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Page	Staff Member	(Expt. Sta) or Location (County)	Preceding Crop	Soil Type	Soil Moist in Experiment Year	Soil Test Information pH	OM	P	K
11	Lowell Hanson, J. Grava	given in text							
44	Grava, Rust, etal.	The Necessary information is given in text							
68	Caldwell, Kline	Goodhue County		Fayette si.l.		7.0		M	
69	Caldwell	Rosemount	given in text	Port Byron si.l.		6.5	3.0	M	M
71	Caldwell	Rosemount		Port Byron si.l.		5.8	4.2	M	M
74	Martin	Nicollet County		Webster c.l.		6.8	—	14	170
81	Caldwell, Kline	Waseca		Nicollet	below normal	5.7	6.9	16-32	175-280
82	Caldwell, Kline	Morris	To complex for appendix	Barnes	very low	7.1	4.6	9	280+
83	Caldwell, Kline	Crookston		Bearden		7.6	5.1	14	280+
95	Overdahl	Wadena County			below normal	given in text			
96	Overdahl	Wadena County			below normal	given in text			
96	Caldwell	Rosemount	corn	Port Byron		6.2	4.0	Low	M
97	Soils Unit (Martin)	Rosemount	corn	Port Byron si.c.l.		5.8		17	105
99	Lowell Hanson	Meeker County	corn	Wadena l.	below normal	6.5	Med.	15 med.	80 Low
101	Overdahl	S. Western Counties			normal				
104	Burson, Rost	Rosemount	corn	Port Byron si.l.			Low	Med-Low	M-L

Page	Staff Member	Location	Crop	Soil Type	Year	pH	O.M.	P	K
116	MacGregor etal.	given in text							
124	Blake and MacGregor	Waseca							
127	Blake and MacGregor	Morris							
131	Caldwell and Halverson	Clay County	Alf.	Bearden si.l.				low	high
132	Caldwell and Weber	Rosemount		Port Byron		6.5	5.0	low	low
133	Burson and Rost			Port Byron si.l.		6.5	M	M	L-M
138	Burson, Arneman, etal.	Necessary information is given							
141	MacGregor	Rosemount	Alf.	Port Byron si.l.		5.2 limed to 7.5			
144	Burau and MacGregor	Polk County etal.				All calcareous soils			
148	MacGregor and Hanson	Several areas				Five soils of different pH and fertility.			
151	Hanson, Hrug	Wabasha County		Fayette si.l.	above ave.		high	high	si.l.
152	Burson, etal.	Rosemount	pasture	Port Byron si.l. —		6.5	M	M	L-M
154	Burson	Rosemount		" "		"	"	"	"
156	Burson, Holcomb	Rosemount		" "		"	"	"	"
159	Caldwell etal.	Grand Rapids		Unclass		6.1		VH	M
159	"	Crookston				given in text			
160	"	R.R. Valley Potato Research Farm				"	"	"	
161	Overdahl	St. Cloud				"	"	"	
163	Arneman	Necessary information is given							
164	Hermanson and Farnham	Wright County		Peat				Low	Low
167	Hermanson and Farnham	Clearwater County	meadow	Peat				V.Low	V.Low
169	Hermanson and Farnham	Aitkin County(1957)		Fibrous Peat	Average	5.7		V.High	M
170	Hermanson and Farnham	Aitkin County (1958)	wild growth	"	below normal	5.1		Low	V.Low
173	Hermanson and Farnham	St. Louis County		Fibrous Peat		5.2		18. Med	35 V.L.

Page	Staff Member	Location	Crop	Soil Type	Year	pH	O.M.	P	K
175	Hermanson and Farmham	Grand Rapids	Virgin Pasture	Peat		3.8		6 Low	50 V.Low
176	Hermanson and Farnham	Aitkin County		Fibrous Peat	Average	5.6		8 Low	48 V.Low
178	Farnham etal.	St. Louis County	Virgin	Fibrous Peat		5.2		18 Med.	35 V.L.
180	MacGregor	Rosemount		Port Byron si.l.	Above Average	6.5	M	M	L-M

A Report on Soils and Soil Fertility

(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, Morris, Rosemount, and Waseca).

University of Minnesota

April, 1960

The results herein reported are largely based on experiments carried on in 1959 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 laboratory. Because these are largely single year results, general conclusions are not in order and results are not for publication. Additional information on field location, soil tests, previous cropping history, and other data from each field are included in the appendix.

Minnesota Weather During the ~~1960~~ 1959 Growing Season

From April through September, temperatures were above normal, the greatest increase occurring in the central portion of the state. At the same time, summer precipitation was above normal in the southern and in the northern sections, with many portions of the central area suffering drouth conditions in late July and August. The elevated temperatures and deficient precipitation resulted in a substantial lowering of possible crop yields in the most seriously moisture deficient central Minnesota areas.

The Recent Climatic Change

Donald G. Baker

Average summer, winter and annual temperatures were determined for several time periods at 19 Minnesota stations. Based on linear regression equation the stations showed an average summer, winter and annual increase of 1.4, 3.7, and 1.3°F., respectively, for the period 1900-1958. It appears that the recent warming began about 100 years ago.

The cause or causes of the warming trend are not yet definitely established. Therefore no prediction can be made whether or not the trend will continue.

For agriculture the essential point is that warmer air can evaporate more water; therefore of the precipitation that does fall more water is evaporated into the atmosphere and less is available for plant growth.

If the warming trend should continue, there may be a gradual shifting of crop boundaries northward, and, assuming precipitation does not change, a greater hardship will be placed upon those areas already in a marginal moisture position.

This study is being continued to determine if equivalent temperature changes have also occurred in the spring and fall, and if there have been any noticeable trends in seasonal and annual precipitation totals.

PRESENT STATUS OF THE MINNESOTA SOIL SURVEY - (1960)

Counties surveyed:	Year of Survey	
Blue Earth (Detailed survey)	1906	Out of print
Rice (Detailed survey)	1909	"
Goodhue (Detailed survey)	1913	"
Ramsey (Detailed survey)	1914	"
Pennington (Detailed survey)	1914	"
Anoka (Detailed survey)	1916	"
Stevens (Detailed survey)	1919	"
Jackson (Detailed survey)	1923	Limited supply
Olmsted (Detailed survey)	1923	"
Lac qui Parle (Detailed survey)	1924	"
Wadena (Detailed survey)	1926	"
Lake of the Woods (Reconnaissance survey)	1926	
Mille Lacs (Part detailed, part reconnaissance)	1927	
Hennepin (Detailed survey)	1929	Out of print
Houston (Detailed survey)	1929	"
Hubbard (Detailed survey)	1930	"
Kanabec (Part detailed, part reconnaissance)	1933	Limited supply
Red River Valley Counties (Reconnaissance survey)	1933	
Traverse, Polk		
Wilkin, Red Lake		
Clay, Marshall		
Norman, Kittson		
Pine (Part detailed, part reconnaissance)	1935	
Roseau (Detailed Reconnaissance survey)	1936	
Winona	1941	Limited supply
Rock (Detailed survey)	1950	
Brown (Semi detailed survey)	1951	
Washington	1952	Limited supply
LeSueur (Semi detailed survey)	1954	
McLeod (Detailed survey)	1955	
Mower (Detailed survey)	1956	
Faribault (Detailed survey)	1957	
Fillmore (Detailed survey)	1958	
Isanti (Detailed survey)	1958	
Nicollet (Detailed survey)	1958	
Scott (Detailed survey)	1959	

Counties being surveyed or maps being published:

Dakota	Crow Wing
Dodge	Wright
Wabasha	Sherburne

The soil maps and reports are published and distributed by the U. S. Department of Agriculture; the Minnesota Agricultural Experiment Station does not generally supply them, but a limited number of copies are on hand and are available as long as the supply lasts. Requests should be made to Department of Soils, Institute of Agriculture, St. Paul 1, Minnesota. Free copies of the maps and reports also may be obtained from a Minnesota representative in Congress as long as his supply lasts or from the Office of Information, U. S. Department of Agriculture, Washington 25, D. C. After their copies are exhausted, copies may be purchased for a fee from the Superintendent of Documents, Government Printing office, Washington 25, D. C. Some of the early reports are now out of print but may be consulted in libraries throughout the state.

Soil Productivity Study

R. H. Rust and J. E. Foss

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.

To date just over 300 farm cooperators are participating by providing annual crop and soil management data on about 325 fields. Of an original selection of about 90 extensive soil types data is being received on some 60 different soils. Examples of the data being recorded are as follows: date and rate of seeding; estimate of stand; soil amendments used in kind and amount; moisture and temperature conditions throughout growing season; weed and insect control measures; date of harvesting; yield and losses to yield from harvesting or abnormal conditions; soil tests for pH, available P and K, organic matter.

Since the estimates are to be based on multiple regression analysis, relatively large numbers of observations (in general more than 30) of each crop on the various soils are necessary in order to establish reliability. In order to reflect some notion of the yield variability associated with weather observations must be spaced geographically and in time (i.e. over some minimum period of years - 5 to 10).

With the foregoing limitations it is not yet possible to make completely reliable statements about the data. It does, however, seem possible to indicate certain relationships associated with higher yields, particularly of corn. The following comments (except no. 9) are derived from a study of yields reported on Clarion, Hayden, and Webster soils. Clarion soils were developed under grass vegetation with good profile drainage on calcareous clay loam till. Hayden soils are similar in topography and parent material but were developed under forest vegetation. Webster soils developed on similar parent materials as Clarion and Hayden but under slough-grass cover.

1. In the 3 year period 1956-58 the summer rainfall (June through August) ranged in two general amounts (1) a total of about 5-6 inches and (2) a total of 11-13 inches. The difference in corn yields (not adjusted for other factors) was about 30 bushels for the higher amount, or about 3-4 bushels per additional inch.

2. Contrary to expectation, there was no overall increase in yield associated with increased stands (ranging from about 12 to 24,000 plants per acre). This result seems to be due to the part that several stands in excess of 20,000 were found in areas of low rainfall (5-6 inches) and suffered definite yield depression. On the other hand, some stands of about 12,000 plants were in areas of higher rainfall (and coupled with adequate fertility, etc.) produced above average yields. The average stand reported on these three soils for this 3-year period was about 17,000 per acre (near to current recommendations).

3. As regards the use of the major nutrients--N, P, and K--the following relationships appear.

   a. There is an apparent increase of about 10 bushels corn yield per acre with the use of about 100 pounds N in the form of legumes or manufactured nitrogen. In the seasons of 11-13 inches rainfall the increase seemed to be about 20 bushels for this amount of N whereas, with 5-6 inches of rainfall there seemed to be less than 5 bushels per acre increase.

   b. There is an apparent increase of about 15 bushels per acre for P applications increasing from about 20 to 80 pounds per acre (i.e. no applications below 20 pounds recorded), or about 1 bushel for 4 pounds P_2O_5 equivalent. This is P from manures and manufactured products. Webster soils also show a similar increase for P.

   c. There is an apparent increase of about 15 bushels per acre on Clarion and Hayden for K applications increasing from 20 to 120 pounds per acre. This is K applied in manures and commercial fertilizers. The apparent increase is greater on Hayden (timered) than on Clarion (grass-developed) soils.

4. The average harvesting loss is reported as about 5 percent, ranging from a few percent to 15 percent.

5. Approximately 20 percent of the cooperators used chemical weed control.

6. The average maturity rating of corn hybrids planted for grain was about 105 days.

7. The approximate rotation used was R-R-R-G-M on the Clarion soils; R-R-G-M-M on Hayden; and R-R-G-M on the Webster (R=row crop, G=grain, M=meadow).

8. The average corn yields reported for 1956-58 was 73 bushels per acre on Clarion, 95 bushels on Hayden, and 88 bushels on the Webster. There was a wide variation in reported yields, ranging from 48 to 146 bushels per acre.

9. Cooperators were asked to estimate crop production losses from a number of hazards. The following table gives the percentage of fields having significant crop losses (more than about 15% of the crop).

Table 3. Per cent of fields having crop losses from various hazards. (all soils)

	Corn	Oats	Alfalfa	Alfalfa-Brome	Soybeans	Other Small Grains
Disease	3	10	0	0	0	8
Flood	10	10	14	7	10	11
Frost	1	0	0	2	0	0
Hail	3	7	2	2	23	6
Insects	14	0	4	12	3	3
None reported	69	73	80	77	64	72

On about 30 per cent of the fields significant losses were reported and, on the average, flooding reduced yields on about 10 per cent of the fields.

MINNESOTA-TEST DEMONSTRATION PROJECT

Roger Harris

This program will run for five years, 1958 through 1962, in five north central Minnesota counties. They are Crow Wing, Hubbard, East Otter Tail, Todd, and Wadena. Twenty-five cooperating farms are participating.

The Tennessee Valley Authority is cooperating in the project, especially in supplying fertilizing material at a reduced cost. The study will attempt to determine the degree of excellence of newer fertilizing materials in addition to other objectives.

Aims and Objectives

The principal aim of this project is to test and demonstrate the adjustments in farm practices and farm organizations that are expected to improve farm income in the selected area. It is hoped that the economic impact of adjustments in specific farm practices such as fertilizing according to soil test recommendations, improved pasture management, and improved feed rations can be ascertained and demonstrated to other farmers. The impact of improved technology on the over-all crop and livestock organization of an individual farm unit will also be determined and demonstrated.

The soils of the area are generally low to medium in nitrogen, high in phosphorus, and low in potash. They are mostly sandy to sandy loam and were developed under forest conditions. On most farms of the area (dairy) feed production, farm income, and enterprise management pose the more important problems.

In order to meet the fertility requirements in an efficient manner "straight goods" were blended locally in order to supply adaptable grades. They are as follows:

Small grain (oats)	15-5-30
Alfalfa	0-15-45
Corn (starter)	10-20-30
Corn (sidedressing)	30-10-0

With only two crop years completed nothing conclusive has been determined as to results. Low starting fertility level, dry seasons, and financing problems have made for a slow start of the program.

In general, to date (1/1/60) our observations as to fertilizer results are as follows:

Oats - Yield increases ranged from 7 to 15 bushels increase per acre. This is not sufficient to pay for the fertilizer. Fertilizing of oats only when seeded down to hay or pasture mixtures is now the recommendation.

Corn for Silage - The average increase has amounted to three tons per acre. This resulted in a net gain over fertilizer cost of a $10 per acre average. The added forage was much needed.

Corn for Grain - Practically no corn for grain was harvested in 1958 due to extreme drouth. In 1959 the average increase (8 fields) was 15.59 bushels per acre representing more feed and a dollar margin of $4.21 per acre over cost of fertilizer.

Hay - 1960 will be the first year for yield check on tame hay in the program.

Each year of the project the complete farm records of the cooperators have been and will be analyzed by the University Farm Management section.

Out of the program will come results of such farm business reorganization possible from the optimum fertilization and land use changes.

A Few Statistics About Your Soil Testing Laboratory

By John Grava

More than 200,000 samples have been analyzed by the University of Minnesota Soil Testing Laboratory in the last eleven years. Starting with 3000 samples tested in 1949, the volume has grown to more than 30,000 samples in 1959.

Table 1. Soil testing activity in Minnesota as shown by the number of samples tested annually.

Year	Number of Soil Samples
1949	3,054
1950	12,994
1951	10,778
1952	14,357
1953	16,783
1954	20,192
1955	19,108
1956	19,951
1957	23,591
1958	29,855
1959	33,491
	203,958

The distribution of samples received from individual counties is shown in Figure 1.

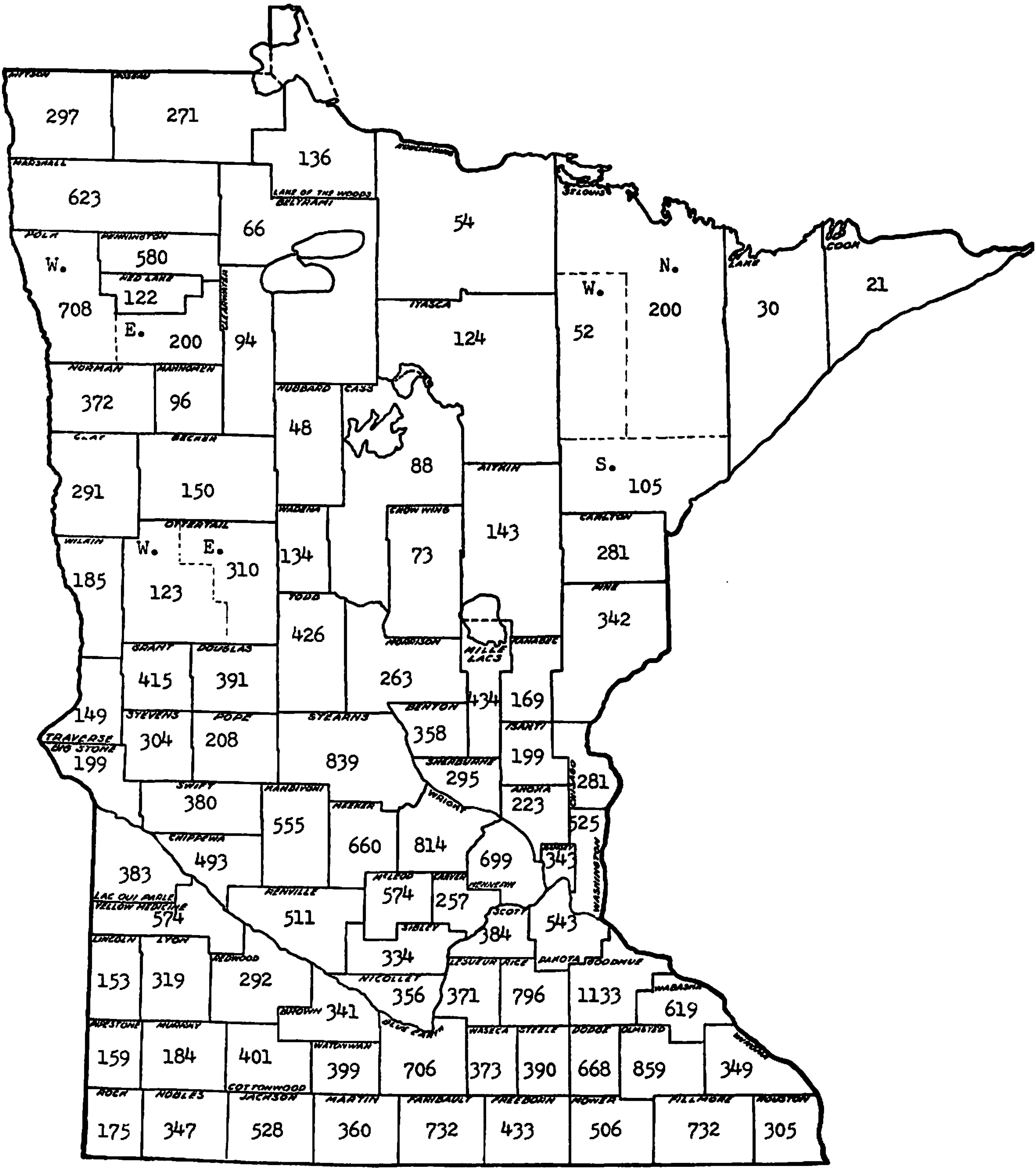

Figure 1. Number of soil samples received per county by University of Minnesota Soil Testing Laboratory during 1959.

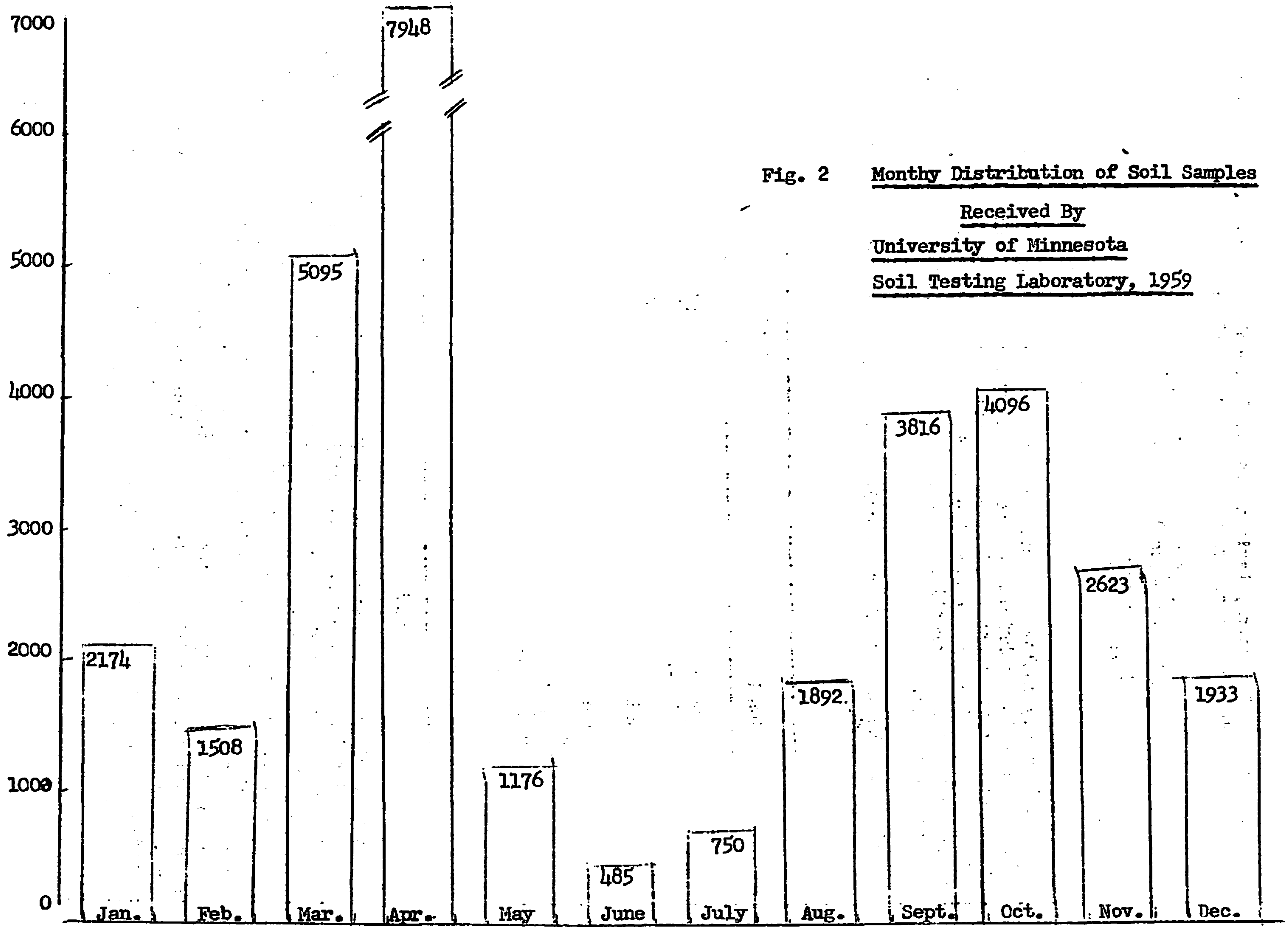

Fig. 2 Monthy Distribution of Soil Samples
Received By
University of Minnesota
Soil Testing Laboratory, 1959

Currently the laboratory tests about 37,000 samples annually. The following data show the number of various samples analyzed in 1959:

Regular farm, garden and lawn samples	33,491
Florist (Greenhouse) samples	923
Limestone samples	217
Departmental research samples	2,368
Total	36,941

The laboratory employs one full-time senior technician, a secretary, and 5 to 12 student part-time technicians. The present capacity of samples that can be processed each month is about 8000. About nine days are required for sample processing. This includes preparation, drying, testing and reporting. Test reports together with sample information forms are mailed to county extension agents, who make recommendations.

Table 2. The number of days required for soil sample processing in 1959.

Month	Monthly Average Days
January	12
February	14
March	10
April	9
May	8
June	6
July	6
August	7
September	8
October	9
November	10
December	10
Year 1959	9

A very serious problem encountered in the operation of the laboratory is the uneven distribution of workload. Soil testing in Minnesota as indicated in Fig. 2 is extremely seasonal and characterized by rush periods and slack seasons. The spring rush of samples generally starts in March and lasts until the first week of May. September, October and the first half of November usually show the greatest influx of samples in the fall. Nearly 70 per cent of all samples tested each year are received during five months of the spring and fall rush periods. Past records also show that soil sampling activities in Minnesota are greatly affected by weather conditions, especially in the early spring and in the fall just before freeze-up. It would be advantageous for everybody concerned to work towards a more uniform sample distribution throughout the year. This could be accomplished by putting more emphasis on sampling in late summer and fall.

A Preliminary Report of the 1959 Soil Test Correlation Study on Corn

L. D. Hanson and John Grava

In order to obtain additional information on the relationship of corn growth and yield to applied fertilizer and soil test values a program of field fertilizer plots was carried out in 1959 by the extension service and the soil testing laboratery. County agricultural and soils agents in 47 counties established 77 experimental fields in cooperation with the extension soils specialists and Soils Department staff.

In addition to the objective of obtaining information on the correlation of yields with the soil test, the fields were used as demonstrations and teaching material by county agents and cooperating vo-ag teachers.

Procedure Followed

Materials used for establishing the plots were assembled and packed into fiber drums at the Soils Department and delivered to agents in April and May.

A uniform randomized block design of 5 treatments and 3 replications was used on all fields, with the exception of 20 which received an additional minor element treatment.

Following are the fertilizer treatments and the rates of application:

Treatment	Lbs. N/A	Lbs. P_2O_5/A	Lbs. K_2O/A
Check	0	0	0
PK	0	100	100
NK	100	0	100
NP	100	100	0
NPK	100	100	100
NPK+ minor elements	100	100	100
	plus 84 lbs. $MnSO_4$, 30 lbs. $MgSO_4$, 20 lbs. $ZnSO_4$, 30 lbs. $CuSO_4$, 30 lbs. $FeSO_4$, and 3 lbs. of Borax per acre.		

The 100-pound rate of nutrients is not to be interpreted as a recommended rate. The high rate was used to be reasonably sure that an individual nutrient was not limiting yield on specific plots.

Before fertilizer treatments were applied 3 surface soil samples were collected from each site, and shipped to the laboratory in a field moist condition.

The fertilizer was broadcast by hand and worked into the surface soil with cultivators. The farmer followed his normal corn planting procedure on the plot area with the exception that a population of between 16,000 and 18,000 was aimed for.

The fields were selected on the basis of representing important county soil types. Information was recorded regarding soil type, past crops for 3 years, past fertilization and manure, time of plowing, kind and maturity of hybrid, and moisture conditions at planting. A rain gauge was provided to each farmer and rainfall was recorded daily from June through September by almost all farmers.

Observations on growth differences and appearance were made by agents during the first two weeks in July, and leaf samples were collected from some fields at tasseling time. Yields were checked by agents and other cooperators on 67 fields.

Weather Conditions and Effect of Rainfall

With the exception of the southeast counties very dry weather prevailed on many fields during the months of June and July. The average July rainfall varies from an average of 3.01 inches in southwest Minnesota to 3.63 in the northeast. The extent of the drouth in 1959 is indicated by the fact that 67% of the plots had less than 2 inches of rainfall in July. Another measure of the effect of low rainfall is a summary of agents evaluation of drouth in limiting yields. This shows that 70% of all fields were moderately or severely limited in yield by drouth.

Important as moisture is in determining yield, there is no close relationship apparent between total rainfall of June, July, and August and yields. There are a number of other factors such as time of rainfall, soil type, subsoil moisture, and past crop which have to be considered. A summary of the information taking these factors into account has not yet been made with the exception of the following table showing average NPK treatment yields on corn following different crops.

Table 1. Average corn yields on NPK plots with low rainfall in 1959 following various 1958 crops.*

Past Crop	Corn Yield	Average Rain June & July
Alfalfa	45.2	3.7"
Corn	84.3	3.7"
Soybeans	85.0	3.1"
Small grain	65.1	3.8"

* Only fields with less than 5" of rain during June and July were averaged.

The lower yield following alfalfa probably reflects the lower soil moisture following that crop.

Effect of Past Crop on Nitrogen Response

Table 2. Average bushel increase from 100 pounds of nitrogen on corn following various crops.

Crop in 1958	Yield Diff. from N	Number of fields
Alfalfa or clover	- 1.9	14
Corn	+ 14.0	22
Soybeans	+ 12.8	13
Oats	+ 15.5	5

Of the three primary nutrients nitrogen was the most important in affecting corn yields. Corn yields were increased an average of about 14 bushels following a nonlegume crop. This was greater than either the phosphate or potash response at the low test level.

The importance of the past crop in determining nitrogen response is illustrated in table 2. In general, corn following a good legume does not need nitrogen beyond that provided in a starter fertilizer.

Phosphate Response and Phosphorus Soil Test

Table 3. Yield difference from 100 pounds P_2O_5 and P level by Bray's #1 method.

P Soil Test Level		Yield Difference	Number of yields
0 - 10	low	+ 10.2	17
11 - 20	medium	+ 2.6	22
21 - 30	high	- 0.5	15
30 +	very high	+ 1.2	11

The average yield response agrees in general with the phosphorus test. However, there is considerable variation within each category indicating need for further study on a number of soils. Soils in Steele and Waseca County, for example, show small phosphate response in spite of low tests.

Potash Response and Potassium Test

Table 4. Yield difference from 100 lbs. K_2O/A and K level of dried samples.

Exchangeable K and relative level	Yield difference	Number of fields
0 - 90 low	+7.0	13
91 - 150 low-medium	+2.3	33
151 - 220 high-medium	+1.9	8
220 + high	+0.6	13

As with phosphate, potash response follows the potassium level as indicated by soil test. The size of the increase on the low and low-medium categories is considerably less than has been observed in research plots over the past few years. Drouth conditions on many of the low testing fields account for part of this difference.

Barren Stalks and Lodging

Data is reported on the number of barren stalks and lodged stalks by treatment. Both of these problems were very severe in 1959. No analysis has been made as yet on the relationship of these to fertilizer treatment. Corn leaf aphid was important in causing barren stalks on some fields. Fields in Freeborn, Kandiyohi, Rice, Sibley, and Jackson counties were reported as having barren stalks associated with corn leaf aphid occurrence. Severe corn rootworm damage was reported on a field in Nobles County.

Effect of Minor Elements on Corn Yield

On all but two fields the addition of a number of minor elements had no effect oncorn yield. On two fields, one is Pope County and one in McLeod County, the effect of the minor elements on yield was highly significant. On the County field the NPK plus minor elements plot averaged 65.3 bushels compared to 53.3 with NPK alone. On the McLeod field the yield on the minor element plot was 111.0 compared to 97.3 on the NPK alone plot. Further work is planned in McLeod County.

Evaluation of Recommended Fertilizer Rates

In considering the results in economic terms of the cost of the fertilizer which would have been recommended and the yield response to the recommended combination of fertilizer, a rather large number did not get an economic increase in yield. Of 67 fields 23 showed an economic response while 41 did not. A number of factors are involved but probably the most important are the low rainfall on a number of fields and the limiting of yields by such factors as weed competition, poor drainage, and insect damage and stand.

This points out the fact that a large number of farmers are probably not getting a good return from fertilizer because other production factors are not taken care of.

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Counties Cooperating in Soil Test Correlation Program - 1959

County	Number of fields	Fields not harvested	County	Number of fields	Fields not harvested
Anoka	2	2	Murray	1	
Benton	1		Nobles	2	
Big Stone	2		Olmsted	2	1 (erosion)
Blue Earth	1		Pine	1	
Brown	1		Pipestone	1	
Chippewa	1		Pope	1	
Dakota	1		Redwood	1	
Dodge	4		Renville	1	
Fillmore	2		Rice	1	
Freeborn	1		Rock	2	
Goodhue	1		Scott	1	1 (drouth)
Hennepin	1		Sherburne	1	
Houston	1		Sibley	2	1 (flooding)
Isanti	1		Stearns	1	
Jackson	2		Steele	4	1
Kanabec	1		Swift	1	
Kandiyohi	1		Wabasha	2	
Lac qui Parle	1		Waseca	1	
Lincoln	1	1 (drouth)	Washington	2	
Lyon	1		Watonwan	2	
McLeod	2		Wright	1	
Meeker	2		Yellow Medicine	1	1 (harvested not reported)
Mille Lacs	1				
Morrison	4				
Mower	9	1 (poor stand)			
			TOTAL	77	9

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture
(3) Benton County - Cornelius Stob										
Alfalfa-Brome	3.4	3.0	7.2	13.6	+2.3	6.3	3.2M	18M-H	58L	Milaca s.l.

This field represents a typical situation on Milaca soils where P is quite high and K is low. The alfalfa-brome did not provide adequate nitrogen on this field. The combination of N & K gave a 32-bushel increase on this low potassium soil.

(4) Big Stone - Leo Taffe										
	4.3	1.4	2.4	8.1	-2.3	7.4	3.6L	10L	317VH	c.l.

This field was in a very dry area which is the cause of the very low yields.

(5) Big Stone - Mel Steen										
	6.2	1.9	3.3	11.4	+1.0	7.1	5.5M	7L	560VH	Si.c.l.

Rainfall was higher at this field resulting in good yields and fertilizer response.

(6) Blue Earth County - Sig Rassmussen and Son										
Wheat	3.0	1.3	7.6	11.9	+0.2	6.1	3.6M	29H	483VH	Clarion l.

Drouth in July limited yields, but a large yield increase would not be expected with this soil test. Number of barren stalks helps explain yield decrease. Corn leaf aphids and drouth apparently hampered pollination.

(7) Brown County - Arthur W. Schultz										
Soybeans	4.5	2.5	7.5	14.5	+2.8	6.0	4.8M	15M	307VH	Nicollet clay loam

This soil test is typical of the Nicollet soil in this area. Growth differences were not apparent in July but phosphate and nitrogen gave expected response in yield. Hail, wind, and July drouth limited yield. Farmer's yield was 70 with no fertilizer.

Treatment Information

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	55	75	87	73	82	
Population	14,600	15,400	15,700	16,700	15,400	
Number Barren Stalks	600	1,100	400	1,000	500	
Number Lodged Stalks	1,600	1,000	800	1,800	300	

	Increase	Decrease
Yield difference due to N =	7 bu.	
" " " " P =		5 bu.
" " " " K =	9 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield.	23	19	14	13	11	
Population	13,100	11,500	13,900	12,500	13,900	
Number Barren Stalks	5,000	5,000	8,400	6,300	8,100	
Number Lodged Stalks	0	0	0	0	0	

	Increase	Decrease
Yield difference due to N =		8 bu.
" " " " P =		3 bu.
" " " " K =		2 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	62	63	68	73	78	
Population	14,100	13,600	14,400	14,100	13,300	
Number Barren Stalks	700	800	700	900	1,600	
Number Lodged Stalks	0	0	0	0	0	

	Increase	Decrease
Yield difference due to N =	15 bu.	
" " " " P =	10 bu.	
" " " " K =	4 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	54	46	33	46	28	50
Population	15,900	14,900	15,200	14,900	14,600	15,400
Number Barren Stalks	6,800	6,800	9,500	5,200	9.700	7,300
Number Lodged Stalks	0	100	0	0	0	0

	Increase	Decrease
Yield difference due to N =		18 bu.
" " " " P =		5 bu.
" " " " K =		18 bu.
" " " " M.E. =	22 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	78	74	77	83	86	
Population	18,800	19,100	19,300	19,300	18,600	
Number Barren Stalks	3,200	5,500	4,000	4,500	3,700	
Number Lodged Stalks	2,800	4,200	4,700	4,300	3,200	

	Increase	Decrease
Yield difference due to N =	12 bu.	
" " " " P =	9 bu.	
" " " " K =	3 bu.	

(8) Chippewa County - Merlin Tjagen

Past Crop (1958)	Rainfall (inches) June	July	August	Total of 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture
Soybeans	2.1	1.9				7.8	5.2M	10L	220M	Flom si.c.l.

A large increase due to phosphate; rainfall was limited but the low lying Flom soil had a good supply of subsoil moisture. August rainfall was not reported. Part of the plots were not harvested because of an alkali effect on corn growth.

(9) Dakota County - David Kamin

Soybeans	7.2	3.4	12.3	22.9	+11.2	5.5	2.2L	12M	97M	Outwash s.l.

Farmer's own yield = 104 (100# 6-24-12 + 40#N)
Nitrogen was the only limiting nutrient here in spite of medium and low tests for P & K. Additional population may have brought out increases from phosphate and potash.

(10) Dodge County - Ed Cutting

Alfalfa-Brome	6.4	1.9	3.6	11.9	+0.2	7.2	4.9H	8L	80L	Racine l.

Farmer's own yield = 87
Dodge County rainfall was generally good in June which carried the fields through a dry July. This field tested low in P and K but only potash showed an effect. A small nitrogen response resulted in spite of following alfalfa-brome. Fertilizer apparently caused more barren stalks.

(11) Dodge - C. C. Gray

Soybeans	6.2	1.7	7.3	15.2	+3.5	5.6	4.5M	11M	107M	Kasson si.l.

Farmer's own yield = 71 (250# 5-20-20 + 100# 33-0-0 + 150# starter)
All nutrients caused yield increases with potassium being most important. Stand was down 25% from that planted. As in the case of other fields following soybeans, a good increase resulted from nitrogen.

(12) Dodge County - Howard Scripture

Soybeans	5.8	2.3	4.0	12.1	+0.4	5.6	3.4M	14M	93M	Kasson si.l.

Farmers own yield = 84 (200# 5-20-20 starter)
All nutrients gave yield increases which are common with medium fertility levels. Fertilizer seemed to decrease the number of lodged stalks.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	76	90	67	107	101	
Population	17,300	20,100	19,600	18,000	16,700	
Number Barren Stalks	1,800	3,400	3,700	2,400	2,900	
Number Lodged Stalks	500	500	3,700	5,200	1,600	

	Increase	Decrease
Yield differences due to N =	11 bu.	
" " " " P =	34 "	
" " " " K =		6 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	80	68	101	101	97	
Population	14,600	15,200	15,200	15,200	14,600	
Number Barren Stalks	400	900	400	300	800	
Number Lodged Stalks	2,400	900	3,200	1,200	2,400	

	Increase	Decrease
Yield Difference due to N =	29 bu.	
" " " " P =		4 bu.
" " " " K =		4 "

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	90	87	99	79	93	
Population	14,100	14,400	15,400	14,900	15,400	
Number Barren Stalks	0	1,000	500	1,000	600	
Number Lodged Stalks	800	500	1,200	2,900	800	

	Increase	Decrease
Yield differences due to N =	6 bu.	
" " " " P =		6 bu.
" " " " K =	14 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	53	65	69	54	76	
Population	13,900	13,900	13,300	12,500	14,100	
Number Barren Stalks	1,200	1,400	100	1,400	1,600	
Number Lodged Stalks	600	400	1,000	2,000	400	

	Increase	Decrease
Yield differences due to N =	11 bu.	
" " " " P =	7 "	
" " " " K =	22 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	81	87	91	89	96	
Population	19,600	16,200	16,200	15,700	16,700	
Number Barren Stalks	1,400	800	600	300	400	
Number Lodged Stalks	5,000	2,300	7,300	1,000	1,500	

	Increase	Decrease
Yield differences due to N =	9 bu.	
" " " " P =	5 "	
" " " " K =	7 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(13) Dodge County - Kasson Mantorville F.F.A. (E. Knudson Farm)

Oats	9.6	1.5	3.2	14.3	+2.6	7.0	3.4M	13M	147M	Kenyon si.l.

Farmer's own yield = 89 (80# N sidedressed)
Nitrogen caused a large increase on corn following oats. As in most other fields in this soil area, potassium is more limiting than phosphorus.

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(14) Fillmore County - Virgil Henry

Corn	8.7	1.6	9.8	20.1	+8.4	6.4	1.7L	22H	147M	Fayette si.l.

On this low organic matter Fayette soil nitrogen gave a large increase in yield.

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(15) Fillmore County - Roger Carson

Soybeans	8.8	1.5	9.0	19.3	+7.6	6.2	6.5H	10L	107M	Floyd si.c.l.

As with the fields of similar soil types in Dodge and Mower counties, this field showed little difference in yield from phosphate. Nitrogen and potash caused substantial increase. Potash seemed to decrease lodging. Minor elements had no effect.

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(16) Freeborn County - John Jordon

Corn	4.5	1.7	6.5	12.7	+1.0	6.4	3.7M	13M	83L	Webster l.

With low P and K tests and corn following corn all nutrients gave substantial increases. Corn leaf aphid was important in causing a large number of barren stalks. Minor elements had no effect.

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(17) Goodhue County - George Dickinson

Pasture	7.5	1.8	19.6	29.0	+17.3	7.0	2.5L	29H	140M	Fayette si.l.

Farmer's own yield = 104 (125# 8-24-12 starter)
Nitrogen was not needed on this field following legume pasture. Phosphorus effect follows the high test. The high yield on PK plots may be due to higher stand as well as fertility.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	59	50	84	77	87	
Population	18,800	17,000	17,300	17,300	17,300	
Number Barren Stalks	1,000	1,000	900	600	300	
Number Lodged Stalks	700	900	700	1,400	1,000	

	Increase	Decrease
Yield differences due to N =	37 bu.	
" " " " P =	3 "	
" " " " K =	10 "	

Yield	85	80	102	115	106	109
Population	19,900	19,600	18,800	19,100	18,800	19,300
Number Barren Stalks	2,900	2,900	1,900	1,100	2,100	2,100
Number Lodged Stalks	2,300	1,000	2,400	800	600	1,100

	Increase	Decrease
Yield differences due to N =	26 bu.	
" " " " P =	4 "	
" " " " K =		9 bu.
" " " " M.E.=	3 bu.	

Yield	75	43	100	78	97	95
Population	19,300	19,100	17,500	18,000	18,800	19,600
Number Barren Stalks	700	3,500	0	400	200	200
Number Lodged Stalks	4,900	2,800	1,800	5,000	1,500	1,800

	Increase	Decrease
Yield differences due to N =	54 bu.	
" " " " P =		3 bu.
" " " " K =	19 bu.	
" " " " M.E.=		2 bu.

Yield	44	49	58	46	77	72
Population	16,500	18,300	16,700	15,900	19,100	19,300
Number Barren Stalks	4,400	5,200	3,500	3,700	2,600	2,900
Number Lodged Stalks	5,400	3,400	5,300	6,400	2,600	3,100

	Increase	Decrease
Yield differences due to N =	28 bu.	
" " " " P =	19 "	
" " " " K =	31 "	
" " " " M.E.=		5 bu.

Yield	94	119	111	103	106
Population	15,400	17,500	15,900	15,400	15,200
Number Barren Stalks	2,100	1,600	1,500	1,000	1,500
Number Lodged Stalks	3,700	2,300	2,400	2,800	1,600

	Increase	Decrease
Yield differences due to N =		13 bu.
" " " " P =		5 "
" " " " K =	3 bu.	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(18) Hennepin County - Glenard Tessmer

Corn						6.2	2.6L	25H	123M	LeSueur l.

Farmer's own yield = 78 (185# 8-16-16 + 60# N sidedressed)
Fertilized plots yielded more than the check but when treatments are compared to the NPK yield there is little difference in yield. An increase from potash and nitrogen would normally be expected on this field.

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(19) Houston County - Donald Schroeder

Alfalfa	7.6	1.5	11.3	20.4	+8.7	7.1	1.6L	51VH	110M	Fayette si.l.

Farmer's own yield = 120 (100# 8-16-16)
With a high yield on the check plot there is essentially no difference in yields due to fertilizer. The 12-bushel difference between the NK and NPK treatments is probably due to stand difference.

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(20) Isanti County - Albert Erickson

Alfalfa	1.0	3.4	6.5	10.9	-1.4	5.8	2.0L	50VH	80L	s.l.

Farmer's own yield = 49 (125# of 8-16-16).
Drouth in June on this sandy loam soil limited yields and fertilizer response. A large number of barren stalks indicates poor pollination.

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(21) Jackson County - Eston Rixmann

Soybeans	2.0	0.0	5.0	7.0	-3.6	5.4	3.5L	12M	167M	Clarion c.l.

This field was severely limited in yield by drouth (no rainfall in July), corn leaf aphid and a wind storm.

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(22) Jackson County - William Freking

Soybeans	3.0	0.8	5.6	9.4	-1.2	7.8	4.3L	9L	163M	Webster c.l.

Although this Jackson County field was also in a low rainfall area, the Webster soil type supplied subsoil moisture sufficient for good yields. Minor elements apparently increased yields as the effect was consistent in all replicates.

Treatment Information

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	76	88	94	100	90	
Population	17,800	17,800	18,000	18,000	16,200	
Number Barren Stalks	1,800	2,900	2,100	1,800	1,600	
Number Lodged Stalks	300	300	300	300	300	

	Increase	Decrease
Yield difference due to N =	2 bu.	
" " " " P =		4 bu.
" " " " K =		10 "

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	127	130	117	123	129	
Population	16,700	17,000	15,700	16,500	16,700	
Number Barren Stalks	300	500	300	300	300	
Number Lodged Stalks	1,300	400	1,000	800	1,500	

	Increase	Decrease
Yield difference due to N =		1 bu.
" " " " P =	12 bu.	
" " " " K =	6 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	47	52	51	42	42	
Population	14,100	16,200	14,100	14,600	16,200	
Number Barren Stalks	3,000	5,800	3,200	6,600	7,700	
Number Lodged Stalks	2,300	300	1,900	3,800	400	

	Increase	Decrease
Yield difference due to N =		10 bu.
" " " " P =		9 "
" " " " K =	No difference	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	43	55	39	41	42	41
Population	13,900	14,100	14,100	14,900	12,500	13,600
Number Barren Stalks	2,600	3.500	4,500	5,400	3,500	3,700
Number Lodged Stalks	Wind storm in late August.					

	Increase	Decrease
Yield difference due to N =		13 bu.
" " " " P =	3 bu.	
" " " " K =	1 "	
" " " " M.E.=		1 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	76	82	76	82	89	97
Population	13,600	14,100	13,900	14,100	14,400	14,400
Number Barren Stalks	300	500	300	200	600	0
Number Lodged Stalks	4,900	3,000	4,600	4,700	3,700	4,300

	Increase	Decrease
Yield difference due to N =	7 bu.	
" " " " P =	13 "	
" " " " K =	7 "	
" " " " ME.=	8 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(23) Kanabec County - W. D. enger

Clover Hay	2.1	2.6	5.6	10.3	-2.0	5.8	2.1L	27H	43VL	Milaca l.

Farmer's own yield = 24 (150# 8-16-16 + 150# 0-0-60)

(24) Kandiyohi County - Harold Taajtes

Corn	3.7	0.9	6.5	11.1	-0.2	7.8	8.2VH	15M	243H	Webster c.l.

Farmer's own yield = 126 (150# 8-24-12 + 40# 82-0-0)
Manure has been applied on this field each of the last 3 years which apparently helped supply needed nutrients, especially nitrogen. Comparison of the check to fertilized plots shows a yield difference but it is not possible to attribute it to P or K alone. Corn leaf aphid occurrence was common and associated with barren stalks. The field has been in corn for 7 years.

(25) LacQuiParle County - Galen Baldwin

Corn	1.8	1.6	0.8	4.2	-6.2	6.7	1.8L	8L	123M	Rothsay s.l.

Timely rainfall made possible good yields despite low total rainfall. Increases from P and K corresponded with soil test values.

(27) Lyon County - Robert Olson

Soybeans	2.7	1.2	3.9	7.8	-2.8	7.8	4.2M	7L	240H	Flom l.

Farmer's own yield = 55 (5-40-10 starter + 40# N)
This field was located on a high lime rim on which a potash response is often observed in spite of a high K test.

(28) McLeod County - Leonard Grenke

Oats	5.0	1.7	7.4	14.1	+2.8	7.8	6.8H	7L	140M	Glencoe c.l.

All nutrients increased yields with nitrogen being most important.

	Check	PK	NK	NP	NPK	NPK+ M.E.
	Treatment Information					
Yield	39	34	27	30	34	28
Population	12,300	14,100	13,600	12,800	13,600	13,600
Number Barren Stalks	1,300	4,000	4,400	3,200	3,700	4,000
Number Lodged Stalks	1,000	1,100	1,400	1,100	2,600	1,300

	Increase	Decrease
Yield difference due to N =	No difference	
" " " " P =	7 bu.	
" " " " K =	4 "	
" " " " M.E=		6 bu.

	Check	PK	NK	NP	NPK
Yield	101	126	119	121	119
Population	21,400	22,200	21,200	20.900	20,900
Number Barren Stalks	1,400	2,000	1,100	800	1,900
Number Lodged Stalks	900	700	600	400	1,100

	Increase	Decrease
Yield difference due to N =		7 bu.
" " " " P =	No difference	
" " " " K =		2 bu.

	Check	PK	NK	NP	NPK
Yield	55	88	82	91	96

	Increase	Decrease
Yield difference due to N =	8 bu.	
" " " " P =	14 "	
" " " " K =	5 "	

	Check	PK	NK	NP	NPK
Yield	37	50	41	47	58

	Increase	Decrease
Yield difference due to N =	8 bu.	
" " " " P =	17 "	
" " " " K =	11 "	

	Check	PK	NK	NP	NPK
Yield	83	94	100	100	109
Population	14,900	12,800	12,800	12,800	15,200
Number Barren Stalks	700	300	200	600	1,400
Number Lodged Stalks	300	0	700	600	400

	Increase	Decrease
Yield difference due to N =	15 bu.	
" " " " P =	9 "	
" " " " K =	9 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture
(29) McLeod County - John Lietz										
Soybeans	2.8	2.2	4.6	9.6	-1.7	7.1	4.9M	26H	225H	Nicollet c.l.

Minor elements increased yields on all three replicates over the NPK treatments.

Past Crop (1958)	June	July	August	Total 3 mo.	Rain diff. from normal	pH	O.M.%	P	K	Soil Type Texture
(30) Meeker County - Leroy McGuire										
Corn	1.3	1.9	3.4	6.6	-4.7	5.5	1.9L	13M	127M	s.l. sandy acid outwash

Farmer's own yield - 55 (165# 6-24-24)

Nitrogen was the most limiting element. Yields were limited by low rainfall and a sandy soil.

Past Crop (1958)	June	July	August	Total 3 mo.	Rain diff. from normal	pH	O.M.%	P	K	Soil Type Texture
(31) Meeker County - Walter Johnson										
Corn	2.4	3.1	5.3	10.8	-0.5	8.0	6.0M	5L	143M	Webster c.l.

Available phosphorus was low as indicated by yields and soil test. Nitrogen as usual gave a good increase when the preceding cropwas corn.

Past Crop (1958)	June	July	August	Total 3 mo.	Rain diff. from normal	pH	O.M.%	P	K	Soil Type Texture
(32) Mille Lacs County - Harold O. Thorsbakken										
Oats	2.0	2.5	8.1	12.6	+0.3	5.1	1.9L	24H	93M	Milaca si.l.

Lack of moisture on this Milaca soil restricted yields and fertilizer response.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	90	86	97	87	98	111
Population	15,400	16,500	15,900	16,500	17,800	17,300
Number Barren Stalks	2,800	4,000	3,700	5,200	4,400	3,100
Number Lodged Stalks	300	300	200	300	600	600

	Increase	Decrease
Yield difference due to N =	12 bu.	
" " " " P =	1 "	
" " " " K =	11 "	
" " " " M.E. =	13 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	54	33	78	66	67	70
Population	15,700	13,900	16,500	14,600	15,200	16,200
Number Barren Stalks	800	1,100	1,500	500	700	900
Number Lodged Stalks	100	0	0	800	0	0

	Increase	Decrease
Yield difference due to N =	34 bu.	
" " " " P =		11 bu.
" " " " K =	1 bu.	
" " " " M.E. =	3 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	62	72	67	87	96	89
Population	14,900	13,300	13,100	13,900	14,600	15,200
Number Barren Stalks	1,000	0	100	0	300	900
Number Lodged Stalks	1,500	600	1,600	3,100	1,800	1,400

	Increase	Decrease
Yield difference due to N =	24 bu.	
" " " " P =	29 "	
" " " " K =	9 "	
" " " " M.E. =		7 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	27	16	36	27	30	25
Population	13,600	14,600	14,100	12,300	17,300	14,900
Number Barren Stalks	3,000	5,500	1,900	1,300	5,200	4,200
Number Lodged Stalks	400	600	900	2,700	1,300	900

	Increase	Decrease
Yield difference due to N =	14 bu.	
" " " " P =		6 bu.
" " " " K =	3 bu.	
" " " " M.E. =		5 bu.

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(33) Morrison County - William C. Gablenz, Jr.

Corn	3.9	1.0	5.9	10.8	-0.5	5.4	1.6L	41VH	147M	Sandy acid outwash

Farmer's own yield = 52 (100# 5-20-20 + 40# 82-0-0)

Nitrogen and potash were most important on this sandy soil which had a typical soil test for this area of the state. The low pH may be restricting the availability of the phosphorus which is indicated as high by test.

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(34) Morrison County - Melvin Hippe

Hay & pasture	0.8	1.9	4.6	7.3	-4.0	6.3	3.9M	15M	83L	si.l.

Farmer's own yield = 70 (250# 5-20-20)

Observations on growth difference in July showed a potash response but yields were lower on the fertilized plots. Rainfall was very low in June and July.

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(35) Morrison County - E. H. Ostrum

Corn	4.0	1.6	3.4	9.0	-2.3	5.3	1.6L	44VH	57VL	Sandy acid outwash s.l.

Large increases in yield here substantiate the low fertility status in nitrogen and potash as indicated by soil test. Phosphorus response was contrary to that expected with this phosphorus test. Note that the plant population was unreasonably high.

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(36) Morrison County - Flicker & O'Brien

Oats	No rainfall records					5.6	1.8L	36VH	90L	Milaca s.l.

No yield differences were measured here despite a low potash test. There was considerable variation in the soil within the plot area.

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(37) Mower County - Wallace Shoedean (LeRoy F.F.A.)

Corn	4.2	1.8	11.5	17.5	+5.8	6.7	2.4L	19M	97M	Skyberg l.

Nitrogen and potash accounted for moderate increases in yield. A high incidence of barren stalks interferred with fertilizer response.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	24	36	44	41	49	43
Population	19,800	19,500	19,300	19,500	20,100	21,500
Number Barren Stalks	3,700	1,700	1,700	1,000	1,800	1,600
Number Lodged Stalks	100	100	200	400	1,700	500

	Increase	Decrease
Yield difference due to N =	13 bu.	
" " " " P =	5 "	
" " " " K =	8 "	
" " " " M.E.=		6 bu.

	Check	PK	NK	NP	NPK
Yield	70	60	63	64	56
Population	16,700	15,700	16,200	15,900	17,000
Number Barren Stalks	1,500	1,300	4,000	2,400	2,100
Number Lodged Stalks	0	0	300	300	0

	Increase	Decrease
Yield difference due to N =		4 bu.
" " " " P =		7 "
" " " " K =		8 "

	Check	PK	NK	NP	NPK
Yield	8	7	13	19	46
Population	33,600	34,700	35,800	30,000	32,200
Number Barren Stalks	23,400	22,800	18,700	12,700	10,200
Number Lodged Stalks	0	400	0	700	700

	Increase	Decrease
Yield difference due to N =	39 bu.	
" " " " P =	33 "	
" " " " K =	27 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	45	48	43	43	43	45

	Increase	Decrease
Yield difference due to N =		5 bu.
" " " " P =	No difference	
" " " " K =	No difference	
" " " " M.E.=	2 bu.	

	Check	PK	NK	NP	NPK
Yield	62	75	84	74	80
Population	17,800	20,400	20,700	19,100	21,700
Number Barren Stalks	2,800	4,500	5,000	2,400	5,800
Number Lodged Stalks	1,300	1,600	2,000	1,900	1,600

	Increase	Decrease
Yield difference due to N =	5 bu.	
" " " " P =		4 bu.
" " " " K =	6 bu.	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(39) Mower County - Ralph Waters

Alfalfa	6.7	0.4	Not recorded			5.7	2.3L	83VH	303VH	Renova s.l.

July rainfall and alfalfa preceding the corn apparently limited yields. Increases would not be expected with the high tests.

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(40) Mower County - Delmar Tapp

Corn	9.0	2.5	12.0	23.5	+11.8	6.4	3.9M	11M	120M	Kenyon si.l.

Farmer's own yield = 78 (200# 5-20-20)

As in the case of 27 other fields the PK treatment was less than the check. Balanced fertilization provided a 14 bushel increase.

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(41) Mower County - Wayne Skov

Corn	5.3	1.9	6.6	13.8	+2.1	5.1	3.4M	23H	113M	Floyd si.l.

Again nitrogen was most important in yield difference. Poor drainage affected growth.

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(42) Mower County - Gay Morrell

Soybeans	8.3	2.2	10.7	21.2	+9.5	5.2	2.6L	23H	123M	Sargeant si.l.

Poor drainage was also a factor in this field. Phosphate and potash response does not follow the soil test levels.

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(43) Mower County - Adams F.F.A.

Corn	6.7	1.6	9.7	18.0	+6.3	6.4	1.7L	12M	107M	Skyberg l.

Nitrogen gave a large yield increase with phosphate and potash affects less than expected.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	62	52	57	50	47	
Population	12,500	13,300	13,300	13,100	12,300	
Number Barren Stalks	1,800	3,100	2,400	3,800	3,500	
Number Lodged Stalks	700	400	600	800	400	

	Increase	Decrease
Yield difference due to N =		5 bu.
" " " " P =		10 "
" " " " K =		3 "

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	90	75	100	98	104	
Population	14,600	14,600	15,700	15,900	14,900	
Number Barren Stalks	0	400	500	600	0	
Number Lodged Stalks	3,100	2,400	2,800	5,500	2,400	

	Increase	Decrease
Yield difference due to N =	29 bu.	
" " " " P =	4 "	
" " " " K =	6 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	68	60	73	72	75	
Population	15,400	15,400	15,900	15,200	15,900	
Number Barren Stalks	1,300	1,200	600	2,000	1,400	
Number Lodged Stalks	1,000	1,100	900	1,000	800	

	Increase	Decrease
Yield difference due to N =	15 bu.	
" " " " P =	2 "	
" " " " K =	3 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	69	76	80	90	93	
Population	14,900	15,200	14,900	15,700	15,700	
Number Barren Stalks	700	1,000	400	700	900	
Number Lodged Stalks	700	700	500	1,300	700	

	Increase	Decrease
Yield difference due to N =	17 bu.	
" " " " P =	13 "	
" " " " K =	3 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	71	65	101	101	105	
Population	19,300	20,600	19,100	19,100	20,900	
Number Barren Stalks	2,500	2,800	1,400	800	1,000	
Number Lodged Stalks	1,300	1,600	1,100	1,500	2,400	

	Increase	Decrease
Yield difference due to N =	40 bu.	
" " " " P =	4 "	
" " " " K =	4 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(44) Mower County - Lyle F.F.A.

Alfalfa	5.7 (est)	2.0	7.0 (est)	14.7 (est)	+3.0	6.6	4.1M	12M	90L	Skyberg si.l.

Nitrogen increased yields despite previous alfalfa crop. Yields although good were limited by weed competitions and wind damage.

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(45) Mower County - Irving Nagel

Clover	5.7	3.0	7.0	15.7	+4.0	6.1	3.4M	11M	107M	Floyd si.l.

Potash accounted for a substantial increase. Adequate rainfall and good weed control made high yields possible. A heavier population could have been used as ears were large.

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(46) Murray County - Elmer Smith

Flax	2.3	1.8	9.7	13.8	+3.2	7.6	5.5M	9L	177M	Webster-Glencoe c.l.

Farmer's own yield = 82 (100# 6-24-12)

Nitrogen and phosphate were needed on this field. Dry July weather limited yields.

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(47) Nobles County - Ed Lenz

Corn	3.0	2.5	9.2	14.7	+4.1	5.8	4.0M	8L	250H	Moody Kranzberg si.l.

Farmer's own yield = 71

Dry conditions in 1958 probably accounted for greater than average N carryover. Phosphorus response expected with test but K response greater than expected with test.

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(48) Nobles County - Herman Danneman

Corn	1.8	2.4	9.2	13.4	+2.8	6.8	5.0M	12M	173M	Webster c.l.

Farmer's own yield = 86 (100# 5-20-20 + 60# N sidedressed)

Root worm limited yields, but all nutrients increased yields.

Treatment Information

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	93	80	87	92	100	
Population	16,500	15,700	15,400	15,900	16,500	
Number Barren Stalks	800	2,000	1,000	100	500	
Number Lodged Stalks	2,600	1,800	1,800	2,800	3,600	

	Increase	Decrease
Yield difference due to N =	20 bu.	
" " " " P =	13 "	
" " " " K =	8 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	108	120	112	106	125	
Population	13,100	14,100	13,600	12,800	13,900	
Number Barren Stalks	200	200	100	100	0	
Number Lodged Stalks	1,300	900	1,000	800	1,100	

	Increase	Decrease
Yield difference due to N =	5 bu.	
" " " " P =	13 "	
" " " " K =	19 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	77	87	93	101	98	
Population	14,600	15,700	14,700	15,200	16,500	
Number Barren Stalks	1,900	2,600	1,800	2,400	3,500	
Number Lodged Stalks	1,200	2,600	700	2,200	2,900	

	Increase	Decrease
Yield difference due to N =	11 bu.	
" " " " P =	5 "	
" " " " K =		3 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	65	75	62	68	80	
Population	15,400	15,400	15,900	14,400	15,200	
Number Barren Stalks	2,000	1,800	1,800	1,000	1,800	
Number Lodged Stalks	1,800	1,000	1,000	2,800	3,500	

	Increase	Decrease
Yield difference due to N =	5 bu.	
" " " " P =	18 "	
" " " " K =	12 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	74	61	81	81	87	
Population	15,700	15,900	16,500	15,200	15,700	
Number Barren Stalks	1,400	3,000	1,400	800	600	
Number Lodged Stalks	0	0	0	0	0	

	Increase	Decrease
Yield difference due to N =	26 bu.	
" " " " P =	6 "	
" " " " K =	6 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(49) Olmsted County - Stanley Eggler

Pasture	5.4	1.8	8.3	15.5	+3.8	6.9	2.6L	27H	103M	Tama si. l.

Farmer's own yield = 103 (168# 5-20-20)

When treatments are compared to check, fertilizer did not increase yields. A greater K response would be expected.

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(51) Pine County - Raymond Barringer

Corn	3.3	2.7	6.6	12.6	+0.3	5.6	1.9L	18M	97M	Milaca s.l.

Weed competition and drouth limited yields. Growth response was evident in July on NPK along with phosphorus deficiency on plots which did not receive phosphate. Earlier pollination on NP plot during adverse weather probably accounts for yield reduction from phosphate.

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(52) Pipestone County - Chris B. Pedersen

Oats	3.0	1.2	4.8	9.0	-1.6	5.9	4.4M	14M	207M	Kranzberg si.l.

Fertilizer treatments did not affect yields. Dry subsoil and low July rainfall limited yields.

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(53) Pope County - Bennie Gregerson

Soybeans	4.1	1.3	8.0	13.4	+3.0	6.9	4.1M	7L	163M	Barnes si.l.

Farmer's own yield = 44 (different variety)

Hail and drouth were reported as limiting yield. Early growth response; nitrogen and phosphate was noted. Yields on minor element plots were higher in all replicates than NPK alone.

	Check	PK	NK	NP	NPK	NPK+ M.E.
	Treatment Information					
Yield	110	101	98	103	105	
Population	19,300	19,900	18,800	19,100	19,100	
Number Barren Stalks	2,000	1,300	1,600	900	1,300	
Number Lodged Stalks	7,100	3,100	5,000	4,400	4,400	

	Increase	Decrease
Yield difference due to N =	4 bu.	
" " " " P =	7 "	
" " " " K =	2 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	34	30	47	26	31	
Population	17,500	18,800	19,100	17,500	20,600	
Number Barren Stalks	4,400	7,900	4,000	6,800	9,100	
Number Lodged Stalks	7,800	1,000	2,700	1,000	6,500	

	Increase	Decrease
Yield difference due to N =	1 bu.	
" " " " P =		16 bu.
" " " " K =	5 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	55	53	57	55	51	47
Population	12,300	12,300	12,000	12,500	12,000	12,000
Number Barren Stalks	1,800	1,100	1,000	2,100	1,800	1,600
Number Lodged Stalks	0	0	0	0	0	0

	Increase	Decrease
Yield difference due to N =		2 bu.
" " " " P =		6 "
" " " " K =		4 "
" " " " M.E. =		4 "

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	47	56	52	53	54	65
Population	15,900	16,500	16,200	16,200	15,200	15,700
Number Barren Stalks	3,900	4,400	4,100	4,400	3,400	4,600
Number Lodged Stalks	600	1,200	1,600	800	1,000	700

	Increase	Decrease
Yield difference due to N =		2 bu.
" " " " P =	2 bu.	
" " " " K =	1 "	
" " " " M.E. =	11 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(54) Redwood County - Earl Fridley

Oats	1.8	0.8	7.7	10.3	-0.3	6.4	3.9M	20M	137M	Nicollet si.l.

Farmer's own yield = 57

Fertilizer treatments reduced final yields although there was an early growth response. Rainfall was very low in June and July.

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(55) Renville County - Marvin Sunvold

Oats	1.9	1.0	7.7	10.6	-0.7	6.9	4.8M	5VL	193M	Nicollet c.l.

In spite of low June and July rainfall yields were good and increases corresponded to soil test. NPK plus minor elements outyielded NPK alone on all replicates by 9 to 11 bushels.

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(56) Rice County - Ralph Le Mieux

Corn	7.1	2.4	6.4	15.9	+4.2	6.3	2.7L	41VH	137M	s.l.

Farmer's own yield = 77 (200# 5-20-20 starter + 75# N sidedressed).

Nitrogen was the only element giving a yield increase. Corn leaf aphids caused a high number of barren stalks especially on the fertilized plots.

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(57) Rock County - Ray O'Toole

Soybeans	2.0	0.0	7.0	9.0	-1.6	5.9	4.1M	13M	283VH	Moody si.l.

Nitrogen and phosphate apparently increased yields somewhat. Lack of rain in July apparently limited response.

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(58) Rock County - Albert Baker

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Yield differences were small although phosphorus test was low.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	55	38	24	34	28	
Population	19,900	19,100	20,900	19,900	19,100	
Number Barren Stalks	8,100	12,200	13,600	11,500	12,600	
Number Lodged Stalks	100	0	0	400	200	

	Increase	Decrease
Yield difference due to N =		10 bu.
" " " " P =	4 bu.	
" " " " K =		6 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	64	65	70	98	81	91
Population	14,600	15,700	14,600	14,600	14,400	15,400
Number Barren Stalks	800	700	600	900	600	1,100
Number Lodged Stalks	5,200	4,500	4,200	4,100	3,800	3,800

	Increase	Decrease
Yield difference due to N =	16 bu.	
" " " " P =	11 "	
" " " " K =		17 bu.
" " " " M.E.=	10 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	54	46	60	60	54	60
Population	17,500	17,800	16,200	17,500	18,300	17,500
Number Barren Stalks	3,700	5,000	3,600	4,900	5,800	3,700
Number Lodged Stalks	1,900	1,000	300	900	600	800

	Increase	Decrease
Yield difference due to N =	8 bu.	
" " " " P =		6 bu.
" " " " K =		6 "
" " " " M.E.=	6 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	74	74	75	82	77	
Population	17,500	15,400	14,400	15,200	15,400	
Number Barren Stalks	300	100	0	200	500	
Number Lodged Stalks	4,400	3,800	2,900	5,500	4,100	

	Increase	Decrease
Yield difference due to N =	3 bu.	
" " " " P =	2 "	
" " " " K =		5 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	85	80	82	80	84	
Population	14,100	10,500	13,600	14,600	12,300	
Number Barren Stalks	800	400	500	400	500	
Number Lodged Stalks	1,800	1,800	1,800	1,700	2,000	

	Increase	Decrease
Yield difference due to N =	4 bu.	
" " " " P =	2 "	
" " " " K =	4 "	

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(60) Sherburne County - Charles Anderson

None	2.7	2.9	5.0	10.6	-0.7	5.8	0.6L	50VH	87L	Zimmerman l.s.

Farmer's own yield - 6 (120# 0-0-60 + 100# 6-24-12)

Yields were low because of cutworm damage and necessity of a second planting. Field was very deficient in nitrogen. Although the potassium level was low, it was apparently adequate for these yields.

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(62) Sibley County - Mauritz Hanson

Soybeans	4.7	1.0	9.8	15.5	+4.2	7.1	5.7M	51VH	290VH	Webster c.l.

Farmer's own yield = 115 (200# 6-24-12)

Yield increases would not be expected on this high fertility soil. Corn leaf aphids were prevalent the first of August which corresponded to incidence of barren stalks.

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(64) Stearns County - Henry Berling

Corn	1.4	0.8	5.0	7.2	-4.1	7.1	5.1H	29H	123M	Nicollet l.

Although fertilizer increased yields over the check, NPK yield was lower than the NP yield.

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(65) Steele County - Victor Calverly

Corn	7.7	1.1	7.1	15.9	+4.2	6.2	2.7L	36VH	137M	Nicollet si.l.

Nitrogen was the only element causing a yield increase.

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(66) Steele County - Eugene Sorg

Corn	4.8	0.8	1.8	7.4	-4.3	7.5	4.3M	6L	97M	Nicollet l.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	10	8	27	29	26	26
Population	14,600	14,600	15,700	15,200	15,400	16,500
Number Barren Stalks	7,400	7,400	6,800	5,200	6,200	6,700
Number Lodged Stalks	5,400	3,400	5,300	6,400	2,600	3,100

	Increase	Decrease
Yield difference due to N =	18 bu.	
" " " " P =		1 bu.
" " " " K =		3 "
" " " " M.E.=	No difference	

	Check	PK	NK	NP	NPK
Yield	100	100	89	94	93
Population	19,300	17,500	18,600	19,600	20,400
Number Barren Stalks	3,200	1,600	3,900	3,900	5,400
Number Lodged Stalks	600	1,000	1,200	500	2,900

	Increase	Decrease
Yield difference due to N =		7 bu.
" " " " P =	4 bu.	
" " " " K =		1 bu.

	Check	PK	NK	NP	NPK
Yield	51	57	61	72	61
Population	19,300	18,000	18,800	18,800	18,600
Number Barren Stalks	4,500	2,900	4,000	2,800	3,400
Number Lodged Stalks	7,000	1,200	3,800	5,200	3,300

	Increase	Decrease
Yield difference due to N =	4 bu.	
" " " " P =	No difference	
" " " " K =		11 bu.

	Check	PK	NK	NP	NPK
Yield	65	57	77	75	72
Population	16,500	16,700	16,500	16,500	14,600
Number Barren Stalks	10,500	11,300	9,500	9,900	9,500
Number Lodged Stalks	0	0	0	0	0

	Increase	Decrease
Yield difference due to N =	15 bu.	
" " " " P =		5 bu.
" " " " K =		3 bu.

	Check	PK	NK	NP	NPK
Yield	100	101	96	96	90
Population	15,900	15,900	15,400	15,400	15,700
Number Barren Stalks	1,300	1,300	300	400	700
Number Lodged Stalks	1,200	1,100	2,200	900	2,600

	Increase	Decrease
Yield difference due to N =		11 bu.
" " " " P =		6 "
" " " " K =		6 "

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(68) Steele County - Lester Oeltjenbruns

Corn	4.7	2.4	3.0	10.1	-1.6	7.8	7.7VH	4VL	97M	Webster si.c.l.

Phosphate and potash increased the yield over no fertilizer but increases cannot be attributed to P or K individually.
NOTE: NP yield represents average of only two replications.

---

(69) Swift County - Irvin Janson

Soybeans	-	-	-	-	-	7.7	5.1M	12M	223H	Colvin c.l.

Nitrogen accounted for a large increase, but phosphate accounted for little difference despite a low medium test.

---

(70) Wabasha County - Ed Freese

Peas	3.5	0.6	9.8	13.9	+2.2	7.1	1.6L	42VH	90L	Fayette si.l.

Again nitrogen was the most important element. Yields are higher than normally expected with a 90 lb. K test.

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(71) Wabasha County - Roscoe Moyer

Hay	4.9	3.0	13.9	21.8	+10.1	6.6	1.7L	19M	90L	Fayette si.l.

Potassium was most important which corresponds to the P and K tests.

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(72) Waseca County - Eugene Scheffert

Wheat	5.3	0.9	6.7	12.9	+1.2	6.5	4.6H	5VL	127M	Webster l.

Some phosphate response is indicated by the difference between the NK and NP yields, but most of the yield increase is due to nitrogen.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	85	105	106	103	105	
Population	16,500	17,800	17,300	16,700	17,800	
Number Barren Stalks	700	1,100	1,800	1,200	1,500	
Number Lodged Stalks	1,400	1,100	1,400	3,400	2,200	

	Increase	Decrease
Yield difference due to N =	No difference	
" " " " P =		1 bu.
" " " " K =	2 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	83	88	123	127	121	
Population	18,300	19,100	19,300	20,100	18,600	
Number Barren Stalks	800	1,600	1,500	1,000	1,100	
Number Lodged Stalks	-	-	-	-	-	

	Increase	Decrease
Yield difference due to N =	33 bu.	
" " " " P =		2 bu.
" " " " K =		6 bu.

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	87	89	124	114	112	
Population	14,900	15,200	14,900	14,400	14,600	
Number Barren Stalks	700	600	600	1,000	800	
Number Lodged Stalks	600	400	400	800	800	

	Increase	Decrease
Yield difference due to N =	23 bu.	
" " " " P =		12 bu.
" " " " K =		2 "

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	93	131	112	107	115	
Population	17,500	19,300	19,100	17,800	18,300	
Number Barren Stalks	1,000	400	500	700	800	
Number Lodged Stalks	4,100	4,000	4,100	4,300	3,300	

	Increase	Decrease
Yield difference due to N =		16 bu.
" " " " P =	3 bu.	
" " " " K =	8 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	73	61	106	114	107	
Population	20,100	19,600	20,100	19,300	20,400	
Number Barren Stalks	1,500	2,700	1,000	1,500	1,800	
Number Lodged Stalks	2,200	7,300	1,800	2,200	1,100	

	Increase	Decrease
Yield difference due to N =	46 bu.	
" " " " P =	1 "	
" " " " K =		7 bu.

Past Crop (1958)	Rainfall (inches) June	July	August	Total 3 mo.	Rain diff. from normal	Soil Test Results pH	O.M.%	P	K	Soil Type Texture

(73) Washington County - Irving Nickelson

Hay and pasture	0.8	4.0	7.0	11.8	-0.5	6.3	0.9L	20M	57VL	Sandy acid outwash l.s.

Observations by soils agent, Cliff Halsey, were that fertilizer gave early response but that pollination was poor on fertilized plots.

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(74) Washington County - Walter and Herman Herzfeld

Soybeans	2.8	1.6	7.5	11.9	-0.4	5.7	3.0L	23H	103M	Waukegan l.

This field showed a larger early growth response to fertilizer than the Nickelson field but yield decreased from fertilizer.

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(75) Watonwan County - Peter F. Stoesz

Soybeans	3.1	1.5	6.5	11.1	-0.6	7.8	3.7M	5VL	120M	Webster clay loam

This field was very phosphorus deficient as shown by the effect of phosphate fertilizer. Yields were good in spite of high population and low rainfall.

---

(76) Watonwan County - Robert Johnson

Corn	7.0	0.4	4.5	11.9	+0.2	7.7	5.7M	10L	130M	Nicollet c.l.

The 18-bushel response to phosphate agrees with the phosphorus test. Good rainfall in June apparently carried corn through a dry July.

---

(77) Wright County - Howard Hess (Comer Farm)

Alfalfa	3.1	2.6	4.7	10.4	-0.9	6.4	2.9L	24H	117M	Clarion l.

Small phosphorus effect agrees with soil test. As in a number of other fields, the 120 K level appeared adequate for 100 bushel yields.

	Treatment Information					
	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	68	71	69	55	57	
Population	12,300	12,300	13,100	12,500	13,300	
Number Barren Stalks	300	900	1,500	1,800	3,200	
Number Lodged Stalks	100	100	0	100	200	

	Increase	Decrease
Yield difference due to N =		14 bu.
" " " " P =		12 "
" " " " K =	2 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	77	55	55	62	44	53
Population	17,300	16,500	17,000	17,300	17,000	17,300
Number Barren Stalks	1,500	3,500	3,500	2,900	7,100	5,500
Number Lodged Stalks	400	200	300	400	200	400

	Increase	Decrease
Yield difference due to N =		11 bu.
" " " " P =		11 "
" " " " K =		18 "
" " " " M.E =	9 bu.	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	46	87	29	89	90	
Population	18,300	17,800	17,800	23,300	16,500	
Number Barren Stalks	4,300	1,600	5,400	2,100	2,200	
Number Lodged Stalks	2,300	2,000	1,200	2,700	2,000	

	Increase	Decrease
Yield difference due to N =	3 bu.	
" " " " P =	61 "	
" " " " K =	1 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	101	112	100	112	118	
Population	15,200	15,400	14,900	15,700	15,400	
Number Barren Stalks	300	200	600	400	200	
Number Lodged Stalks	1,600	2,200	800	1,800	1,300	

	Increase	Decrease
Yield difference due to N =	6 bu.	
" " " " P =	18 "	
" " " " K =	6 "	

	Check	PK	NK	NP	NPK	NPK+ M.E.
Yield	106	92	102	99	98	
Population	15,700	16,500	16,700	16,700	17,000	
Number Barren Stalks	1,600	2,600	2,300	2,500	2,200	
Number Lodged Stalks	800	500	1,000	1,300	1,600	

	Increase	Decrease
Yield difference due to N =	6 bu.	
" " " " P =		4 bu.
" " " " K =		1 "

Minnesota Subsoil Fertility Study (1956-1959)[1)]

J. Grava, R. H. Rust, H. F. Arneman, R. S. Farnham,
G. E. Spalding, A. S. Robertson

Introduction

Difficulties are frequently encountered by making lime and fertilizer recommendations on basis of soil tests on surface samples alone without information of the subsoil fertility. Although farmers are encouraged to obtain subsoil samples for testing purposes, their response has not been adequate. Since subsoil sampling is both time comsuming as well as inconvenient to the average farmer, it is doubtful whether the practice can be successfully established as an integral part of a soil sampling and testing program. However, if the nutrient levels in the subsoil of individual soil series were known and were reasonably uniform within each series, sampling of the plow layer would be adequate if the soil weries were known.

For this purpose a cooperative study on subsoil fertility of Minnesota's major soil series was initiated in 1956. The cooperating agencies are the Department of Soils of the University of Minnesota and the Soil Conservation Service. The purpose of this report is to describe briefly the procedure which is followed in this study, and, with the help of a few examples, to illustrate the possibilities of a study such as this.

Procedure

Profile samples are obtained by S.C.S. area soil scientists in connection with their regular soil survey work. Some profiles are taken from fields that have been included in the "Soil Productivity Study" conducted in cooperation with the Department of Soils. It is expected that 20 to 50 profiles of each major soil series will be collected. However, the choice of profiles within a given soil series is left entirely to the soil scientists. Sometimes samples are submitted to the laboratory for chemical and/or mechanical analysis where the identification by regular field methods seems to be insufficient.

Duplicate, one pint samples of each horizon are taken, put in plastic bags, sealed, labeled and placed in carboard containers. Samples and soil description forms (S.C.S. Form 232C) are mailed or brought to the Soil Testing Laboratory. File numbers are given to each profile as well as individual horizon samples. Samples, after being air-dried, crushed and screened, are tested by regular soil testing procedures. These include determinations for pH, organic matter, phosphorus and potassium. The pH is determined with a Beckman pH meter on a soil-water paste. Organic matter is determined by employing the potassium dichromate and sulfuric acid method. The color differences are measured by means of a colorimeter. Extractable phosphorus is determined colorimetrically by the Bray's No. 1 method. Exchangeable potassium is determined on a neutral 1N ammonium acetate extract using the Perkin-Elmer flame photometer. The contents of phosphorus and potassium are expressed in parts per two million. (One part per two million of phosphorus or potassium is equivalent to one pound per acre assuming the sample represents a 6 inch layer or 2 million pounds of soil).

1) In cooperation with the S.C.S.

After the completion of the analyses, test results are recorded and a copy is sent to the S.C.S. Soil Scientist, who had submitted the samples. Samples are saved with the intention of undertaking additional determinations on soil physical, mechanical and chemical properties as resources will permit.

During last year it became apparent that, because of lack of funds, it will be possible to investigate more thoroughly only a limited number of profiles. For that purpose "modal" profiles of 27 soil series were selected. Mechanical and chemical analyses on these samples are now nearly completed.

Results

A total of 2608 samples from 503 profiles have been submitted for this study. Tables 1 and 2 show the number of profiles obtained from each S.C.S. area since the establishment of this study. A list of profiles obtained from major soil series is also included.

Tables 3 to 11 show results of mechanical and chemical analyses which have been completed on nine profiles considered as "modal" for the Lester, LeSueur, Clarion, Kranzburg, Aastad, Flom, Bearden, Ulen and Hubbard series.

Previous studies on soils of Iowa, Wisconsin and Minnesota have indicated that exchangeable potassium content may be considerably higher in air-dry samples, especially in subsoil, in comparison to that determined on field moist soil. On coarse textured soils which are rather low in clay content, such drying effect is much less pronounced. The data of Figures 1 to 9 illustrate the effect of sample drying upon the exchangeable potassium content on nine different Minnesota soils.

Conclusions

The information already obtained indicates that this study can greatly contribute to our knowledge of the subsoil fertility status of soils of Minnesota. It should lead to a better understanding of various soil series in respect to problems concerning liming, fertilization and overall management.

Table 1. NUMBER OF SOIL PROFILES RECEIVED ANNUALLY FOR THE SUBSOIL FERTILITY STUDY, 1956 to 1959

YEAR	NUMBER OF PROFILES	NUMBER OF SAMPLES
1956	55	333
1957	185	984
1958	162	804
1959	101	487
Four Year Total	503	2608

Table 2. NUMBER OF SOIL PROFILES OBTAINED FOR MINNESOTA'S SUBSOIL FERTILITY STUDY BY COUNTIES AND S.C.S. AREAS, 1956 to 1959.

AREA I.		AREA II.		AREA III.		AREA IV.		AREA V.		AREA VI.		AREA VII.	
S.C.S. Soil Scientists:													
Scilley, Ravenholt, Barron		Erickson, Lewis		Grimes, Ziebell, Chamberlain		Edwards, Diedrick, Sutton, Lueth, Munter, Nyberg		Hokanson, Lorenzen		Cummins		Harms, Poch	
Kittson	3	Douglas	3	Aitkin	4	Carver	29	Lincoln	10	Blue Earth	3	Wabasha	17
Lake of the Woods	8	Ottertail	4	Benton	3	Chippewa	17	Lyon	9	Brown	19	Mower	1
Marshall	1	Stevens	1	Chisago	3	Kandiyohi	16	Murray	13	Freeborn	21	Dodge	1
Norman	6	Grant	5	Kanabec	1	Meeker	22	Nobles	20	LeSueur	15	Goodhue	3
Red Lake	1			Mille Lacs	4	Renville	13	Pipestone	6	Martin	6		
Beltrami	8			Sherburne	17	Sibley	15	Redwood	3	Rice	36		
Pennington	3			Stearns	4	Swift	21	Jackson	1	Steele	41		
Polk	3					Wright	1	Rock	1	Watonwan	10		
Clearwater	3					Bigstone	12	Yellow Medicine	2	Waseca	20		
Koochiching	2					Pope	12						
Area Total	38		13		36		158		65		171		22
State Total	503												

LIST OF PROFILES OBTAINED FROM MAJOR SOIL SERIES FOR MINNESOTA'S SUBSOIL FERTILITY STUDY, 1956-1959

FD Fayette - Dubuque	
Fayette	5
Dubuque	2
Bertrand	2
TD Tama - Downs	
Tama	5
Downs	4
LH Lester - Hayden	
Dundas	8
Hayden	29
CL Clarion - Lester	
Lester	31
LeSueur	16
HB Hayden - Bluffton	
Bluffton	2
Nessel	1
Ames	1
OKF Ostrander - Kenyon - Floyd	
Ostrander	3
Kenyon	3
Floyd	3
Racine	1
Taopi	3
Varco	1
Lerdahl	3
SK Skyberg - Kasson	
Skyberg	1
CNW Clarion - Nicollet - Webster	
Storden	5
Lakeville	1
Clarion	23
Nicollet	29
Webster (Timbered)	6
Webster	16
Webster, Calc. Var.	18
Harpster	2
Glencoe	7
Blue Earth	1
Truman	1
Kinston	4
Madelia	5
Marna	8
Laura	4
Beauford	4
CNW	
Terril	1
Comfrey	1
Fieldon	1
Arlington	4
Rolfe	1
Thurman	1
MKU Moody - Kranzburg - Vienna	
Kranzburg	10
Moody	1
Primghar	1
Marcus	1
Afton	1
Vienna	2
Lismore	2
Leota	1
BA Barnes - Aastad	
Buse	9
Barnes	17
Aastad	10
Flom	7
Parnell	6
Hamerly	7
Vallers	6
Alcester	1
Arco	2
Sverdrup	3
Hendricks	1
Tetonka	1
Pierce	1
WB Waukon - Barnes	
Waukon	3
Gonvich	1
FB Fargo - Bearden	
Fargo	2

FB	
Bearden	4
Colvin	3
Sletten	1
Borup	2
UST Ulen - Sioux - Tanberg	
Ulen	2
Sioux	2
Grimstad	1
Mavie	1
MW McIntosh - Winger	
McIntosh	1
Winger	1
NR Nebish - Rockwood	
Nebish	3
Beltrami	1
Shooks	2
Brickton	2
RKP Rocksbury - Kittson - Peat	
Kittson	1
Rockwell	3
TGP Taylor - Grygla - Peat	
Baudette	2
Hiwood	2
Chilgren	3
Grygla	1
Wildwood	1
Indus	1
MBH Milaca - Brainerd - Hibbing	
Freon	3
Freer	1
Milaca	1
Mora	1
Bock	1
Flak	2
ZIP Zimmerman - Isanti - Peat	
Zimmerman	4
Nymore	2
Lino	2
Isanti	2
M Menahga	
Menahga	3
Redby	1
WH Wadena - Hubbard and Terrace Soils	
Hubbard	13
Wadena	4
Estherville (BA group)	9
Fairhaven (CNW group)	4
Litchfield	1
Biscay	3
Kasota	1
Kato	1
Bixby	2
Waukegan	2
Estilline	1
Central	3

Table 3. Soil Type Lester Loam Location Carver County
Legal Description SW¼ of SW¼ Sec. 1 Benton Twp. R 25 W T 115 N
Sampled by R. J. Edwards Laboratory No. 106:1-6

Depth Inches	Horizon	Per cent: Sand	Per cent: Silt	Per cent: Clay	Texture: Field method	Texture: Mechan. Anal.	pH Paste	Organic matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m.: Field moist	Exchangeable K p.p.2m.: Air-dry	Extractable Cations m.e./100 g. soil: Ca	Mg	K	Na	$CaCO_3$ Equivalent %	Electrical Conductivity EC x 10^3 Millimhos per CM @ 25° C
0-6	A_1	46.1	32.3	21.6	h.l	l	6.9	7.7	64	634	547	19.3	6.4	0.70	0.10	-	-
6-8	A_2	48.7	30.8	20.5	l	l	7.0	2.2	45	289	321	11.9	3.4	0.41	0.06	-	-
8-14	B_1	40.8	28.8	30.4	cl	cl	7.0	1.6	37	186	375	14.3	5.7	0.48	0.09	-	-
14-23	B_{21}	39.9	30.6	29.5	cl	cl	6.9	1.0	15	77	321	13.7	6.8	0.41	0.18	-	-
23-30	B_{22}	40.0	32.0	28.0	h.cl	cl	6.8	0.6	18	77	313	12.8	6.5	0.40	0.24	-	-
30-42+	C	37.0	39.2	23.0	cl	l	7.8	0.3	3	66	274	11.5	5.0	0.35	0.23	17.1	0.5

Table 4. Soil Type LeSueur Silty Clay Loam Location Carver County
Legal Description NE¼ of NW¼ Sec. 5. San Francisco Twp.
Sampled by R.O. Lueth Laboratory No. 402:1-8

Depth Inches	Horizon	Per cent: Sand	Silt	Clay	Texture: Field method	Mechan. Anal.	pH Paste	Organic matter %	Extractable P p.p.2m.	Exchange-able K p.p.2m.: Field moist	Air-dry	Extractable Cations (m.e./100g. soil): Ca	Mg	K	Na	$CaCO_3$ Equiva-lent %	Electrical Conductivity EC x 10^3 Millimhos per CM @ 25°C
0-7	A_1	11.1	51.9	37.0	lt.cl	si.cl	7.0	7.8	11	231	360	27.0	9.4	0.46	0.11	-	-
7-9	AB	11.8	50.4	37.8	cl	si.cl	6.7	6.9	37	162	328	20.2	7.4	0.42	0.10	-	-
9-14	B_1	9.1	49.2	41.7	cl	si.c	6.2	3.6	25	117	399	20.2	8.1	0.51	0.11	-	-
14-18	B_{21}	10.0	37.7	52.3	h.cl	c	5.1	1.9	4	103	587	19.9	8.2	0.75	0.22	-	-
18-28	B_{22}	17.1	35.3	47.6	vh.cl	c	4.5	1.0	3	82	485	14.9	7.3	0.62	0.22	-	-
28-34	B_3	18.3	40.5	41.2	cl	si.c	6.4	0.6	7	87	493	20.2	10.3	0.63	0.39	-	-
34-39	C_1	33.2	38.0	28.8	cl	cl	7.1	0.4	3	83	415	16.4	6.1	0.53	0.37	4.9	0.5
39+	C_2	-	-	-	cl	-	7.5	0.2	3	87	297	11.1	4.0	0.38	0.37	9.2	0.5

Table 5. Soil type Clarion clay loam Location Brown county
Legal description SE¼ SE¼ Sec. 26 Home township R 32 W T 110 N
Sampled by J. F. Cummins Laboratory No. 367:1-5

Depth Inches	Horizon	Per cent			Texture		pH Paste	Organic matter %	Extractable P p.p.2m.	Exchange-able K p.p.2m.		Extractable Cations m.e./100 g. soil				$CaCO_3$ Equiva-lent %	Electrical Conductivity EC x 10^3 Millimhos per CM @ 25° C.
		Sand	Silt	Clay	Field method	Mechan. anal.				Field moist	Air-dry	Ca	Mg	K	Na		
0-8	A_p	35.8	33.8	30.4	cl	cl	5.6	4.6	14	277	399	13.4	6.0	0.51	0.09	-	-
8-13	A_1	37.1	32.8	30.1	cl	cl	5.6	4.4	8	193	360	13.4	5.9	0.46	0.09	-	-
13-23	B_1	38.2	31.9	29.9	cl	cl	6.1	1.0	2	99	344	13.7	6.7	0.44	0.17	-	-
23-32	B_2	40.0	33.4	26.6	cl	l	6.4	0.7	3	99	328	13.4	6.4	0.42	0.20	-	-
32-36	C_1	40.4	33.5	26.1	cl	l	8.0	0.3	3	101	282	10.9	4.0	0.36	0.20	15.2	0.5

Table 6. Soil Type Kranzburg Silty Clay Loam Location Nobles County

Legal Description NE$\frac{1}{4}$ Sec. 15. Grand Prairie Twp. R43 W T 101 N.
Sampled by F. D. Lorenzen Laboratory No. 298:1-6

Depth Inches	Horizon	Per Cent			Texture		pH Paste	Organic matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m.		Extractable Cations			
		Sand	Silt	Clay	Field Method	Mechan. Anal.				Field Moist	Air-Dry	Ca	Mg	K	Na
0-7	A_{1p}	5.8	64.1	29.9	si.l	si.cl.	6.5	4.6	10	206	266	15.2	7.1	0.34	0.08
7-12	AB	4.8	63.5	31.7	si.l	si.cl.	6.6	4.5	11	245	305	14.9	7.3	0.39	0.08
12-16	B_{21}	2.9	64.3	32.8	si.l	si.cl.	6.2	3.1	7	128	297	14.9	7.3	0.38	0.11
16-21	B_{22}	2.9	62.7	34.4	si.l	si.cl.	6.0	2.1	5	63	313	15.5	8.2	0.40	0.12
21-32	C	4.7	69.7	25.6	si.l	si.l	6.3	1.2	11	53	313	12.8	7.4	0.40	0.16
32+	D	33.9	45.8	20.3	calc. till	l	6.4	0.7	9	56	289	11.9	7.5	0.37	0.14

Table 7. Soil type Aastad loam Location Swift county
Legal description NW¼ NW¼ Sec. 16, Hayes township
Sampled by R. T. Diedrick Laboratory No. 308:1-5

Depth Inches	Horizon	Per cent			Texture		pH Paste	Organic matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m.		Extractable Cations				$CaCO_3$ Equivalent %	Electrical Conductivity EC x 10^3 Millimhos per CM @ 25° C
		Sand	Silt	Clay	Field method	Mechan. anal.				Field moist	Air-dry	Ca	Mg	K	Na		
												m.e./100 g. soil					
0-6	A_p	41.0	36.6	22.4	lt.cl	l	7.4	5.4	10	138	219	18.9	4.6	0.28	0.12	-	0.8
6-14	A_1	30.1	42.8	25.1	lt.cl	l	7.1	5.3	8	108	211	19.9	4.8	0.27	0.12	-	0.4
14-19	B_{21}	28.2	47.0	24.8	cl	l	6.7	3.6	6	63	227	14.6	5.5	0.29	0.09	-	-
19-24	B_{22}	27.2	47.5	25.3	cl	l	6.5	2.1	3	77	266	13.4	5.2	0.34	0.09	-	-
24-27	B_{23}	-	-	-	scl	-	-	-	-	-	-	-	-	-	-	-	-
27-52+	C_1	24.2	50.2	25.6	cl	sil	6.4	2.0	5	70	282	14.0	5.5	0.36	0.11	-	-

Table 8. Soil type Flom silty clay loam Location Swift county
Legal description NW¼ NW¼ Sec. 16 Hayes township
Sampled by R. T. Diedrick Laboratory No. 182:1-5

Depth Inches	Horizon	Texture Field Method	pH Paste	Organic matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m. Field Moist	Exchangeable K p.p.2m. Air-dry	Extractable cations Ca (m.e./100 g. soil)	Extractable cations Mg (m.e./100 g. soil)	Extractable cations K (m.e./100 g. soil)	Extractable cations Na (m.e./100 g. soil)	$CaCO_3$ Equiva-lent %	Electrical Conductivity EC x 10^3 Millimhos per CM @ 25° C.
0-6	A_p	lt.sicl	7.7	6.9	9	285	469	27.5	14.0	0.60	0.11	2.2	1.0
6-14	A_1	lt.sicl	7.7	5.9	5	149	328	24.7	15.7	0.42	0.11	1.6	0.5
14-18	B_{21}	sicl	8.2	1.9	3	54	274	10.2	17.5	0.35	0.13	8.1	0.5
18-22	B_{22}	sicl	8.4	0.9	2	48	203	6.2	14.3	0.26	0.13	13.4	0.5
22-30	C_1	cl	8.4	0.3	2	54	164	3.7	10.4	0.21	0.16	17.3	0.5

Table 9. Soil Type Bearden Silty Clay Loam Location Chippewa County

Legal Description NE¼ NE¼ Sec. 3. Grace Twp.

Sampled By R. T. Diedrick Laboratory No. 183:1-5

Depth Inches	Horizon	Per Cent			Texture		pH	Organic matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m.		Extractable Cations m.e./100 g. soil				$CaCO_3$ Equivalent %	Electrical Conductivity EC x 10^3 Millimhos per CM @ 25° C
		Sand	Silt	Clay	Field method	Mechan. Anal.	Paste			Field moist	Air-dry	Ca	Mg	K	Na		
0-7	A_p	6.5	56.9	36.6	si.l	si.cl.	7.7	8.1	8	320	422	31.9	6.9	0.54	0.26	11.6	1.3
7-11	A_1	6.4	57.1	36.5	si.l	si.cl.	7.8	7.6	8	345	422	34.2	6.9	0.54	0.24	12.3	1.2
11-14	A_{1Ca}	6.7	55.6	38.7	si.l	si.cl.	8.0	4.7	3	134	305	24.5	6.9	0.39	0.17	19.0	1.0
14-20	B_2	7.2	58.6	34.2	si.cl.	si.cl	7.7	1.8	3	101	321	16.7	6.4	0.41	0.18	21.2	0.8
20-33	C	12.0	52.7	35.3	si.cl.	si.cl.	7.5	0.4	3	127	360	17.4	4.0	0.46	0.29	18.0	2.4

Table 10. Soil Type Ulen Loam Location Kittson County
Legal Description NE corner Sec. 36. Jupiter Twp. R47 W T 160 N.
Sampled by F. M. Scilley Laboratory No. 213: 1-4

Depth inches	Horizon	Texture Field Method	pH Paste	Organic matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m. Field Moist	Exchangeable K p.p.2m. Air-Dry	Extractable Cations (m.e./100 g. soil) Ca	Mg	K	Na	$CaCO_3$ Equivalent %	Electical Conductivity EC x 10^3 Millimhos per CM @ 25° C
0-8	A_p & A_1	lt.l	8.3	4.0	5	134	125	12.0	4.9	0.16	0.06	8.5	0.8
8-17	A_3 Ca	lt.sl	8.3	3.1	2	30	70	10.8	4.7	0.09	0.10	11.8	0.8
17-25	C_1 Ca	f.s.	8.1	0.8	1	18	39	5.4	1.6	0.05	0.07	17.1	1.1
25-40	C_2 Ca	f.s.	8.5	0.4	1	11	16	1.8	0.8	0.02	0.04	17.2	0.3

Table 11. Soil type Hubbard loamy coarse sand Location Sherburne county
Legal description SW¼, SW¼, Sec. 33, Haven township
Sampled by M. F. Grimes Laboratory No. 301:1-5

Depth Inches	Horizon	Particle Size Distribution (in mm) (per cent): Very coarse sand 2-1	Coarse sand 1-0.5	Medium sand 0.5-0.25	Fine sand 0.25-0.10	Very fine sand 0.10-0.05	Total sands	Total silts	Total clays	Texture: Field method	Texture: Mechan. analysis
0-8	A_{1p}	3.5	38.3	18.8	20.2	1.5	82.3	11.4	6.3	l s	l c s
8-14	A_{12}	4.8	38.7	23.0	13.4	1.4	81.3	11.7	7.0	l s	l c s
14-24	A-B	9.9	41.1	19.9	17.9	1.2	90.0	6.4	3.6	l s	c s
24-40	B	1.4	50.4	31.8	14.1	0.6	98.3	1.0	0.7	s	c s
40-72	C_1	7.9	61.7	19.1	9.8	0.3	98.8	1.2	0	s	c s

Depth Inches	pH Paste	Organic Matter %	Extractable P p.p.2m.	Exchangeable K p.p.2m.: Field Moist	Exchangeable K p.p.2m.: Air-Dry	Extractable Cations m.e./100 g.: Ca	Mg	K	Na
0-8	6.2	2.8	38	45	47	4.4	1.8	0.06	0.04
8-14	5.7	1.6	7	13	39	4.4	0.8	0.05	0.03
14-24	5.7	0.8	12	12	16	1.8	0.5	0.02	0.03
24-40	6.1	0.1	9	21	16	0.9	0.2	0.02	0.03
40-72	6.2	0.0	13	15	16	0.6	0.4	0.02	0.02

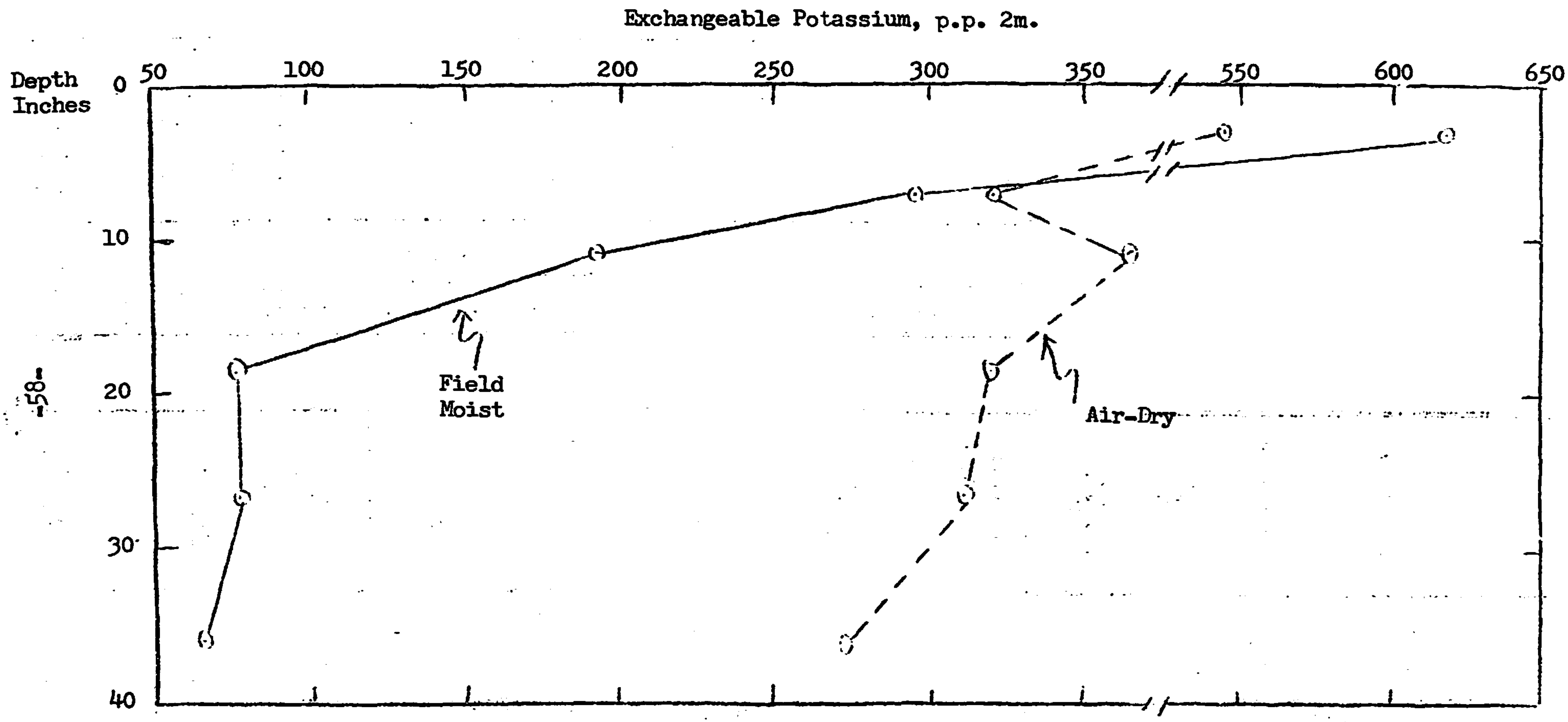

Fig. 1. Effect of drying upon the content of exchangeable potassium in Lester Loam, Carver County.

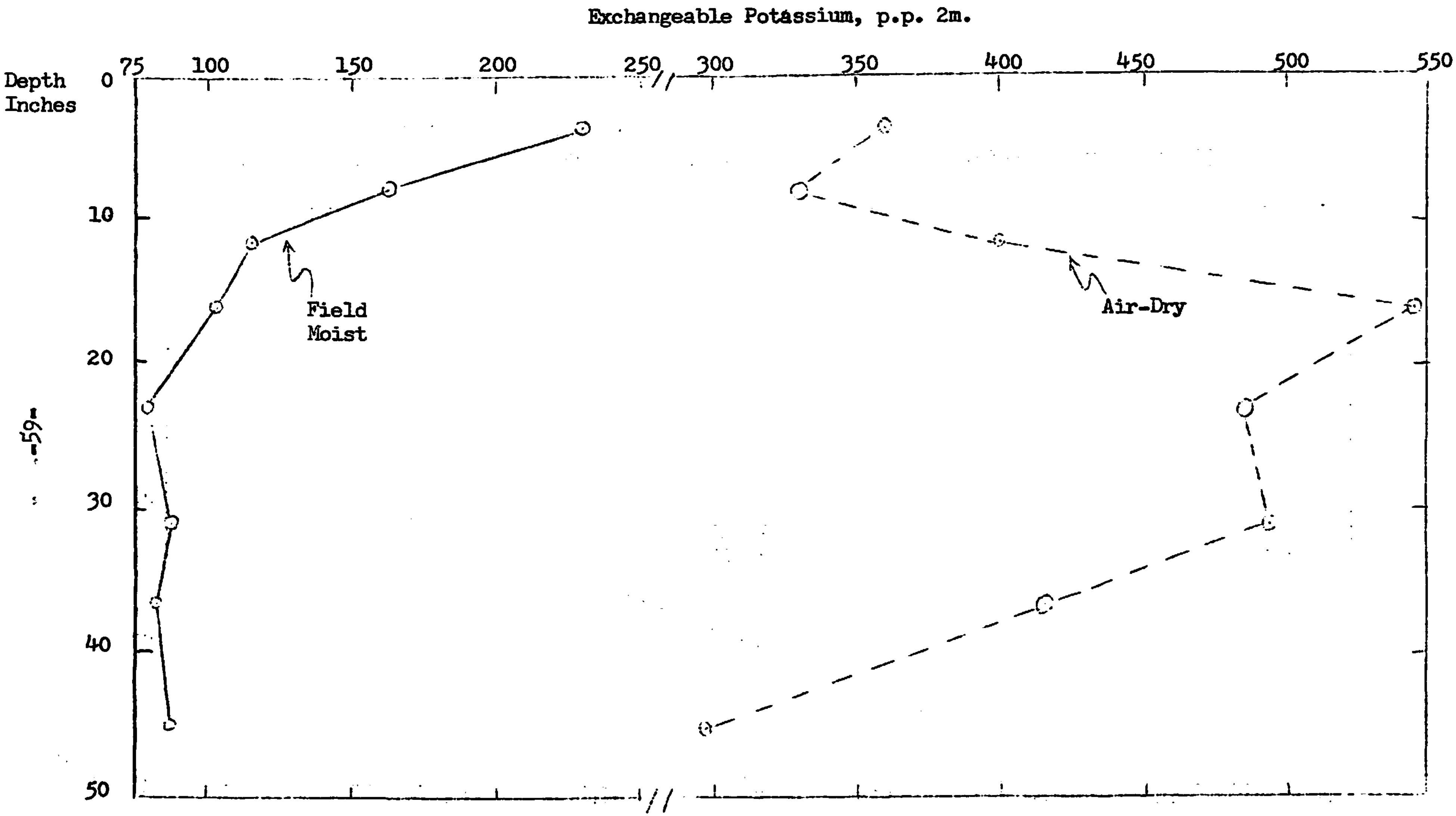

Fig. 2. Effect of drying upon the content of exchangeable potassium in Le Sueur Silty Clay Loam, Carver County.

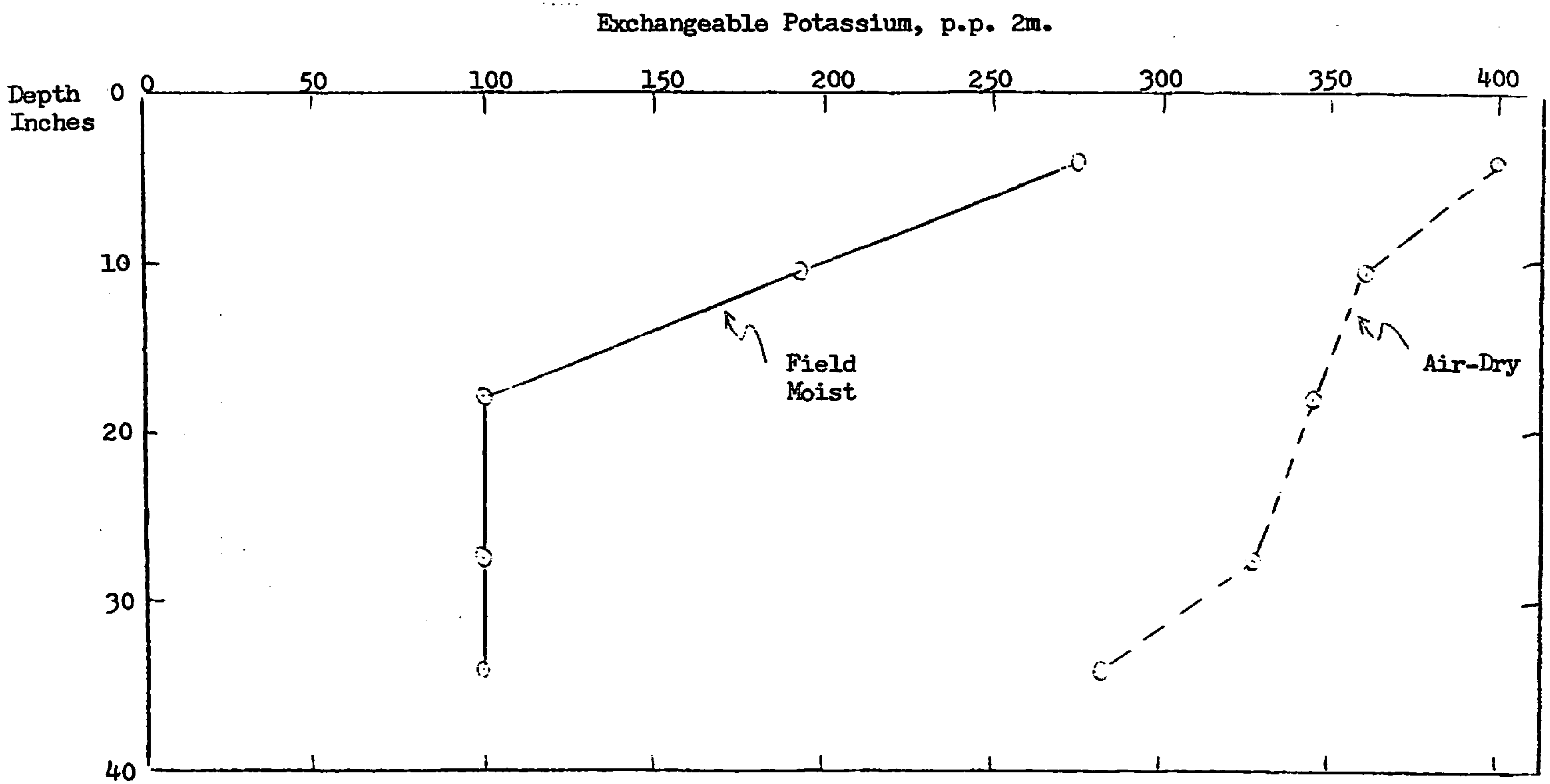

Fig. 3. Effect of drying upon the content of exchangeable potassium content in Clarion Clay Loam, Brown County.

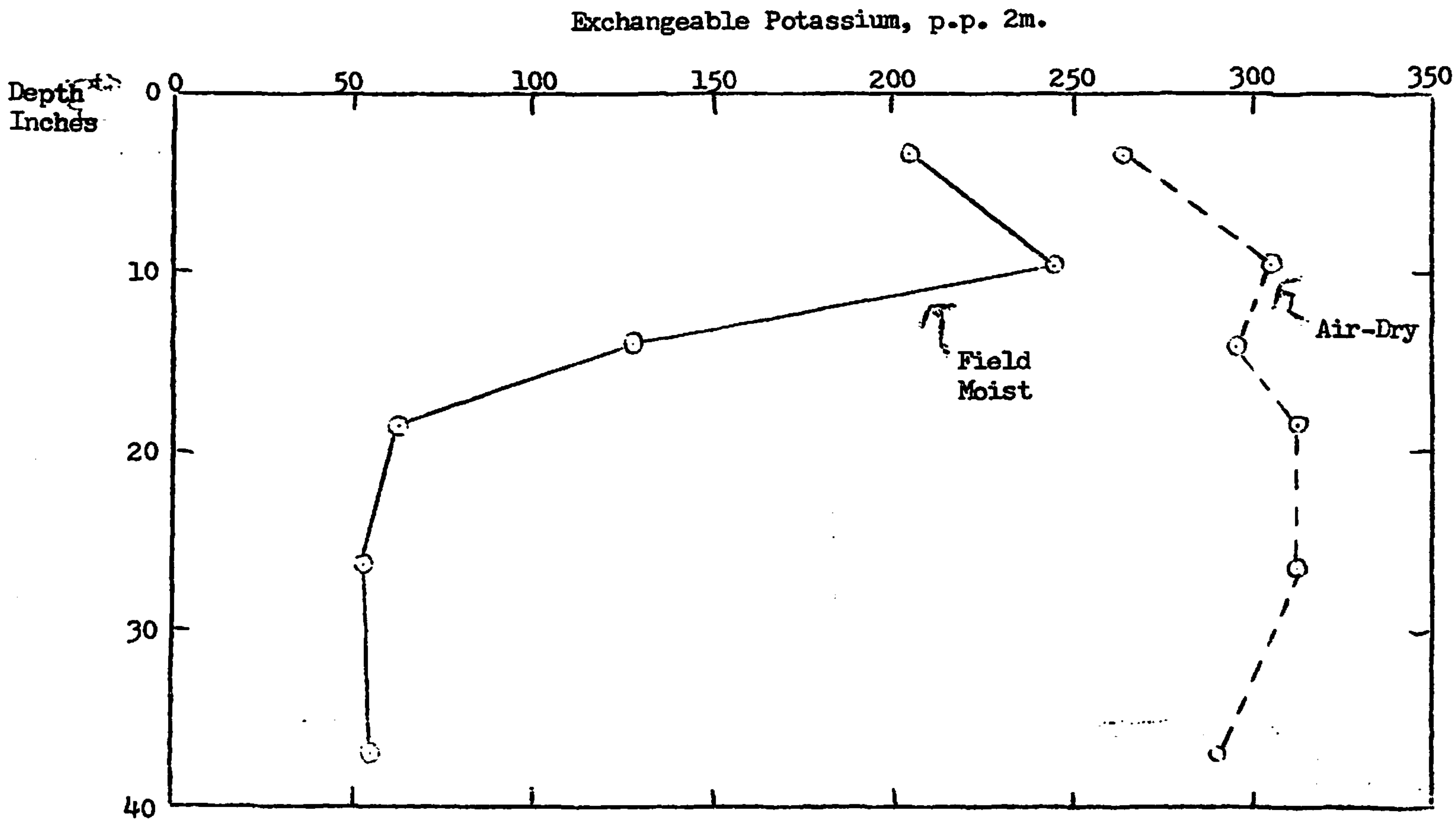

Fig. 4. Effect of drying upon the content of exchangeable potassium in <u>Kranzburg Silty Clay Loam</u>, Nobles County.

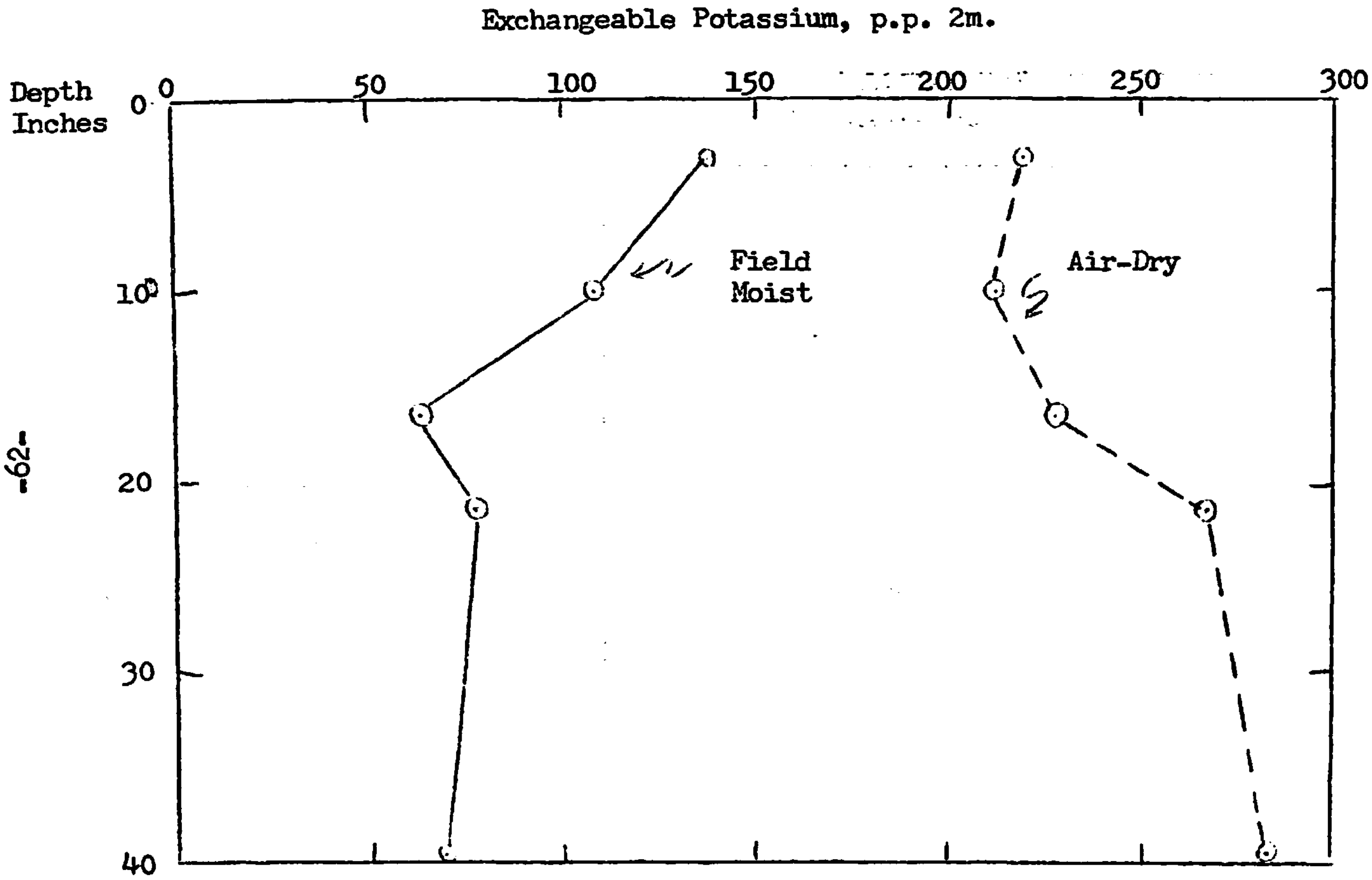

Fig. 5. Effect of drying upon the content of exchangeable potassium in Aastad Loam, Swift County.

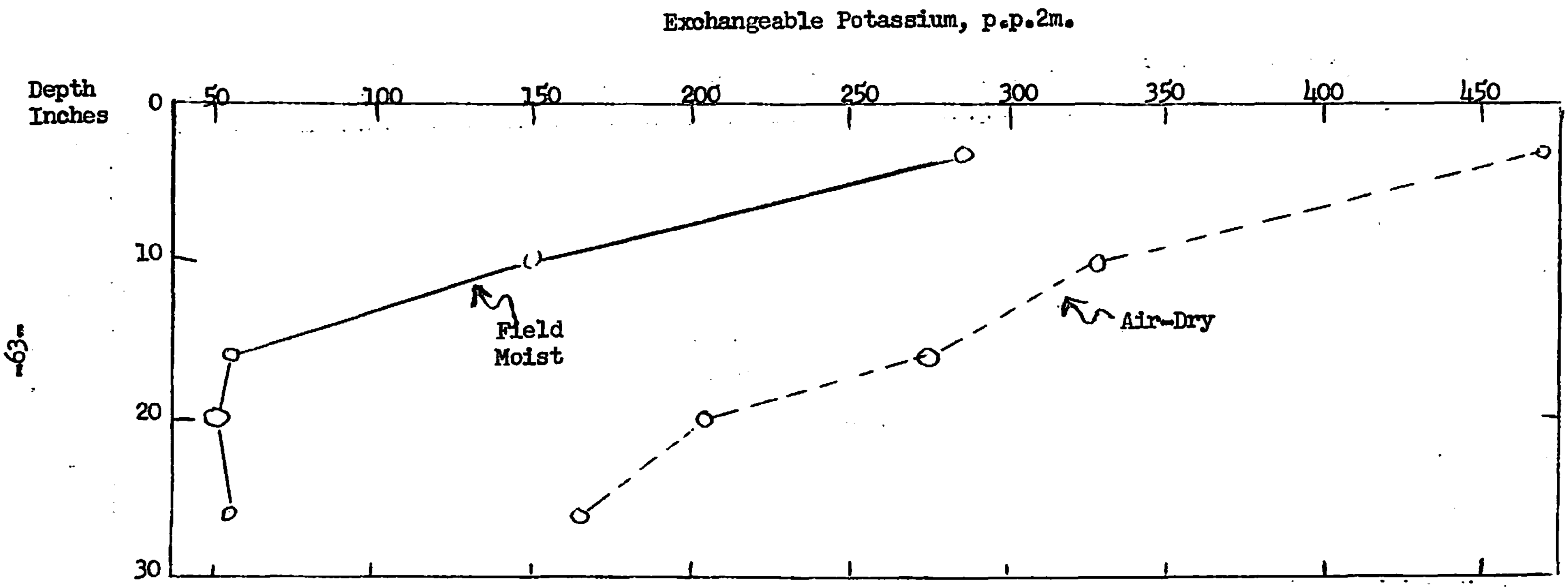

Fig. 6. Effect of drying upon the content of exchangeable potassium in Flom Silty Clay Loam. Swift County.

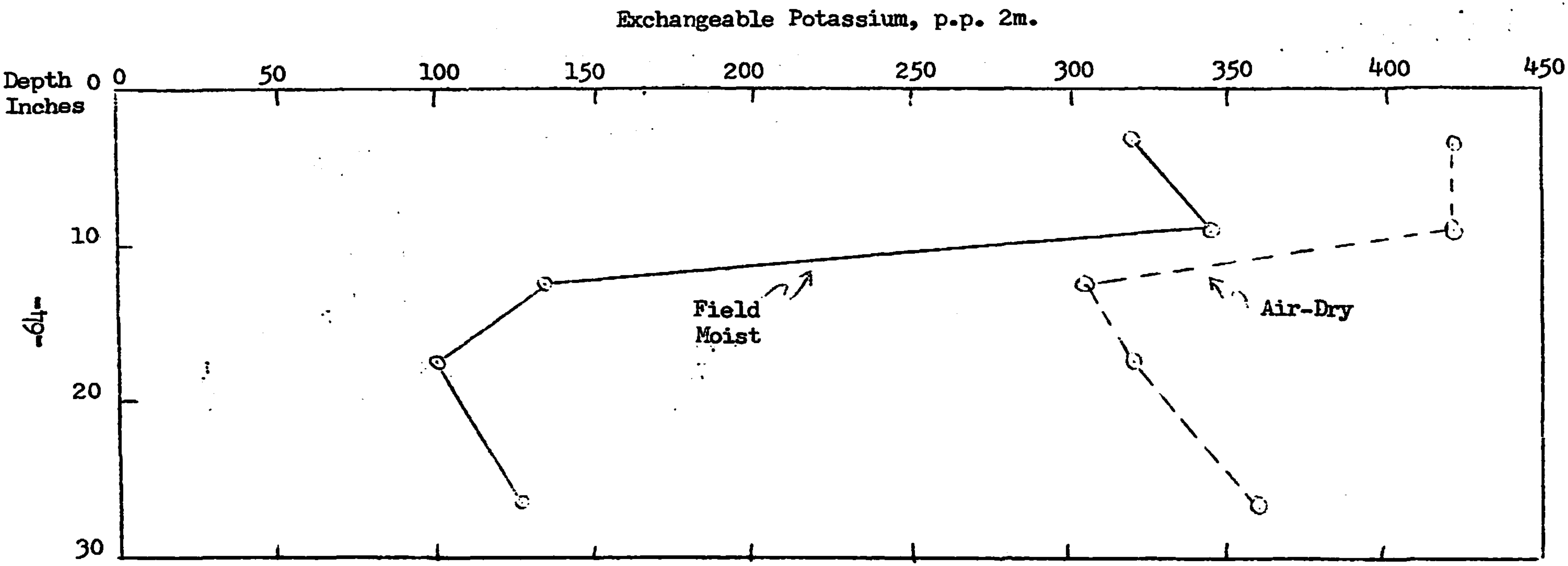

Fig. 7. Effect of drying upon the content of exchangeable potassium in Bearden Silt Loam, Chippewa County.

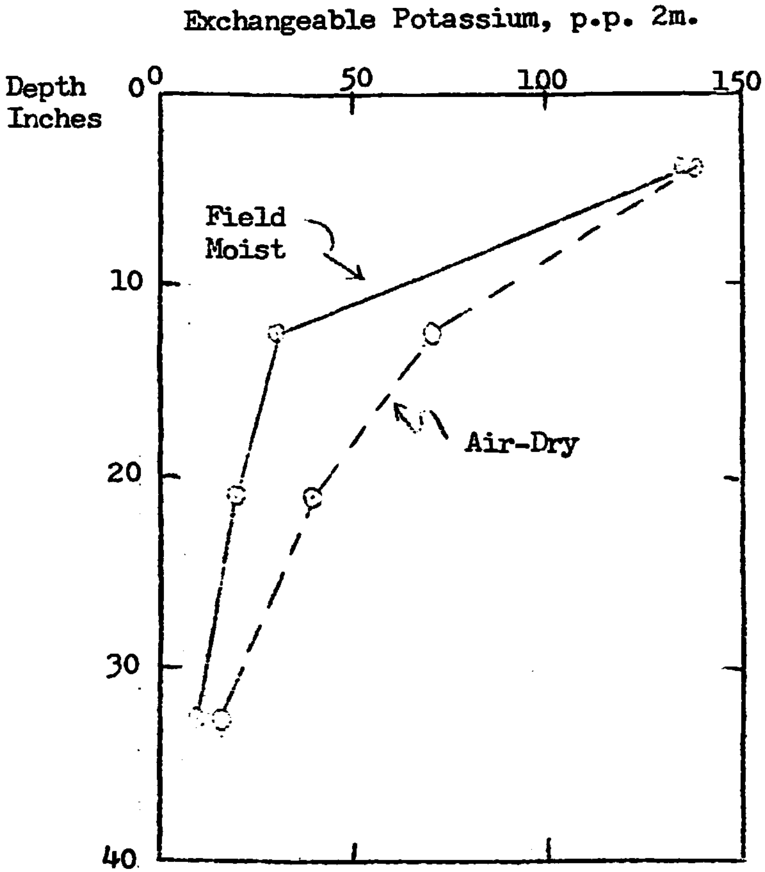

Fig. 8. Effect of drying upon the content of exchangeable potassium in <u>Ulen Loam</u>, Kittson County.

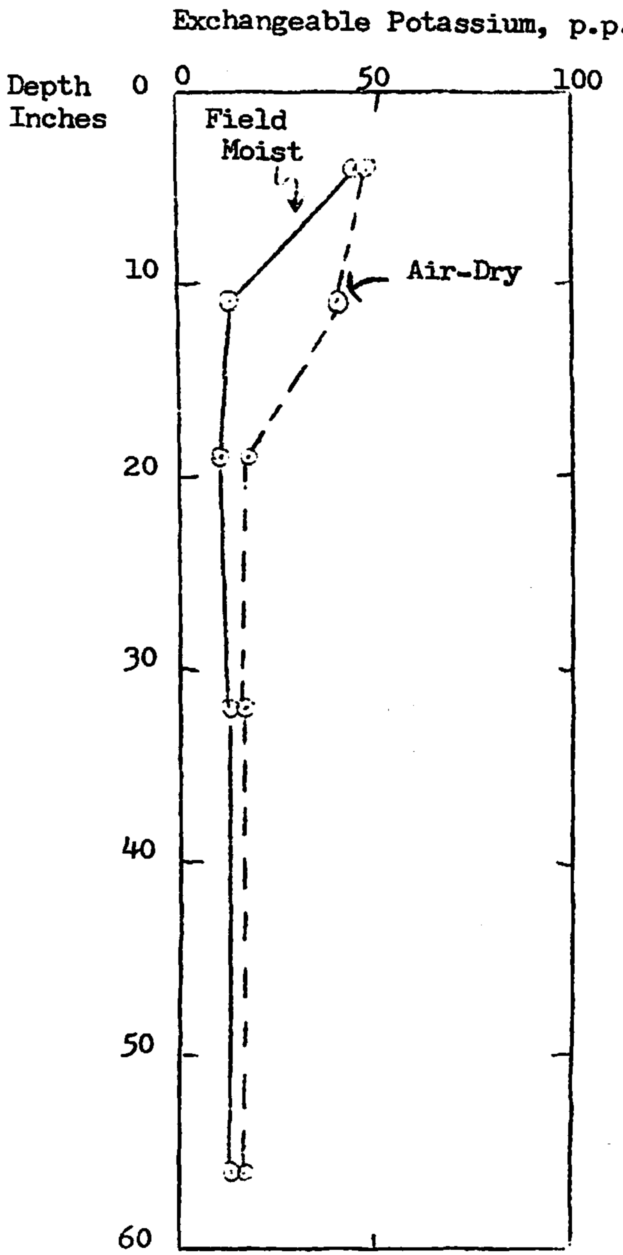

Fig. 9. Effect of drying upon the content of exchangeable potassium in Hubbard Loamy Coarse Sand, Sherburne County.

Nitrogen Losses to the Atmosphere

J. M. MacGregor

Soil investigators have always been unable to balance the nitrogen economy of soils, and it has long been suspected that nitrogen losses not accountable were being lost to the air as NH_3, N_2, N_2O and possibly as N_2O_2.

Recent laboratory investigations in the Department of Soils, using infra-red and mass spectrometric procedures, have shown that wet soils lose appreciable amounts of some fertilizer nitrogen in the air. These losses were most serious where nitrogen was applied in large amounts as the nitrate form, with little loss where applied as urea or as ammonium chloride.

However, under drier soil conditions, when urea was broadcast on the surface of a fine textured soil (Nicollet silty clay loam), at the rate of 100 pounds of N per acre, about 3% was lost as ammonia to the atmosphere over a four week period. Where the same amount of urea was broadcast on a sandy soil, 6% of the nitrogen was lost to the air in 14 days. Covering the urea with a half inch of the sandy soil reduced the loss to half of that of the surface application (3%). Some field experiments have indicated a slightly greater use of the nitrate nitrogen by corn plants, but this varies with different soil and weather conditions.

It must be kept in mind that nitrogen is not a mineral element, but can revert to gaseous forms and be lost from the soil in this way. Good results have been obtained with all of our commonly used nitrogen fertilizers - and more research is essential to increase this nitrogen efficiency in crop production even more.

Comparison of Sources of Phosphate (Goodhue County, 1959)

A. C. Caldwell and J. Kline

An experiment comparing sources of phosphate was established on an alfalfa field on the Augustine brothers farm in the spring of 1959. This soil is a Fayette silt loam testing medium in available P and neutral in reaction. Fertilizer treatments consisted of tunisian rock, Florida rock, concentrated superphosphate, calcium metaphosphate, and monodicalcium phosphate. Two samples of alfalfa were taken for yields, and one (the first) for P analysis. Results are given in the following tables.

Yield results show that responses to phosphorus were small (which was somewhat contrary to what might have been expected on the basis of soil test). All materials brought about a small increase in alfalfa yields, none differing significantly from another.

All phosphorus materials increased the phosphorus content of alfalfa. The more available forms of phosphorus had greater effects than the rock phosphates, however Tunisian rock supplied more phosphorus to plants than did Florida rock.

Effect of phosphate source on the yield and phosphorus content of alfalfa (Augustine Bros. Farm, Goodhue County, 1959).

Treatment	Alfalfa Yield T/A 1st cutting	Alfalfa Yield T/A 2nd cutting	% P 1st cutting
None	1.9	1.1	0.233
Conc. super - 80# P_2O_5/ac	2.1	1.2	0.287
" " -160 " "	2.2	1.4	0.335
Cal. meta - 80 " "	2.2	1.3	0.296
" 160 " "	2.0	1.3	0.281
Monodical - 80 " "	2.0	1.1	0.269
" 160 " "	2.0	1.4	0.312
Florida rock - 1000 #material/ac	2.0	1.2	0.249
Tunisian rock - 1000 # " "	2.2	1.3	0.257
" 500# " "	2.1	1.2	0.263

Phosphorus Source Experiment

A. C. Caldwell and J. Kline

A phosphate source experiment was established at Rosemount in 1951. Twelve treatments of various phosphate materials were replicated four times across a regular rotation of corn, wheat alfalfa, and alfalfa.

The crop rotation was changed in 1959 to corn, soybeans, wheat, and alfalfa.

Table 2 shows the effects of the various phosphorus treatments on the extractable phosphorus content of the soil as determined by the Soil Testing Laboratory. The readily available forms of phosphorus more than doubled the extractable phosphorus content of the soil, while rock phosphorus forms had no significant effect.

Yield results for 1959 are included in Table 3. No significant yield increases resulted on any of the crops by any of the phosphate sources. Close observation of the data, however, shows that the yields of corn, wheat, and alfalfa are nearly always larger on plots receiving phosphorus as opposed to those receiving none. This does indicate a response to phosphorus, in general, on this soil.

Table 2. The effect of various phosphate treatments on the extractable phosphorus content of a Port Byron silt loam soil (Rosemount Experiment Station, 1959).

Treatments	lbs. P_2O_5/A/yr.	Bray's # 1 Phosphorus lbs./A	Bray's # 1 Phosphorus diff. from Check
Check	-	12	---
Ord. super phos.	40	31	19
Conc. super phos.	40	32	20
Ca. meta phos.	40	30	18
H_3PO_4	40	29	17
Fused tri Ca.	40	21	9
Fla. rock (lt.)	100	14	2
Fla. rock + Ord. super	20 + 20	20	8
	lbs. material/A./4 yrs.		
Fla. rock (hvy.)	1000	17	5
West rock	1000	14	2
Col. clay rock	1000	12	0
Tunis rock	1000	17	5

LSD (F_{95}) = 10.5

Because of the large variation in the experiment, over all yield results showed no significant differences due to the residual fertilizer, Table 4. By selecting out a factorial design of 23 and 97 pounds per acre N, P_2O_5, and K_2O some interesting results were obtained. Residual potassium was found to have had significant effects on corn yield at the 10% level. Interaction effects of residual N and K, and P and K were found to be significant at the 5% level.

The best yields for the entire experiment resulted on plots that has received all three nutrients.

Table 3. The effect of various phosphate treatments on the yield of corn, soybeans, wheat, and alfalfa in a rotation, 1959.

		Corn[1]		Soybeans		Wheat		Alfalfa[2]	
Treatments	lbs. P_2O_5/A./yr.	bu./A	diff.	bu./A	diff.	bu./A	diff.	tons/A	diff.
1. Check	--	118	--	31.9	---	24.7	---	1.54	---
2. Ord. super phos.	40	119	1	32.2	0.3	28.7	4.0	2.05	0.51
3. Conc. super phos.	40	124	6	31.7	-0.2	27.1	2.4	2.17	0.63
4. Ca. meta phos.	40	123	5	31.8	-0.1	32.7	8.0	1.90	0.36
5. H_3PO_4	40	127	9	31.5	-0.4	30.4	5.7	1.83	0.29
6. Fused tri Ca.	40	126	8	33.4	1.5	29.6	4.9	2.39	0.85
7. Fla. rock + Ord. super	20 + 20	127	9	31.6	-0.3	28.7	4.0	1.69	0.15
8. Fla. rock (lt.)	100	130	12	31.5	-0.4	23.2	-1.5	1.70	0.16
	lbs. material/A/4 yrs.								
9. Fla. rock (hvy.)	1000	117	-1	32.1	0.2	27.7	3.0	2.47	0.93
10. West rock	1000	137	19	31.5	-0.4	28.0	3.3	1.80	0.26
11. Col. Clay rock	1000	126	8	31.3	-0.6	26.4	1.7	1.81	0.27
12. Tunis rock	1000	140	22	32.5	0.6	25.3	0.6	2.06	0.52

No significant differences.

[1] @ 15% moisture

[2] Dry weight

The effect of lime on the yield of corn, soybeans, oats, and alfalfa in a rotation, 1959

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, a research project with lime was started at Rosemount station in the fall of 1951. Plots were laid out consisting of four replications of five treatments. Treatments were 0, 3, 6, 12, and 24 tons of lime per acre. A regular rotation of corn, oats, alfalfa, and alfalfa was set up. Each year corn and grain have received 200 pounds of 5-20-20 per acre as a fertilizer treatment.

In 1959, it was decided to study the effect of lime on soybeans also, so the rotation was changed to corn, soybeans, oats, and alfalfa. Another change which was made at the same time included an application of five ounces of $(NH_4)_2 MoO_4$ per acre on one-half of a check plot in each replication.

Yield results from the four crops for 1959 are included in Table 1. Corn yields were substantially better on the three and six ton per acre rates of lime as compared with the plots receiving no lime. The higher rates of lime, however, did not continue the trend of increased yield.

Soybean yields were not significantly affected by the lime application.

Table 1. The effect of lime on the yield of corn, soybeans, oats, and alfalfa in a rotation, 1959.

		Yields							
		Corn[1]		Soybeans		Oats		Alfalfa[2]	
Treatment	Soil pH	bu/A	diff.	bu/A	diff.	bu/A	diff.	tons/A	diff.
0, tons lime/A	5.8	114	---	33.4	---	33	---	1.35	---
3, tons lime/A	6.1	144	30	32.6	-0.8	38	5	2.71	1.36
6, tons lime/A	6.6	156	42	33.3	-0.1	42	9	3.25	1.90
12, tons lime/A	6.6	123	9	32.2	-1.1	43	10	3.03	1.68
24, tons lime/A	7.1	118	4	34.3	0.9	38	5	3.16	1.81
0[3] tons lime/A	5.8	131	---	34.4	---	38	---	1.68	---
5 oz. $(NH_4)_2MoO_4$/A	5.8	128	-3	34.1	-0.3	33	-5	2.06	0.38
LSD(F_{95}) =			13.0		NS		8.75		.473

1 15% moisture
2 Dry weight
3 Boarder effects limit the use of this check plot to comparisons with the molybdenum treatment only.

Oat yields were increased significantly by the six and twelve ton per acre rates of lime, but the three and 24 ton rates were not significantly different.

Alfalfa yields were very significantly affected by the lime applications. The largest yield increase of 1.9 tons per acre resulted on the plots receiving six tons per acre of lime.

The molybdenum treatment had no significant effects on the yields of any of the four crops.

Included in the table are the soil pH values corresponding to the various treatments. The soil pH has increased with increased lime applied. This trend has remained constant for the past several years.

farm and home
FACT SHEET
SOILS
NO. 5

Sulfur for Minnesota Soils

C. J. OVERDAHL AND A. C. CALDWELL

Sulfur is an essential element for plant growth and is a constituent of the proteins. It is also found in important plant hormones. Consequently inadequate supplies of soil sulfur may seriously affect crop yields.

Legumes suffering from lack of sulfur can be recognized by their light yellow to almost white leaves. The entire leaf area including the veins is affected with this discoloration. Sulfur is associated with plant nitrogen metabolism in protein formation. Thus when sulfur is absent there is low nitrate assimilation which makes the plant appear to be nitrogen deficient. When adequate nitrogen is present, oats and other nonlegume crops may benefit from sulfur fertilization. A recent publication (Station Bulletin 444) by Rost, Evans, and Kramer, presents data in this regard. At present, however, the major emphasis is on supplying sulfur for legumes.

Sulfur deficiency restricts yields, principally of legumes, in many of the northern Minnesota counties. These areas are not well defined but see the map for the tentative boundaries. The most prominent soils where the deficiencies occur are usually sandy in texture and were originally covered with forest.

Sources of Soil Sulfur

Sulfur problems in Minnesota are not new. Research dates back to the very early days of soil's research in the state. F. J. Alway, former head of the Department of Soils, was a pioneer in this field. He carefully studied the effect of sulfur added to soils by rains and by direct soil-air contact, and even direct uptake by leaves of sulfur from the atmosphere.

Alway found that large industrial areas create a sufficient supply of sulfur for soils in the immediate area. Coal, natural gas, petroleum, and refinery sludge when burned give off sulfur to the air.

The sulfur from precipitation was measured at various locations in Minnesota for 12 months in 1936 and 9 months in 1937. The figures from three locations in pounds per acre of sulfur for the year 1936 are as follows:

Minneapolis	197
St. Paul Campus	26
Bemidji	3

For the 9-month period in 1937, 4.5 pounds was measured at Bemidji, but it seems safe to say that the annual accumulation from precipitation in areas quite remote from industrial centers will be 5 pounds per acre or less.

Direct absorption of sulfur from the atmosphere by plants was found to be very low. Therefore in low sulfur areas away from industral centers the natural supply from the atmosphere cannot maintain an adequate level in the soil.

Sulfur Bearing Materials

Gypsum is the chief source of sulfur for sulfur deficient soils. Most gypsum materials will contain about 18 percent sulfur. There are, however, other important sources such as in commercial fertilizers like ammonium sulfate and potassium sulfate.

The sulfur content of fertilizers has been measured and averages have been reported from many sources and manufacturers. It is important

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that users of fertilizers in sulfur deficient areas understand the tremendous variation in the sulfur content of various fertilizers. The following figures show the percent sulfur content of fertilizer, manure, and soil amendments commonly available in northern Minnesota.

Material	Percent sulfur
Gypsum	18.0
Ammonium sulfate (21-0-0)	23.9
Barnyard manure	0.1
Potassium chloride (0-0-60)	0.4
Potassium sulfate (0-0-50)	17.6
Sul-Po-Mag	22.7
Superphosphate (0-20-0)	11.5
Concentrated super (0-47-0)	0.7
Limestone	0.04
5-20-20	3.1

Sulfur Removal by Crops

The removal of sulfur by crops has been determined by analyzing the plants. Some of the average yields and the sulfur removed are as follows:

Crop	Yield per acre	Sulfur removed
		Lbs/acre
Alfalfa	2 tons	12
Red clover	1½ tons	9
Corn	50 bushels	8
Potatoes	300 bushels	24

The efficiency of use of sulfur is never 100 percent, hence approximately 20 pounds of sulfur or an application of about 100 pounds of gypsum per year would be a minimum necessary to offset the annual crop removal. It would appear that higher rates would be necessary for crops such as potatoes unless yields are much less than 300 bushels.

Leaching Losses

Figures on losses of sulfur by internal drainage are not available in Minnesota. However, there have been experiments on leaching losses conducted in other states. Data in literature from several states indicates large losses of sulfur on sandy soils by leaching. The Experiment Station at Cornell University reports losses of more than half of the applied sulfur. These losses in the drainage water depend upon the amount of sand, the sulfur content to begin with, the quantity added, and even the soil temperature.

Recommendations

There is no soil test for sulfur made in the Minnesota Soil Testing Laboratory. Plant analysis shows promise, but correlation studies are necessary. Evaluation of sulfur needs must be based on observing sulfur deficiency symptoms and on knowing the soil area. If potassium, phosphorus, and lime have been adequately supplied in the past, but legume growth is still poor, then sulfur should be added.

Since the price of gypsum is reasonable, material should be applied wherever a deficiency is suspected. Check strips can be left to see if yields have been improved. Apply gypsum at 300 pounds per acre or an equal amount of sulfur-bearing material. Apply about once every three years.

Gypsum is not a substitute for lime, crops on acid soils will still need lime applications.

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ST. PAUL 1, MINNESOTA

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3-59

THE NICOLLET COUNTY PLOTS

SOIL FERTILITY AND CROP PRODUCTION STUDIES ON THE WEBSTER SOILS OF SOUTHERN MINNESOTA

Webster and the closely related Nicollet soil series make up nearly 10% of the total land area of Minnesota or nearly 5 million acres. The soils are productive, almost level in topography, and erosion is not a serious problem but drainage is often necessary.

The Nicollet Soils Experimental Field was established by the Department in 1948 under the direction of Prof. C. O. Rost. The field is located on the Sidney Johnson farm, northwest of St. Peter in Nicollet County. Results obtained from 1949 through 1954 were published as Minn. Agr. Exp. Sta. Bul. 438, April 1957, under the authorship of Prof. Rost and Senior Plot Supervisor H. W. Kramer. Leadership of the project was passed on to W. P. Martin, upon Prof. Rost's retirement in 1954. Establishment and care of the plots would not have been possible without the close collaboration of Fred Wetherill, Nicollet County Agent. Prof. Paul Burson has also provided helpful suggestions as have others in the soil fertility and including Soil Extension group.

Cropping Systems:

Three cropping systems were initially used: (1) corn-oats, (2) corn-oats with clover* as a green manure crop, and (3) a 4-year rotation of oats-hay**-corn-corn.

In the corn-oats rotation, these two crops were grown in alternate years. Clover was seeded in oats and it was plowed down as a green manure in the fall of the same year. Each crop appeared each year in replicated plots. No manure was used in the 2-year rotations, but nutrients were supplied with commercial fertilizers. The 4-year rotation included barnyard manure for first-year corn (commonly used in the area) plus commercial fertilizer treatments.

In 1958, the 4-year rotation was extended to five years with the inclusion of soybeans in the rotation between the two corn crops. The 5-year rotation is now: oats-hay**-corn-soybeans-corn. Fertility treatments and use of barnyard manure remain about the same.

In 1954 a continuous corn program was instituted with fertility treatments to evaluate interactions with amount and time of application of nitrogen. In 1955, these plots were planted to oats to evaluate nitrogen residuals. Since 1956, these plots have been in continuous corn.

*Originally sweetclover. In 1959 shifted to southern alfalfa mixed with mammouth red clover.

**In 1959, in addition to the vernal alfalfa, some red clover, alsike and timothy were added to assure stand if season dry.

Fertilizer Treatments: (Four replications in all exp.)

Corn-Oats (with or without clover*)

1. Check (untreated)
2. 135 lbs. 33-0-0 broadcast for oats.
3. Same as 2 + 150 lbs 0-46-0 broadcast for oats.
4. Same as 3 + 100 lbs 0-0-60 broadcast for oats.
5. 150 lbs 0-46-0 broadcast for oats.
6. 175 lbs 6-24-12 in hill for corn.
7. 200 lbs 33-0-0 broadcast for corn planting time.
8. 200 lbs 33-0-0 broadcast for corn 1st cultivation.

Regular fertilization (approx. plant food application; see under "heavy fertilization" for actual application rates.)

6. check (no treatment)
1. 0-40-0 for oats
2. 0-40-40 for oats
7. 40-40-0 for oats
3. 40-40-40 for oats
10. 0-40-0 for oats and 0-40-0 broadcast 1st yr. corn
9. 0-60-0 broadcast 2nd yr. corn
4. 8 tons manure 1st yr. corn
5. 8 tons manure 1st yr. corn + 10-40-20 hill 2nd yr. corn
8. 8 tons manure 1st yr. corn + 10-40-20 hill 1st yr. corn

Heavy fertilization

During early years of experiment it was noted that yields were not approaching potential with ordinary treatments. Consequently plots were split in half and heavier treatments made. Though emphasis was on fertilization of corn, some treatments were included for all crops in the rotation.

1. 100 lbs 0-46-0 broadcast for oats.
1X Same as 1 + 150 lbs 0-46-0 top-dressed on hay in spring.

2. 200 lbs. 0-20-20 broadcast for oats.
2X Same as 2 + 300 lbs 0-20-20 top-dressed for hay in spring.

3. 135 lbs. 33-0-0 + 200 lbs 0-20-20 broadcast for oats.
3X Same as 3 + 300 lbs 0-20-20 broadcast on sod before plowing + 200 lbs 33-0-0 broadcast 1st yr. corn at planting.

4. 8 tons manure 1st yr. corn
4X Same as 4 + 8 tons manure plowed under 2nd yr. corn.

5. 8 tons manure 1st yr. corn + 175 lbs. 6-24-12 in hill 2nd yr. corn.
5X Same as 5 + 8 tons manure plowed under 2nd yr. corn + 175 lbs. 6-24-12 in hill 1st yr. corn.

6. Check, no treatment

6X 1000 lbs 10-10-10, on sod, fall-plowed for corn.+
175 lbs 6-24-12 in hill 1st yr. corn+
" " " 2nd yr. corn+
200 lbs 33-0-0 side-dress 2nd yr. corn 1st cultivation+
135 lbs 33-0-0 + 100 lbs 0-46-0 broadcast for oats+
100 lbs 0-0-60 topdress for hay in spring.

7. 135 lbs 33-0-0 + 100 lbs 0-46-0 broadcast for oats
7X Same as 7 + 100 lbs 0-0-60 topdress for hay in spring.

8. 8 tons manure 1st yr. corn + 175 lbs 6-24-12 in hill.
8X Same as 8 + 8 tons manure plowed under 2nd yr. corn + 175 lbs 6-24-12 in hill 2nd yr. corn.

9. 150 lbs 0-46-0 broadcast 2nd yr. corn
9X Same as 9 + 135 lbs 33-0-0 broadcast for oats + 200 lbs 0-20-20

10. 100 lbs 0-46-0 broadcast for oats + 100 lbs 0-46-0 broadcast 1st yr. corn.
10X Same as 10 + 0-0-60 topdress for hay in spring + 200 lbs 33-0-0 broadcast 2nd yr. corn.

Continuous corn-nitrogen interaction:

Rate and time of nitrogen application: (broadcast)

	Planting	1st cult.	2nd cult.	Total N applied (lbs.)
1.	0	0	0	0
2.	40	0	0	40
3.	40	40	0	80
4.	40	40	40	120
5.	40	0	40	80
6.	0	40	40	80
7.	0	0	40	40
8.	0	40	0	40
9.	80	0	0	80
10.	120	0	0	120

All plots received 175 lbs. 6-24-12 in the row at planting. North half of each plot received in addition 300 lbs. 0-20-20 in the hill.

Soil Test

Phosphorus: 5-17 lbs (low to very low) surface soil
2-18 lbs " sub-surface soil

Potassium: 110-315 lbs (medium) surface soil
90-220 lbs " sub-surface soil

NICOLLET COUNTY RESIDUAL EFFECT OF NITROGEN FOR OATS IN 1955

APPLIED ON CORN IN 1954

Treatments				
Total N Applied	Planting Time	First Cultivation	Second Cultivation	Ave. Yields in Bu./A.
0	0	0	0	55
		Increase over check		
40	40	0	0	+12
80	40	40	0	+19
120	40	40	40	+39
80	40	0	40	+30
80	0	40	40	+19
40	0	0	40	+10
40	0	40	0	+21
80	80	0	0	+29
120	120	0	0	+41

At planting time on corn in 1954 a starter fertilizer (5-20-20) was used at 150 lbs. per acre.

Nitrogen is in lbs. of N per acre applied as Am. Nitrate.

Continuous Corn

(Rate and time of nitrogen application)

Treatment*		Yield**	
Total N	Time applied*	(Bu/Ac.)	+PK Starter
None	0-0-0	58	
None	0-0-0	Increase over check	0
40 lbs	1-0-0	+ 5	+11
80	1-1-0	+ 4	+19
120	1-1-1	+ 6	+17
80	1-0-1	+ 9	+18
80	0-1-1	+ 4	+18
40	0-0-1	+ 7	+18
40	0-1-0	+ 8	+21
80	2-0-0	+ 8	+18
120	3-0-0	+ 8	+17

*0-0-0 refers to time of application, i.e. planting time-1st cultivation-2nd cultivation.
1 = 40 lbs. N as ammonium nitrate
2 = 80 lbs. N as ammonium nitrate
3 = 120 lbs. N as ammonium nitrate

**Yields damaged because 2,4-D decreased stand.

NICOLLET COUNTY SOIL FERTILITY AND CROP PRODUCTION PLOTS - 1959 YIELDS

TREATMENTS (regular)	Corn (1) Reg.	Corn (1) Extra*	Soybeans Reg.	Soybeans Extra*	Corn[1] (2) Reg.	Corn[1] (2) Extra*	Oats Reg.	Oats Extra*	Hay Reg.	Hay Extra*
6. Check (untreated)	109 bu.	+18	44 bu.	+10	138 bu.	+4	87 bu.	+18	2.80 T	+2.24
1. P for oats	+15	+ 3	+ 1	+ 3	- 2	+8	+22	+ 4	+1.08	+1.23
2. PK for oats	+11	+ 8	+ 1	+ 3	+ 3	-1	+15	0	+1.38	+1.07
7. NP for oats	+11	0	+ 1	+ 3	+ 5	-7	+27	+ 1	+1.09	+0.83
3. NPK for oats	+ 7	+13	+ 3	+ 6	- 4	+9	+23	+ 1	+1.06	+1.08
10. P for oats & corn	+14	+ 4	0	+ 7	- 1	+9	+14	+13	+1.40	+ .30
9. P for corn	+13	0	+ 1	+ 2	- 2	+5	+18	+ 5	+1.46	+ .75
4. Manure for corn	+21	+ 1	+ 7	+ 2	0	+7	+18	+13	+ .52	+1.06
8. Manure & P for corn	+17	+ 5	+ 9	+ 2	- 2	0	+17	+10	+1.07	+1.19
5. Manure & NPK for corn	+20	+ 1	+ 6	+ 3	0	-2	+13	+15	+1.21	+1.21
L.S.D.	10	10	4	7	39	14	15.1	13.7	0.82	.74

Note: See earlier outline of actual fertilizer treatments. *Extra column refers to heavy fertilization treatments; results given as increases over regular treatments. Corn damaged somewhat from heavy wind following 2,4-D treatment. Oats damaged by red leaf transported by aphids (green bug) particularly on outside series.

[1]Corn in Series XI and XII, two years removed from alfalfa hay.

	Corn	(With Legume)	Oats*	(With legume)
1. Check (untreated)	71 bu.	---	40 bu.	---
		Increase over check		
1. Legume with oats	---	+18	---	0
2. N for oats	+17	+37	+ 6	+ 7
3. NP for oats	+22	+39	+58	+60
4. NPK for oats	+20	+40	+58	+53
5. P for oats	+ 3	+53	+12	+35
6. NPK in hill for corn	+17	+32	+12	+23
7. N plowdown for corn	+35	+46	- 5	- 9
8. N sidedress corn 1st cult.	+29	+20	+11	+ 1
L.S.D.	15.9	13.6	19.2	17.6

*Red leaf noted to be worse with N and not as bad with P.
Matt Moore - Dept. Plant Path.

NICOLLET COUNTY SOIL FERTILITY AND ROTATION PLOTS — 1958 YIELD RESULTS

TREATMENTS	Corn (1) Reg.	Corn (1) Plus*	Soybeans Reg.	Soybeans Plus	Corn (2) Reg.	Corn (2) Plus	Oats Reg.	Oats Plus	Hay Reg.	Hay Plus
6. Check	80bu.	103bu.	28bu.	—	52bu.	81bu.	61bu.	118bu.	2.7t.	3.5t.
1. P on oats	86	94	33		62	70	75	94	4.6	5.3
2. PK on oats	90	98	34		58	68	75	99	4.6	4.8
3. NPK on oats	80	102	34		62	74	96	113	3.5	3.8
4. Manure on corn	94	97	—		79	91	73	112	4.0	4.2
5. Manure & NPK on corn	100	104	—		81	89	88	118	3.8	4.2
7. NP on oats	82	91	35		61	69	92	107	3.3	4.2
8. Manure & P on corn	100	107	—		78	88	79	128	4.4	4.7
9. P on corn	81	98	—		65	73	73	105	4.6	4.8
10. P on oats & corn	90	95	33		64	71	76	97	4.4	4.8

Plus** Supplementary treatments, i.e. 6x = 1000 lbs 10-10-10 on sod in fall; 175 lbs. 6-24-12 on 1st & on 2nd year corn; 200 lbs 33-0-0 sidedress on corn; 135 lbs 33-0-0 & 100 lbs 0-43-0 on oats; 100 lbs. 0-0-60 topdress hay in spring.

	Corn Reg.	Corn With legume	Oats Reg.	Oats With legume
1. Check	56bu.	61bu.	48bu.	56bu.
2. N on oats	59	70	63	63
3. NP on oats	73	83	94	100
4. NPK on oats	77	87	85	89
5. P plowdown	68	77	58	73
6. NPK in hill	73	93	54	67
7. N plowdown	63	60	46	48
8. N sidedress	79	69	71	59

Corn yields with time of N application: 1-0-0 = N at planting; 0-1-0 = N at 1st cultivation; 0-0-1 = N at 2nd cultivation

	0-0-0	0-0-1	0-1-0	1-0-0	0-1-1	1-1-0	1-0-1	1-1-1	2-0-0	3-0-3
N alone	35bu.	53	52	53	55	60	52	54	53	58
N + 6-24-12 hill	44	62	61	62	57	66	57	62	61	64

Note: 1958 dry year (13" ppc. below normal). Excellent yields for county.

Fertilizer Rotation Studies

A.C. Caldwell and J. Kline

(A report on 1959 fertilizer experiments)

In 1956 a fertilizer rotation study was designed and established at the Waseca, Morris, and Crookston experiment stations. These studies were begun with the object of evaluating the effect of fertilizer treatment and crop rotation on soil properties and crop response. The fertilizer treatments in this experiment are a complete factorial of the nutrients nitrogen, phosphorus, and potassium. The rates of application of these nutrients are chosen appropriate to the crop and soil type under study. All fertilizers are applied in the spring as a broadcast application with the exception of a small portion for corn which is applied in the hill at planting time. All experiments are replicated three times.

The crops at Waseca and Morris are in a five year rotation plus continuous corn. The cropping sequence for these stations are as shown below:

Waseca	Morris
Corn	Corn
Corn	Corn
Soybeans	Soybeans
Oats	Flax
Alfalfa	Alfalfa
Continuous Corn (not in rotation)	Continuous Corn (not in rotation)

The Crookston experiment consists of two separate rotations. The three year rotation has the crop sequence of sugar beets, wheat and sweet clover fallow, while the four year sequence consists of corn, soybeans, wheat and alfalfa.

In addition to the fertilizer treatments outlined each crop is fertilized with an additional heavy treatment called NPK+ which is not analyzed statistically with the experiment but is used only for comparative purposes.

Discussion of Results

Waseca

Corn

Continuous corn yields at Waseca ranged from 91 to 125 bushels per acre in 1959 although this was the second year with less than normal precipitation. Fertilizer treatments resulted in general yield decreases with respect to non-treated plots. Nitrogen and potash treatments both caused significant decreases in corn yields amounting to 17 to 18 bushels per acre (table 1).

Similar results were obtained with first and second year corn with fertilizer treatments resulting in generally lower corn yields. Potash applications resulted in a significantly lower corn yield on first year corn. The positive and significant PK interaction on first and second year corn (table 2 and 3) should not be interpreted to mean that PK combinations resulted in yield increases. The PK interaction in this case means that while potash alone resulted in yield decreases, this effect was minimized by the application of phosphate along with potash.

Soybeans

Soybean yields were generally good, ranging from 33 to 37.4 bushels per acre. As is usually the case, no fertilizer response was found on soybeans in 1959.

Corn Forage

Forage samples were taken from the continuous corn and first year corn. The forage yields ranged from 16.5 to 21.3 tons per acre on continuous corn and from 19.3 to 23.1 tons per acre on first year corn. No significant positive or negative fertilizer effects were found for forage yields.

Oats Grain

The yield of oats ranged from 54.9 to 78.1 bushels per acre. Nitrogen treatments resulted in lodging and a significant reduction in yield. Phosphate and potash treatments had no effect on oats yield.

Oats Forage

Samples of oats for forage were taken when the grain was in the dough stage. The yields ranged from 5.8 to 8.5 tons per acre and a significant positive response was found due to phosphate application. The significant PK interaction (table 8) may be interpreted to mean in this case that phosphate and potash together were more beneficial to yields than either one alone.

Alfalfa

Two cuttings of alfalfa were obtained from the Waseca plots in 1959. The yields ranged from 1.8 to 2.8 tons per acre. A significant positive response was found showing that 80 pounds P_2O_5 per acre resulted in yield increases over plots not treated with phosphate.

Morris

Corn

The rainfall during the period from April to August was three inches below the long time average at Morris in 1959. Only four inches of precipitation were received during the fall of 1958 and winter of 1959. The low rainfall resulted in almost total corn failure at the Morris station. There were few fertilizer effects, however, the position in the rotation did influence yields. Second year corn was the highest in over-all yield with an average of 36.8 bushels per acre. Continuous corn was next with an average of 30.6 bushels per acre and first year corn following alfalfa resulted in complete failure with an average of only 14.6 bushels per acre.

Soybeans

Soybean yields were generally low ranging from 13.6 to about 19 bushels per acre. Fertilizers had no beneficial effect on yield. The significant NK interaction shown on table 13 does not mean that these nutrients improved soybean yields. It means only that nitrogen modified somewhat the negative effects of potash on yields.

Flax

Yields of flax were poor ranging from 6.7 to 15.1 bushels per acre. A significant reduction in flax yields wax observed due to the application of 40 pounds P_2O_5 per acre. Although nitrogen is usually beneficial to flax no such effect was found in 1959.

Alfalfa

Two cuttings of alfalfa were obtained from the Morris plots in 1959. As in previous years a strong positive response to 80 pounds P_2O_5 per acre was found. In addition a significant NP interaction was found which can be interpreted to mean that nitrogen and phosphorus together resulted in lower yields than when phosphorus was used alone.

Crookston

Corn (Four year rotation)

Corn yields at the Crookston station ranged from 66.3 to 93.4 bushels per acre and were generally superior to yields of previous years. Forty pounds P_2O_5 per acre was found to increase yields by 18.6 bushels per acre.

Soybeans (Four year rotation)

In 1959 soybeans were planted instead of barley in the four year rotation. The yields ranged from 23.8 to 30.8 bushels per acre and a significant phosphate response amounting to three bushels per acre was found.

Wheat (Four year rotation)

Wheat yields were significantly increased by the application of both nitrogen and phosphorus. Nitrogen resulted in a 13 bushel increase and phosphorus in an 8.6 bushel increase (table 18). In addition a significant NP interaction was found showing that nitrogen and phosphorus together resulted in greater yields than either one alone. This interaction is shown below.

	No N	40 lbs. N
No P	23.2 bu/A	31.0 bu/A
40 lbs. P	26.6 bu/A	44.9 bu/A

Alfalfa (Four year rotation)

Alfalfa yields were very low; ranging from 0.4 to 1.34 tons per acre. Forty pounds P_2O_5 per acre resulted in an increased yield of about 0.4 tons per acre.

Sugar Beets (Three year rotation)

Yield of sugar beets was increased by the application of both nitrogen and potash but sugar percentage was decreased to a significant degree by nitrogen applications. The yield of sugar as shown on table 22 indicates that fertilization had neither a positive nor negative effect on the total sugar produced per acre.

Wheat (Three year rotation)

Wheat yields on the 3-year rotation were not influenced by nitrogen application. A significant increase amounting to about 6.8 bushels per acre was found due to the application of 40 pounds P_2O_5 per acre.

Fertilizer Rotation Experiment

Table 1. Continuous Corn (15% moisture). Waseca, 1959

Treatment	lbs/ac $N-P_2O_5-K_2O$	Average Yield bu/ac	Diff.	Treatment effect [1]
None	0-0-0	125	-	
N	160-0-0	116	- 9	-17.8*
P	0-160-0	135	10	- 9.6
K	0-0-160	113	-12	-18.6*
NP	160-160-0	91	-34	- 4.6
NK	160-0-160	95	-32	8.8
PK	0-160-160	93	-30	- 1.8
NPK	160-160-160	92	-33	
NPK+	320-320-320	113	-12	

* Significant at 95% level.

** Significant at 99% level.

Table 2. First year corn. Waseca, 1959

Treatment	lbs/ac $N-P_2O_5-K_2O$	Average Yield bu/ac	Diff.	Treatment effect [1]
None	0-0-0	141		
N	40-0-0	142	1	- 6.5
P	0-80-0	137	-4	- 0.7
K	0-0-80	121	-20	-10.8*
NP	40-80-0	112	-29	- 0.3
NK	40-0-80	108	-33	5.5
PK	0-80-80	124	-17	16.0**
NPK	40-80-80	135	- 6	
NPK+	80-160-160	142	1	

Table 3. Second Year Corn. Waseca, 1959

Treatment	lbs/ac $N-P_2O_5-K_2O$	Average Yield bu/ac	Diff.	Treatment effect
None	0-0-0	137		
N	80-0-0	118	-19	- 5.6
P	0-80-0	126	-11	7.1
K	0-0-80	90	-47	-11.6
NP	80-80-0	102	-35	- 0.9
NK	80-0-80	100	-37	16.1
PK	0-80-80	117	-20	20.4*
NPK	80-80-80	128	- 9	
NPK+	160-160-160	121	-16	

Table 4. Soybeans Waseca, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	36.0		
N	20-0-0	35.2	-0.8	0
P	0-40-0	36.3	0.3	0.39
L	0-0-40	33.0	-3.0	-0.62
NP	20-40-0	34.5	-1.5	-1.0
NK	20-0-40	35.9	-0.1	1.27
PK	0-40-40	35.5	-0.5	0.51
NPK	20-40-40	35.1	-0.9	
NPK+	40-80-80	37.4	1.4	

Table 5. Continuous Corn Forage* Waseca, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	18.1		
N	160-0-0	21.3	3.2	1.44 Sig. at 94%
P	0-160-0	18.1	0.0	-0.84
K	0-0-160	17.3	-0.8	-0.94
NP	160-160-0	17.3	-0.8	-0.42
NK	160-0-160	17.8	-0.3	0.24
PK	0-160-160	16.5	-1.6	1.16
NPK	160-160-160	19.3	1.2	
NPK+	320-320-320	20.8	2.7	

*Field weight 74% moisture.

Table 6. First Year Corn Forage Waseca, 1959

None	0-0-0	20.8		
N	40-0-0	21.1	0.3	-0.99
P	0-80-0	20.9	0.1	-0.71
K	0-0-80	22.3	1.5	0.66
NP	40-80-0	19.3	-1.5	-0.26
NK	40-0-80	20.6	-0.2	-0.29
PK	0-80-80	21.3	0.5	+0.13
NPK	40-80-80	20.5	-0.3	
NPK+	80-160-160	23.1	2.3	

Table 7. Oats Grain Waseca, 1959

Treatments	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment Effect
None	0-0-0	77.0		
N	80-0-0	67.3	-9.7	-18.9**
P	0-80-0	84.9	7.9	1.5
K	0-0-80	77.5	0.5	- 4.7
NP	80-80-0	59.9	-17.1	- 2.8
NK	80-0-80	54.9	-21.1	- 1.6
PK	0-80-80	78.1	1.1	1.2
NPK	80-80-80	59.7	-17.3	
NPK+	120-160-160	64.0	-13.0	

Table 8. Oats Forage * Waseca, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	6.67		
N	80-0-0	6.32	-0.35	-0.62
P	0-80-0	6.56	-0.11	0.73*
K	0-0-80	5.81	-0.86	0.32
NP	80-80-0	6.11	-0.56	-0.56
NK	80-0-80	6.03	-0.64	-0.22
PK	0-80-80	8.50	1.83	0.89*
NPK	80-80-80	6.59	-0.08	
NPK+	120-160-160	7.56	0.89	

*59% H_2O

Table 9. Alfalfa (2 cuttings)* Waseca, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	1.83		
N	20-0-0	2.20	0.37	0.04
P	0-80-0	2.49	0.66	0.62**
K	0-0-80	2.06	0.23	0.16
NP	20-80-0	2.36	0.53	-0.07
NK	20-0-80	1.89	0.06	-0.09
PK	0-80-80	2.76	0.93	0.20
NPK	20-80-80	2.83	1.00	
NPK+	20-160-160	2.58	0.75	

* 15% Moisture.

Table 10. Continuous Corn* Morris, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Bushels/A	Diff.	Treatment effect
None	0-0-0	32.5		
N	160-0-0	37.9	5.4	7.7*
P	0-160-0	23.2	-9.3	-4.1
K	0-0-40	31.0	-1.5	0.2
NP	160-160-0	33.1	.6	3.6
NK	160-0-40	33.9	1.4	0.1
PK	0-160-40	24.9	-7.6	2.9
NPK	160-160-160	37.7	5.2	
NPK+	320-320-80	21.8	-10.7	

Table 11. First Year Corn* Morris, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	15.1		
N	60-0-0	13.4	-1.7	-1.47
P	0-40-0	15.5	0.4	0.31
K	0-0-40	17.4	2.3	-1.56
NP	60-40-0	17.4	2.3	2.18
NK	60-0-40	11.7	-3.4	-1.56
PK	0-40-40	13.2	-1.9	-1.88
NPK	60-40-40	12.8	-2.3	
NPK+	100-120-80	15.1	0	

Table 12. Second Year Corn* Morris, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	43.0		
N	80-0-0	34.3	-9.7	-6.9**
P	0-80-0	40.6	-2.4	-1.8
K	0-0-40	41.5	-1.5	-3.0
NP	80-80-0	32.7	-10.3	3.3
NK	80-0-40	29.5	-13.5	1.3
PK	0-80-40	33.5	-9.5	0.2
NPK	80-80-40	34.1	-8.9	
NPK+	120-120-80	37.3	-5.7	

*15.5% Moisture

Table 13. Soybeans Morris, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	15.8		
N	20-0-0	17.8	2.0	0.75
P	0-40-0	18.3	2.5	-0.67
K	0-0-40	17.6	1.8	0.21
NP	20-40-0	14.4	-1.2	0.07
NK	20-0-40	16.9	1.1	1.7*
PK	0-40-40	13.6	-2.2	-0.27
NPK	20-40-40	19.1	3.3	
NPK+	40-80-80	16.3	0.5	

Table 14. Flax Morris, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	15.1		
N	60-0-0	13.6	-1.5	-0.96
P	0-40-0	11.0	-4.1	-2.9**
K	0-0-20	14.5	-0.6	-0.08
NP	60-40-0	11.2	-3.9	0.21
NK	60-0-20	13.6	-1.5	-0.34
PK	0-40-20	12.2	-2.9	0.26
NPK	60-40-20	10.5	-4.6	
NPK+	120-80-40	6.7	-8.4	

Table 15. Alfalfa - Yield of Two Cuttings (15% moisture). Morris, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	1.0		
N	20-0-0	1.2	0.2	-0.42
P	0-80-0	3.2	2.2	1.7 **
K	0-0-40	1.1	0.1	0.01
NP	20-80-0	2.4	1.4	-0.52**
NK	20-0-40	1.0	0.0	-0.16
PK	0-80-40	3.4	2.4	0.02
NPK	20-80-40	2.3	1.3	
NPK+	20-160-80	2.6	1.6	

Table 16. Corn - 7 year rotation. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	78.7		
N	40-0-0	70.1	- 8.6	- 3.7
P	0-40-0	94.6	15.9	18.6**
K	0-0-20	66.3	-12.4	- 4.1
NP	40-40-0	90.3	11.6	- 2.9
NK	40-0-20	73.1	- 5.6	2.7
PK	0-40-20	93.4	14.7	0.5
NPK	40-40-20	84.4	5.7	
NPK+	80-120-40	84.6	5.9	

Table 17. Soybeans - 4 year rotation. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	23.8		
N	40-0-0	24.6	0.8	1.6
P	0-40-0	27.5	3.7	3.0*
K	0-0-20	25.8	2.0	-0.1
NP	40-40-0	30.8	7.0	1.0
NK	40-0-20	26.2	2.4	-0.4
PK	0-40-20	26.2	2.4	-1.9
NPK	40-40-20	28.2	4.4	
NPK+	40-120-40	29.7	5.9	

Table 18. Wheat - 4 year rotation. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	24.1		
N	40-0-0	31.2	7.1	13.1**
P	0-40-0	25.5	1.4	8.6**
K	0-0-20	22.3	-1.8	-0.6
NP	40-40-0	46.2	22.1	5.3**
NK	40-0-20	30.8	6.7	-0.9
PK	0-40-20	27.6	3.5	0.4
NPK	40-40-20	43.6	19.5	
NPK+	40-120-40	50.0	25.9	

Table 19. Alfalfa - 4 year rotation. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	0.47		
N	20-0-0	0.52	0.05	0.03
P	0-40-0	0.88	0.41	0.43**
K	0-0-20	0.43	-0.04	-0.05
NP	20-40-0	0.99	0.52	-0.02
NK	20-0-20	0.49	0.02	-0.04
PK	0-40-20	0.91	0.44	-0.02
NPK	20-40-20	0.83	0.36	
NPK+	20-160-80	1.34	0.87	

Table 20. Sugar Beets - 3 year rotation. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	13.8		
N	40-0-0	14.9	1.1	3.02**
P	0-120-0	14.3	0.5	1.12
K	0-0-40	13.9	0.1	1.92*
NP	40-120-0	17.3	3.5	-0.30
NK	40-0-40	19.4	5.6	0.97
PK	0-120-40	16.2	2.4	-0.33
NPK	40-120-40	18.6	4.8	
NPK+	80-240-80	21.7	7.9	

Table 21. Percent Sugar in Sugar Beets. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	% Sugar	Diff.	Treatment effect
None	0-0-0	17.1		
N	40-0-0	14.9	-2.2	-2.18*
P	0-120-0	16.9	-0.2	-0.17
K	0-0-40	17.4	0.3	-0.32
NP	40-120-0	15.2	-1.9	0.35
NK	40-0-40	14.4	-2.7	-0.23
PK	0-120-40	16.5	-0.6	-0.22
NPK	40-120-40	14.6	-2.5	
NPK+	80-240-80	14.2	-2.9	

Table 22. Yield of Sugar. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield Tons/A	Diff.	Treatment effect
None	0-0-0	2.35		
N	40-0-0	2.23	0.12	0.14
P	0-120-0	2.43	0.08	0.15
K	0-0-40	2.41	0.06	0.23
NP	40-120-0	2.62	0.27	0.01
NK	40-0-40	2.80	0.35	0.10
PK	0-120-40	2.62	0.27	-0.09
NPK	40-120-40	2.72	0.37	
NPK+	80-240-80	3.08	0.73	

Table 23. Wheat - 3 year rotation. Crookston, 1959

Treatment	lbs/A $N-P_2O_5-K_2O$	Average Yield bu/A	Diff.	Treatment effect
None	0-0-0	22.1		
N	20-0-0	21.0	-1.1	-1.16
P	0-40-0	30.2	8.1	6.79**
K	0-0-20	25.3	3.2	-0.53
NP	20-40-0	30.6	8.5	1.56
NK	20.0-20	20.9	-1.2	-0.83
PK	0-40-20	27.7	5.6	-2.04
NPK	20-40-20	28.0	5.9	
NPK+	40-80-40	31.4	9.3	

Fertilizer Demonstrations on Sandy Loam Areas of North Central Minnesota

C. J. Overdahl

Fertilizer plots were established on corn and new seedings of alfalfa on sandy loam soils in north central Minnesota in 1959. Plots were established as follows: Corn - Wadena County 4, E. Otter Tail 1, Hubbard 1; alfalfa - E. Otter Tail 1, Wadena 2, Hubbard 1, Todd 2, Crow Wing 1, Milacs 1, and St. Louis 2.

Treatments

Corn - K_2O = 0, 60, 120 and 240#/acre
N = 0, 100, 200#/acre
P_2O_5 = Blanket application of starter phosphate over all plot area.

Alfalfa - K_2O = 0, 60, 120, 240#/acre
N and P_2O_5 = 11-48-0 broadcast at 100#/acre over all plot area.
Gypsum = 0, 100, and 300#/acre
Borated Gypsum = 0, 300#/acre

Results

All but two corn plots failed, apparently due to high temperature and drouth at pollination time. Alfalfa plots will not be harvested until 1960.

No nitrogen response was observed on any plots following alfalfa. No potash response could be observed throughout the growing season.

Henry Pierce Plot - Corn following corn - Wadena County
Soil test: pH 5.5, OM 1.7 (low), P 63 (very high), K 150 med, texture sandy loam.

Average response

K_2O	Yield*	N	Yield**
0	48.2	0	22.4
60	47.5	100	34.7
120	38.0	200	57.3
240	50.2		

* Average of 100# and 200# N levels.
** Average for 4 levels of K_2O.

The increased yields due to nitrogen would appear to be practical even at the 200# rate.

Art Miller Plot - Corn following alfalfa-quack grass sod - Wadena County
Soil test: pH-5.6, OM - 2.4 (low), P-81 (very high), K-100 (med), texture- sandy loam.

		Nitrogen rates			
		0	100	200	Average for K_2O
	0	59.5	59.1	64.8	61.1
Rates	60	58.1	56.6	55.4	56.7
of	120	59.9	67.5	63.0	63.5
K_2O	240	65.8	72.9	64.0	67.6
Average for N		60.8	64.0	61.8	

There is no apparent nitrogen or definite potash response. The zero potash yields appear high; other than this there is an upward trend with the 60, 120 and 240 lb. potash rates.

Potash furnished by American Potash Institute.
Nitrogen furnished by Tennessee Valley Authority.
Cooperators on plots - Dr. R. D. Munson, American Potash Institute, R. D. Curley, TVA, Miles Rowe, County Agent.

N, P, and K Experiment on Continuous Corn

A. C. Caldwell

This experiment was designed to study the effects of different combinations and rates of N, P, and K on the yield of continuous corn. Twenty-two treatments were laid out in two replicates, of five blocks each, in the spring of 1957.

In 1958 and 1959, no fertilizer was applied in order to study the residual effects of the previously applied fertilizer.

Table 4. The effect of residual N, P, and K on the yield of continuous corn, 1959.

Fertilizer $N-P_2O_5-K_2O$ lbs./A.	Yield bu./A.	diff.
0-0-0	79	---
0-60-37	95	+16
0-60-83	67	-12
37-0-60	72	- 7
37-120-60	69	-10
60-37-0	74	- 5
60-37-120	96	+17
60-60-60	88	+ 9
60-83-0	82	+ 3
60-83-120	82	+ 3
83-0-60	68	-11
83-120-60	91	+12
120-60-37	89	+10
120-60-83	84	+ 5
23-23-23	87	+ 8
23-23-97	84	+ 5
23-97-23	77	- 2
23-97-97	93	+14
97-23-23	77	- 2
97-23-97	103	+24
97-97-23	93	+14
97-97-97	85	+ 6

Overall exp. showed no significance.
Selected treatments of N-P-K at 23 and 97 lbs./A N, P_2O_5, and K_2O showed
K significant @ 10%
NK " @ 5%
PK " @ 5%
LSD (F_{95}) = 13.9

Continuous Corn-High Fertility Experiment
Soils Unit, Rosemount Experiment Station, Rosemount, Minnesota

This experiment was established on a Port Byron silty clay loam at Rosemount in 1953 under the direction of Prof. C. O. Rost. Direction of the project was passed on to W. P. Martin in 1954. Contributions to the project have been made by Prof. Paul Burson and Senior Plot Supervisor H. W. Kramer. Dr. John Grava has run soil tests periodically.

The project is designed to determine profitable rates of fertilization when corn is grown continuously. Rates of application vary from light to heavy and included in the study are different methods of application--broadcast, hill or row drop with planter attachment, sidedressing with an attachment on the cultivator and combinations of these. Planting rates for corn also vary from approximately 16,000 to 20,000 plants per acre. There are four replications of each treatment.

The site was chosen in a manner which would be compatible with land use recommendations in a conservation farm plan. The site is fairly level so as to minimize erosion, and since it is below a hill-pasture area, it is protected from erosion deposition by terrace structures; it is artificially drained. The soil area has not been heavily cropped in the past and is high in organic matter and "natural" fertility. Randox and 2-4, D are used to help control weeds so as to minimize compaction by cutting down on cultivations, residues are fully incorporated and the principles of minimum tillage are practiced where feasible. Insects are controlled with aldrin.

Corn yields have varied greatly in past years usually because of excess weediness and moisture early and premature frost, severe stalk breakage. In general, however, drought has not been serious and yields have remained high for the area. Check yields have been very good and are not decreasing as rapidly as anticipated. Response to fertilizer has been significant but not as marked as expected largely because of high natural fertility noted above. Results are expected to become more significant with time and it will be of particular interest to note how soon check yields will decline and how long yields can be retained on the fertilized plots at satisfactory levels.

It should be noted also that stalk breakage some years has been quite severe and particularly on the heavier fertilized plots and at the high plant rates.

Fertilizer treatments: (Four replications)

1. Check (no treatment)

	Pounds of Fertilizer Applied		
	6-24-12	10-20-20	33-0-0
	Broadcast	Hill Drop	Sidedress
2.	0	200	0
3.	0	200	100
4.	0	200	200
5.	400	200	0
6.	400	200	100
7.	400	200	200
8.	800	200	0
9.	800	200	100
10.	800	200	200

The plots are approximately 1/25 acre in size and there are six rows in each plot at the 16,000 planting rate and six at the 20,000. Treatments are completely randomized.

Results:

Yields have varied from 45 bushels to 133 bushels (as an average of the treatments) from 1953-1959. Highest yields were obtained in 1954 and lowest in 1957 as a result of excessive precipitation, resulting weediness and premature frost. Yields in 1959 were second highest on record. Response to fertilizer was consistent through all years of the experiment except in 1957 for the reasons above noted.

Yields obtained in 1959 in bushels/acre

	16,000 plants	20,000 plants
1. (Check)	94	109
2. H*	98	123
3. HS_1	97	121
4. HS_2	165	128
5. B_1H	103	127
6. B_1HS_1	103	131
7. B_1HS_2	102	125
8. B_2H	103	106
9. B_2HS_1	104	128
10. B_2HS_2	110	124
L.S.D.	9.4	10.2

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

Phosphate - Potash Rate and Placement Experiment

Eden Valley - 1958

Lowell Hanson

This experiment was on a Wadena loam soil located near the Crow River in Meeker County. The soil test was: pH - 6.5, P - 15 med., K - 80 low. Corn was the preceding crop and moisture during the growing season was below normal.

Fertilizers used were urea, concentrated superphosphate, and muriate of potash. The broadcast treatments of phosphate and potash were applied before plowing in the spring. Row applied phosphate and potash was placed in a continuous band to the side of the seed with a planter junior applicator. Nitrogen was broadcast when plants were 3 to 4 inches high.

Potassium and nitrogen deficiency symptoms were evident all summer on plots not receiving these nutrients.

Potash treatments significantly increased yields, but phosphate did not. Placement effect was not significant. Phosphate appeared to increase yields at the 20 and 40 lb. rate when no potash was applied.

Ear moisture was 10 to 15 percent higher on plots without potash compared to those receiving some potash.

Corn Yields at 15.5% Moisture

	Rep I		Rep II		Row	Broadcast	
Treatment	Row	Broadcast	Row	Broadcast	Ave.	Ave.	Ave.
Check	32		42				37.0
100+0+0	32		43				37.5
100+20+0	45	35	43	67	44.0	51.0	47.5
100+40+0	57	59	59	41	58.0	50.0	54.0
100+100+0	45	29	39	34	42.0	31.5	36.7
Ave.	49.0	41.0	47.0	47.3	48.0	44.2	46.1
100+0+40	72	67	70	72	71.0	69.5	70.2
100+20+40	74	70	68	54	71.0	62.0	66.5
100+40+40	82	63	76	59	79.0	61.0	70.0
100+100+40	62	58	71	59	66.5	58.5	62.5
Ave.	72.5	64.5	71.2	61.0	71.9	62.5	67.3
100+0+80	73	80	90	67	81.5	73.5	77.5
100+20+80	72	68	73	73	72.5	70.5	71.5
100+40+80	66	75	63	68	64.5	71.5	68.0
100+100+80	76	65	74	64	75.0	64.5	69.7
Ave.	71.8	72.0	75.0	68.0	73.4	70.0	71.7
100+0+160	86	80	84	91	85.0	85.5	85.2
100+20+160	76	80			76.0	80.0	78.0
100+40+160	86	76	74	88	80.0	82.0	81.0
100+100+160	76	78	68		72.0	78.0	74.0
Ave.	81.0	78.5	75.3	89.5	78.2	81.4	80.3
Ave. of all plots	66.7	63.5	67.1	67.0	66.9	65.2	

Starter vs. Broadcast Fertilizer Demonstration for Corn in Southwestern Minnesota

C. J. Overdahl

The question frequently arises in the western tier of counties mainly in the Moody-Kranzberg and the Barnes-Aastad areas as to starter fertilizer recommendations. Farmers, fertilizer dealers, and county agents claim that yields are either reduced or are no better than the unfertilized areas.

Locations

Plots were located in the following counties in 1958: Bigstone 3, Stevens 2, Lac Qui Parle 2, Chippewa 2, Yellow Medicine 4, Lyon 3, Pipestone 2, and Rock 2.

The 1959 plots were located as follows: Rock 2, Pipestone 2, Yellow Medicine 2, Lac Qui Parle 1, Chippewa 2, and Swift 2.

Fertilizer Rates

The 1958 plots had 60+0+30 broadcast before plowing over the entire area. Broadcast phosphate was applied at 60 pounds and starter phosphate applied by the farmer averaged 43 pounds per acre. The 1959 plots had two nitrogen rates, 0 and 60 pounds of N as well as a phosphate variable. Phosphate was applied at 40 pounds per acre broadcast and plots averaged 35 pounds for the planter applied starter, although the aim was 40 pounds for both. All plots had 2 replicates.

Weather Conditions

1958 - Subsoil moisture levels were high, but early season rainfall was low. Corn emergence was very uneven due to dry surface soil. On flat, poorly drained soils the surface was wet at planting time. June was very cold.

1959 - Subsoil moisture levels were low. Certain areas had fair rainfall. Temperatures were above normal during tasseling time.

Results (1958) Average increase above check (2 reps)

County	Check	Starter	Broadcast	Broadcast + Starter
Bigstone	67.0	-.2	5.3	8.1
"	35.0	6.4	5.6	16.5
"	33.9	8.1	17.4	23.1
Lyon	74.3	8.5	6.2	9.5
Rock	39.4	6.3	7.6	8.7
Chippewa	59.6	9.4	5.4	18.6
Yellow Medicine	71.3	1.0	13.4	18.2
" "	82.3	10.4	11.2	12.6
Lac Qui Parle	101.4	3.3	8.8	11.9
" " "	90.1	9.3	16.7	27.0
Stevens	66.5	16.6	27.5	30.8
Average	65.5	7.2	11.4	16.8
Value of increase above fertilizer		$2.90	$5.40	$6.50

Several plots were not included in averages because of extreme variability (several bad dried out areas across plots). Plots with no increase beyond check were excluded since difference between starter and broadcast would be unreal.

(1959)

County	N rates	Check	Starter	Broadcast	Broadcast + Starter
			Average increase above check (2 reps)		
Rock	40	54.2	23.6	36.7	51.8
	100	42.0	36.5	34.3	57.0
Rock	0	75.4	4.9	8.2	14.6
	60	85.2	- .5	2.2	8.6
Swift	24	87.6	16.2	8.5	16.9
	84	93.7	- .9	5.1	14.9
Yellow Medicine*	0	51.4	- .2	-12.5	-4.6
	60	47.6	-2.8	-3.9	13.4
Chippewa*	30	44.4	-2.2	7.2	28.8
	90	66.5	-20.5	7.8	6.5
Lac Qui Parle	0	50.2	24.6	6.1	20.6
	60	42.5	25.6	26.2	43.2
Swift*	0	91.5	-3.4	-2.6	-5.8
	60	89.4	- .4	3.6	-3.6
Chippewa*	0	58.8	-2.4	2.0	-2.8
	60	67.5	-12.5	-2.3	-17.3
Average		64.9	7.8	11.4	22.0
Value of increase above fertilizer			$4.60	$7.40	$14.80

*Excluding non response plots $13.00 $11.90

Observations

On poorly drained soils starter fertilizer was very effective. Starter appeared to be less effective than broadcast where surface soil was dry at planting time or if May or June temperatures were too cold for good plant growth. This was the situation for most of the plots in 1958.

The soils in most fields tested relatively low in phosphorus. The combination of starter and plowdown was superior indicating that starter fertilizer was effective if broadcast applications were present for late season needs.

General recommendations for corn based on the above as well as other observations might be as follows:

Where soils are low in phosphorus and high in potassium use a combination of starter and plow-down fertilizer. Starter might be approximately 100 pounds of a 1:4:2 ratio with as near as possible to 1:1:0 ratio plowed down if not following a legume. If following a legume, use straight phosphate as the broadcast material.

If phosphorus levels are in the medium range, use either the starter or broadcast but not both. Little, if any, phosphate response was observed on fields testing high.

Results on Nitrogen

Urea fertilizer* was applied to half of each treatment on the 1959 plots. The following are yield increase averages over no nitrogen treatment from 2 reps where 60 pounds of N were applied. Farmers in many cases applied nitrogen as well, hence in several fields there were no zero nitrogen treatments.

Nitrogen rates		Yield where no N. applied	Phosphate applied as:			
Check	N plot		Check	Starter	Broadcast	Broadcast + starter
**40	100 pounds	44.2	-2.2	10.7	-4.6	3.1
0	60	75.4	9.8	4.4	3.8	3.8
**24	84	87.6	6.1	-11.0	2.7	4.1
0	60	51.4	-3.8	-6.4	5.8	14.2
**30	90	44.4	22.1	3.8	22.7	- .2
0	60	50.2	-7.7	-6.7	12.4	14.9
0	60	91.5	-2.1	0.9	4.1	0.1
0	60	58.8	8.7	-1.4	4.4	-5.8
	Average increase	62.9	3.6	-0.7	6.4	4.3
Average increase over no Nitrogen			1.0	1.8	6.1	5.4

** Plots excluded in average.

All plots either followed corn, soybeans, or oats.

* Supplied by Cyanamid Co.

ROOT DEVELOPMENT AND FERTILIZER PLACEMENT FOR CORN

By

Paul M. Burson and C. O. Rost*

There is an old saying among farmers that if you are going to have good growth above the ground, you are going to have to have good growth below the ground. This is true, but if there is insufficient fertility in the soil, there will be both poor growth of roots and tops. Roots vary in total growth the same as tops. We see large increases in top growth due to the plant nutrients added. We, too, see the root growth vary proportionally. When we see a response to fertilizer, we are definitely sure that the roots, likewise, have increased in growth. The plant nutrients in the soil and the root system that is developed constitute the team that determines the crop yields. The roots pick up the nutrients and water and see that they get to the tops that will produce the crop. When a plant is deficient in nutrients, the top growth shows certain signs of deficiency symptoms. The roots, likewise, change in appearance and growth, but this is not so readily seen because they are hidden in the soil. An example of a root deficiency symptom is the shortage of potash as shown by lodging. In this the roots are restricted in growth, anchorage is weak, so the stalks lodge. Such lodging is characterized by "bow-legged" or curved stalks. Roots are actually the first part of the plant to suffer when a deficiency of nutrients occur.

Root Development

Root response to fertilization has received very little attention and has been studied very little because most attention is given to the yield per acre

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* Professor, Emeritus Professor of Soils, University of Minnesota, respectively.
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and not what was taking place in the soil where the roots gather the nutrients and water to produce the higher yields. Also, because the roots are in the soil they are hard to see, hard to wash out of the soil so they can be studied. Fertilizer affects roots in some of the following ways:

1. It encourages a more extensive root system.
2. It may encourage a more intensive growth of roots in the zone of fertilizer application.
3. It may change some of the chemical properties of the roots.

Intensive and extensive root growth is essential as follows:

1. Intensive roots more completely utilize the nutrients in the fertilizer band.
2. Extensive roots will penetrate to an area more favorable for minor nutrient availability as in the case of high lime soils of high pH or in highly acid soils of low pH.
3. Better growth and development of roots have larger reservoirs of water to draw on because deeper penetration of the roots, thus giving the plant a larger reserve supply in case of drouth.
4. Corn plants are better anchored to prevent lodging. Winter killing of legumes usually occurs when there is unbalanced or a low supply of essential nutrients, resulting in poorly developed roots.

There are many factors that can influence the extent of the root system such as the type and stage of development of the crop and compaction, aeration, and moisture of the soil. However, in most soils the supply of plant food is the most important single factor limiting root growth. On the other hand, well fertilized soils resulting in good root development may reduce the damage caused by such conditions as compaction and lack of moisture.

In the case of legume roots, if they are to be effective in breaking up a compact layer in the soil, they must be properly fertilized if they are to be vigorous in their growth and deep in their penetration.

More vigorous root growth means better penetration into compacted soils and will reach to greater areas of the soil volume for needed moisture. There is still a lot to be known about why roots expand in well fertilized soils or into a fertilized band.

Plant roots must intercept the fertilizer band in their development and growth. They do not "smell out" the fertilizer and then grow to it. If there is enough plant food, they remain there and proliferate or develop in the band. If there are very small amounts of nutrients, they will continue to grow in all directions. This apparently was the situation a few years ago when the starter rates of fertilizer were low and low analysis fertilizer was used. Corn at knee-high to 18 inches would tend to grow away from the starter fertilizer area. Not too recent experimental work showed this to be true, but now with better placement, higher rates per acre, and much higher concentration of plant food in the fertilizer it may be possible to apply enough fertilizer in the band to feed the crop for the whole season.

The proliferation of the roots in the fertilizer band is in response to the higher nitrogen and phosphate levels. The result is the dividing and elongating of root cells which are in direct contact with the high nitrogen and phosphate concentrations in the fertilizer band. Nutrient uptake and the rate of use by the plant are related to the concentration of nutrients.

Plant physiologists say nitrogen is needed in the roots for protein and enzyme processes. Phosphorus is needed for the metabolic processes. The function of potassium is not exactly known, but it is related to enzyme activity.

All of these nutrients and processes contribute to more growth and root cell division.

For a plant to obtain nutrients and water the roots must be in intimate contact with the soil particles. This is accomplished by the root hairs that develop behind the advancing root tip and by the rapidly dividing cells near the root tip.

Data given in the 1957 U.S.D.A. yearbook, SOIL, on the extensiveness of the root system of a single four-month old rye plant growing in one cubic foot of soil may help to understand soil-root relationships:

	Total Length	Surface Area
Roots	385 miles	2550 sq. ft.
Root hairs	6600 miles	4320 sq. ft.
	6985 miles	6870 sq. ft.

This seems to be a tremendous system of roots, but the surface area of the soil particles in one cubic foot of soil might exceed 500,000 square feet. Therefore, the root system is in contact with only about one per cent of the soil area at any one time. As the roots move through the soil, new root hairs continue to develop and the older ones die. Thus the root system of a plant will come in contact with a considerable proportion of the soil during the life of the plant.

The band of fertilizer occupies a very small volume in the soil. This varies with the kind of fertilizer, rate of application, method of application, and the texture of the soil; but with the average fertilizer on a silt loam soil the effective volume would not exceed an inch square in cross section. Therefore, it may occupy from 1/100 to 1/1000 of the root volume depending on the stage of the growth of the crop. Therefore, such a small volume of fertilizer must be placed where the roots will come in contact with the band. For intensive root development there must be a high concentration of both nitrogen and phosphate. One without the other is of little value and will not result in much root development. The proliferation of roots in the band, of course, will not be as great on soils of high fertility. Under conditions of low soil fertility the basic broadcast application of fertilizers will develop an extensive root system while the band application will develop the more intensive root system. A combination of the two methods will provide a root system that can lead to maximum crop yields providing other practices of good soil management are properly applied.

Fertilizer Placement

Until a few years ago there was little emphasis as to where to place the starter fertilizer as long as it got into the soil - sometimes with the seed, sometimes above it and sometimes directly below it. It didn't seem to matter much because the fertilizer was not concentrated enough to damage germination and the rates per acre were not heavy enough to injure the primary root or sprout, but it did help give the young plant an early start. This placement of fertilizer was made by the old split boot attachment on the corn planter that had been used for many years. Now with present-day fertilizers of higher concentration that are applied at higher rates per acre and at faster speeds the fertilizer comes in contact with the seed resulting in poor germination, reduction of stand, stunted growth, and low crop yields. Where the fertilizer is placed will determine the difference between a good stand, a poor stand, or no stand at all.

The trend today in fertilizer placement for row crops is toward a single band placement which is the safest and most efficient way to place starter fertilizer. The single band attachment on the corn planter can be adjusted so the fertilizer can be placed at a certain distance to the side and below the seed. At the present time the band is usually placed 2 inches to the side and 2 inches below. This placement is safe because the fertilizer salts do not contact the germinating seed sprout (primary roots). It is more efficient because the fertilizer is placed where the feeder roots (secondary or branching roots) can soon intercept the fertilizer nutrients and the band is down where the soil is most likely to be moist. In drier areas it might be well to place the fertilizer 3 inches or more below the seed to take advantage of the deeper soil moisture. At this depth there may be some sacrifice in the quick start in the spring, but if there should be a shortage of moisture later on in the season, this early starter disadvantage might be more than offset by a greater supply of soil moisture.

Plan of Trials

In 1959 starter fertilizer placement trials were conducted with corn on the Soils Farm at Rosemount. The different soil treatments were applied at different rates, placed 2 inches to the side and 2 inches below the seed. The rates of application were 200, 400, and 600 pounds per acre of nitrogen:phosphate ratios of 1:3 (8-24-12), 1:4 (5-20-20), and 3:1 (30-10-0). In the 1:3 and 1:4 ratios, 66 pounds of actual nitrogen were applied as sidedressing in two bands, one on either side of the row in late June. With the 3:1 ratio all the nitrogen for the season was applied in the band as a starter. These trials were conducted on the Port Byron silt loam soil type which was moderately eroded, low in organic matter and nitrogen, and in the fourth year of corn. The soil had been limed at 3 tons per acre. The soil tests showed medium to low levels of available phosphate and potash. Additional phosphate and potash was applied broadcast as 0-20-20 at 300 and 600 pounds per acre on some of the plots.

The purpose of these trials was to observe what ratios and rates of fertilizers that could be applied in a band as a starter and what would be the difference in root proliferation and yields with the different fertilizer treatments. Different nitrogen:phosphate ratios were used because work in other states seemed to indicate that a 1:3 ratio was the best for root proliferation. This might be true for soils higher in organic matter and nitrogen, but soils such as the ones used in these trials with low organic matter and nitrogen a greater proportion of nitrogen to phosphate might be better.

About August 1 when the roots were fully developed, they were examined to determine if there was any difference in root proliferation and distribution with the different fertilizer treatments. Representative corn root samples from different plots were carefully dug and washed clean to determine how they grew in relation to the fertilizer band, if there was any difference in the extent of proliferation with different fertilizer treatments, methods of application and time of application.

Root Proliferation

Regardless of the fertilizer treatment and method of application all corn roots proliferated in the fertilizer bands.

There was no fertilizer injury to the germination and stand of the corn and growth of the root systems regardless of the rate per acre, grade, ratio of fertilizers used, method, and time of application.

The results show that root proliferation was by far superior with the 3:1 ratio of nitrogen:phosphate than with the 1:3 or 1:4 ratios.

The higher nitrogen in the fertilizer band stimulated the intensive proliferation of the roots.

The most noticeable difference was the tremendous mass of fibrous roots with the 3:1 ratio where all the nitrogen was applied as starter as compared to limited fibrous roots growing in the bands of the 1:3 and 1:4 ratios and where the nitrogen was applied later as sidedressing.

With the 3:1 ratio practically all proliferated roots were concentrated in the single fertilizer band. In the 1:3 and 1:4 ratios with much less proliferation in the fertilizer band there was a similar proliferation of roots in the two bands where the sidedressing of nitrogen was later applied. With this combination of treatments the corn roots were concentrated in three bands while in the 3:1 ratio with all the fertilizer applied as a starter the roots were proliferated in only one band. The question now may be raised as to which distribution of roots would be best in case limited moisture conditions should occur. As far as the total root systems were concerned, there appeared to be no visible difference resulting from the different ratios and the time and method of application provided enough nitrogen was applied.

These observations would indicate that soils low in organic matter and nitrogen are in need of sufficient fertilizer nitrogen along with phosphate and potash if proliferated, vigorous, and intensive root systems are to be developed.

Corn Yield Results

Yields were harvested from all plots (Table I). All fertilizers in 1959 regardless of ratio, rate per acre, methods and time of application gave increases of more than 20.0 bushels per acre over the unfertilized plots. The 0-20-20 fertilizer applied broadcast at 300 and 600 pounds per acre gave yield increases of 21.4 and 25.8 bushels respectively. The root development with this method of application was extensive and well distributed through the top 6 inches of soil. On all of the other treatments the yield increases in 1959 ranged from 46.1 bushels per acre for treatment 13 to 68.1 bushels for treatment 6. In both treatments the root proliferation was both extensive and intensive because the starter fertilizers were 1:3 and 1:4 nitrogen:phosphate ratios and the additional nitrogen was applied as sidedressing. This resulted in extensive root proliferation developing in three bands instead of intensive root proliferation in one band as was the case in treatments 7, 8, 9, 10, 16, and 17.

In 1958 only limited trials and observations were made. However, similar responses in yield increase and root proliferation were found as in 1959. The yield increases ranged from 17.0 bushels per acre on treatment 20 to 57.0 bushels per acre on treatment 18. The difference of 18.0 bushels per acre in favor of treatment 18 over treatment 19 can probably be contributed to the greater amount of phosphate. The Port Byron soil type is very responsive to phosphate treatments. Further detailed trials need to be made to study root proliferation and corn yields as related to ratio, rates of application, method and time of fertilizer application. The following table gives the details on the yields of different treatments and comparative root proliferation.

Lodging

Considerable lodging occurred on all treatments. The most severe lodging, however, was noted on treatments where no potash was contained in the starter fertilizer.

On treatment 9 there was 23 per cent lodging where phosphate and potash was broadcast in addition to the starter as compared to a high of 52 per cent lodging on treatments 16, when phosphate and potash was broadcast and no potash was included in the starter. Even though potash was added broadcast as 0-20-20 it apparently was not as effective in preventing lodging as if the potash had been applied in a band as a starter. With intensive root proliferation in the fertilizer band, containing no potash, the roots did not pick up sufficient amounts of the needed potash when it was all applied broadcast.

Table I - Fertilizer Placement, Corn Yield Increases and Root Proliferation

1959

Treatment Number	Fertilizer Treatments	Method Applied	Ratio:[4] Nitrogen to Phosphate	Yield Increase over check Bu./acre	Percent Lodging	Root[5] Proliferation
1	300# 0-20-20	B. C.[1]	-	21.4	-	-
2	600# 0-20-20	B. C.	-	25.8	-	-
3	300# 0-20-20 200# 5-20-20 50# N	B. C. St.[2] S. D.[3]	1:4	49.5	21	E & I
4	600# 0-20-20 200# 5-20-20 50# N	B. C. St. S. D.	1:4	63.6	22	E & I
5	300# 0-20-20 200# 5-20-20 110# N	B. C. St. S. D.	1:4	59.2	24	E & I
6	600# 0-20-20 200# 5-20-20 110# N	B. C. St. S. D.	1:4	68.1	20	E & I
7	300# 0-20-20 200# 30-10-0	B. C. St.	3:1	53.5	34	I
8	600# 0-20-20 200# 30-10-0	B. C. St.	3:1	57.9	36	I

9	300# 0-20-20 400# 30-10-0	B. C. St.	3:1	50.0	23	I
10	600# 0-20-20 400# 30-10-0	B. C. St.	3:1	61.3	39	I
11	200# 5-20-20 50# N	St. S. D.	1:4	51.5	26	E & I
12	200# 5-20-20 110# N	St. S. D.	1:4	52.5	20	E & I
13	200# 8-24-12 60# N	St. S. D.	1:3	46.1	-	E & I
14	400# 8-24-12 60#	St. S. D.	1:3	49.2	-	E & I
15	600# 8-24-12 60# N	St. S. D.	1:3	52.5	-	E & I
16	200# 30-10-0	St.	3:1	51.7	52	I
17	400# 30-100	St.	3:1	53.1	35	I
			1958			
18	400# 8-24-12 60# N	St. S. D.	1:3	57.0	-	E & I
19	400# 8-16-16 60# N	St. S. D.	1:2	39.0	-	E & I
20	200# 8-16-16 60# N	St. S. D.	1:2	17.0	-	E & I

[1] B. C. - Broadcast and disked in or plowed under.
[2] St. - Starter fertilizer applied at time of planting corn.
[3] S. D. - Sidedressed nitrogen applied in late June.
[4] Ratio - Proportion of Nitrogen to phosphate (1:3, 1:4 and 3:1) in the starter fertilizer.
[5] E - Extensive - Root proliferation in starter band and sidedressing bands combination.
I - Intensive - Root proliferation in single band. All fertilizer applied as starter. No sidedressing.

Plant population - 21,000 per acre.
Soil type - Port Byron silt loam.

Progress Report on Fall, Spring, or Sidedressed Nitrate or Ammonium Nitrogen Treatments on Corn in Minnesota.

January, 1960

J. M. MacGregor, H. W. Kramer, O. C. Soine
R. Thompson and R. Dennistoun

Since applications of the two nitrogen fertilizers at the Rosemount field in 1956-57 and in 1957-58 had failed to significantly increase corn yields (due to droughty soil conditions and soil variability in the experimental areas) this location was eliminated from the 1958-59 trials. However, the experiment at the two remaining locations were enlarged to include a June or an early July sidedressing on the Hegne clay at Crookston (in northwestern Minnesota) and on the Barnes loam at Morris (in west central Minnesota). Residual nitrogen effects on crop yield and compaction were studied on each of the three fields.

Since the areas were adjacent to the experimental plots of the two previous years the soil tests were the same:

Soil Test	Crookston (Hegne clay) 0"-7"	7"-14"	Morris (Barnes loam) 0"-7"	7"-14"	Rosemount (Waukegan silt loam) 0"-7"	7"-14"
pH	7.6	7.6	7.3	7.4	5.7	5.6
Avail. P (lbs/A)	15	4	18	8	29	12
Ex. K (lbs/A)	600+	535	538	458	188	153
% O.M.	5.2	2.1	6.1	4.6	4.8	3.9

Previous cropping history and soil treatments were as follows:

	Crookston	Morris	Rosemount (No 1958-59 experiment)
1954	Oats + 100# of 0-45-0	-------	Alfalfa-brome
1955	Durum wheat + 100# of 8-32-0	Soybeans	Corn + 150# of 5-20-20
1956	Durum wheat - no fertilizer	Flax	Flax + 200# of 6-24-12
1957	Oats 125# of 0-47-0 per acre	Corn	Corn + 200# of 8-16-16
1958	Durum wheat - 100# of 0-46-0/A	Silage corn	Corn experiments

The fall nitrogen applications were made at Crookston in late October (soil temperature 45°F) and at Morris on November 8, 1958 (soil temperature 40°F). The nitrogen fertilizers were broadcast and left over winter on the soil surface. Each of the thirteen treatments had six replicates, the individual plot size being 26' 8" x 35' (or 8 x 10.5 rows of 40" spaced corn). The soils were sampled as outlined, but since they were adjacent to the 1957-58 plots, the soil tests were approximately the same. Phosphate-potash fertilizer (500# of 0-20-20 per acre, was broadcast over the entire area at the time of the spring nitrogen treatments at Morris on May 9 (soil temperature 44°), and at Crookston on May 14, 1959 (soil temperature 46°). Soil moisture samples were taken to a depth of six feet with the following moisture percentages obtained:

Crookston - % Soil Moisture - Hegne clay - May 14, 1959

Depth (inches)	Replicate						Average
	I	II	III	IV	V	VI	
0"-12"	17.6	21.1	18.4	21.7	21.6	20.8	20.2
12"-24"	17.3	18.3	19.8	19.6	20.3	19.0	19.1
24"-36"	17.7	18.6	19.6	19.0	20.0	23.2	19.7
36"-48"	18.5	16.4	19.3	21.0	18.6	19.2	18.8
48"-60"	18.9	21.8	19.0	19.1	19.6	23.5	20.3
60"-72"	16.3	21.0	20.7	21.8	29.4	24.0	22.2

Morris - % Soil Moisture - Barnes loam - May 9, 1959

Depth (inches)	Replicate						Average
	I	II	III	IV	V	VI	
0"-12"	14.4	12.9	16.4	13.5	18.7	17.8	15.6
12"-24"	13.8	13.1	14.5	14.1	18.7	18.7	15.5
24"-36"	12.2	9.7	11.9	10.0	14.1	13.9	12.0
36"-48"	14.9	15.8	8.5	11.2	11.2	16.6	13.0
48"-60"	15.7	15.3	10.5	8.5	10.6	14.7	12.6
60"-65"	14.0	15.7	9.3	8.8	13.6	13.3	12.5

The experimental soils at Morris and Crookston were relatively dry when sampled. Soil samples were forwarded in plastic bags to the Iowa soil testing laboratory for analysis.

Plant Populations

The corn was planted in forty inch rows on the two fields, and both were sprayed with Randox for weed control. At Crookston two kernels were dropped at 16" intervals which resulted in a stand of approximately 18,000 stalks per acre. The corn at Morris was thinned to four plants per 40" hill with approximately 15,000 stalks per acre.

Weather

The 1959 growing season was very dry at Morris with drought conditions prevailing in late July and August. The dry soil conditions seriously limited yield and nitrogen effect. Ample rainfall fell at Crookston during July and August, which resulted in good corn yields for this northern area.

Table 1. Monthly Precipitation and Percentage of Normal

Month	Morris		Crookston	
	Total	% of normal	Total	% of normal
October 1958	0.57"	42	2.04"	176
November 1958	1.65"	660	1.95"	212
December 1958	0.16"	25	0.41"	66
January 1959	0.15"	25	0.20"	34
February 1959	0.39"	54	0.37"	63
March 1959	0.12"	10	0.21"	21
April 1959	0.63"	30	0.44"	30
May 1959	5.71"	200	2.48"	95
June 1959	1.65"	42	2.10"	61
July 1959	1.40"	42	3.96"	141
August 1959	3.00"	103	6.13"	196
September 1959	1.20"	63	1.20"	62
Total	16.63"		21.49"	
Deficit	5.25"	Excess	1.23"	

Wheat was grown with no additional fertilizer at Crookston on the 1957-58 fall-spring nitrogen area and oats following wheat on the 1956-57 fall-spring nitrogen area. At Morris, corn was grown on the 1957-58 experimental area and oats were grown on the like area at Rosemount and these yields will be shown later.

1959 Results

Crop yield response from fertilization is still the most important consideration to the farm purchaser and these are shown in the following tables:

Table 2

1959 Yield of Corn and Stover with Fall, Spring, or Summer Applied Nitrate or Ammonium Nitrogen

N (lbs/A)[(a)]	Application Time	Morris		Crookston	
		Corn - bu/A	Fodder - T/A	Corn - bu/A	Fodder - T/A
None	----	37.2	1.00	71.3	2.25
		Increase above check			
40 NO_3	Fall	7.0	0.10	13.1**	0.45
" "	Spring	2.8	0.11	15.6**	0.41
" "	Summer	8.4	0.01	15.9**	0.56
40 NH_4	Fall	1.4	0.96	4.5	0.04
" "	Spring	8.1	0.00	10.6**	0.21
" "	Summer	0.2	0.00	11.1**	0.40
80 NO_3	Fall	7.3	0.09	18.6**	0.57
" "	Spring	3.3	0.08	18.9**	0.35
" "	Summer	8.0	0.14	20.5**	0.66

80 NH_4	Fall	3.4	-0.17	14.2**	0.15
" "	Spring	14.6**	-0.11	14.2**	0.43
" "	Summer	8.1	0.04	15.6**	0.28
*L.S.D. - (0.05)		9.5 bu.		5.3 bu.	
**L.S.D. - (0.01)		12.7 bu.		7.1 bu.	
H.S.D. - (0.05)		16.4 bu.		9.3 bu.	
H.S.D. - (0.01)		19.1 bu.		10.8 bu.	

Means of Grain Yields

40# N	41.8	L.S.D. 1% = 3.9 bu/A	83.2	L.S.D. 1% = 2.8 bu/A
80# N	44.9		88.4	
Diff.	3.1		5.2	
NH_4	43.3	L.S.D. 1% = 3.9 bu/A	83.0	L.S.D. 1% = 2.8 bu/A
NO_3	43.3		88.5	
	0.0		5.5	
Fall	41.9		84.0	
Spring	44.7	H.S.D. 1% = 55 bu/A	86.2	H.S.D. 1% = 3.1 bu/A
Summer	43.4		87.1	

(a) 500 lbs. of 0-20-20 per acre (0-100-100 spring broadcast on all plots.

With the late summer drought, the increased yields of the Morris field are rather questionable. At Crookston, NH_4-Nitrogen seems to be less effective than the NO_3-Nitrogen, especially where the mean values are considered. Time of nitrogen application corn yields varied significantly with the individual treatments, only in the case of the 40 pound NH_4 application, but the summer sidedressing was significantly better than fall fertilization on the means of all plots. On the same basis, the higher rate of N treatment was significantly more effective, especially the nitrate form.

The nitrogen concentrations of the grain and stover are shown in Table 3.

Table 3. Percentage Nitrogen in 1959 Corn Grain and Stover with Fall, Spring, or Summer Applied Nitrate or Ammonium Nitrogen in Minnesota (O. D. basis)

N (lbs/A)	Application Time	Morris		Crookston	
		Grain	Stover	Grain	Stover
			Percentage N		
None	——	1.43	0.62	1.45	0.56
			Increase above check		
40 NO_3	Fall	0.15	0.12	-0.04	0.07
" "	Spring	0.23	0.15	0.11	0.09
" "	Summer	0.18	0.22	0.12	0.22

40 NH_4	Fall	0.11	0.04	-0.22	-0.02
" "	Spring	0.33	0.22	-0.25	-0.07
" "	Summer	0.28	0.33	0.05	0.18
80 NO_3	Fall	0.27	0.30	0.23	0.26
" "	Spring	0.36	0.36	0.23	0.42
" "	Summer	0.34	0.33	0.22	0.32
80 NH_4	Fall	0.23	0.30	0.17	0.21
" "	Spring	0.17	0.50	0.21	0.22
" "	Summer	0.17	0.28	0.14	0.25

Table 4. Pounds of Nitrogen Removed per acre in 1959 Corn Grain and Stover with Fall, Spring or Summer Applied Nitrate or Ammonium Nitrogen in Minnesota.

Applied N (lbs./A)	Application Time	Morris Grain	Morris Stover	Crookston Grain	Crookston Stover
			Pounds N per Acre		
None	----	25.5	12.3	48.9	24.8
			Increase over check		
40 NO_3	Fall	9.0	3.1	7.4	8.5
" "	Spring	4.4	4.5	15.3	9.2
" "	Summer	5.7	4.4	15.9	17.9
40 NH_4	Fall	2.9	0.1	-4.8	-0.7
" "	Spring	12.2	4.0	-2.5	-1.3
" "	Summer	4.8	6.4	11.0	12.5
80 NO_3	Fall	10.3	7.3	22.6	20.8
" "	Spring	6.8	9.1	22.8	24.9
" "	Summer	12.4	9.0	23.6	25.2
80 NH_4	Fall	3.3	3.3	16.6	15.2
" "	Spring	10.2	7.2	18.3	16.3
" "	Summer	8.8	6.1	16.5	15.4

Table 5. Nitrogen Removed per Acre by 1959 Corn Crop and Percentage Recovery of Fertilizer Nitrogen Applied in Fall, Summer, or Spring as Nitrate or Ammonium Nitrogen.

Applied N (lbs/A)	Application Time	Morris		Crookston	
		lbs. N removed	% recovery	lbs. N removed	% recovery
None	----	37.8	----	73.7	----
			Increase over check		
40 NO_3	Fall	12.1	30	15.9	40
" "	Spring	8.9	22	14.6	37
" "	Summer	10.1	25	33.8	85
40 NH_4	Fall	3.0	8	-5.5	-13
" "	Spring	16.2	41	-3.7	- 9
" "	Summer	11.2	28	23.5	59
80 NO_3	Fall	17.6	22	43.4	54
" "	Spring	15.9	20	47.7	60
" "	Summer	21.4	27	48.8	61
80 NH_4	Fall	6.6	8	31.8	40
" "	Spring	17.4	22	34.6	43
" "	Summer	14.9	19	31.9	40

The recovery of nitrogen at Morris was both low and variable. At Crookston a much better recovery was obtained by the summer sidedressing at the lower rate with little difference where 80 pounds of nitrogen was applied. Nitrate nitrogen recovery was higher than with the ammonium form.

Direct and Residual N Fertilization Effect on Crop Yields

In 1959 oats were grown 1957-58 experimental field, and corn was grown as a residual crop at Morris with no additional fertilizer. The yields obtained for the two years are shown in Table 6.

Table 6. Corn Yields at Rosemount and at Morris in 1958 and in 1959 with Nitrate or Ammonium Nitrogen Applied in Fall of 1957 or Spring of 1958.

Applied N (lbs/A)	Application time	Rosemount		Morris	
		1958 Corn	1959 Corn	1958 Corn	1959 Corn
			(bushels per acre)		
Check	----	111.7	82.2	70.5	39.4
			Increase over check		
40 NO_3	Fall 1957	-12.0	1.9	3.5	10.5
" "	Spring 1958	- 3.2	-1.4	-1.0	9.2
40 NH_4	Fall 1957	- 4.5	1.1	-1.8	7.0
" "	Spring 1958	8.8	12.3	2.3	15.5

80 NO_3	Fall 1957	-6.0	-3.3	4.4	14.5
" "	Spring 1958	-8.5	5.1	9.0	9.3
80 NH_4	Fall 1957	-1.4	3.8	6.2	4.0
" "	Spring 1958	-1.5	4.1	2.6	11.1

It is evident that the corn yields in both years were erratic and there was no significant nitrogen effect. Rainfall was somewhat limited in both years at Morris and in 1958 at Rosemount.

Nitrogen effect has generally been more consistent at Crookston then at the other two locations but no residual effect was obtained. The 1956-57 corn yields and that of two succeeding crops are shown in Table 7.

Table 7. The Effect of Nitrate or Ammonium Nitrogen on Yield of Corn and Succeeding Crops at Crookston.

Applied N (lbs/A)	Application Time	Crop yields in bushels per acre		
		1957 Corn	1958 Wheat	1959 Oats
Check	----	44.2	33.9	49.7
		Increases over check		
40 NO_3	Fall 1956	8.3*	-0.4	-3.6
" "	Spring 1957	6.4*	2.0	-4.2
40 NH_4	Fall 1956	3.5	-2.6	0.0
" "	Spring 1957	3.0	-0.1	6.0
80 NO_3	Fall 1956	7.3*	1.6	2.1
" "	Spring 1957	8.0*	1.7	1.7
80 NH_4	Fall 1956	7.2*	-0.1	2.3
" "	Spring 1957	7.5*	3.0	1.0
	*Sig (5%)	6.3 bu.		

Wheat grown at Crookston in 1959 following the 1958 corn experiment showed no residual nitrogen effect and this is shown in Table 8.

Table 8. The Effect of Fall or Spring Applied Ammonium or Nitrate Nitrogen on the Yield of 1958 Corn and 1959 Wheat at Crookston.

Applied N (lbs/A)	Application Time	1958 Corn (bu/A)	1959 Wheat (bu/A)
Check	----	55.6	21.9
		Increase over check	
40 NO_3	Fall 1957	18.3	-0.4
" "	Spring 1958	18.7	1.4
40 NH_4	Fall 1957	13.2	-1.4
" "	Spring 1958	8.4	-1.5
80 NO_3	Fall 1957	24.3	3.8
" "	Spring 1958	22.0	1.2
80 NH_4	Fall 1957	22.3	1.4
" "	Spring 1958	21.1	-0.4

Table 9 presents the pounds per acre of applied fertilizer nitrogen recovered in 1959 wheat (from the 1957-58 N applications for 1958 corn) and in 1959 oats (from the 1956-67 N applications for 1957 corn with wheat grown in 1958). This represents the increased amounts of fertilizer nitrogen found in small grain in the second and third following crops.

Table 9. Pounds of nitrogen present in 1959 wheat grain and straw (following N applications in 1957 and 1958 for corn) and pounds of nitrogen in 1959 oat grain and straw (following N applications in 1956 and 1957 corn and 1958 wheat).

Applied N lbs/A		Pounds of Nitrogen in 1959 Crop					
		Wheat (N applied 1957-58)			Oats (N applied 1956-57		
		Grain	Straw	Total	Grain	Straw	Total
Check		19.1	4.4	23.5	20.5	5.0	25.5
				Increase over check			
40 NO_3	Fall	0.8	0.7	1.5	1.2	0.1	1.3
" "	Spring	2.1	1.4	3.5	-0.9	1.6	0.7
40 NH_4	Fall	-0.9	0.0	-0.9	3.2	-0.4	2.8
" "	Spring	-0.4	1.2	0.8	2.4	1.7	4.1
80 NO_3	Fall	6.1	3.2	9.3	1.0	0.2	1.2
" "	Spring	3.1	1.9	5.0	4.1	-0.7	3.4
80 NH_4	Fall	2.2	0.6	2.8	1.1	0.7	1.8
" "	Spring	1.3	0.6	1.9	-0.2	-0.2	-0.4

Structure - Nitrogen Study
Waseca, 1959
Corn Populations

In 1959 corn was planted at about 22,000 plants per acre so that after population counts it could be thinned uniformly.

There was considerable damage to corn population when corn was 2-3 inches high. Consequently, stands on some plots were very poor.

The damage to population was believed to be due to rodents. Pheasant damage was suspected, paritcularly in minimum tillage plots where birds could hide in the furrow indentations. Two reasons indicated they were not the primary cause of population damage. First, damage boundaries were sharper and more distinct than one normally expects from pheasants. Second, as will be seen later, minimum tillage plots were not consistently damaged even when laying side by side in the field.

Visual observation of the damage indicated whole tillage plots (including in a block all fertilizer treatments) were affected thus that the damage was related to tillage treatment. The following tabulation was made to observe this effect. Values given in the table are plants per 6-row replicate (720 feet of row).

	Tillage Treatment				
Reps	1	2	3	4	5
I	709	454	1143	1136	999
II	911	989	1150	1147	946
III	930	802	1004	1096	897
Totals	2550	2245	3297	3379	2842

Treatments 1, 2 and 5 suffered population damage. Treatments 1 and 2 are spring plowed. Residues in these, and also in 5 to a lesser extent, are left at the surface over winter. Thus rodents may have been either (a) protected from frost or (b) were attracted to spring plowed plots possibly because of food availability.

Part of the observed differences could have been due to differences in germination. This would be suspected from past experience to apply more to treatment 5 than to 1 or 2.

That there were no differences between minimum and conventional tillage is obvious from the tabulated data for treatments 3 and 4. Treatment 4, minimum tillage, fall plowed, had the highest population remaining after rodent damage. There is no evidence that chopping residues affected population damage.

In analyzing for yields, moisture content at harvest, and stalk lodging efforts were made to remove the bias of population differences. First, all plots having more than 17,800 plants per acre were thinned to this value. Secondly, rows within plots were selected so as to harvest and count equal populations. Further treatments of the data after yields were taken aimed at eliminating the population bias. These are described in tables where the data are presented.

Structure - Nitrogen Study
Waseca
Corn Yields Bu./A.*
October 10, 1959

Fertilizer Treatment	Tillage Treatment 1	2	3	4	5	Averages
A	112.4	123.1	108.9	99.3	79.6	104.7
B	114.9	131.6	95.3	109.2	88.0	107.8
C	135.6	110.4	103.1	107.2	90.7	109.4
D	117.8	173.4	99.4	112.2	91.1	118.8
E	118.1	121.9	108.8	89.7	85.1	104.7
F	125.5	111.4	90.6	98.5	80.0	101.2
Average	120.7	128.6	101.0	102.7	85.8	

*Yields in above table are from the complete experiment. Where yields from plots with less than 18,000 plants/A. were corrected in proportion to the population deficiency. Since population was poorest on spring plowed land (See separate write-up on corn populations at Waseca; Also data book 16:96), a great proportional correction gives undue favor to spring plowed treatments i.e. 1 and 2. These results are therefore to be interpreted with great caution.

Structure - Nitrogen Study
Waseca
Corn Yields and Moisture*
October 10, 1959

	Treatment	Bu./A. 15.5%	Moisture at Harvest
1.	Min. tillage, chop residues fall, spring plow	84.8	38.8
2.	Min. tillage, not chop, spring plow	92.4	37.8
3.	Conv. tillage, chopped, fall plow	88.8	39.0
4.	Min. tillage, chopped, fall plow	102.7	37.7
5.	Field cultivate fall and spring, chop residues	80.7	39.4
A	No fertilizer	89.1	
B	0-40-40	95.9	
C	40-40-40 (fall application)	104.3	
D	40-40-40	98.4	
E	80-40-40	95.0	
F	240-40-40	88.6	

*Values in the above table are from selected plots to avoid those with populations less than about 18,000 per acre. For tillage, values are from 2 reps; for fertilizer, 10 reps. See data book 16:98 for details of selected plots. Since there were 10 fertilizer reps., statistical analysis could be applied; no significant differences were found. See also separate writeup on corn populations.

Structure-Nitrogen Study
Morris
Corn Lodging
1959

Treatment	Lodged Stalks in 70' of row
Tillage	
1. Min. tillage, chop residues, spring plow	15.9
2. Min. tillage, not chop, spring plow	13.8
3. Conv. tillage, chop residues, fall plow	15.1
4. Min. tillage, chop residues, fall plow	18.8
5. Field cultivate fall & spring, shop residues	9.7
L.S.D.	N.S.
Fertilizer	
A. 0-40-40	10.9
B. 40-40-40 (Fall)	13.5
C. 40-40-40	14.9
D. 80-40-40	14.4
E. 240-40-40	19.6
L.S.D.	5.9

Structure-Nitrogen Study
Morris
Percent Phosphorus in 6th Corn Leaf at Tasseling
1959

Treatment	Percent Phosphorus
Tillage	
1. Min. tillage, chop residues, spring plow	.257
2. Min. tillage, not chop., spring plow	.275
3. Conv. tillage, chop residues, fall plow	.248
4. Min. tillage, chop residues, fall plow	.280
5. Field cultivate fall & spring, chop residues	.271
Fertilizer	
A. 0-40-40	.270
B. 40-40-40 (Fall)	.266
C. 40-40-40	.265
D. 80-40-40	.258
E. 240-40-40	.275

Values are averages of 3 replicates. Analysis of variance not made because of several missing plots.

Structure-Nitrogen Study
Morris
Corn Yields Bu./A. at 15.5% H_2O
1959

Treatment	Yield Bu./A.
Tillage	
1. Min. tillage, chop residues, spring plow	43.6
2. Min. tillage, not chop, spring plow	44.4
3. Conv. tillage, chop residues, fall plow	30.1
4. Min. tillage, chop residues, fall plow	40.0
5. Field cultivate fall & spring, chop residues	37.0
Fertilizer	
A. 0-40-40	36.1
B. 40-40-40 (Fall)	40.9
C. 40-40-40	41.5
D. 80-40-40	39.7
E. 240-40-40	36.8

Fertilizer and tillage treatments not significant. A fertilizer tillage interaction was significant at 5% level. The meaning of this is not clear but there is an indication that tillage treatment 5 (unlike other treatments) responded consistently to each added increment of nitrogen. This should be watched in the future.

Structure-Nitrogen Study
Morris
Yield Bu./A*
1959

Treatment		Yield Bu./A.
	Tillage	
1, 2.	Spring plow	44.0
3, 4.	Fall plow	34.8
5.	Field cultivate	37.0
	L.S.D. (.05)	7.1
	Fertilizer	
A.	0-40-40	35.1
B.	40-40-40 (Fall)	40.5
C.	40-40-40	40.2
D.	80-40-40	39.4
E.	240-40-40	37.7
	L.S.D. (.10)	3.9

*Fall plowing treatments (3,4) condensed and spring plowing treatments (1,2) condensed so as to test for fall vs. spring plowing.

High Fertility and Wheat Seeding Rates in Clay County

A. C. Caldwell and Merle Halverson

The effect upon corn yield of increasing the plant population when soil fertility and moisture are adequate, is well know. Less attention has been given to comparing small grain yields from various seeding rates when relatively large amounts of fertilizer are used. At ordinary seeding rates, such environmental factors as temperature, light, fertility level and moisture supply are thought to regulate tillering or "stooling" in such a manner that stand becomes adjusted to a more or less optimum level at which existing soil moisture and nutrient supplied are efficiently used.

It was of interest to the Extension Service, the Department of Soils and Deere and Company to determine what the effects of heavy plant population on wheat yields might be, when coupled with conditions of adequate fertility. Last spring these agencies cooperated in putting the idea to preliminary test on the George Landsverk farm in Clay county. The soil was a Bearden silt loam of low phosphorus and high potassium status, on which alfalfa had been plowed down in 1958. Seeding rate totals ranging from 1 to 6 bushels per acre were put down in "criss cross" fashion with a Deere and Company experimental drill. For example, the 5 bushel per acre rate was arrived at by seeding 1½ bushels per acre in a north-south direction and crossing it with a 3½ bushel per acre seeding in an east-west direction. 0-46-0 fertilizer at the rate of 40 lbs. P_2O_5 per acre was placed 1½ inch to the side of, and 1½ inch below the seed in each direction, resulting in a total application of 80 lbs. P_2O_5 per acre. One of the two sets of plots received no nitrogen; on the other, a broadcast nitrogen application of 60 lbs. per acre was made throughout.

No yield differences occurred due to the nitrogen treatment, an observation explainable by the history of alfalfa plowdown on the field the preceding season. Average yields for the 6 seeding rates, calculated to a bushel-per-acre basis, are shown in table 5.

Table 5. Wheat yields at 6 seeding rates with 80 lbs. P_2O_5 placed 1½" x 1½" (Each yield is the average of 4 replicates and 2 nitrogen rates)

SEEDING RATE Bu/A	YIELD Bu/A
1	22.0
2	36.3
3	44.0
4	47.2
5	49.6
6	47.7

Fertilizer Experiment on Continuous Soybeans at Rosemount

A. C. Caldwell and J. Weber

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. Plots were laid out consisting of four replications and fifteen treatments.

In 1958 and 1959 no fertilizer was applied in order to study the residual effects of the previous fertilization.

Yield results for 1959 are included in table 5. Highly significant yield differences resulted on the residual P and K plots. Residual P alone had a significant depressing effect on the yield of soybeans. Plots which had received relatively high rates of both P and K showed a significant increase in yield over those not fertilized.

Table 5. The effect of residual fertilizer on the yield of continuous soybeans, 1959.

Treatment $N-P_2O_5-K_2O$ lbs./A.	Yield bu./A.	Yield diff.
0-0-0	24.3	----
0-0-20	23.2	-1.1
0-0-80	24.4	0.1
0-0-400	26.0	1.7
0-20-20	22.9	-1.4
0-40-40	24.2	-0.1
0-60-60	24.9	0.6
0-80-80	26.3	2.0
0-400-400	28.3	4.0
0-400-400 +6T	27.1	2.8
0-20-0	23.2	-1.1
0-80-0	23.8	-0.5
0-400-0	22.0	-2.3
0-20-0 + 6T	24.2	-0.1
6T	25.8	1.5

LSD (F_{95}) = 2.25

How Great is the Residual or Carry-Over Effect of Fertilizer?

P. M. Burson and C. O. Rost*

The carry-over or residual effect of fertilizers has been observed by many farmers and Experiment Station workers. While farmers have noticed the effect, very few have attempted to measure it accurately.

Many Experiment Station workers, on the other hand, have determined increases produced by the carry-over effect rather accurately.

In this article some of the results obtained by the authors are summarized. Other members of the staff of the Department of Soils, University of Minnesota, have also observed and determined the residual effects of fertilizer.

Under what condition are carry-over effects obtained and what conditions or factors affect them? Just how great an increase in crop yield can be expected and on what crops?

Workers at the University of Wisconsin have estimated the approximate percentages of nitrogen, phosphate, and potash present in the soil and applied in fertilizers and manure, that may be obtained by the first crop grown after the application of the fertilizer. The amounts, as percentages, removed by the first crop are shown in Table 1.

This indicates that only a portion of the available nutrients in the soil, manure, and fertilizer are used by the first crop and that there is a residue left for use by succeeding crops.

There are a number of conditions or factors which will influence the amounts which may be left for the second and succeeding crops. One of these is the rate of application of the fertilizer.

With a light application the amount of nutrients left after the first crop would be less than if heavier applications are used.

A dry season could be a factor, since the growth of the crop might be limited by the amount of moisture and the crop under such condition could not fully utilize the nutrients applied. Likewise such conditions as unseasonable frosts and cold seasons could limit crop growth and nutrient utilization.

In order to obtain a maximum crop yield in normal seasons, the amount of fertilizer applied must be large enough to supply the nutrients which will be used by the first crop, taking into consideration the amounts supplied from the soil and any manure applied to the land.

When this is done there are considerable amounts of nutrients left in the soil which become available to succeeding crops.

Experiments in Minnesota have shown that these subsequent crops are benefited by the unused nutrients. A number of years ago fertilizers were applied for potatoes in the Red River Valley. In the experiments, 45 pounds of P_2O_5 and 120 lbs. of K_2O per acre were applied. The phosphate was applied along the row and the potash broadcasted.

The crop following the potatoes was grain for which no additional fertilizer was applied. The carry-over or residual effect on the grain crops is shown in Table 2.

Table 1. Percentages of nutrients removed by the first crop grown.

Source of Nutrients	Percentages obtained by first crop Nitrogen	Phosphate	Potash
Soil (Available by test)..........	40	40	40
Manure (Of total present).........	30	30	30
Fertilizer (Of available).........	60	30	50

Table 2.* Residual Effects of Fertilizers on Grains Following Potatoes

Crop	No. of Fields	Yield on CK Bu/A	Percentage P	Incr. From PK
		HEAVY SOILS		
Wheat	17	28.3	12.2	17.0
Barley	4	41.5	17.0	19.0
Oats	1	72.0	15.2	29.7
		LIGHT SOILS		
Wheat	4	25.4	12.6	24.0
Barley	7	38.8	31.8	51.6
Oats	3	41.8	26.0	24.5

*See Bulletin 385 Minnesota Agricultural Experiment Station.

The carry-over effects in these experiments were considerable, especially on the light textured soils.

It is to be noted that the carry-over effect was greater on barley and oats than on wheat. The effect on the wheat would very probably have been greater if some nitrogen had been included in the fertilizer.

Since yields were determined on only one succeeding crop, these experiments do not show whether or not the effect of the fertilizer might have been evident after the second year.

In another experiment in Nicollet County, fertilizer was applied for a four year rotation of oats-hay-corn-corn. Two hundred pounds per acre of fertilizer was broadcasted for grain and no additional fertilizer or manure applied during the rotation. The soil was a Webster silty clay loam. The percentage increase in yield for the first four crops are shown in Table 3.

The experiment was designed to give the maximum carry-over effect on hay since the main farm enterprise was dairying. The oat crop in which the clover-timothy mixture was seeded was not greatly improved unless nitrogen was included in the fertilizer. Twenty pounds of nitrogen substantially increased yields.

The carry-over on the hay crop was very evident from the percentage increases obtained. While the increases on the two corn crops was less, there is still evidence of some benefit to the crops.

When one considers the total percentage increases for the four crops it is very evident that there is a distinct carry-over effect and it is a worth while one. In the experiment relatively light applications of fertilizer were used and the increase would probably have been greater if a more adequate amount of fertilizer had been used.

The effect of heavier rates of fertilization are shown by an experiment in which the fertilizer was applied for alsike and red clover seed production. The rates used were 500 and 1000 pounds per acre applied for the legume seed crop and no additional fertilizer applied for crops which followed.

Under ordinary circumstances the fields are plowed following the removal of the seed and other crops grown for one or more years and then the land is reseeded to one of the clovers. These experiments were carried out in the northern half of the state since the climate there is favorable for legume seed production.

The results of the experiments are shown in Table 4. It will be noticed the percentage increase in yield on the second crop was generally higher than when ligher applications of fertilizer were used.

The results obtained on field No. 6 deserve special consideration. On this field the fertilizer was applied for alsike clover. Yields were increased from 236 to 352 per cent. Two crops of barley followed and the residual effect was pronounced, especially on the barley which followed the alsike.

In the fourth year the land was in fallow and this was followed by barley. Yields were not determined although very definite effects from the fertilizer were observed.

Alsike clover was seeded with the barley and a crop of seed taken in the following year which was the sixth crop following the application of the fertilizer. Yields of alsike clover seed were still increased from 84 to 162 per cent.

To further demonstrate the long-time residual effect of fertilizers the results of an experiment conducted at the West Central Experiment Station, University of Minnesota, may be cited.

Table 3.* Residual effect of fertilizers on a four year rotation shown as percentage increases over unfertilized land.

Treatment	Rate	1st Crop Oats	2nd Crop Hay	3rd Crop Corn	4th Crop Corn	% Increase Four Crops
0-20-0	200	17.2	33.0	11.1	7.7	69.0
0-20-20	200	4.2	44.8	5.4	4.3	68.7
10-20-0	200	38.5	20.6	2.7	2.5	64.3
10-20-20	200	34.6	27.3	10.9	5.9	78.7

*See Minnesota Agricultural Experiment Station Bulletin 438.

Table 4. Residual or carry-over effect of fertilizers applied for legume seed. All the fertilizer applied for the 1st year crop. Percentage increases over the unfertilized land.

Field No.	Year	Crop	0-20-0 500 lbs	0-20-0 1000 lbs	0-20-20 500 lbs	0-20-20 1000 lbs	0-20-40 500 lbs	0-20-40 1000 lbs
1	1st	Red Clover Seed	0.0	0.0	9.0	24.0	10.0	10.0
	2nd	Corn	6.4	14.9	59.5	58.0	63.1	68.4
2	1st	Red Clover Seed	4.6	23.3	--	--	28.7	21.7
	2nd	Silage	15.0	15.0	30.0	30.0	15.0	15.0
3	1st	Red Clover Seed	33.7	--	60.8	--	27.1	--
	2nd	Flax	37.5	--	50.0	--	43.7	--
4	1st	Red Clover Seed*	--	--	--	--	--	--
	2nd	Oats and Wheat	44.0	--	38.0	--	30.0	--
5	1st	Red Clover Seed	73.0	68.0	68.0	64.6	71.0	61.0
	2nd	Red Clover Seed	62.2	90.0	86.1	79.4	100.0	85.4
6	1st	Alsike Clover Seed	236.8	273.0	251.0	348.0	261.1	352.6
	2nd	Barley	60.9	80.6	84.0	94.0	88.7	89.7
	3rd	Barley	38.0	40.1	35.0	35.0	18.7	35.0
	4th	Fallow	--	--	--	--	--	--
	5th	Barley*	--	--	--	--	--	--
	6th	Alsike Seed	84.1	127.6	82.1	162.7	91.7	142.7

*Not Sampled For Yield

In the experiment the equivalent of 167 pounds per acre of 46 per cent super-phosphate was broadcast for corn in a corn, oats, wheat, clover-timothy hay rotation.

The experiment ran for 20 years. This meant that the plots receiving phosphate were fertilized five times at the 167 pound rate and in the 20 year period received a total 835 pounds of super-phosphate per acre.

Following the 20 year period no super-phosochate was applied and the land was cropped to alfalfa, corn, and grain. After a lapse of 10 years, the plots were divided into three parts and a three year rotation of corn, wheat, and clover-timothy hay was re-established, each crop being grown each year. Nine crops were grown. The percentage increases in yields are shown in Table 5.

Using present day prices the annual increase from any one of the crops would, after a lapse of ten years, still have paid for the cost of one of the original 167 pound fertilizer applications.

The data presented in the tables above clearly show that there is a residual or carry-over effect on crops which follow the crop for which the fertilizer was applied.

Furthermore, they show that higher rates of application produce greater carry-over effects. This emphasizes the importance of making fertilizer applications heavy enough to supply all the nutrients needed to produce maximum crop yields under prevailing soil and weather conditions.

These consistent yield return from the use of fertilizer and the residual increases in yields carry through from 2 to 6 years or possibly more, after fertilizer application.

The question now being asked by farmers is what can this practice mean to me on my farm in economic returns?

These residual fertilizer responses indicate that such a fertility program will apply to any type of farming regardless of the crops grown and in the different agricultural areas of Minnesota.

In all the residual yield responses reported above on the 6 fields studied, the dollar ratio return for fertilizer over fertilizer cost ranged from about $3.00 for each $1.00 spent.

For the year of application up to over $9.00 return for a 6 year residual response. To illustrate what these ratios of dollar returns over fertilizer cost would mean as applied to a certain cropping system or field, field No. 6 above is an excellent example.

On the basis of the 0-20-20 fertilizer which gave the greatest consistent increase in crop yields for the 6 years and applied at two ratio of 500 and 1000 pounds per acre and costing $17.00 and $35.00 per acre respectively. The acre return over fertilizer cost would be $164.10 for the 500 pound ratio and $211.50 for the 1000 pound rate. Crop prices were figured on the current farm price.

Table 5. Residual effect of super-phosphate on the nine year average yield of corn, wheat and hay. (No fertilizer applied in the ten years preceding or during the nine years of cropping)*.

Crop	Yield on Unfertilized	Increase From Super-phosphate	Percentage Increase
Corn	47.5 bu.	9.5 bu.	20.0
Wheat	18.3 bu.	4.7 bu.	25.7
Hay	1.38 Tons	0.38 Tons	27.5

*Minnesota Agricultural Experiment Station Bulletin No. 448

If a typical 50 acre Minnesota field was cropped in the same way as field No. 6, the return over fertilizer cost would amount to $8,205.00 for the 500 pound rate as compared to $10,575.00 for the 1000 pound rate for the 6 year residual period.

Furthermore, the difference in the return over fertilizer cost between the two rates of application per acre is $2,370.00 in favor of the 1000 pound rate. This means that the second 500 pounds per acre of fertilizer added to the 50 acre field brought this additional return.

How much longer these residual responses may continue beyond the 6 years reported in this study is not known, but such a fertility program is now in progress on the other 5 fields. These fields are being cropped with different kinds of crops and in different sequences than field 6, but all are showing similar yield increases and similar ratios of dollar returns over fertilizer costs for the different crops.

There is no substitute for good soil fertility and management. It is the best insurance and investment a farmer can make, no matter how large or how small his scale of farming operations may be.

*Paul Burson, Professor of Soils, University of Minnesota. Dr. C. O. Rost, Consulting Chemist, Minnesota Farm Bureau Service Co., formerly Chief of Department of Soils, University of Minnesota.

Know Your Soils for Legume Seed Production

P.M. Burson, H.F. Arneman, F.G. Holdaway, and H.W. Kramer

Successful legume seed production depends on soil type conditions. The soil properties which determine the soil type include soil reaction (pH), texture, structure and surface, and internal drainage.

One soil may produce a good seed crop for one legume but not for another. Soils must therefore be selected for the kind of legume seed to be produced. Soil and climatic conditions determine where legume seed can be most successfully and economically grown.

Every farmer must consider legume seed production on the basis of which legume seed crop best fits the soil-type conditions on his own farm. Because different soil types occur between farms, not all farmers in a community can grow and produce the same legume seeds.

Production of legume seed is specialty farming. Therefore, successful seed production requires a knowledge of soil-type conditions, and good, timely soil management and production practices.

Selecting the Right Soils

All legume seed crops grow best on neutral soils---soils that have a neutral soil reaction or a pH of about 7.0 ("pH is a test of the sourness [acidity] or sweetness [akalinity] of the soil.) Some legumes, however, are more sensitive to pH changes than others. Alfalfa and sweet clover, for example, are very sensitive to acid soils, especially those having a pH of 6.0 or below.

Legume seed crops may be classified on the basis of their lime requirement. Alfalfa and sweet clover are in the high lime requirement group, medium red clover in the medium group, and alsike clover in the low group. However, if the soils are properly limed the medium and low groups will give a big response to lime treatments. All of these legume seed crops will make vigorous growth on soils of high-lime reaction having a pH range of 7.2 to as high as 8.0. However, alfalfa is very sensitive to pH ranges of 7.5 and higher.

Along with soil reaction, proper fertilization based on soil tests is essential for successful seed production. Important as soil reaction and fertilization are, the careful selection of the proper soil-type conditions--as determined by texture, structure (tilth), and drainage--are the basic factors for the successful production of legume seed crops.

A legume seed production program can be established and set up on either a community or individual farm basis. Use county soil survey reports or the individual Soil Conservation District soil surveys to select the soil type best suited for growing the various legume seed crops. County soil surveys can determine the general soil type groups for different legume crops in certain areas of a county, while individual farm soil surveys can determine what legume seed crop is most adaptable and should be grown on a certain individual farm.

The University of Minnesota--working with committees and cooperating farmers of Roseau, Lake of the Woods, East Polk, West Polk, and Clearwater counties--has carried on extensive research in legume seed production. Researchers studied and grouped all the experimental fields on the basis of their soil type characteristics as related to their adaptability for growing various legume seed crops.

General Classification

The following is a general classification of soil type characteristics according to the adaptability of the various legume seed crop to be produced.

Suitable for all Legume Crops--

Soils of medium texture, moderately well to well drained including: Nebish loam, Rockwood sandy loam, McIntosh silt loam, Aastad loam, Baudette silt loam, Beltrami loam, and Barnes silt loam.

Suitable for Alfalfa--

Sandy, light-textured soils subject to rapid internal drainage. These are two droughty for medium red and alsike clover. Included in this group are Grygla loamy fine sand, Hiwood loamy fine sand, Menahga loamy sand, Gudrid loamy sand, and Ulen loamy sand.

Suitable for Medium Red and Alsike Clovers--

Soils ranging in texture from very fine sandy loam to heavy clays with poor to moderate drainage. These are too wet for alfalfa seed production. These include Shooks clay loam, Bearden silty clay loam, Chilgren loam, Kittson clay loam, and Peat-shallow phase (with special treatments and practices).

Suitable for Alsike clover--

These soils have all textural ranges from wet sands to heavy clays. All are too wet for alfalfa, questionable for medium red clover, but are more suitable for alsike clover. They include: Tanberg fime sandy loam, Fargo clay, Taylor silt loam, Rocksbury clay loam, and Peat-shallow phase--(with special treatments and practices).

Not suitable for legume seed production--

These soils have gravelly layers or gravelly subsoils which retrict growth and developments and include: Marquette sandy loam, Sioux loamy sand, Foxhome sandy loam, and Menahga sand.

The research reported in this story was carried on in Northern Minnesota. There are many other areas of Minnesota that can grow legume seed successfully. Legume seed production, however, has been largely concentrated in the northern part of the state so our research has been conducted in that area.

Plan Your Legume Seed Production Program

1. Plan a community legume seed production program based on the major soil type characteristics of the community.
2. Use the County Soil Survey reports and the Soil Conservation District Soil survey maps to determine the soil type conditions in selecting the suitable legume seed crop for the community.
3. For the individual farm, plant the legume adapted to the major soil conditions on the farm.
4. Fertilize and apply lime according to the soil test.
5. Provide proper pollination on a community and field basis.
6. Control harmful insects.
7. Use adapted and recommended seed varieties.

The Effect of Rate, Time and Kind of Fertilizer on Yield of Alfalfa at Rosemount

March, 1960

J. M. MacGregor

Introduction

There are many acres of productive land in southeastern Minnesota which are too sloping for cultivation without severe losses of soil and water. Much of this land could be utilized for the permanent production of high quality hay, provided a good stand could be maintained for several years. Minnesota farmers now utilize about two million acres for alfalfa production. This acreage of high quality hay could be doubled by better soil fertility management of our more steeply sloping soil areas. In addition, the improved soil fertility practices over our entire potential alfalfa growing area might result in trebling Minnesota alfalfa production--and improve quality as well.

In the autumn of 1949, an experiment was commenced on the Soils Unit of the Rosemount Experiment Station to determine the effect of commercially available fertilizers on yield and maintenance of alfalfa stand.

Experimental

The site selected was a south-southwest facing slope varying from 5 to 12 per cent. The Port Byron silt loam of the experimental area developed from wind laid silty material of varying depth and is underlain by glacial materials at depths of three to five feet. Since the soil was quite acid, (pH 5.2) it was limed at the rate of six tons per acre in the fall of 1949 which resulted in a pH rise to 7.5 when tested late in 1952. Thirty treatments were replicated eight times in plots eighteen feet long and nine feet in width. The initial fertilizer treatments were made in October of 1949, and early June of 1950, with inoculated Ranger alfalfa being seeded on June 16, 1950. Three cuttings per year have been removed annually commencing in 1951.

Within a few years, it was realized that the southeastern replication (8) was producing hay yields considerably above those of the other seven replicates, and the results from this area were then excluded from the reported average.

Results

The following table shows the different fertilizer treatments included in the experiment, the first year alfalfa yields obtained in 1951, those obtained in the eighth year (1958), the total eight year hay yield, as well as the yield increases obtained on the fertilized plots, all arranged or ranked in order of decreasing yields for the eight year period.

TOTAL YIELDS - ROSEMOUNT ALFALFA - 1951 - 1958
AVERAGE OF SEVEN REPLICATIONS - THREE CUTTINGS

8 year yield rank	Treatment	(Tons/Acre @ 15% moisture) 1951	1958	Eight year total Yield	Increase
30	CHECK	3.10	2.46	25.07	------
1	300# 0-20-20 SBS + 200# AS	3.96	4.23	37.54	12.47
2	300# 0-20-20 FBS + 200# AF	3.89	4.26	36.64	11.57
3	300# 5-20-20 SBS + 200# AS	4.03	3.99	36.48	11.41
4	1000# 0-20-20 SBS + 200# AS	4.42	3.84	36.15	11.08
5	1000# 0-20-0 SBS + 200# 5-20-20 AS	4.34	3.42	35.93	10.86
6	1000# 0-20-0 SBS + 200# 0-20-20 AS	4.14	3.87	35.49	10.42
7	200# 0-20-20 AS	3.25	4.18	35.44	10.37
8	1000# 0-20-0 SBS + 100# KCl @ 1st cutting	4.26	4.39	35.27	10.20
9	200# 0-20-20 AF	3.60	3.81	33.89	8.82
10	300# 0-20-20 FBS + 200# BF	3.51	4.28	33.55	8.48
11	1000# 0-20-20 SBS + 200# BS	4.30	2.93	32.93	7.86
12	300# 0-20-20 SBS + 200# BS	3.79	3.24	32.37	7.20
13	1000# 0-20-0 SBS + 200# 0-20-20 BS	3.95	3.10	30.70	5.63
14	300# 0-20-0 SBS + 200# AS	3.77	3.33	30.69	5.62
15	200# 0-20-0 AF	3.84	2.66	29.27	4.20
16	1000# 0-20-20 SBS	4.09	2.88	29.25	4.18
17	200# 0-20-0 AS	3.64	2.76	29.18	4.11
18	300# 0-20-20 SBS	3.90	3.03	29.07	4.00
19	1000# 0-20-0 SBS + 200# AS	4.04	2.40	28.95	3.88
20	300# 0-20-0 FBS + 200# BF	3.68	2.87	28.62	3.55
21	300# 0-20-20 + TRACE ELEMENTS SBS	3.88	2.98	28.18	3.11
22	300# 0-20-0 FBS + 200# AF	3.77	2.24	28.17	3.10
23	300# 0-20-0 SBS + 200# BS	3.64	2.43	27.66	2.59
24	300# 5-20-20 SBS + 20# N AS	3.75	2.89	27.28	2.21
25	300# 0-20-0 FBS	3.61	3.03	26.67	1.60
26	300# 0-20-20 + 20# B SBS	3.84	2.51	26.49	1.42
27	1000# 0-20-0 SBS	4.01	2.16	26.02	0.95
28	300# 0-20-20 FBS	3.78	2.16	25.33	0.26
29	300# 5-20-20 SBS	3.82	2.39	25.29	0.22
31	300# 0-20-0 SBS	3.59	2.60	24.71	-0.36

SBS - Spring before seeding
FBS - Fall before seeding
AS - Annual spring
BS - Biennial spring
AF - Annual fall
BF - Biennial fall
TRACE ELEMENTS - $CuSO_4$ 25#/A; $ZnSO_4$ 25#/A; $MnSO_4$ 25#/A; $FeSO_4$ 25#/A; B 20#/A

Acknowledgement

This experiment was designed and initiated by Dr. C. O. Rost. The original work was carried on by Dr. W. W. Nelson until 1954 and later by J. R. Brownell. The project was originally financed by the Midwest Soil Improvement Committee.

Conclusions

Some of the better fertilizer treatments have maintained alfalfa stands very well over the eight year period, whereas others have been badly invaded by grasses (largely Kentucky bluegrass) and weed growth, and alfalfa stands are now comparatively poor. Many important comparisons may be made from the results in the table, but the following are some of the more important findings:

1. Potassium fertilization is essential along with the phosphorus for the maintenance of alfalfa stands over many years. This is evident from the fact that the thirteen most productive fertilizer treatments all included potassium.

2. The addition of nitrogen to alfalfa was not profitable. By the end of the 1959 growing season, the third highest yielding treatment (300 pounds of 5-20-20 spring before seeding and 200 pounds topdressed each spring) produced 12.66 tons alfalfa per acre more than the unfertilized check yields. This nitrogen application over the nine years cost approximately eleven dollars per acre and resulted in somewhat lower alfalfa production than fertilization with the same amounts of phosphorus and potassium with no nitrogen present (13.39 tons per acre).

3. Annual topdressing of the established alfalfa stand was very beneficial, and much more effective than where applied in alternate years. The additional fertilizer used in the annual applications (1000 pounds of 0-20-20) would cost a total of $30 more, but produce an extra half ton of hay each year.

4. Moderate amounts of starter fertilizer in addition to the later topdressings are effective. Starter fertilizer plus annual topdressings produced 3.5 tons more hay per acre over the 9 year period than did the topdressings alone.

5. High initial rates of fertilization alone were not economical. Initial application of 1000 pounds per acre increased yields during the first few years, but these declined rapidly.

6. Trace element applications (copper, boron, zinc, manganese, and iron) did not increase alfalfa yields and apparently were not essential to good alfalfa production.

7. Fall topdressing produced much the same increase in alfalfa yields as the same fertilizer applied in the spring.

8. Alfalfa should be topdressed at least every second year, as the beneficial fertilizer effect will otherwise largely disappear, even though large amounts of fertilizer were originally applied.

Good soil fertility management is an essential for efficient alfalfa production-irrespective of the soil on which it is grown. Good management is especially true where the more steeply sloping lands are to be utilized, since lower fertility levels frequently ends in the loss of good alfalfa stands, and in serious soil erosion. One of the first steps in making better use of our more marginal sloping areas must be a thorough soil testing program, and a strict adherence to the best fertility and general soil management practices.

Studies on Iron Chlorosis

by R. G. Burau and J. M. MacGregor

More attention has recently been focused upon the chlorosis or yellowing of leaves of certain field crops and ornamental plants growing on the high lime soils in western Minnesota. The general symptom of an affected plant is a yellowing of the intra-veinal leaf tissue, while the veins retain a dark green color. Leaves may become paper-white in severely affected plants, and growth is restricted. The reason that affected leaves appear yellow is that chlorophyll, the green pigment of normal leaves, is present only to a limited extent in chlorotic leaves. Thus, the cause of a chlorosis must be related to factors affecting the production and/or preservation of chlorophyll in plant tissues.

Although much of the work on this problem has been confined to investigations with soybeans and flax, similar chloroses have been observed in gladioli, roses, spiraea, flowering crab, strawberries, apple, plum, maple, elm, box elder, larch and birch.

Preliminary work definitely established that the chlorosis in soybeans was a plant nutrient deficiency symptom known as iron chlorosis. It is known that this chlorosis may develop if high pH, excessive amounts of phosphate, bicarbonate, copper, manganese, and zinc reduce the availability of iron in the soil. In any given soil region, only one or a few of these factors may be responsible. Therefore, one line of investigation has been directed toward establishing the causative soil factors with the hope that such information will lead to practical preventive cultural practices.

Results of previous greenhouse experiments with a limited number of soils indicated that high available phosphorus and manganese were possible causative factors. A study of the mineral composition of chlorotic and of green soybean plants in the field was initiated in the spring of 1959. Complete above-ground parts of soybean plants as well as upper, mature soybean leaves were collected, washed to remove dust contamination, and then analyzed for calcium, phosphorus, manganese, and iron. Since the validity of conclusions drawn from greenhouse experiments must be tested in a field situation, the objective of this experiment was to determine if manganese and/or phosphate were possible causative factors. The results of these analyses are shown in Table 1.

Table 1. Mineral concentrations in immature chlorotic (CH) and healthy (HE) soybeans (June, 1959)

Field Number	County	Soybean Variety	% Calcium CH Leaf	% Calcium HE Leaf	% Calcium CH Plant	% Calcium HE Plant	ppm* Iron CH Leaf	ppm* Iron HE Leaf	ppm* Iron CH Plant	ppm* Iron HE Plant	ppm Manganese CH Leaf	ppm Manganese HE Leaf	ppm Manganese CH Plant	ppm Manganese HE Plant	ppt** Phosphorus CH Leaf	ppt** Phosphorus HE Leaf	ppt** Phosphorus CH Plant	ppt** Phosphorus HE Plant
1	Polk	------	1.20	1.65	2.31	2.29	102	102	116	122	118	73	129	76	4.16	2.15	4.46	2.36
2	Norman 1	Comet	1.11	1.64	1.56	1.58	160	195	313	278	185	71	186	69	5.56	3.17	5.98	3.62
3	Norman 2	Flambeau	1.52	1.98	2.43	2.07	79	100	134	122	354	108	332	84	6.50	3.57	8.88	3.78
4	Clay 1	------	1.18	1.16	1.63	1.73	114	130	110	248	128	124	68	117	4.93	1.88	5.37	2.10
5	Clay 2	Flambeau	0.99	1.68	1.36	1.81	371	276	435	392	83	95	96	103	5.88	3.60	5.43	4.07
6	Clay 3	Norchief	1.60	1.66	2.55	2.50	229	183	307	296	187	206	282	153	10.08	7.62	7.69	7.01
7	Wilkin	------	1.13	1.58	1.41	1.36	280	236	280	232	255	215	253	160	7.42	4.68	6.72	4.94
8	Pope 1	Comet	1.91	2.57	2.38	2.46	250	299	441	260	339	244	308	172	5.49	2.71	5.07	3.07
9	Pope 2	Ottawa Mandarin	1.55	1.59	1.63	1.11	97	97	299	81	64	86	158	129	2.64	2.57	5.91	5.75
10	Swift 1	Chippewa	1.46	1.68	1.78	1.89	219	284	370	183	222	198	191	115	5.20	2.42	4.62	2.52
11	Swift 2	------	1.08	1.85	1.77	2.57	75	116	107	100	99	54	92	29	5.21	3.46	5.91	3.75
12	Kandiyohi	Chippewa	0.75	0.88	1.92	1.86	94	165	104	96	59	41	41	38	6.74	4.74	6.34	4.01
13	Renville	-------	1.29	1.61	2.52	2.65	116	102	297	213	102	104	165	88	5.34	3.93	5.56	4.46
14	Sibley	Ottawa Mandarin	1.18	2.30	2.52	2.50	121	134	218	154	67	48	96	50	3.77	3.88	6.56	4.97

* Parts per million
** Parts per thousand

Although the chlorosis is caused by an iron deficiency, iron concentrations in chlorotic leaves are frequently higher than in non-chlorotic leaves. This has been observed by other workers, who suggest that some of the iron measured by a total chemical analysis is present in the plant tissues in an inactive form. Manganese concentrations were generally higher in chlorotic tissues, but the concentrations are probably too low to account for the chlorosis. Some investigators characterize the manganese status of plant tissues by examining the ratio of iron to manganese. On this basis, only in samples from Field 3 is there a clear indication of manganese toxicity since manganese concentrations are high with respect to iron in the chlorotic samples. This data indicates that manganese is probably not a general cause of the chlorosis.

The only element measured which shows a consistent relationship to chlorosis is phosphorus. In general, chlorotic tissues have greater concentrations of phosphorus than the non-chlorotic. On Fields 9 and 14 phosphorus in chlorotic leaves is approximately the same as in non-chlorotic leaves, but the general relationship still holds in the analyses of the whole plant. Very high concentrations of phosphorus in samples from Field 6 may have been related to the severe hail damage which these plants received approximately one week before sampling. It is apparent from these results that phosphorus is the most likely causative agent for the chlorosis. Many of the fields which contained chlorotic soybeans had histories of relatively heavy phosphate fertilization. It is also true that even in these fields only a fraction of the whole field was chlorotic. On the basis of these results and observations, insufficient evidence is present to warrant a general recommendation of decreased phosphate fertilization for soybeans grown on these problem soils.

The experimental soybean plants were harvested in the fall to obtain an estimate of the effect of chlorosis on final yield. The results (Table 2) show that chlorosis significantly decreased yield on seven of the nine fields harvested. Frequently chlorosis which is present early in the season apparently disappears later. Since this situation prevailed in all fields except Field 6, the presence of chlorosis for only part of the growing season still results in decreased soybean yields. Soybeans in Field 6 were damaged by hail and remained chlorotic all summer, which contributed to the drastic yield reduction.

Table 2. Yield of initially chlorotic and of non-chlorotic soybeans (1959)

Field Number	County	Soybean yield (Bu./A) Chlorotic	Non-chlorotic	
1	Polk	15	14	N.S.
2	Norman 1	7	18	***
5	Clay 2	11	11	N.S.
6	Clay 3	2	20	***
7	Wilkin	22	32	***
8	Pope 1	13	20	**
10	Swift 1	18	24	**
11	Swift 2	5	10	*
14	Sibley	22	31	***
	Average	13	20	***

N.S. = Not significant
* = Significantly different at the 10% level
** = Significantly different at the 5% level
*** = Significantly different at the 1% level

Field 1 was located in Polk County where soybeans account for only a small fraction of the total crop acreage, presumably because of the shorter growing season and lower soil temperatures in the spring. Plots in Field 5 were located on a gravelly soil which was probably drouthy with respect to plant growth. Thus, the adverse plant growth conditions present in Fields 1 and 5 probably account for both the low yields and nonsignificant effect of chlorosis on yield.

Another line of investigation was devoted to studying the effectiveness of certain iron compounds in reducing chlorosis. In cooperation with Agricultural Extension Agents in Polk County, field trials with chelated iron compounds were established at three locations. Previous work at locations south of Polk County had shown these compounds to be highly effective in reducing chlorosis and in many cases increased yields of soybeans resulted. The results of trials in Polk County are presented in Table 3.

Table 3. Yield of chlorotic soybeans in Polk County treated with various iron chelates.

Material	Rate of Application (lbs. Fe/A)	George Campbell	George Hagen and Son	Johnson Brothers
Check	----	22.8	21.9	21.1
Sequestrene 330	5	23.8	20.2	24.5
Versenol F	5	22.8	18.5	23.3
Sequestrene 138	5	25.2	23.5	26.1
Sequestrene 138	0.5	25.8	22.8	27.0
Sequestrene 138	0.05	22.6	20.7	22.1

Increased growth and reduction of chlorosis were reported after treatment application; however, yield increases were small. Largest yield increases were obtained with the 5.0 and 0.5 pounds of iron per acre applications of Sequestrene 138 at the Johnson Brothers location. This chelate was found to be superior to the other chelates in previous trials, but the cost of effective application rates of all these materials is excessive for crops such as soybeans and flax. Treatment of chlorotic ornamental plants is more practical because of their greater aesthetic value and because of the smaller areas involved. Currently investigations are being conducted to increase the efficiency of iron chelates for chlorosis-susceptible annual plants by special techniques of application.

In view of the high cost of iron chelates, development of less expensive iron compounds also capable of supplying iron to plants would be desirable. It is known that certain constituents of soil organic matter known as humic acids are capable of solubilizing or chelating iron. It was suspected that iron humates might serve as sources of iron for plants growing on calcareous soils.

In cooperation with the Department of Chemical Engineering at the University of Minnesota, humic acids were extracted from various Minnesota peat deposits, since peat is a relatively rich source of these compounds. Iron humates prepared from these extracts were tested for their ability to supply iron to soybeans growing in an alkaline soil. To identify the iron in the plant which was taken up from the iron humates, a small portion of the total was supplied as a radioactive isotope of iron. Iron chloride and iron chelate treatments were included to estimate the relative efficiency of the iron humates. Iron chloride is known to be a poor source of iron while iron chelates are highly available sources of iron for plants in these soils. It was found experimentally that iron humates were no more efficient than iron chloride. It was therefore concluded that the iron humates were not promising soil amendments, although foliar application of these materials might be more effective.

The Effect of Molybdenum Fertilization of Five Soil Types on Alfalfa

J. M. MacGregor and Roger Hanson

Since the addition of molybdenum to a few soils in the United States has resulted in increased crop production, it is desirable that several important agricultural soils of Minnesota be investigated as to possible fertility effect from the addition of molybdenum. In general, research has shown that molybdenum has been most effective when applied to acid soils and appears to be related to soils where available calcium is generally somewhat limited. Relatively few of the agriculturally important Minnesota soils are strongly acid in reaction, but the value of molybdenum fertilization should be investigated.

Objectives of the Experiment:

1. To determine if molybdenum applications increased alfalfa yields on five well fertilized Minnesota soils.

2. To establish if molybdenum is needed to increase the protein concentrations in the alfalfa grown on these five Minnesota soils.

3. To observe the effect of liming an acid soil prior to applying molybdenum.

Experimental Methods:

Fifty four two gallon glazed crocks were filled with the surface soil of five types in triplicate. The most acid of these soils (Anoka loamy fine sand, having a pH of 5.0) was arranged in two series - one with no lime treatment and the other with lime applied at the rate of 3 tons per acre. Each pot was fertilized with 0-20-20 at the rate of 500 pounds per acre on the basis of surface area of the crocks.

The source of molybdenum used was the commercial preparation with the trade name "Moly-Gro", prepared by American Metal Climax Incorporated, with a minimum molybdenum content of 38%. This was supplied by Midland Cooperatives, Inc.

Three rates of application were used on the five soils:

1. No molybdenum

2. At the recommended rate of approximately 0.1 pound of Mo per acre (4 oz. Moly-Gro per acre).

3. Twice the recommended rate--approximately 0.2 pounds Mo per acre (8 oz. of Moly-Gro per acre).

After the phosphate and potash was thoroughly mixed into the soil, 25 inoculated Ranger Alfalfa seeds were planted in each pot on June 15, 1959. The Moly-Gro was then dissolved in water and the required amount was applied to the surface of the soil in each crock by means of a pipette. The crocks were then dug into the surface soil of a field on the University Farm, leaving approximately two inches of the crock rim projecting above the surface. Due to the limited quantity of soil in the crocks, rainfall was generally inadequate, so additional water was necessary. Each crock was later thinned to 20 alfalfa plants. In the fall, the pots were moved into the greenhouse and artificial light was used during the hours of darkness to promote normal alfalfa growth as much as possible.

Results

The first cutting of alfalfa was made before the plants were moved into the greenhouse, and growth was so limited that yields were not determined, with only total nitrogen being determined and crude protein levels of the alfalfa being established. The initial soil pH of the five soils and the crude protein (N x 6.25) content of the first cutting is given in Table 1.

Table 1. Soil type, treatment, initial pH and crude protein content of the first cutting of fertilized alfalfa.

Soil Type	Initial soil pH	No. Mo	Recommended* Mo. rate	Double rec. Mo. rate
		average percent protein		
Anoka loamy fine sand	5.0	15.4	14.9	15.5
" " " " + 3 T lime	5.0	14.1	14.2	14.2
Fayette silt loam	6.9	14.6	14.3	15.3
Barnes loam	6.3	14.9	14.3	14.3
Nicollet clay loam	6.7	14.4	14.1	14.6
Hegne clay	7.8	13.4	14.2	14.0
	Average	14.5	14.3	14.7

*4 oz. Moly-Gro or 0.1 pound of molybdenum/A

It is apparent that the molybdenum additions to the soil have not appreciably affected protein concentrations in the first cutting.

The second cutting of alfalfa was more substantial and Table 2 presents hay yields, percentage crude protein, and the pounds of crude protein produced on the acre basis.

Table 2. Alfalfa yield and crude protein concentration and production when grown on five soil types with molybdenum treatments (second cutting).

Soils Type	No Mo.			Recommended Mo. rate*			Double Mo. recommended rate		
	+hay T/A	% Pro.	lbs. pro/A.	+hay T/A	% Pro.	lbs. pro./A.	+hay T/A	% pro.	lbs. pro/A.
Anoka l.f.s.	1.78	24.3	773	1.73	24.5	760	1.69	24.2	728
" " " " (+ 3 T lime/A)	1.07	22.3	428	.98	23.1	407	0.96	21.4	359
Fayette si.l.	1.52	22.9	622	1.35	22.2	577	1.16	21.8	453
Barnes l.	1.46	21.9	573	1.27	21.5	491	1.12	21.6	431
Nicollet c.l.	1.52	22.6	615	1.46	22.0	576	1.23	22.1	487
Hegne c.	1.55	21.8	606	1.49	22.3	593	1.27	22.8	520
Average	1.48	22.6	603	1.38	22.6	561	1.23	22.3	498

*4 oz. Moly-Gro or 0.1 pound of molybdenum per acre.
+ calculated yield at 15% moisture level (air-dry)

It is obvious that the two molydbenum treatments have not increased alfalfa yields, protein concentrations or the yield of protein on the acre basis on any of the five soil types investigated.

Since the two rates of molybdenum application used did not appear to have any appreciable effect on alfalfa growth, it was then decided to increase the Mo. application to 10 and 20 times the recommended rates. The results obtained with the third cutting are shown in Table 3.

Table 3. Alfalfa yield and crude protein concentration and production when grown on five soil types with molybdenum treatments (third cutting).

Soil Type	No. Mo.			10 times recommended Mo. rate*			20 times recommended Mo. rate		
	+ hay T/A	% Pro.	lbs. Pro/A	+ hay T/A	% Pro.	lbs. Pro/A	+ hay T/A	% Pro.	lbs. Pro/A
Anoka l.f.s.	1.23	23.6	520	0.94	23.7	397	0.94	21.7	365
" " " " (≠ 3 T lime/A)	0.92	26.5	434	0.69	20.9	259	0.80	26.2	377
Fayette si.l.	1.01	25.5	459	0.83	23.3	344	1.10	25.9	455
Barnes l.	1.27	25.6	581	1.10	18.8	460	0.98	19.3	455
Nicollet c.l.	1.16	25.8	536	0.98	23.7	418	0.89	21.7	347
Hegne c.	1.40	25.2	641	1.23	20.1	413	1.16	19.4	402
Average	1.17	25.4	529	0.96	21.8	382	0.98	22.4	400

*40 cc. of Moly-Gro or 1.0 pounds of molybdenum per acre.

+ calculated yield at 15% moisture level (air-dry)

Apparently the heavy molybdenum soil applications have had no beneficial effect on alfalfa yield crude protein concentration or protein production on the five soils investigated.

Conclusions

An experiment with five Minnesota soil types where alfalfa was first grown outside in two gallon crocks and then moved into the greenhouse, molybdenum applications at both recommended rates and doubled rates, then ten and twenty times recommended rates to five Minnesota soils (with adequate previous phosphate-potash treatment) resulted in no increase in alfalfa yield or in protein content of the alfalfa. One of the soils investigated (Anoka loamy fine sand) was quite acid in reaction and would be normally expected to respond to molybdenum applications if these were desirable.

The restricted amount of soil used in the two gallon crocks in growing the alfalfa should induce a nutrient deficiency more readily than where alfalfa is grown in the field. It would be reasonable to assume that molybdenum applications for alfalfa in Minnesota would probably not be a recommended practice.

Grass and Legume-mixture Pasture Trial

L. Hanson and Bill Hueg

One of the seven southeast grass pasture fertilizer demonstration fields conducted in 1958 was followed through in 1959. This was on the Vincent Everman farm in Wabasha County. This was done because of an opportunity to also measure pasture yield from a legume-grass mixture on the same farm. However, the data should not be considered as a completely valid comparison of the pasture type. The fields were not located together and part of the forage yield from the legume was harvested as grass silage.

The data do, however, give an indication of the pasture yields possible from different fertilizer treatments under intensive grazing management. Ration-a-day grazing was used in all plots and barn feeding was adjusted to make maximum use of pasture forage.

All but 50 lbs. N/A of the fertilizer on the grass pasture was applied in 1958. The yield in TDN are calculated on the basis of requirements for maintainence of the animals, milk production and gain in weight, less the amount of TDN fed off the pasture.

The soil type is Fayette and Dubuque silt loam testing high in P and K. Rainfall was below average in 1958 and above average in 1959. The grass pasture is primarily bluegrass and brome. The legume mixture is a combination of alfalfa, red clover and brome.

Grass pasture area - 1958 and 1959 (per acre, per year)

Plot #	Fertilizer Treatment Total for 2 years N	P_2O_5	K_2O	Cow Days	Milk Produced-lbs	Net TDN-lbs	Cost of Fertilizer
1	300	+ 40	+ 80	260	9160	4352	$44.00
2	250	+ 40	+ 80	238	8213	4006	38.00
3	200	+ 40	+ 80	207	7146	3306	32.00
4	150	+ 40	+ 80	138	4971	1700	26.00
5	100	+ 40	+ 80	144	5157	2286	20.00
6	Check			110	3818	1717	
7	0	+ 40	+ 80	75	2534	1174	8.00

Renovated Area. 1959 yield.

Fertilizer Treatment N	P_2O_5	K_2O	Net TDN per acre	Cost of fertilizer per acre
36	66	96	5194	$17.00

2,856 lbs. of the TDN were calculated to come from 8.4 tons of grass silage harvested per acre of the first cutting.

The Effect of Fertilizer on Pasture Composition

Rosemount Agricultural Experiment Station
Soils Experimental Farm
Rosemount, Minnesota

Paul M. Burson and George D. Holcomb
Soils Department

The application of phosphate and potash fertilizers stimulates the growth of legumes. These treatments must be applied if satisfactory stands of legumes are to be established and maintained. The rates per acre and the amount of each should be determined by soil test. Nitrogen fertilizer stimulates the growth of grasses provided sufficient phosphate and potash is available.

Soils that are badly eroded, with no topsoil remaining are low in organic matter and nitrogen. It is on these soils where the available supply of nitrogen is most critical. The response to nitrogen increases as the degree of erosion increases. On soils with little or no topsoil the rates of nitrogen application should be much higher than on soils with six inches or more of topsoil if comparable production of grasses are to be established and maintained.

If pasture grasses are to be successfully established on eroded pasture soils, adequate amounts of nitrogen must be applied at seeding time followed by annual applications to maintain satisfactory growth, yield and a desirable composition of legumes to grasses. However, as regular renovation occurs later and there is some buildup of organic matter and a reserve of nitrogen from the legumes together with some residual carryover from the nitrogen fertilizer, the application of nitrogen at seeding time is not as necessary.

In 1957 annual application of 60 pounds of nitrogen per acre was applied in addition to the annual application of the 200 pounds per acre of phosphate and potash. Not enough nitrogen was obtained from the inoculated legumes to meet the needs for maximum growth of grass and to provide a more balanced composition of grasses to the legumes. These conditions were particularly more noticeable on the more eroded soils where the topsoil was less than 6 inches in depth. Nitrogen fertilizer was applied at different times and at different rates throughout the grazing season, but the total ammunt for the year was 60 pounds per acre. The time of application and the amounts per acre were as follows: (1) all in early spring during the last of April, (2) all in early June or when the early spring pasture growth was over, (3) one-half (30 pounds of nitrogen) in April and one-half (30 pounds of nitrogen) in early July, (4) one-half applied in early June and one-half applied in early July. The purpose of these comparisons was to determine if it were possible to get more uniformity of grass growth and composition of grasses to legumes throughout the grazing season by reducing letdown in grass production during the midseason. Bloat has been a serious problem when the percentage of legumes was in excess of grasses. It has been observed in these and other studies that if the legume component exceeds 50 per cent of the total pasturage, bloating in cattle may become a very serious problem.

A summary of two years' work (1957 and 1958) in Table I shows that the application of 60 pounds per acre of nitrogen fertilizer, regardless of the time of season applied, increased the percentage of grass composition in the pasturage. This increase in grass composition ranged from 3 percent in May, which is the most vigorous period of grass growth, to 24 per cent in July which is the usual letdown period for grass production. It is during this summer period that legumes continue in good growth and unfertilized grasses are in low production.

Table I. Effect of nitrogen fertilization on pasture composition. 1957-1958.

Month	No nitrogen	Grasses - Per cent 60 lb. nitrogen	Increase
1. May	57	60	3
2. June	43	63	20
3. July	38	62	24
4. August	37	52	15
5. September	31	48	17

Pastures fertilized: A, B, C, D, and E.

The split nitrogen applications as compared to applying all of the nitrogen at one time showed little difference in the composition of the pasturage (Table 2). There was very little difference in composition in May regardless of time of application because of the usual early spring growth. In July the single spring application was far superior to the split application. This is probably due to: (1) insufficient amount of nitrogen applied (30 pounds per acre) in the spring to meet the nitrogen need on the eroded soils, (2) shortage of moisture when the summer application of 30 pounds per acre of nitrogen was made. The moisture supply in July quite often may be limited which will make a summer application of nitrogen ineffective.

Table 2 shows the split application resulted in a high of 59 per cent in May to a low of 40 per cent grass in September. When all of the nitrogen was applied in the spring the grass composition was 80 per cent in July and 40 per cent in September. The spring application of 60 pounds of nitrogen all applied at one time was superior because enough nitrogen was supplied to meet the shortage of soil nitrogen and a time when there was sufficient moisture. On the pastures the single application was best.

Table 2. Effect of split versus single application of nitrogen fertilizer on pasture composition. 1957-1958.

Month	Grasses - Per cent No nitrogen	Nitrogen 30/30 pounds	60 pounds
1. May	57	59	60
2. June	43	56	61
3. July	38	55	80
4. August	37	57	67
5. September	31	40	40

The Effect of Fertilizer on Pasture Yields Via Clippings

Rosemount Agricultural Experiment Station
Soils Experimental Farm
Grassland-Beef Cattle Project 2512
Rosemount, Minnesota

Paul M. Burson
Soils Department

Yield clippings were taken on pilot plots and all pastures to determine the actual tonnage of pasturage produced per acre. All yields were determined on the basis of tons of pasturage per acre at 15 per cent moisture. The clippings were taken in advance of the movement of the steers to the next pasture.

Yields of pasturage per acre as shown in Table I increased from 1.57 tons per acre on the unfertilized plots to 2.63 tons per acre on fertilized plots. The largest increase was obtained from the first 300 pound per acre increment of 0-20-20.

Table I. Pasturage yields from various amounts of fertilizer applied to a legume-grass mixture in pilot plots. 1953-54.

Soil Treatment	Average tons per acre at 15% moisture
1. Unfertilized	1.57
2. 300 lbs. 0-20-20	2.34
3. 600 lbs. 0-20-20	2.40
4. 900 lbs. 0-20-20	2.55
5. 1200 lbs. 0-20-20	2.63
6. 1500 lbs. 0-20-20	2.63

Seeding mixture: Alfalfa, Ladino clover, bromegrass and meadow fescue.

Beginning in 1957 annual applications of 60 pounds of nitrogen were applied to all pastures in addition to the annual application of 200 pounds of 0-20-20. The nitrogen was applied in two ways: (1) all at one time, in April or June, (2) split applications with one-half in April or June and one-half in the summer. No important difference was found in the yield per acre between the two ways of application. This is shown in Table 2. When all the nitrogen was applied at one time the yield of pasturage increased 0.87 tons per acre (1.28 to 2.15 tons per acre) as compared to the unfertilized pastures. The yield per acre at the different times of application ranged from 2.02 tons where the nitrogen was split in application to 2.15 tons where all the nitrogen was applied as one application. There was an increase of 0.13 ton per acre in favor of the split application. When all of the nitrogen was applied in April as compared to all being applied in early June, the yield increase was only .03 ton in favor of the early June. These data indicate no advantage of using split applications over the single application in yield. By applying all the nitrogen, phosphate, and potash at one time the cost of operation to the farmer can be materially reduced.

Table 2. Clipping yields from fertilized pastures[a] comparing nitrogen fertilization as to time of application and split versus one application. 1958-1959.

Lb. of nitrogen applied per acre	Date of application	Average tons per acre at 15% moisture
1. Unfertilized	-	1.28
2. 60 lb.	April 28	2.12
3. 60 lb.	June 8	2.15
4. 30 lb.	April 28	2.11
30 lb.	July 9	
5. 30 lb.	June 8	2.02
30 lb.	July 9	

[a] Pastures: B, C, D, E, F, and G 2-4-5-6.
Pasture C was renovated in 1959. No yields taken.

Bloat and Pasture Composition

Rosemount Agricultural Experiment Station
Soils Experimental Farm
Grassland-Beef Cattle Project 2512
Rosemount, Minnesota

Paul M. Burson and George D. Holcomb
Soils Department

Bloat has been a serious problem in grazing steers on legume-grass pasture. In 1956 and 1957 when comparisons were made between weekly rotational grazing and ration-a-day grazing considerable bloat occurred starting late in June. This trouble may be explained by the fact that the first spring growth of a legume-grass mixture is higher in grass content than midsummer growth. Bloat is less likely to occur with a higher grass content. The two most abundant legumes in the mixture were Ladino clover and alfalfa. Ladino clover normally does not overwinter well in Minnesota. However, the mild winters preceeding the 1956 and 1957 pasture season allowed the Ladino clover to survive and contribute substantially to the pasturage. Since 1957 the pasture mixtures newly seeded contain no Ladino clover but some orchard grass. Orchard grass is not very winter hardy but when it does survive it becomes a good grass contributor.

No fixed pattern of bloating could be observed except that no bloat occurred when the grass percentage was high. On the fertilized pastures on A and E in 1957 less bloat occurred than on the unfertilized because of the higher grass content resulting from the application of 60 pounds of actual nitrogen fertilizer per acre. Some, however, occurred in July when the grass content became near or less than 50 per cent. The grass and legume composition of these pastures is shown in the following graph.

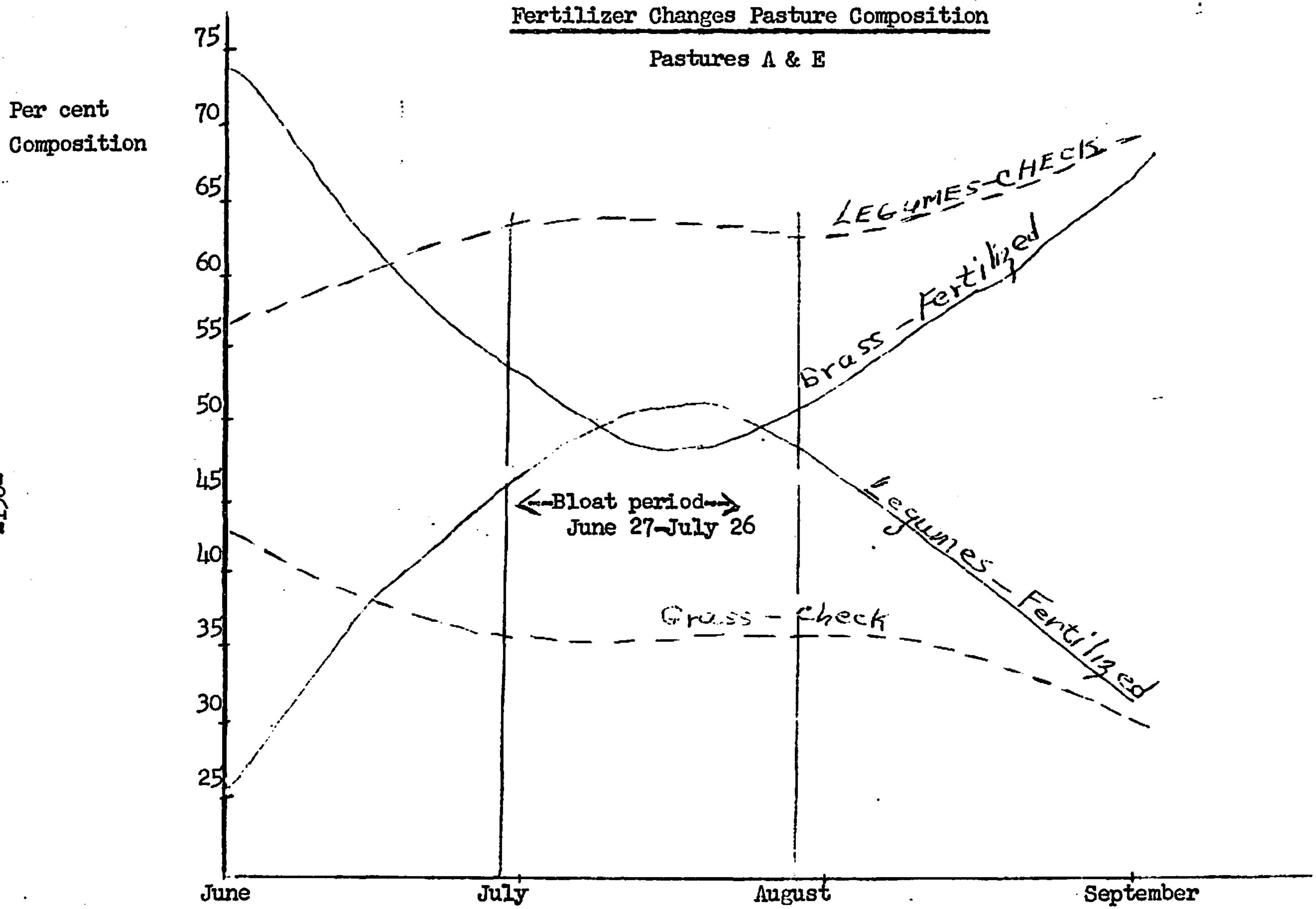
Steers bloated on ration-a-day grazing as well as on weekly rotational grazing. When bloating started, hay was placed in the pastures to help prevent it but was ineffective. One steer bloated on immature alfalfa soilage. The following table shows the bloat record for 1957 with the graph showing the composition of the pasture during the bloat period.

Table 2. Bloat record for 1957

	Number of steers treated for bloat on fertilized and unfertilized pastures			
	A ck.	A fert.	E ck.	E fert.
June 27	1		1 died	
29	1			
July 5	5	6	5	6
17			1 died	
18			2	
19	2			
23	2			
25	1			
26	4			
Total cases of bloat	16	6	9	6

Fertilizer Changes Pasture Composition

Pastures A & E



Seeding Mixture - Alfalfa 7#, Ladino 1/2#. Alsike 1/2#, Meadow Fescue 3#, and Lincoln Brome 6# - seeded spring, 1954.

Supplementary Soil Fertility Studies (1959)
A. C. Caldwell and Others

Grand Rapids (North Central Experiment Station)

An old experiment designed to evaluate the effect of fertilizers, time of application, and gypsum on yield of alfalfa was harvested for the last time in 1959. Previous experience has led to the conclusion that time of fertilizer application and gypsum applications were not important influences on hay yields on this location. For this reason, only the fertilizer treatments were studied in 1959. The results shown in Table 1 show no significant fertilizer response of alfalfa-brome hay.

Table I. Effect of Fertilizer Treatment on Yield of Hay at Grand Rapids Experiment Station*

Pounds N, P_2O_5 K_2O Per Acre	Yield Tons Per Acre	Difference From Check
0-0-0	2.37	0.51
60-60-60	2.88	0.40
60-120-120	2.77	0.25
0-60-60	2.62	0.65
0-120-120	3.02	0.36
0-0-120	2.73	0.41
60-0-120	2.78	

*Yields are from a single cutting.

Crookston (Northwest Experiment Station)

Fertilizer Trials on Sugar Beets
O. C. Soine

Fertility work on sugar beets conducted by the Northwest Experiment Station involved a nitrogen study on six different farms in the Crookston area, and a N-P-K combination trial on a three-year rotation at the Experiment Station.

In the nitrogen study, six different rates of ammonium nitrate were used. On three of the farms, a sweet clover or alfalfa fallow was used in 1958, and on three farms, a black fallow was used in 1958. The results are given in Tables 2 and 3.

Table 2. Effect of Nitrogen on Yield and Sugar Content on Legume Fallow versus Black Fallow. (Average of three farms for each type of fallow.)

	Legume Fallow		Black Fallow	
Treatment	Yield Tons/Acre	Per Cent Sugar	Yield Tons/Acre	Per Cent Sugar
Check	17.57	15.35	16.55	14.69
10 lb. N/A	17.45	15.36	16.53	14.82
20 lb. N/A	17.18	15.33	16.36	14.49
30 lb. N/A	18.23	15.02	16.93	14.37
40 lb. N/A	18.08	14.89	16.86	14.23
50 lb. N/A	17.69	14.98	16.79	14.06
General Mean	17.67	15.15	16.67	14.44
Soil Test Report				
pH	7.9		7.8	
Organic Matter	5.7% Medium		6.8% Medium	
Available phosphorus	26.5 lb./A Medium		37.5 lb./A High	
Available potash	320 lb./A High		345 lb./A High	

Summary:

1. The sugar beets on the legume fallow plots averaged one ton more per acre than on the black fallow plots.

2. The sugar content of the beets on the legume fallow averaged 0.71 per cent more sugar thatn the beets from the black fallow.

3. The three highest rates of nitrogen fertilizer increased the yield of sugar beets on the legume fallow plots from .12 to .66 tons per acre; on the black fallow, the same three rates produce increases of .24 to .38 tons per acre.

4. The addition of nitrogen fertilizer lowered the per cent of sugar below the check on all the plots except the 10-lb. rate on the black fallow.

Table 3. The Effect of Nitrogen on the Yield of Sugar and Gross Value per Acre.

	Legume Fallow		Black Fallow	
	Sugar lbs./acre	Gross Value	Sugar lbs./acre	Gross Value
Check	5368	$ 234.70	4844	$ 212.34
10# N/A	5339	232.78	4894	213.73
20# N/A	5249	228.53	4734	207.44
30# N/A	5471	238.63	4864	213.32
40# N/A	5363	234.68	4792	210.46
50# N/A	5282	230.85	4719	207.69
General Mean	5346	233.36	4809	210.83

1. The General Mean shows that the Legume Fallow Plots outyielded the Black Fallow by 537 pounds of sugar.

2. All applications of nitrogen fertilizer, except the 30-lb. rate, produced less sugar per acre than the check plot on the legume fallow.

3. On the black fallow, only the 10-lb. and 30-lb. rates yielded more sugar per acre than the check.

4. The sugar beets on the legume fallow averaged $22.53 more per acre than the black fallow.

5. There was no significant increase in the gross income from the application of nitrogen fertilizer on either legume or black fallow plots.

Red River Valley Potato Research Farm

Yields of Kennebec, Cobbler, Norland, and Pontiac potatoes increased with increasing rate of P_2O_5 application up to 1000 pounds P_2O_5 per acre. Highest yields of potatoes were obtained with the Pontiac variety and a fertilizer treatment of 120-1000-80. While Kennebec potato yields increased with increasing rate of fertilizer, the top yields obtained with this variety were well below those of Pontiacs. (table 9). It should be noted that fertilizer applications up to 1000 pounds P_2O_5 per acre did not reduce potato quality as indicated by specific gravity determinations.

Table 4. Effect of Fertilizers on the Yield and Specific Gravity of Four Potato Varieties (Red River Valley Potato Research Farm, 1959)

Fertilizer per acre			Kennebec	Cobbler	Norland	Pontiac	Kennebec	Cobbler	Norland	Pontiac
N	P_2O_5	K_2O	bu/acre, No 1				Sp. gravity			
0	0	0	218.8	184.1	203.8	227.5	1.075	1.085	1.064	1.067
60	100	40	287.6	250.4	294.3	320.8	1.077	1.085	1.063	1.066
60	200	40	324.2	294.6	325.7	336.3	1.079	1.081	1.066	1.065
60	300	40	356.2	320.9	348.1	372.8	1.076	1.078	1.065	1.065
60	400	40	367.5	328.1	345.6	358.0	1.077	1.085	1.064	1.068
60	500	40	374.9	320.3	357.5	416.9	1.077	1.083	1.064	1.065
120	500	80	351.4	390.0	395.5	417.0	1.072	1.083	1.064	1.064
120	1000	80	353.0	425.5	425.2	444.9	1.071	1.083	1.062	1.066

Notes: Soil is a silty clay loam, organic matter content of about 6, available P averaging 10 pounds, exchangeable K 400 pounds per acre, pH 7.8. Plots were on non-fallowed land. Phosphorus was supplied by conc. super, potassium by potassium chloride, nitrogen by ammonium nitrate. All fertilizers were applied with the seed as a band application.

The large and increasing yields with increased fertilizer application indicates substantially more use of fertilizer on potatoes in the Red River Valley.

Note particularly that increased fertilizer use has not affected potato quality (except for Kennebec) as indicated by specific gravity tests.

Chemical and Organic Fertilizer Comparison on Potatoes
C. J. Overdahl

In 1958 on an acid sandy loam soil near St. Cloud 600 pounds per acre of a 1-2-1 organic fertilizer appeared to out yield 300 to 600 pounds per acre of a chemical fertilizer on corn, soybeans, radishes, and potatoes. The yields, however, were all too low to be considered satisfactory.

A plot of early gem potatoes was established in 1959 on an area where the soil pH was measured at 5.4 in 1958.

Treatments

The total plot area received a basic application of 100 lbs. of N and 40 pounds of P_2O_5. The nitrogen was broadcast at planting time and phosphate was applied with the planter.

Other applications were broadcast as follows:

Potash - 0 and 120 lb/acre.
Organic fertilizer - 0 and 600 lbs/acre.
Gypsum - 0 and 400 lbs/acre to supply calcium as a plant food without raising the pH.
Borated gypsum - 0 and 400 lbs/acre.
Lime - 0, 2, and 8 tons per acre.

Results

Treatment**	No Lime		8 Tons Lime	
	Yield bu/A*	Specific gravity	Yield bu/A*	Specific gravity
NPK	219.5	1.0555	205.0	1.0565
NPKG	190.0	1.0580	186.1	1.0580
NPKGB	210.0	1.0575	196.0	1.0630
NPBG	166.2	1.0580	190.1	1.0560
NPOBG	140.8	1.0570	171.9	1.0605
Average	185.3	1.0572	189.8	1.0588

*Average of 2 reps.
**O = Organic fertilizer, G = gypsum, B = Boron.

Organic fertilizer was applied alone immediately adjacent to the above plots. The yield was 137 bu/acre.

Only the 8 ton lime plots were harvested since there was no visual lime response, and one of the plots harvested having a two-ton rate yielded the same as an equivalent treatment with no lime.

The soil test resulting from a sampling at planting time was as follows: pH -6.1, OM - 2.4 (low), P - 117 (very high), K - 170 (med), texture - sandy loam.

All the plots receiving potash averaged 201.1 bushels and all plots with no potash averaged 167.2 bushels. The average yield increase due to potash was 33.9 bushels. Figuring potatoes conservatively at 1¢ per pound would mean that potash returned $20.34 for a $6 per acre investment.

The plot was not designed to determine the value of nitrogen and phosphate. The small average difference of 4.5 bushels due to the 8 ton per acre lime rate is hardly significant since variation was quite large within treatments. No lime response is not surprising since the pH of the plot area was 6.1. No increases were observed due to calcium supplied by gypsum or to boron applications.

The demonstration did not include a plot with no fertilizer. For this reason it could not be determined whether organic fertilizers gave a response, but this treatment had the lowest yielding plots. They may have given no increase but at least it was apparent that organic fertilizers were not as effective as chemical fertilizers in increasing yield.

Specific Gravity

Specific gravity was low for all the potatoes and no differences are apparent due to treatments.

Insects

Insects damaged the potato vines in July. The plots were sprayed shortly after the insects were discovered but serious damage had already occurred.

Summary

The plot site was established on an area immediately adjacent to where growth differences were observed in 1958 and where the pH was 5.4. The pH 6.1 on the actual plot site, however, prevented establishing whether soil pH was a factor in poor yields. The pH of the organic fertilizer was above 9 and when applied near the seed in 1958 may have had a desirable effect from the improved pH or calcium content. In a preliminary study in small pots Dr. Rose observed very beneficial effects from lime treatments. It was also observed that soybeans on the farm were a pale green color and appeared nitrogen deficient. Soils from the more typical acid fields on the farm should be used in a greenhouse study to more accurately determine the cause of poor yields.

Fertilizer furnished by Howe, Inc., Minneapolis

Cooperators on demonstration: Enock E. Bjuge, Sherburne County Agent
Dr. R. D. Munson, American Potash Institute
Dr. Ray Rose, Howe, Incorporated
Dr. O. C. Turnquist, Extension Horticulturist

Fertilizers in Forestry

H. F. Arneman

A cooperative experiment with the Northwest Paper Co. was started in May of 1958 to test the effect of fertilizers on Red Pine seedlings.

The Northwest Paper Company furnished the seedlings and planted them for the experiment.

Soils used were Menahga loamy sand. The areas planted were "worn-out" agricultural areas that were beginning to revert to timber.

The experiment consisted of a factorial design with 20# and 40# of N, 20# P_2O_5 and 20# and 40# K_2O applied in all combinations. One plot in each replicate had Gypsum applied to it. The treatments were applied in quadruplicate with two replicates located near Huntersville, Wadena County and two replicates near Baxter in Crow Wing County. Each plot contained approximately 100 trees.

Urea (45-0-0) was used as the source of nitrogen, concentrated superphosphate (0-45-0) as the phosphorus source and muriate of potash (0-0-60) the source of potassium. The fertilizer was applied about six inches deep and three inches to the side of each tree.

The only definite results to report at this time is that both the nitrogen and potassium treatments cause considerable mortality of seedlings.

Measurements are being made annually.

A Corn Fertility Trial on a Wright County Peat Soil

by H. P. Hermanson and R. S. Farnham[1]

Purpose

The purpose of this trial was to determine the effect on corn grain yield of ammonium nitrate, treble superphosphate, and muriate of potash applied at different levels to a peat soil in 1958.

Experimental Conditions

The University of Minnesota Soil Testing Service indicated that this partly decomposed fibrous peat was low in "available" phosphorus and exchangeable potassium.

The treatments were applied in a randomized incomplete block design having two reps. The factorial treatments were the combinations required for the dodecohedron response surface points.[2] The plots were 20 by 14.4 feet and consisted of four rows.

The Pioneer 390 corn was seeded during the last of May and fertilized May 30th to June 2nd with the amounts of fertilizer material equivalent to the nutrient levels shown in table 1. The fertilizer was applied in a band 2 to 4 inches to the side of each row at seed level. The blanket treatment, which was broadcast, included magnesium, iron, sulfur and manganese applied as 63.4 lb./A. $MgSO_4 \cdot 7H_2O$, 16.1 lb./A. $Fe_2(SO_4)_3 \cdot 6H_2O$, and 89.9 lb./A. of $MnSO_4$. July 3rd the plots were hoed and the corn thinned to a constant population of 13,730 plants/A.

The summer was cool and the 94 to 98 day corn grew slowly. It was killed by frost before the plants in many plots had reached maturity. The ears from the center two rows were harvested, dried and shelled. The wieght of the grain was obtained and adjusted to 15.5% moisture.

Results

The yield of corn grain is described over the range of fertilizer levels used by the following equation.

$$Y = 57.4 - .2N + 4.4^{*} P + .6K - 2.0N^2 - 2.3P^2 - 1.5K^2 - .5NP + .9NK + 1.3 PK$$

Where:

Y is bu. of 15.5% moisture grain/A.
N is 31.46 lb. N/A units scaled from 82.35 lb. N/A.
P is 19.66 lb. P_2O_5/A. units scaled from 51.47 P_2O_5/A.
K is 39.32 lb. K_2O/A. units scaled from 102.94 lb. K_2O/A.

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1 In cooperation with Mr. Richard Vandergon and Mr. Eugene Ellis

2 As suggested by J. W. Chapman and Dr. C. E. Gates.

The 4.4 is significantly different from zero at the 5% level, -2. at the 10% level, and all others at higher levels. This means that when treble superphosphate was applied over the levels tried, grain yields were increased and that this increase was not straight but convex. Our measurements do not disprove the statement that addition of ammonium nitrate or muriate of potash did not change the amount of grain produced even though consistent trends occurred.

Theoretical treatment of the equation indicates that the highest yield during 1958 would have occurred for the treatment receiving 81 lb. N/A., 73 lb. P_2O_5/A., and 130 lb. K_2O/A. The yield from this treatment would have been 60 bu./A. The change in yield as phosphorus was varied at these levels of nitrogen and potassium is shown in column four of Table 2.

The optimum economic fertilizer treatment for 1958 assuming unlimited capital, a corn price of 90¢/lb., a nitrogen price of 12¢/lb., a P_2O_5 price of 9¢/lb., and a K_2O price of 5¢/lb. would have been the one receiving 34 lb. N/A., 58 lb. P_2O_5/A., and 67 lb. K_2O/A. Column three of Table 2 shows the effect of phosphorus at these levels of nitrogen and potash. This treatment would have given a yield of 54 bu./A. in contrast to the 17 bu./A. for no fertilizer. An increase of 37 bu./A. having a value of 34 dollars. This amount of fertilizer would have cost 13 dollars, so the net return would be 21 dollars/A. This would consist of fertilizer management profit and the additional cost of harvesting the extra 37 bu./A.

The corn maturity seemed to be influenced by fertilizer treatment.

Summary:

Since the corn yield was limited by climatic conditions and plant population and not soil fertility, inferences based on this data about yield on other years must be considered risky. During 1958, treble superphosphate changed the amount of corn produced. On normal years, the temperatures are generally higher and perhaps the increases due to nitrogen lower than observed here.

Table 1. Fertilizer treatments used in the Wright County corn fertility trial and the yields they produced.

Treatment No.	Treatment N (lb./A.)	P_2O_5 (lb./A.)	K_2O (lb./A.)	Yield (bu./A.)
1	114	103	103	53
2	82	32	206	53
3	0	52	64	50
4	133	20	39	40
5	114	0	103	41
6	82	71	0	41
7	0	52	142	47
8	133	83	166	51
9	51	103	103	52
10	82	32	0	45
11	165	52	142	39
12	32	20	166	32
13	51	0	103	39
14	82	71	206	52
15	165	52	64	52
16	32	83	39	51
17	32	83	166	55
18	32	20	39	50
19	133	83	39	55
20	133	20	166	46
21	82	52	103	53
22	82	52	103	52

Table 2. Effect of phosphorus fertilization on yield of corn.

	Corn (bu./A., 15.5% H_2O)		
P_2O_5 (lb./A.)	0 lb.N/A 0 lb.K_2O/A	35 lb.N/A 70 lb.K_2O/A	80 lb.N/A 130 lb.K_2O/A
0	17	26	27
20	29	40	43
40	37	50	53
60	39	54	59
80	37	54	60
100	31	49	56

The Influence of Fertilization of a Peat Soil in Clearwater County on the Yield of Potatoes

H. P. Hermanson & R. S. Farnham[1]

Purpose

The purpose of the two trials reported here was to observe the effect of nitrogen, phosphorus, and potassium carrying materials on the yield of potatoes grown on an organic soil in 1958.

Experimental Considerations

The two trials were conducted on an organic soil located at SE 1/4 sec. 7 T151N R38W in Clearwater County. The surface eight inches was muck with a pyrophosphate solubility of more than 2%. The underlying fiberous peat had a pyrophosphate solubility of 1/4 to 3/4%. The Soil Testing Laboratory at the University of Minnesota reported that both layers were very low in "available" phosphorus and exchangeable potassium. Mineral soil was encountered at about four feet and is overlaid by six inches of muck. The soil reaction of the upper 20 inches was 6.0 to 6.2. This field had been in meadow and had not been fertilized previously.

The temperature during June and July was 5°F lower than normal. The total precipitation reported by a weather station 15 miles south of the plots showed a dry August.

On June ninth certified Cherekee potatoes were seeded in the loose unpacked seedbed. About two weeks later the fertilizer was banded two to six inches to the side and level with the unsprouted potato pieces.

The nitrogen rate study consisted of a randomized complete block design having five reps. The plots were 30 by 13.7 feet and consisted of four rows. Ammonium nitrate, treble superphosphate, and muriate of potash were applied at rates equivalent to those shown in Table 1.

Table 1. The average plant population and yield for the various treatments in the nitrogen rate trial.

Treatment No.	Treatment (lb/A) N	P_2O_5	K_2O	Population (Plants/A)	Yield[2] (100 lbs/A)
1	39	0	0	6,340	112
2	0	98	292	5,560	75
3	39	98	292	6,160	112
4	78	98	292	6,380	121
5	117	98	292	6,000	99
6	0	0	0	6,500	94
			hsd	1,380	88
			lsd	923	58

[1]In cooperation with Del Darst (grower) and Arnold Heikkila, County Agent, Clearwater Co.

[2]Linearly adjusted to mean population of 6,250 plants/A.

The phosphorus and potassium study utilized the randomized incomplete block design having five reps. The factorial treatments correspond to the points[1] at vertices of a pentagon along with the center point. Ammonium nitrate, treble superphosphate, and potassium sulfate were applied at rates equivalent to those shown in Table 2.

Table 2. The average yields for the various treatments in the phosphorus and potash rate study.

Treatment No.	Treatment (lb/A) N	P_2O_5	K_2O	Yield[1] (100 lb/A)
1	39	195	292	90
2	39	121	585	101
3	39	0	475	91
4	39	0	111	74
5	39	121	0	78
6 to 8	39	121	292	94
			hsd	46
			lsd	25

[1]Linearly adjusted to mean population of 5,750 plants/A.

During the last part of July the two center rows were weeded and the number of plants present was ascertained. The phosphorus-potassium plots were thinned to 30 plants but a large number of plots had less than this. The average population for each treatment of the nitrogen carrier trial is shown in Table 1. This is about a quarter the desired population.

The two center rows from all plots in both experiments were harvested and the tubers were weighed.

Results

The yields were linearly adjusted to mean population. The analysis of variance was conducted on the plant population and potato yields obtained in the nitrogen trial. The hypothesis that these treatments had the same mean population and the same mean yield was accepted even though notes taken the last of July indicated a large vine response to nitrogen. The treatment means are given in Table 1.

Analysis of variance on the phosphorus-potassium data showed no significant treatment difference for potato yield. These means are given in Table 2.

Summary

A poor and variable potato stand resulted in a very high variance and a low yield. The application of nitrogen, phosphorus, and potassium fertilizer materials did not change potato yield to a measurable extent. It is probable that plant population and not soil fertility limited the yield since a quarter of the recommended stand gave half the expected yield. An earlier planting, a firmer seedbed, and a normal season would have produced more favorable and useful results.

A Three Year Fertility Study of Potatoes Grown on an Aitkin County Peat

by H. P. Hermansnn and R. S. Farnham[1]

Purpose

The purpose of this work was to observe the effect of fertilizer materials carrying nitrogen, phosphorus, and potassium on the yield and quality of Red Pontiac potatoes grown on a fibrous peat during the years 1957-1959.

Experimental Details and Discussion

The soil studied was a fibrous peat located in W1/2 SE1/4 section 18 of Fleming Township in Aitkin County. The location used in 1957 had been farmed and fertilized previously and had a reaction of pH 5.7, a very high (51 lb/A) "available" phosphorus content, and a medium (115 lb/A) exchangeable potassium content. This peat is 18% ash and 2.2% N. In 1957 one hundred lbs. K_2O/A as muriate of potash was broadcast before seeding. Certified Red Pontiac potatoes were planted May 16 and the rest of the fertilizer was applied May 22 by spreading on the soil surface on each side of the potato rows. The nutrients were applied as ammonium nitrate, treble superphosphate, and muriate of potash except for treatment six where K_2SO_4 was substituted for KCl. The factorial treatments used are shown in Table 1. They were applied to 5.50×10^{-3} acre plots in a randomized complete block design including three reps.

The 1957 season was about normal for the area.

Duncan's multiple range test indicates that treatment 1 through 5 and 2 through 10 are not significantly different but that treatments 2 through 10 are significantly better than treatment 1. The better yields were produced by the treatments containing no phosphorus. No difference in potato density was observed between the KCl and K_2SO_4 potassium sources.

Table 1. The effect of various fertilizer treatments on potato yield and quality during 1957.

Treatment No.	$N-P_2O_5-K_2O$ (lb/A)[2]	Yield (100 lb/A)	Dry Matter (%)
1	0-100-100	205	------
2	80-200-600	229	------
3	40-150-450	229	------
4	40-100-300	232	17.9
5	0-100-300	243	------
6	40-100-300[1]	249	17.7
7	40-0-100	249	------
8	0-0-100	261	------
9	40-0-300	263	------
10	0-0-300	278	------
	hsd	65	
	lsd	38	

[1]Potassium applied as K_2SO_4

[1]In cooperation with Wm. Ruud and Sons

1958 Season

This season the experiment was located about 300 feet west of the 1957 site. This site had been cultivated eight or ten years before and let go wild again. It probably had not been fertilized. The Minnesota soil testing laboratory indicated that this soil had a soil reaction of pH 5.1, was low (7 lb/A) in "available" phosphorus and very low (60 lb/A) in exchangeable potassium. The season was about 5°F cooler than normal during June and July. Rainfall was three inches below normal for the period March and April.

The factorial treatments shown in Table 2 were applied to 8.22×10^{-3}A plots in an incomplete block design replicated four times. Red Pontiac potatoes were seeded the last of May and during early June 29 lb/A $MgSO_4$ and 58 lb/A CaO was broadcast over the area. The ammonium nitrate, treble superphosphate, and potassium sulfate were then placed in trenches four to six inches to the side and level with the seed pieces. July 17th the plant population was adjusted to 11.7 thousand plants per acre. The average treatment yields are shown in Table 2 along with the dry matter content. Analysis of variance showed highly significant treatment effect. Since the factorial treatments[1] represent the points at the vertices of a dodecohedron along with the one at the center, the fitting of a quadratic cross product function with the calculation of the reduction in sums of squares is convenient to carry out. It gave the following regression equation in which only the potassium produces a significant effect.

$$Y = 211 - .4N - 8.6P + 19.0^{**} K + 7.1N^2 - 2.8P^2 - 10.7^{*}K^2 - 4.8NP + 1.6NK + 4.3PK$$

Where:

Y is in units of 100 lb/A.
N is 45.2 lb N/A units scaled from 73.2 lb N/A.
P is 60.3 lb P_2O_5/A units scaled from 97.6 lb P_2O_5/A.
K is 180.9 lb K_2O/A units scaled from 292.7 lb K_2O/A.

[1] Recommended by Dr. C. E. Gates and J. W. Chapman

Table 2. Yield and dry matter content of Red Pontiac potatoes produced by various $N-P_2O_5-K_2O$ combinations during 1958 and 1959.

Treatment (lb/A)				Yield (100 lb/A)		Dry Matter Content (%)	
				1958	1959	1958[1]	1959[2]
101	195	293		226	226	16.4	15.2
73	60	585		248	257	16.4	13.9
0	98	181		247	253	18.1	16.0
119	37	112		232	194	17.5	16.8
101	0	293		222	162	17.3	14.9
73	135	0		123	104	17.3	16.6
0	98	405		242	272	17.0	14.3
119	158	474		218	223	16.2	13.9
45	195	293		176	170	16.8	14.3
73	60	0		144	123	18.1	16.4
146	98	405		191	155	16.6	13.4
28	37	474		198	206	17.0	13.7
45	0	293		198	140	16.8	14.3
73	135	585		210	194	16.4	13.4
146	98	181		222	172	17.3	15.6
28	158	112		180	230	17.5	16.4
28	158	474		207	194	16.8	13.7
28	37	112		200	183	17.5	15.8
119	158	112		164	151	17.0	16.2
119	37	474		246	185	16.6	13.9
73	98	293		210	180	16.8	14.9
0	0	0		137	104	17.7	17.0
			hsd	70	115	1.6	1.2
			lsd	36	58	.8	.6

[1]Potassium furnished as K_2SO_4
[2]Potassium furnished as KCl

Economic analysis of the surface was performed assuming unlimited capital, a N price of 13¢/lb, a P_2O_5 price of 10¢/lb, a K_2O price of 5¢/lb, and the 1958 potato price of 84¢/100 lb. The optimum economic fertilizer treatment for 1958 was 72 lb N/A, 0 lb P_2O_5/A, and 303 lb K_2O/A which should have produced a yield of 218 bags/A. The net return for this fertilization treatment should have been $43/A which would be attributed to fertilizer management return plus the cost of digging and bringing in the extra 80 bags/A. Table 3 shows the variation in yield upon addition of K_2SO_4 when the nitrogen and phosphorus carrier rates were held at their 1958 economic optimum.

Analysis of variance indicates that the measurable treatment variation in specific gravity was solely attributable to the highly significant linear effect of K_2SO_4 rate and can be adequately expressed by the following regression equation where K_2O is expressed as lb/A. Specific gravity = 1.0676 - .0000102**K_2O.

See Table 3.

Table 3. The effect of rate of potassium carrier on the yield and dry matter content of Red Pontiac potatoes.

K_2O (lb /A)	Yield (100 lb/A)		Dry Matter Content (%)	
	1958[1] 70 lb N/A 0 lb P_2O_5	1959[2] 0 lb N/A 110 lb P_2O_5/A	1958[1]	1959[2]
0	170	186	17.7	16.6
100	192	217	17.5	16.0
200	207	239	17.3	15.6
300	217	251	16.8	14.9
400	221	254	16.8	14.3
500	219	247	16.6	13.7
600	211	230	16.4	13.1
Check	137	104	17.7	17.0

[1]Potassium applied as K_2SO_4
[2]Potassium applied as KCl

1959 Season

The treatments applied in 1959 were applied to the same plots again in 1959. The only variation was that KCl was used instead of K_2SO_4. Red Pontiac potatoes were planted the last of May. Rep four on the north end of the experimental area was fertilized May 30th and rain stopped operations. Five inches of rain fell which evidently leached appreciable nutrients as the rep gave no significant treatment effect. June 2 to 4 the other three reps were fertilized. The spring was somewhat dry while temperatures were about normal. July 2nd the population was adjusted to 11.7 thousand plants per acre. The average potato yields from reps 1 to three and dry matter contents from reps 1 to four are given in Table 2. Analysis of variance of the data from reps 1 to 3 indicated highly significant treatment effect. The following regression equation adequately describes the treatment variation in yield.

$$Y = 220.6 - 16.6^{*} + 6.5\,P + 20.7K^{*} + .0N^2 - 16.3^{*}P^2 - 15.6K^2 - .4NP + 3.4NK - 1.9PK$$

Where:

Y is in units of 100 lb/A
N is 45.2 lb N/A units scaled from 73.2 lb N/A
P is 60.3 lb P_2O_5/A units scaled from 97.6 lb P_2O_5/A
K is 180.9 lb K_2O/A units scaled from 292.7 lb K_2O/A

The nitrogen, phosphorus, and potassium carriers all produced significant effects as shown by the astericks in the regression equation. The significant main effect of N carrier is negative while that for K carrier is positive. The significant second order P carrier effect indicates P response is curvilinear. Similar conditions to those accepted for the 1958 economic analysis were taken with the exception that the potato price was changed to the 1959 figure, $1.39. The optimum economic treatment for 1959 was calculated to be 0 lb N/A, 109 lb P_2O_5/A, and 378 lb K_2O/A. This treatment should give a yield of 254 bags/A. Table 3[2] illustrates how KCl changes potato yeild and quality. Fertilization at this optimum economic rate would increase the yield 150 bags/A giving a net return over fertilizer cost of $178/A.

As with the 1958 data, the treatment variation in specific gravity is adequately expressed as a linear function of potassium carrier rate. See Table 3.

Specific gravity = 1.0632 - .0000282**K_2O

The lower specific gravity for this season can be explained partly by the immature stage of the plant when frozen and partly by the use of KCl instead of K_2SO_4.

Summary

During 1957 to 1959, fertility experiments were conducted with Red Pontiac potatoes grown on a fibrous Aitkin County peat soil. The effect of nitrogen, phosphorus, and potassium carriers on yield and specific gravity was observed. Consistantly excellent yields were produced all three years from 300 to 380 lb. K_2O/A, whereas, the specific gravity was decreased by addition of potassium carrier. The yield response to nitrogen and phosphorus carriers was variable.

The Effect of Various Phosphate Fertilizer Materials on the Yield of Celery

H. P. Hermanson and R. S. Farnham[1]

Purpose

The purpose of this experiment was to compare the effect upon celery yield of various phosphate fertilizer materials to that of an ammonium nitrate-treble superphosphate-potassium chloride treatment.

Materials and Methods

The soil was an unfertilized fibrous peat located at Fens in St. Louis County, Minnesota. During the 1957 field season, the addition of nitrogen, phosphorus, and potassium to this soil had each given an increase in celery yield. The University of Minnesota Soil Testing Laboratory reported the following data for this soil: pH 5.2, "available" phosphorus medium (18 lbs/A), and exchangeable potassium very low (35 lbs/A). This peat was 43% C and 2.9% N.

The fertilizer materials applied are shown in table 1. Ammonium nitrate (0-33.5-0) was used to bring the rate of nitrogen application up to 70 lbs/A and potassium chloride (0-0-60) to furnish 526 lbs/A of K_2O. In order to maximize the differential response to phosphorus, nitrogen and potash were applied at the recommended rate for maximum yield and phosphorus at one-half this rate. The phosphate sources were applied at quantities which would furnish 35 lbs/A of available P_2O_5. The NPK fertilizers were applied June 26, 1958, in a trench two inches in depth

[1] In cooperation with Mr. Harold Andrews, A. C. Caldwell, and Richard Curley (T.V.A.)

and four to six inches to the east side of the celery row. Ferro Fritted Trace Elements were broadcast as a blanket treatment at the rate of 300 lbs/A to furnish a minimum of 37 lbs/A Fe, .4 lb/A Mo, 6 lbs/A B, 6 lbs/A Cu, 12 lbs/A Zn, and 15 lbs/A Mn. These figures are based on the total analysis appearing on the fertilizer bag.

June 24, 1958, Utah 52-70 celery slips were planted in rows whose spacing alternated between 28 and 36 inches. Two days later the treatments were applied in a randomized incomplete block design to four row plots 20 feet in length.

Results

September 16, 1958, the celery plants from the two inside rows of each plot were harvested, counted, and weighed. Since plant population was quite variable, the yields were adjusted to that expected for the mean population, 19,100 plants/A, by use of linear regression. The adjusted treatment means are shown in Table 1. Analysis of variance results in rejection at the one percent level of the hypothesis of no treatment difference. Using the test of Roessler[2] the observed yields were compared to that of the treble superphosphate yield. These differences are shown in Table 1. The hypothesis of no difference between the hyperphosphate mean and the control, treble superphosphate mean, was rejected at the one percent level; whereas, the null hypothesis for the calcium metaphosphate and concentrated superphosphate comparison to the control was rejected at the five percent level. The null hypothesis for the other two comparisons was accepted.

Table 1. The effect of fertilizer materials upon celery yields.

Treatment	Fertilizer Analysis	Rate (lb/A)	Replication	Yield (T/A)	Difference from control (T/A)
Hyperphosphate	0-5-0	722	9	6.84	-2.82**
Calcium metaphosphate	0-62-0	58	9	7.50	-2.15*
Potassium metaphosphate	0-55-31	65	3	8.09	-1.56
Treble superphosphate	0-45-0	79	9	9.65	
Diammonium phosphate	21-53-0	67	3	9.92	.27
Concentrated superphosphate	0-53-0	67	3	10.84	1.19*

Summary

The effect of several fertilizer materials on the yield of Utah 52-70 celery grown on peat was observed and compared with an ammonium nitrate-treble superphosphate-potassium chloride control. The hyperphosphate and calcium metaphosphate treatments produced less celery than did the control. This was probably due to the lower availability of the phosphorus. The potassium metaphosphate and diammonium phosphate means could not be distinguished from the control mean, but the concentrated superphosphate treatment produced a higher yield than did the control. It is interesting to note that the phosphorus of the concentrated superphosphate is 100% water soluble; whereas, that of the treble superphosphate is 85% water soluble. If diammonium phosphate were not also 100% water soluble, the increase in yields of the concentrated superphosphate treatment might be attributed to greater phosphorus availability. Phosphorus analysis of the plant material is necessary.

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[2] Proc. Amer. Soc. Hort. Sci. 47:249. 1946.

Forage Adaptability Study on a Peat Soil at the North Central Agricultural Experiment Station - Grand Rapids, Minnesota

by H. P. Hermanson and R. S. Farnham[1]

Purpose

The purpose of this trial was to determine the adaptability of a commonly recommended seeding mixture and several forage species to produce hay on a fibrous peat soil adequately fertilized with nitrogen, phosphorus, and potassium.

Experimental Considerations

The peat soil is located at SW 1/4 SE 1/4 Sec. 15 T55N R25W on the North Central Agricultural Experiment Station 400 feet west of the new federal Lake States Forestry Building. This soil had not been previously farmed or fertilized. It had been drained earlier (about 1920) and was used as a blue grass pasture until the seedbed was prepared for this trial. The drainage resulted in the water table being below two feet most of the time. The Soil Testing Laboratory of the University of Minnesota reports this soil to be low (6 lb/A) in "available" phosphorus, very low (50 lb/A) in exchangeable potassium, and extremely acid (pH 3.8).

During the last of June, 1958, the forages shown in Table 1 were broadcast on a well prepared seedbed at the rates shown. Six replicates were used for all treatments except Ranger Alfalfa and rough stalked meadow grass which were repeated only three times. The following fertilizer blanket treatment was applied to the (5' x 9') 1.031×10^{-3} acre plots at this time: 10 lb N/A as 33-0-0, 30 lb P_2O_5/A and 90 lb K_2O/A as 0-20-20 and 0-0-60, 25 lb $MgSO_4$/A, 5 lb borax/A, 25 lb $CuSO_4$/A, 2.46T $CaCO_3$ equivalent/A as $Ca(OH)_2$ and $CaCO_3$, 25 lb $MnSO_4$/A, and 1 lb $(NH_4)_2MoO_4$/A. The seedbed was then packed somewhat by running a crawler-type tractor over it.

June and July of 1958 were about 5°F below normal and the period April and May, 1959, received three inches below normal rainfall. Good snow cover existed during the 1958-59 winter.

June 16, 1959, the plots were cut and the yield determined. The dry matter content was estimated to be 25% and the data in Table 1 is expressed on this basis. June 22 to 28, fifty pounds per acre N was applied as 33-0-0 to all treatments consisting solely of grass. All plots received 100 lb P_2O_5/A as 0-46-0 and 300 lb K_2O/A as 0-0-60. August 5, 1959, the second crop was harvested and yield and matter content ascertained. Table 1 shows the dry matter yield for the second harvest and the seasonal total. Duncan's multiple range test shows alsike cover to be superior to all treatments in the first harvest and timothy in the second. Narragansett Alfalfa and alsike clover produced as much forage during the season as timothy.

Summary

The ability of a commonly recommended seeding mixture and several forage species to produce hay on a fibrous peat soil well fertilized with N, P and K has been observed for the first harvest year. Timothy and alsike clover performed very well and exceeded the alfalfa by a very small amount. This work will be continued several years to evaluate the productivity of these stand.

[1]In cooperation with the North Central Agricultural Exprériment Station

Table 1. The yield of a seeding mixture and several forage species in 1959

Forage	Treatment Seeding Rate (lb/A)	Yield (T/A) 1st Cutting	2nd Cutting	Total
Timothy	10	2.1	1.4	3.5
Alsike Clover	8	2.7	.8	3.5
Narragansett Alfalfa	15	2.1	1.1	3.2
Ranger Alfalfa[1]	15	2.1	1.0	3.1
Vernal Alfalfa-smooth bromegrass-timothy	8-6-2	2.0	1.0	3.0
Smooth bromegrass	10	2.0	.9	2.9
Empire birdsfoot trefoil	5	1.9	1.0	2.0
Meadow foxtail	10	1.5	1.2	2.7
Ladino clover	3	1.7	1.0	2.7
Meadow fescue	8	1.7	.7	2.4
Rough stalked meadow grass[1]	10	1.4	.8	2.2
hsd		.6	.4	.7
lsd		.4	.2	.4

[1]Only three replicates used.

A Forage Adaptability Study on an Aitkin County Peat Soil

by H. P. Hermanson and R. S. Farnham[1]

Purpose

The purpose of this trial was to determine the adaptability of several grasses and legumes to production hay on a fibrous peat.

Experimental Considerations

These trials were located at NE 1/4 Sec. 19 T48N R25W on a soil which the Soil Testing Laboratory of the University of Minnesota indicates is low (8 lb/A) in "available" phosphorus and very low (48 lb/A) in exchangeable potassium, and has a pH of 5.6. A sample taken 1/2 mile away has given N, P, and K response for potatoes in greenhouse but only K response in the field. Copper response by Piper Sudan Grass has been observed in the greenhouse. Two sites of differing distance from the drainage ditch were chosen. However, during the experiment little difference in water table level was observed.

During June, 1958, the following blanket treatment was broadcast: 10 lb N/A as 33-0-0, 30 lb P_2O_5/A and 90 lb K_2O/A as 0-20-20 and 0-0-60, 25 lb $MgSO_4$/A, 5 lb boric acid/A, 25 lb $CuSO_4$/A, 2T $CaCO_3$ equivalent/A as hydrated lime, 25 lb $MnSO_4$/A, 1 lb $(NH_4)_2MoO_4$/A and 10 lb $FeSO_4$/A. After broadcasting the grass and legumes shown in Table I at the indicated rates, the soil was rolled. The treatments

[1]In cooperation with Mr. Jacobsen

were repeated four times at each of the two sites,

The rainfall during the rest of 1958 and during the 1959 season was about normal for the area; whereas, the temperatures during June and July, 1958, were about 5°F below normal. Good snow cover existed during the winter and stand counts taken in the fall and the summer of 1959 indicated very good maintenance of stand.

June 27, 1959, the plots were cut and the yield and dry matter content of the forage was ascertained. At this time the alfalfa was just beginning to bloom. Subsequently, the plots were rolled and 50 lb N/A as 33-0-0 was broadcast on the plots having no legume while 100 lb P_2O_5/A as 0-46-0 with 300 lb K_2O/A as 0-0-60 was applied to all plots. August 6, 1959, the plots were again cut and yield and dry matter content determined. The total yield of dry matter of these two cuttings is given in Table 1. Analysis of variance on each site indicated rejection of the hypothesis of no treatment effect at the 1% level. Site had little effect on yield. Duncan's multiple range test indicated that the timothy, Vernal alfalfa-smooth bromegrass-timothy mixture, smooth bromegrass, and Narragansett Alfalfa performed at the same high level. The Kentucky Bluegrass and rough stalked meadow grass contained more weeds than the other treatment so occur higher in the table than their production ability could place them.

Summary

A forage adaptability study showed that with adequate N-P-K fertilization of a fibrous Aitkin County peat soil, timothy, smooth bromegrass and alfalfa produced very good hay yields the first season. Inferences about the overall performance of these legumes and grasses cannot be attempted until several years data is obtained so that maintenance of stand can be observed.

Table 1. Total 1959 forage yields produced by the Aitkin County peat soil

Treatment	Seeding Rate	Yield (T/A)		
Forage	(lb/A)	"Wet" site	"Dry" site	Both sites
Timothy	10	2.72	3.83	3.28
Vernal alfalfa, Smooth bromegrass and Timothy	8-6-2	3.15	3.39	3.27
Smooth bromegrass	10	2.88	3.56	3.22
Narragansett Alfalfa	15	2.80	3.33	3.07
Kentucky Bluegrass	10	2.36	3.21	2.78
Reed canary grass	10	2.16	3.31	2.74
Red top	10	2.00	3.14	2.57
Meadow fescue	7	2.22	2.88	2.55
Meadow foxtail	10	1.99	2.84	2.42
Rough stalked meadow grass	10	1.75	3.04	2.40
Birdsfoot trefoil	5	1.91	2.86	2.38
Red clover	10	1.71	2.67	2.19
hsd		1.00	.64	
lsd		.58	.38	

A Nitrogen, Phosphorus and Potassium Fertility Trial with Celery on a Peat Soil Located in St. Louis County

by R. S. Farnham, W. W. Nelson[1] and H. P. Hermanson

Purpose

The purpose of this trial was to determine the effect of rate of nitrogen, phosphorus, and potassium carriers on the yield of celery grown on a peat soil.

Experimental Considerations

The soil was an unfertilized fibrous peat located one half mile east of the Fens railroad station in St. Louis County, Minnesota. The soil had been recently cleared and had never been farmed or fertilized previously and was adequately drained. The University of Minnesota Soil Testing Laboratory reports this soil to be medium (18 lb/A) in "available" phosphorus, very low (35 lb/A) in exchangeable potassium, and strongly acid (pH 5.2).

In the springs of 1957-59 Utah 52-70 celery was fertilized with nitrogen as ammonium nitrate, P_2O_5 as treble superphosphate, and K_2O as muriate of potash at the rates shown in Table 1. The factorial treatments were laid out in a split plot design[2] having every combination of the nitrogen and phosphorus carrier rates as the 16 whole plots in each replicate. The whole plots were divided into six parts to furnish the subplots for the different potassium carrier rates.

Aster yellows attacked the 1957 crop and produced severe damage. The weather during 1957 and 1959 was near normal for the area but June and July, 1958 was considerably cooler than normal. The yield of celery plants showing no external damage from aster yellows is shown in table 1.

Analysis of variance of the 1957 yield shows that the main effect of nitrogen carrier is significant and those for phosphorus and potash carrier highly significant. No interaction effect was significant. As phosphorus carrier rate increased, portion of marketable celery plants decreased markedly. More aster yellows damaged plants occurred where some phosphorus carrier was applied than where none was put on. This effect is probably related to the physiology of the plant. The percent cull aster yellow plants declined as potassium carrier rate increased. Observation of Table 1 indicates that the highest 1957 yield of celery occurred at the 160-0-640 treatment. The data given is the average yield over all levels of the other two fertilizers. Had aster yellows been controlled, it is likely that a considerable higher response would have been observed especially with respect to phosphorus carrier rate. The top yield of marketable celery in 1957 was 19 T/A produced by the treatment 160-0-640.

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[1]Dr. Nelson formerly of the NE Experiment Station, Duluth did this work in cooperation with Mr. Harold Andrews of Chunking Co.
[2]Suggested by Dr. C. E. Gates

In 1958 the total weight of celery produced was increased to a highly significant extent by the rates of nitrogen, phosphorus and potassium carriers. The interactions were not significant. Observation of Table 1 indicates that the highest yield would have occurred at a $N-P_2O_5-K_2O$ treatment level of about 160-160-640 during this year. Observations of individual plot yields indicates that 160 lb/A additional nitrogen increased yield from 25.9 to 27.1 T/A.

The analysis of variance has not yet been conducted on the 1959 data but it appears from Table 1 that 80-160-640 would have given the highest yield. The plot receiving this treatment produced 56.6 T/A.

Summary

Three years data indicates that 33-0-0 and 0-0-60 increases the amount of celery grown on a fibrous peat soil located in St. Louis County. The highest yields are produced by 80 to 160 lb N/A and 640 lb K_2O/A. Treble superphosphate increased aster yellow damage to such in 1957 as to cause a decrease in yield of marketable celery. During the following two years 160 lb P_2O_5/A produced the highest total yield of celery.

Table 1. The average yield (T/A) of Utah 52-70 celery produced by several levels of nitrogen, phosphorus and potassium carriers during 1957 to 1959.

N				P_2O_5				K_2O			
Rate (lb/A)	Year 1957[1]	1958[2]	1959[2]	Rate (lb/A)	Year 1957[1]	1958[2]	1959[2]	Rate (lb/A)	Year 1957[1]	1958[2]	1959[2]
0	3.3	14.7	36.6	0	5.1	12.3	13.3	0	1.6	11.1	28.8
80	3.8	15.6	38.2	80	4.4	18.6	38.0	80	2.8	14.4	31.7
160	5.2	18.5	37.6	160	3.8	19.3	39.3	160	3.8	15.8	35.7
320	3.7	17.3	37.0	320	2.7	16.0	38.7	320	4.9	18.2	40.0
								480	5.3	19.0	42.8
								640	5.5	20.3	44.3
hsd	1.8	2.9			1.8	2.9			1.2	1.8	
lsd	1.3	2.5			1.3	2.5			.8	1.2	

[1]Weight of celery showing no external symtoms of aster yellows
[2]Weight of all celery produced.

SOIL SERIES 59

Soil Erosion Experiments at Rosemount in 1959[1]

March, 1960

J. M. MacGregor

Soil erosion studies were initiated in 1952 on a 9% south-facing slope of Port Byron silt loam for the purpose of determining the effect of length and kind of crop rotation on soil and water losses. Resulting yields were also to be obtained on the differentially rotated crops. The twelve plots were 14 feet wide and 80 feet long (approximately 1/39 acre), having corrugated metal strips driven along the sides and the upper ends. A collection trough, sampling wheel, and sample tank were installed at the lower end. The 12" diameter sampling wheel was designed to divert one percent of the total soil and water removed from each plot into the sampling tank, where measurements of such losses could be made. None of the treatments were replicated, since it was initially considered to be more desirable to have a larger number of treatments on the limited areas and equipment available.

In addition to a pair of standard total rainfall gauges, a recording rainfall-intensity gauge was installed near the center of the 12 plot area. Measurements of rainfall characteristics were recorded from April 1st to November 1st of each year. Since the initial recording gauge stopped occasionally, a second recording rainfall-intensity gauge was later installed to insure a continuous record of the rainfall characteristics.

Plots to be planted to corn or to oats were plowed in the late fall of the preceeding year. All residues were returned to the soil. Since the installation of the collection equipment was not completed until late August of 1952, runoff and soil loss data were only obtained during September and October. However, rainfall records and crop yields were obtained.

In 1953, eight additional 14' x 80' plots were established on a west-facing 8% slope of the same soil type, for the purpose of comparing the effect of seedbed preparation by plowing versus that obtained by deep cultivation on the resulting water and soil losses and on crop yields. A four year rotation of corn, oats, and two years of alfalfa was established on each of two four-plot series, the soil of one set to be plowed for corn and for oats, the seedbed of the other set was prepared by deep cultivation for these two crops. Fertilizer was applied in the spring of each year to all 20 plots of the two erosion studies at the rate of 200 pounds of 5-20-20 per acre.

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[1]The erosion plots are maintained on the Soils Unit of the Agricultural Experiment Station, Rosemount.

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It was soon evident that erosion plots need prompt, experienced, and almost daily care if reasonable results were to be secured. Variations in soil depth and composition within the two experimental areas, the depredations of both pocket and striped gophers, pheasants, badgers, and intra plot competition from crabgrass were real problems. The combined effect of the problems mentioned made the gathering of reliable soil and water loss data from individual plots essentially impossible, and crop yields were generally the most meaningful of the information obtained. Since corn populations were not uniform on all plots, yields were also unreliable in some years. There remained a reasonable possibility that experimental results would have more meaning as the experiment progressed over a period of years, but the results obtained in late years were no more reliable than those originally secured. It also became evident that a rotation with alfalfa occupying the land half of the time was maintaining the soil in very desirable tilth, but this very maintenance allowed little opportunity for measurable losses of soil and water to occur. It was evident that both adequate replication and a more rigorous land use regime were essential in both experiments and should be initiated if reliable results were to be obtained.

Therefore, early in 1959, the entire 12 plot area on the south slope was planted to oats seeded down to alfalfa, with the intention of equalizing the crop rotation effect of the differential cropping systems used during the previous seven year period. This was necessary since the fertility levels of these plots had been considerably modified by the different cropping practices previously employed, and there was little possibility of satisfactory replication until these differences were removed by similar fertility and cropping practices of a few years at least. The collection troughs and sampling equipment were left in place and these plots will be again used with fewer treatments and adequate replication when experimentally practical.

Many Minnesota farmers are growing continuous corn under good fertility management with apparently good results. The success of this innovation on comparatively level fields has made more information of the possibilities and hazards of such practices on sloping fields. For this reason, the cropping system of the eight plots of the western slope, where two methods of seedbed preparation were being compared, was changed in 1959 from the corn-oats-alfalfa-alfalfa rotation to a four-replicate study of soil and water losses under well fertilized continuous corn. The experimental management consisted of contoured 40" rows with a population of approximately 17,000 corn plants per acre, fertilized with 5-20-20 at the rate of 200 pounds per acre in the hill at planting. Ammonium nitrate to supply 80 pounds of fertilizer nitrogen per acre was broadcast on each plot in early July. The plots were cultivated once and later hand-hoed in early July.

Weather

Although the month of April, 1959, was drier than normal, more than 32 inches of rain fell during the seven month (April-October) period, with 12.13 inches falling during August alone. Ten rains caused water runoff from the eight plots, with three of these rains removing measurable amounts of soil.

Water runoff occurred on June 11, 18, 26, and 28; July 8, August 5, 17, 22, and 24; and on September 2. Soil was carried off the plots by the rains of June 26 (averaging 0.30 tons per acre), June 28 (averaging 1.26 tons per acre) and on July 8 (average soil loss of 0.28 tons per acre).

Although rainfall intensity is one important factor contributing to soil and water losses, high intensity rains do not always result in such losses, since they may be of relatively short duration or the soil might be initially dry and relatively absorbent. The dates of the higher intensity rains during the seven month period are shown below:

June 28	-	1 1/4 inches of rain in 45 minutes
July 8	-	2 1/20 inches of rain in 65 minutes
August 5	-	2 1/2 inches of rain in 180 minutes
August 16	-	1 1/2 inches of rain in 60 minutes
August 21	-	1 1/2 inches of rain in 40 minutes

The months of June, July, and August appeared to be the more critical period for possible soil and water losses in 1959.

Results

Runoff and Soil Erosion from Two Types of Seedbed Preparation on an 8% Slope of Port Byron silt loam at Rosemount with Resulting Corn Yields

(April-October inclusive, 1959)

	Av. of 4 plowed plots	Av. of 4 deeply tilled plots	Advantage for deep tillage soil preparation
Water runoff in inches	6.25	5.60	0.65 less
Runoff as % of total pptn.	19.2	17.2	2% less
Soil loss in tons per acre	2.37	1.29	1.08 less
Bushels of ear corn/A @ 15.5% moisture	118.5	122.4	3.9 bushels more
% moisture in ear corn	33.3	31.4	1.9 less

Conclusions from the 1959 experiments

1. Nearly a fifth of the total seven month precipitation was lost by runoff. Approximately six inches of rain which fell was not available for crop production and possible storage in the soil.

2. The six inches of runoff water removed approximately two tons of soil per acre.

3. The plowed corn plots lost more water and more soil than did the corn plots where the seedbed was prepared by deep cultivation only.

4. The eight plots produced ear corn at the average rate of 120 bushels per acre. Although the average yield of the deep tillage plots was approximately four bushels greater than that of the plowed plots, this was of doubtful significance.