8	Urea medium coated	4	81.93	86.20	168.13	8
10	Milorganite	4	82.87	85.04	167.91	9
5	NH_4NO_3 uncoated	4	74.85	88.24	163.09	10
4	20-10-5 coated	4	84.36	76.09	160.45	11
3	20-10-5 uncoated	4	62.81	94.72	157.53	12
14	Check no fert.	0	71.95	73.05	145.00	13
12	Organic (81)	0	68.79	69.88	138.67	14