A Report on Field Research in Soils

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

Department of Soil Science
University of Minnesota

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Some of the results herein reported are from experiments carried on during 1963 only, and should not be regarded as the results obtained over a number of years. The investigations are those of a more practical nature, and do not include some of the more theoretical problems presently under study in greenhouse and in the laboratory. Because these are largely one year results they should not be considered as conclusive and the results are not for publication.

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Soil Surveys

H. F. Arneman, R. S. Farnham and R. H. Rust

The soil survey project is a project of long standing which deals with the mapping, correlation and classification of the soils of the state. Soil surveys are thought of as an inventory of this important resource.

The soil survey in Minnesota is a cooperative effort between the Department of Soil Science, Minnesota Agricultural Experiment Station, and the U.S.D.A. Soil Conservation Service. In recent years the Soil Conservation Service has had some 30 soil scientists mapping soils in Minnesota. With the sizeable group of men mapping soils many problems in classification and laboratory characterization of the soils have come about. With this in mind and because of our fine physical facilities, we in the Department of Soil Science have strengthened our survey effort in the field of laboratory characterization of the soils and in the field of soil correlation.

Soil correlation is a necessary step in the publication of the soil survey in any county. This past year we took part in final field reviews in Stevens and Steele Counties and the Lamberton Experimental Station. Reports are in progress for the counties.

Other activities of the soil survey group this past year included:

1) Publication of the revised generalized soils map and report on "The Soils of Minnesota".

2) Soil survey progress reviews in 6 counties.

3) Began making a systematic soil inventory on areas of possible plot area expansion at the Rosemount Station.

4) Gave assistance to county assessors where they are planning to use soil survey information as a real estate tax base.

5) Laboratory characterization of soil profiles was carried out to aid in soil correlation procedures.

This next year we plan to participate in final soil survey reviews in Goodhue and Swift Counties and progress reviews in Benton, Carlton, and Houston Counties; soils in the Chippewa National Forest will be studied broadly in the field; and an effort will be made to inform certain agencies and individuals such as the metropolitan planners, highway engineers and residential developers of the use and value of soil surveys in multiple land use planning.

Soil Productivity Study

R. H. Rust

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

Since the project began 491 farm cooperators have furnished crop and soil management data on some 92 extensive soil types in the state. Currently 327 cooperators are enrolled in the project. The following kinds of data are recorded: date and rate of seeding; stand estimate; kind and amount of soil amendments used; moisture and temperature conditions during the growing season; weed and insect control measures; yields and losses of yield from harvesting or abnormal conditions; soil tests of pH, available P and K, organic matter.

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

In the following table the various soils included in the study are listed together with (1) number of fields, and (2) number of yields. Where 2 or more yields of a crop have been recorded, the crops, number of fields, and the average yields are given. The reader may establish the location of the listed soils by reference to Soils of Minnesota, Ext. Bul. 278 (1963), or to the appropriate county soil report.

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

Table 1. Soil series, number of fields, and number of yields included in soil productivity study to date. Average yields of selected crops given where two or more yields received. Yields of grain crops in bushels; hay, silage, and sugar beets, in tons; pasture, in cow-acre days.

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

Aastad	(11)*	(39)**
Corn	11	48
Flax	6	12
Oats	5	53
Spring wheat	3	32
Barley	3	49
Alfalfa-brome-past.	3	136
Soybeans	2	22
Hay (other)	2	4.6
Anoka	(1)*	(1)**
Arlington	(1)	(4)
Oats	2	64
Barnes	(15)	(74)
Corn	25	56
Oats	11	61
Flax	7	8
Soybeans	6	23
Alfalfa-brome	6	1.6
Barley	5	42
Alfalfa	5	1.9
Spring wheat	4	31
Corn silage	2	6.0
Bearden	(7)	(15)
Corn	4	56
Barley	3	56
Spring wheat	3	37
Sugar beets	3	11.6
Beltrami	(4)	(11)
Oats	3	66
Alfalfa	3	3.4
Alfalfa-brome-past.	2	76
Corn	2	66
Blue Earth	(3)	(11)
Corn silage	4	8.9
Corn	3	48
Soybeans	3	18
Oats	2	25
Alfalfa-brome	2	3.0
Borup	(1)	(1)
Braham	(2)	(2)
Brainerd	(5)	(11)
Oats	4	32
Corn	2	52
Corn silage	2	13.0
Brickton	(4)	(4)
Buse-Barnes	(2)	(10)
Alfalfa-brome	3	1.6
Flax	2	9
Soybeans	2	13
Central	(4)	(5)
Chilgren	(5)	(22)
Oats	5	36
Barley	3	47
Flax	2	10
Spring wheat	2	25
Alfalfa	2	2.3
Alfalfa-tim.	3	2.4
Hay (other)	3	2.4
Corn silage	2	13.0
Clarion	(34)	(223)
Corn	44	75
Oats	24	67
Soybeans	10	29
Spring wheat	8	31
Alfalfa-brome	12	2.9
Alfalfa	9	2.6
Mix. Leg. grass	3	5.0
Corn silage	3	14.5
Alfalfa-brome-past.	3	228
Colvin	(5)	(14)
Alfalfa	4	3.6
Corn	5	61
Comfrey	(1)	(7)
Sorghum	3	8.0
Corn	2	60
Cormant	(4)	(12)
Oats	6	33
Alfalfa-brome	3	4.0

Downs	(3)	(12)
Corn	6	105
Oats	2	72
Alfalfa	3	3.4
Dubuque	(4)	(4)
Dundas	(4)	(12)
Alfalfa-brome	3	4.5
Alfalfa	2	1.7
Enstrom	(1)	(4)
Alfalfa-brome-past.	2	222
Estelline	(1)	(2)
Esterville	(14)	(49)
Corn	16	59
Oats	10	42
Alfalfa-brome	9	2.2
Alfalfa	6	3.3
Corn silage	6	7.8
Fairhaven	(4)	(12)
Corn	6	62
Oats	4	63
Fargo	(19)	(60)
Spring wheat	13	36
Oats	8	41
Soybeans	3	23
Flax	6	12
Barley	6	29
Alfalfa-brome	5	1.6
Alfalfa	2	3.1
Sugar beets	7	12.5
Fayette	(7)	(34)
Corn	14	92
Oats	6	50
Alfalfa-brome	6	6.0
Alfalfa	3	3.0
Flom	(8)	(27)
Corn	8	68
Oats	6	56
Soybeans	3	17
Flax	3	19
Corn silage	3	15.0
Floyd	(5)	(18)
Corn	9	81
Soybeans	4	26
Oats	3	87
Fossum	(2)	(4)

Foxhome	(1)	(3)
Freer	(3)	(15)
Oats	5	66
Hay (other)	3	2.3
Corn silage	2	6.7
Freon	(6)	(8)
Oats	5	56
Glencoe	(1)	(1)
Greenbush	(3)	(7)
Corn silage	2	12.5
Hay (other)	2	1.5
Grimstad	(6)	(21)
Barley	4	44
Flax	3	10
Soybeans	3	15
Spring wheat	3	27
Oats	3	75
Grygla	(3)	(9)
Oats	3	35
Hamerly	(1)	(3)
Flax	2	15
Hantho	(1)	(1)
Harpster	(1)	(2)
Oats	2	34
Hayden	(22)	(79)
Corn	24	76
Oats	15	55
Alfalfa	15	3.6
Alfalfa-brome	15	3.8
Alfalfa-brome-past.	6	267
Hegne	(6)	(14)
Spring wheat	4	35
Barley	3	47
Alfalfa	2	1.2
Potatoes	2	251
Hibbing	(4)	(4)
Hubbard	(14)	(59)
Corn	24	63
Soybeans	11	21
Oats	6	43
Potatoes	5	425
Alfalfa	6	2.4
Alfalfa-brome	3	2.3
Corn silage	3	15.5

Kasson	(2)	(7)
Oats	2	65
Kato	(1)	(5)
Kenyon	(2)	(9)
Corn	4	86
Hay (other)	3	3.7
Kingston	(3)	(13)
Corn	9	80
Soybeans	3	18
Kittson	(2)	(9)
Corn silage	2	4.9
Kranzberg	(2)	(7)
Alfalfa-brome	3	2.3
Alfalfa	2	2.3
Lamoure	(2)	(12)
Corn	4	56
Soybeans	3	32
Sweet corn	3	7.0
Lerdal	(1)	(6)
Corn	3	82
Lester	(10)	(36)
Alfalfa	13	3.8
Corn	9	69
Oats	6	58
Alfalfa-brome	5	3.2
LeSueur	(9)	(33)
Corn	20	76
Soybeans	5	22
Oats	3	53
Barley	2	49
Litchfield	(2)	(9)
Corn	2	83
Soybeans	2	23
Oats	2	86
Potatoes	2	455
Marcus	(1)	(1)
Marna	(5)	(16)
Corn	8	95
Soybeans	3	38
Alfalfa	2	5.1
Mavie	(1)	(2)
McDonaldsville	(1)	(2)
McIntosh	(3)	(16)
Oats	4	66
Spring wheat	4	35
Barley	3	64
Corn	2	70
Alfalfa	2	3.0
Menahga	(6)	(12)
Oats	2	31
Alfalfa-brome	4	2.5
Corn silage	4	9.4
Milaca	(8)	(25)
Oats	4	41
Corn	3	54
Hay (other)	5	2.2
Mix leg.-grass	4	2.0
Corn silage	4	12.1
Moody	(2)	(6)
Corn	4	70
Mora	(4)	(12)
Corn	4	55
Oats	2	75
Mixed leg.-grass	3	3.1
Nebish	(7)	(28)
Oats	9	48
Alfalfa	5	1.4
Alfalfa-brome	5	1.9
Alfalfa-brome-past.	5	80
Nicollet	(19)	(89)
Corn	37	75
Oats	13	58
Soybeans	12	29
Spring wheat	3	32
Barley	2	94
Alfalfa	11	3.8
Alfalfa-brome	4	4.0
Corn silage	4	7.9
Nokay	(5)	(10)
Corn	5	64
Oats	2	55
Nymore	(1)	(1)
Onamia	(5)	(19)
Oats	5	63
Corn	4	68
Alfalfa	4	3.5
Alfalfa-brome	2	1.8

Ostrander	(7)	(18)
Corn	6	86
Soybeans	2	26
Alfalfa	2	4.8
Parnell	(1)	(7)
Corn	4	38
Oats	2	75
Deep Peat	(6)	(19)
Corn	3	77
Soybeans	2	24
Timothy (seed)	2	330
Corn silage	2	6.5
Hay (other) past.	2	100
Leg.-grass past.	2	242
Shallow Peat	(5)	(7)
Soybeans	3	24
Barley	2	56
Pierce	(1)	(1)
Racine	(1)	(1)
Redby	(3)	(9)
Leg.-grass hay	3	1.5
Leg.-grass past.	3	63
Rocksbury	(12)	(32)
Oats	9	62
Flax	4	8
Alfalfa	2	2.3
Hay (other)	5	1.5
Sweet corn-brome	2	1.7
Hay (other) past.	3	117
Rockwell	(5)	(13)
Oats	3	52
Barley	3	23
Alfalfa	2	1.7
Corn silage	2	12.9
Rothsay	(1)	(1)
Sioux	(3)	(8)
Oats	4	31
Soybeans	2	12
Alfalfa	2	0.8
Shooks	(2)	(6)
Oats	2	38
Alfalfa	2	2.0
Skyberg	(3)	(10)
Corn	4	81
Oats	2	83
Leg.-grass past.	2	154
Sletton	(1)	(3)
Soybeans	2	30
Storden-Clarion	(1)	(6)
Oats	2	80
Alfalfa	4	2.6
Tama	(8)	(33)
Oats	10	64
Corn	6	94
Corn silage	3	14.2
Alfalfa	3	4.1
Alfalfa-brome	3	4.6
Leg.-grass hay	3	3.0
Alfalfa-brome past.	3	178
Taylor	(1)	(3)
Terrill	(1)	(2)
Todd	(2)	(6)
Alfalfa-brome	4	2.2
Truman	(3)	(9)
Corn	4	90
Ulen	(4)	(21)
Oats	6	43
Corn	5	56
Corn silage	2	15.5
Alfalfa	2	2.6
Vallers	(3)	(16)
Corn	4	55
Oats	2	63
Soybean	5	20
Varco	(1)	(5)
Corn	3	88
Alfalfa-brome	2	2.8
Vienna	(2)	(6)
Corn	3	63
Oats	2	60
Wabash	(1)	(4)
Corn	3	109
Wadena	(4)	(15)
Corn	6	81
Soybean	3	19
Oats	3	80

Waukegan	(9)	(33)
Corn	14	80
Oats	8	81
Alfalfa-brome	3	3.1
Alfalfa	2	2.5
Waukon	(9)	(32)
Corn	8	59
Oats	6	54
Barley	4	36
Spring wheat	2	30
Alfalfa	9	2.1
Mix. leg.-grass	2	3.2
Webster	(36)	(132)
Corn	62	88
Oats	22	61
Soybeans	14	19
Alfalfa	14	4.2
Alfalfa-brome	8	2.9
Corn silage	5	10.1
Alfalfa-brome past.	2	75
Webster Calc. Var.	(8)	(34)
Corn	12	89
Oats	3	85
Soybeans	10	34
Alfalfa	4	3.2
Wildwood	(2)	(6)
Oats	2	33
Winger	(4)	(18)
Oats	7	75
Barley	3	46
Spring wheat	3	34
Alfalfa	3	1.6
Zimmerman	(3)	(13)
Corn	2	71
Oats	2	57
Corn silage	3	11.0
Hay (other)	2	10.9

	No. Fields	No. Yields
Grand total as of December 1963	508	1844

Water Infiltration Studies on Some Minnesota Soils

R. H. Rust

During the past year a portable sprinkling infiltrometer (developed in a North Central States project) has been used to measure infiltration on the Port Byron soils (at Rosemount) and the Kenyon soils (in southeastern Minnesota).

Infiltration was measured on soils under bromegrass and on soils under corn for 2 or more years. The average intake rate on the Port Byron soils under corn was 0.8 in/hr; under bromegrass, 1.9 in/hr. On the Kenyon soils under bromegrass, 1.1 in/hr. (Corn plot measurements not completed). Water is applied at the rate of 4-5 inches per hour. As compared to other soils in the region, these rates are indicative of rather permeable soils.

The depth of wetting after 24 hours and after applying a total of about 6 inches of water was about 30 inches on the corn plots and about 48 inches under the bromegrass. Corn and bromegrass roots extend to at least 5 feet on the Port Byron and Kenyon soils.

The Probable Occurrence and Significance of Fragipan Soils in Minnesota

R. H. Rust

During the course of soil survey mapping in several areas in central and east-central Minnesota counties, a number of soils have been found to have horizons of a compacted, or somewhat cemented, character. To a considerable extent these soils seem to be associated with the occurrence of drumlin fields (the Wadena, Pierz-Brainerd, possibly the Toimi in parts of Ottertail east), Wadena, Todd, Morrison, Crow Wing, Benton, and St. Louis Counties. In addition, the soils in east-central Minnesota on the red to brown sandy loam tills often exhibit a compacted horizon in the lower part of the rooting zone.

One of the principal effects of this "fragi-zone" is to produce perched water tables which are most evident in late spring and result in delayed field operations often on the crests of drumlin ridges. The perched water table apparently also inhibits good root penetration by corn and legumes and probably increases the damage from frost-heaving on legumes. Whether the "fragi-zone" is compacted or cemented to the extent that roots cannot penetrate has not been fully established although preliminary observations suggest this is the case.

The occurrence of the "fragi-zones" is generally below 24 inches and commonly observed below 30 inches. This reduces the possibility of mechanical or chemical treatment of the zone as such although at the present no research has been done on this aspect.

Commonly a fertility problem also exists on these soils. Lime and potash are generally needed. Where these needs are met, the adverse effect of the fragipan seems to be somewhat reduced.

The Soil Conservation Service and the Experiment Station are currently studying the duration and effect of the perched water table as well as certain other physical and chemical properties of the soils.

Subsoil Fertility Study[1]

John Grava

Soil testing, in most cases, means analyses of samples collected from the top six inches, or plow layer. Since a great majority of recommendations are made for fields going into corn, a crop with comparatively shallow fibrous root system, sampling the topsoil alone seems to be sufficient. However, the subsoil largely determines the amount of moisture available to plants and often may be an important source of plant nutrients. Subsoil fertility may be especially important to deep rooted plants, such as alfalfa.

Since subsoil sampling is both time consuming and inconvenient, it is doubtful that farmers will adopt the practice as an integral part of a soil testing program. However, if information were available on subsoil fertility of major soil series, sampling the plow layer alone would be sufficient. With this in mind a subsoil fertility study was initiated in 1956. Profile samples were obtained by S.C.S. area soil scientists in connection with their regular soil survey work. Some profile samples are taken from fields included in the "Soil Productivity Study". It is expected that 20 or 30 profiles of each major soil series will be collected.

The samples are analyzed by routine testing methods and the results made available to S.C.S. soil scientists and staff members of the Soil Science Department. Information provided by this study has been used by staff members in selecting soils for a number of specific research projects. A portion of each sample is stored in a sample library for future use.

During the eight years of this study 4225 horizon samples from 840 soil profiles have been collected. General information on the soil profiles obtained for this study are given in tables 1 and 2. A list is also included to indicate the number of profiles collected for each soil series.

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[1]Department of Soil Science and Soil Conservation Service cooperating.

Table 1. Number of soil profiles received for the subsoil fertility study, 1956 to 1963.

Year	Number of Profiles	Number of Samples
1956	55	333
1957	185	984
1958	162	804
1959	101	487
1960	89	426
1961	60	307
1962	112	531
1963	76	353
Eight Year Total	840	4225

Table 2. Number of soil profiles obtained for Minnesota's subsoil fertility study by counties and SCS areas, 1956 to 1963

Area I. Scilley, Ravenholt, Barron Jacobson		Area II. Tordeen, Erickson, Lewis Friedrich, DeMartelaere, Miller		Area III. Grimes, Ziebell, Chamberlain		Area IV. Edwards, Diedrick, Sutton, Lueth, Munter Nyberg		Area V. Hokanson, Lorenzen, Paulson, Murray		Area VI. Cummins, Carlson		Area VII. Harms, Poch	
Beltrami	10	Becker	2	Aitkin	4	Big Stone	16	Jackson	1	Blue Earth	3	Dodge	3
Clearwater	3	Douglas	11	Benton	15	Carver	42	Lincoln	16	Brown	21	Fillmore	8
Kittson	7	Grant	7	Chisago	3	Chippewa	23	Lyon	10	Freeborn	21	Goodhue	9
Koochiching	4	Ottertail	19	Kanabec	4	Hennepin	6	Murray	13	LeSueur	15	Houston	6
Lake of the Woods	8	Stevens	24	Mille Lacs	6	Kandiyohi	20	Nobles	20	Martin	6	Mower	6
Mahnomen	6	Traverse	11	Morrison	12	Meeker	28	Pipestone	36	Rice	38	Olmsted	8
Marshall	3	Wadena	14	Sherburne	21	Pope	18	Redwood	4	Steele	42	Wabasha	19
Norman	14	Wilkin	10	Stearns	4	Renville	26	Rock	1	Waseca	20		
Pennington	5					Sibley	38	Yellow Medicine	6	Watonwan	10		
Polk	6					Swift	33						
Red Lake	4					Wright	6						
Area Total	70		101		69		256		109		176		59

List of profiles obtained from major soil series for Minnesota's subsoil fertility study, 1956-63.

FD Fayette - Dubuque	
Fayette	15
Dubuque	5
Whalan	1
Bertrand	3
TD Tama - Downs	
Tama	8
Muscatine	1
Downs	6
Watopa	2
Cashton	1
LH Lester - Hayden	
Dundas	9
Hayden	32
Erin	2
CL Clarion - Lester	
Lester	36
LeSueur	19
Cordova	20
Lerdal	4
HB Hayden - Bluffton	
Bluffton	2
Nessel	1
Ames	1
OFK Ostrander - Kenyon - Floyd	
Ostrander	3
Kenyon	5
Floyd	2
Racine	1
Taopi	3
Varco	1
SK Skyberg - Kasson	
Skyberg	2
Kasson	4
CNW Clarion - Nicollet - Webster	
Storden	6
Lakeville	1
CNW (Continued)	
Clarion	24
Nicollet	29
Webster	17
Webster, Calc. Var. (Canisteo)	21
Harpster	7
Terril	1
Comfrey	1
Fieldon	1
Rolfe	1
Thurman	1
Glencoe	9
Blue Earth	1
Truman	2
Kingston	4
Madelia	5
Marna	12
Lura	6
Guckeen	5
Beauford	9
MKV Moody - Kranzburg - Vienna	
Kranzburg	14
Brookings	3
Hidwood	2
Moody	2
Primghar	2
Marcus	2
Afton	1
Vienna	4
Lismore	4
Leota	2
Lamoure	3
Ihlen	1
BA Barnes - Aastad	
Buse	9
Barnes	28
Arco	3
Aastad	22
Hendricks	1
Flom	10
Parnell	7

BA (Continued)

Hamerly	13
Vallers	10
Alcester	2
Sverdrup	5
Tetonka	1
Pierce	1
Rothsay	2
Hantho	2

WB Waukon - Barnes

Waukon	4
Gonvick	2

FB Fargo - Bearden

Hegne	1
Fargo	5
Glyndon	1
Bearden	12
Colvin	9
Sletten	2
Borup	2

UST Ulen - Sioux - Tanberg

Ulen	9
Sioux	8
Fossum	2
Grimstad	3
Rockwell	4
Mavie	2

MW McIntosh - Winger

McIntosh	3
Winger	2
McDonaldsville	1

NR Nebish - Rockwood

Nebish	6
Beltrami	2
Shooks	2
Rockwood	3
Blowers	3
Paddock	2
Brickton	2
Todd	1

RKP Rocksbury - Kittson - Peat

Kittson	1
Rocksbury	3

TGP Taylor - Grygla - Peat

Baudette	2
Hiwood	2
Redby	1
Potamo	1
Chilgren	4
Grygla	1
Wildwood	1
Indus	1

MBH Milaca - Brainerd - Hibbing

Freon	7
Freer	2
Parent	2
Milaca	3
Mora	6
Bock	3
Langola	1
Pomroy	2
Watab	1
Flak	2
Brainerd	3
Barrows	1

ZIP Zimmerman - Isanti - Peat

Zimmerman	7
Nymore	8
Lino	2
Isanti	2

M Menahga

Menahga	5

WH Wadena - Hubbard & Terrace Soils

Hubbard	16
Wadena	6
Dickinson (CNW Group)	1
Estherville (BA group)	11
Fairhaven (CNW group)	6
Litchfield	2
Biscay	4
Kasota	5
Kato	1
Bixby	2
Waukegan	3
Estelline	5
Central	4
Renshaw	2
Fordville	1

Summary of Climatological Investigations 1963

by Donald G. Baker

Dept. of Soil Science

University of Minnesota

Soil Moisture

In table 1 are shown the fall, 1963, soil moisture results at various sites within the state. Almost all sites are lower in moisture than they were in fall, 1962. It is not apparent from these data, since only a limited part of the state is sampled, but from precipitation data and river flow it is known that except for the South-west, south-central and a part of the southeast the state is in a very dry condition. Unless conditions change drastically it would appear that the soil moisture status is indeed low and in a precarious position for the 1964 season in all but the south-west, south-central and a small part of the southeast.

For all sites except Crookston, Polk County, the approximate amount of water used during the season by the crop (see last column in table 1) is almost certainly too high. It would appear that either runoff or drainage, or both, were excessive at these stations this year. Values of 18-22 inches are more nearly what is to be expected. The low values at Crookston, 12.72-16.09 inches, are some lower than usual largely due to the low precipitation that fell during the sampling period, 9.88 inches.

Tables 2 and 3 show water use by period and the average amount consumer per day for several crops. Perhaps the most outstanding feature in these tables is the fact that water use per day is very nearly the same regardless of the crop. The total amount of water consumed during a season may vary between crops but this difference is essentially due to a longer or shorter growing period and in periods of moisture stress to one crop being able to exploit a greater volume of soil.

Based upon the data from Lamberton and Crookston (tables 2 and 3) the average amount of moisture used per day is the following:

April - 0.03 in./day	August - 0.14 in./day
May - 0.09 "	September - 0.09 "
June - 0.15 "	October - 0.05 "
July - 0.17 "	

Table 1. Summary of fall, 1963, soil moisture measurements.[1]

County	Nearby Town	Farm Operator	Soil Type	Date Sampled	Crop	Tot. available water present[2]	% Poss. Water	Diff. Fall'63-Fall'62	Approx. Am't water used in season[3]
Chippewa	Milan	H.S.Olson	Rothsay silt loam	11/5/63		8.12 in.	59%	-0.12 in.	
Dodge	Dodge Center	Sutherland	Kasson silt loam	11/12/63	Corn	6.45 in.	61%	+1.41 in.	
Kandiyohi		E. Nordstrom	Clarion silt loam	11/5/63	Alfalfa			Not sampled '62	
Kandiyohi		H. Arvidson	Nicollet	11/5/63		7.80 in.	54%	Not sampled '62	
Lac Qui Parle		Thompson	Aastad	11/5/63		9.64 in.	61%	-1.85 in.	
Lac Qui Parle	Marietta	I. Aebli	Rothsay silt loam	11/5/63		4.16 in.	32%	-4.14 in.	
Lac Qui Parle		M. Nelson	Barnes	11/5/63					
Lincoln	Arco	C. Madsen	Barnes clay loam	11/5/63					
Lincoln	Porter	B. Boulton	Barnes silty clay loam	11/5/63	Flax				
Lyon	Minneota	N. Orsen	Barnes clay loam	11/5/63		6.15 in.	53%	Not sampled '62	

Table 1. (Cont.)

County	Nearby Town	Farm Operator	Soil Type	Date Sampled	Crop	Tot. available water present[2]	% Poss. Water	Diff. Fall'63-Fall'62	Approx. Am't water used in season[3]
Lyon	Cottonwood	R. Olson	Aastad silty clay loam	11/5/63		8.37 in.	63%	Not sampled'62	
Lyon	Cottonwood	R. Olson	Barnes clay loam	11/11/63	Corn	6.68 in.	66%	Not sampled'62	
Lyon	Marshall	C. Boenboom	Vallers clay loam	11/11/63	Alfalfa	6.32 in.	51%	Not Sampled'62	
Mille Lacs	Milaca	T. Nichols	Mora silt loam	11/6/63	Hay	6.32 in.	65%	-1.99 in.	27.66 in.
Polk	Crookston	U. Minn.	Hegne silty clay	11/1/63	Alfalfa	0.07 in.	0%	-5.06 in.	16.09 in.
Polk	Crookston	U. Minn.	Fargo silty clay loam	11/1/63	Wheat	4.30 in.	25%	-3.82 in.	12.72 in.
Polk	Crookston	U. Minn.	Fargo silty clay loam	11/1/63	Sugarbeets	1.69 in.	10%	-4.92 in.	15.43 in.
Ramsey	St. Paul	U. Minn.	Waukegan silt loam	9/8/63	Soybeans	1.80 in.	21%	-6.30 in.	10.36 in.

Table 1. (Cont.)

County	Nearby Town	Farm Operator	Soil Type	Date Sampled	Crop	Tot. Available water present[2]	% Poss. water	Diff. Fall'63-Fall'62	Approx. Am't water used in season[3]
Redwood	Wabasso	D. Kuehn	Clarion silty clay loam	11/5/63	Corn	5.41 in.	42%	Not sampled'62	
Redwood	Belview	V. Anderson	Nicollet clay loam	11/5/63		7.09 in.	61%	-2.61 in.	
Redwood	Wabasso	D. Kuehn	Nicollet clay loam	11/6/63		7.18 in.	55%	Not sampled'62	
Redwood	Lamberton	U. Minn.	Webster silty clay loam	11/4/63	Corn	6.21 in.	63%	-1.12 in.	22.49 in.
Sibley	Gaylord	D. Woods	Nicollet clay loam	11/8/63	Corn	8.63 in.	73%	-0.47 in.	26.64 in.
Swift		C. Stobbs	Barnes	11/5/63				Not sampled'62	
Swift		J. Koosman	Pierce	11/5/63				Not sampled'62	
Swift		R. Tucker	Vallers	11/5/63		6.99 in.	48%	Not sampled'62	
Wabasha	Kellogg	K. Zickerick	Fayette silt loam	11/6/63	Oats	8.26 in.	53%	-3.33 in.	26.04 in.
Watonwan	Butter-field	E. Hansen	Nicollet clay loam	11/4/63	Alfalfa	5.19 in.	37%	-3.52 in.	27.77 in.

Table 1. (Cont.)

County	Nearby Town	Farm Operator	Soil Type	Date Sampled	Crop	Tot. Available water present[2]	% Poss. water	Diff. Fall'63-Fall'62	Approx. Am't water used in season[3]
Watonwan	Butterfield	Tilney	Kingston silt loam	11/15/63	Corn	5.61 in.	47%	+1.41 in.	24.14 in.
Yellow Medicine	Granite Falls	K. Velde	Aastad silty clay loam	11/5/63	Corn	10.24 in.	68%	Not sampled'62	

1. For the soil moisture samples we are indebted to many individuals of the Soil Conservation Service, U.S.D.A., the Agricultural Extension Service and the University of Minnesota Experiment Stations.

2. Within a 5 foot column of soil.

3. In all calculations it was assumed that all measured precipitation was used by the crop and that there was neither runoff nor drainage losses, which of course, is incorrect.

Table 2. Water consumption by corn, Lamberton, Minnesota - 1961, 1962 and 1963.[1]

1961			1962			1963		
Period	Water Use*	Water Use/ Day	Period	Water Use*	Water Use/ Day	Period	Water Use*	Water Use/ Day
4/12-5/1	3.14 in.	0.16 in.	5/1-5/28	2.22 in.	0.08 in.	4/3-5/1	1.28 in.	0.05 in.
5/1-6/28	6.89	0.12	5/28-6/27	7.31	0.24	5/1-6/13	6.07	0.14
6/28-7/28	3.01	0.10	6/27-7/31	6.86	0.20	6/13-6/27	2.15	0.15
7/28-8/30	5.11	0.15	7/31-8/31	4.61	0.15	6/27-7/29	5.92	0.19
8/30-10/2	4.01	0.12	8/31-9/26	2.03	0.08	7/29-8/29	4.65	0.15
Total = 22.16			9/26-10/31	0.02	0.00	8/29-10/19	2.42	0.05
			Total = 23.05			Total = 22.49		

* As determined in a 5 foot column of soil.

1. In all calculations it was assumed that all measured precipitation was used by the crop and that there was neither runoff nor drainage losses, which, of course, is incorrect; soil moisture determined gravimetrically; field soil moisture samples and precipitation data obtained through the courtesy of Dr. W. W. Nelson, Southwest Experiment Station, Lamberton.

Table 3. Water consumption of three crops, Crookston, Minnesota, 1962 and 1963.[1]

Alfalfa			Soybeans			Sugarbeets		
Period 1962	Water Use*	Water Use/ Day	Period 1962	Water Use*	Water Use/ Day	Period 1962	Water Use*	Water Use/ Day
4/17-5/7	0.13 in.	0.01 in.						
5/7-6/1	2.68	0.11	4/25-6/1	2.04 in.	0.05 in.			
6/1-6/30	4.65	0.16	6/1-7/2	4.51	0.15	5/31-6/30	4.55 in.	0.15 in.
6/30-7/31	5.46	0.18	7/2-7/31	5.58	0.19	6/30-7/31	6.05	0.19
7/31-8/30	4.55	0.15	7/31-8/30	3.58	0.12	7/31-8/30	2.98	0.10
8/30-10/1	2.85	0.09	8/30-10/1	2.39	0.07	8/30-10/1	2.84	0.09
10/1-11/1	2.59	0.08	10/1-11/1	1.60	0.05	10/1-11/2	2.82	0.09
Total = 22.91			Total = 19.70			Total = 19.24		

Alfalfa			Wheat			Sugarbeets		
Period 1963	Water Use*	Water Use/ Day	Period 1963	Water Use*	Water Use/ Day	Period 1963	Water Use*	Water Use/ Day
6/3-7/1	1.64 in.	0.06 in.	6/3-7/1	5.99 in.	0.21 in.	6/3-7/1	2.71 in.	0.10 in.
7/1-8/1	9.09	0.29	7/1-8/1	1.68	0.05	7/1-8/1	5.15	0.17
8/1-9/3	2.10	0.06	8/1-9/3	4.83	0.15	8/1-9/3	6.48	0.20
9/3-11/1	3.26	0.12	9/3-11/1	0.22	0.01	9/3-11/1	1.09	0.04
Total = 16.09			Total = 12.72			Total = 15.43		

* As determined in a 5 foot column of soil.

1. In all calculations it was assumed that all measured precipitation was used by the crop and that there was neither runoff nor drainage losses, which, of course, is incorrect; soil moisture determined gravimetrically; field soil moisture and precipitation data obtained through the courtesy of Dr. Olaf Soine, Northwest Experiment Station, Crookston.

Soil Temperatures

Average monthly soil temperatures under three different covers, sod, soybeans, and bare soil, are shown in Table 4. The great insulating value of sod is apparent for soil temperatures under the sod are cooler in summer and warmer in winter than in the other two plots.

Possibly the most interesting feature is the lag of both the average monthly maximum and minimum temperatures with depth. From about 960 cm. on the maxima and minima are about six months out of phase. This is apparent in Table 4 and particularly so in figure 1, in which is also presented a representation of the amount of heat gained and lost from the soil on an annual basis. This was calculated to be 3198 calories which is a bit less than 2½% of the annual incoming solar radiation as measured by an Eppley pyrheliometer. Most of the incoming solar energy is expended in evaporation rather than heating the earth.

Figures 2 and 3 show the sod plot soil temperatures at two different times of the year, one of which, figure 2, shows the "heating cycle" and the other is the "cooling cycle", figure 3.

As indicated in both figures 1 and 2 there is apparently still a 1° F. change at the 1280 cm. depth. It is not known for certain if this is real. Hopefully, with improved instrumentation this can be resolved in the coming year. If this temperature difference is real, then the fact that the annual heat wave is still apparent at 1280 cm. becomes rather surprising.

Table 4. Average Monthly soil temperatures, °F., St. Paul Campus, October, 1962, through September, 1963.

Depth	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Ave.
						Sod Covered Soil							
1	55	40	32	25	22	32	45	59	73	81	78	68	51
5	55	40	32	25	22	31	44	58	73	79	77	68	50
10	55	40	33	26	22	30	42	56	71	77	75	67	49
20	55	41	34	27	22	29	38	53	67	73	72	65	48
40	55	43	36	30	24	29	35	50	62	68	69	64	47
80	56	46	40	34	27	29	32	46	57	64	66	63	47
120	57	49	43	37	33	31	33	43	53	60	63	62	47
160	57	51	44	39	35	33	33	41	51	58	61	61	47
320	56	54	50	45	42	39	38	40	45	50	54	56	47
480	53	53	51	49	47	45	43	42	44	46	49	51	48
640	50	51	51	50	49	48	47	46	45	45	47	48	48
800	--	49	50	50	49	49	49	48	47	47	47	49	49
960	--	48	49	49	49	49	49	48	48	47	47	47	48
1120	--	48	48	48	48	49	49	48	48	48	47	47	48
1280	--	48	48	48	48	49	49	49	48	48	48	48	48
						Bare Soil							
1	56	37	23	10	20	39	57	69	89	95	89	74	55
5	57	37	26	11	21	37	55	67	87	93	87	75	54
10	56	38	27	12	20	33	51	62	81	88	83	72	52
20	54	37	28	12	18	30	46	57	74	82	78	68	49
40	54	39	32	15	17	28	40	52	69	77	75	67	47
80	56	44	37	23	20	27	35	48	62	71	72	66	47
						Soybean Soil							
1	54	37	26	18	20	37	53	65	89	85	74	68	52
5	56	37	28	19	19	35	52	63	83	80	72	67	51
10	55	38	29	19	19	33	50	61	79	79	71	67	50
20	54	38	30	21	19	31	45	56	73	76	70	65	48
40	53	40	33	24	20	28	38	51	66	72	68	64	46
80	55	44	38	31	24	28	33	47	60	67	66	63	46

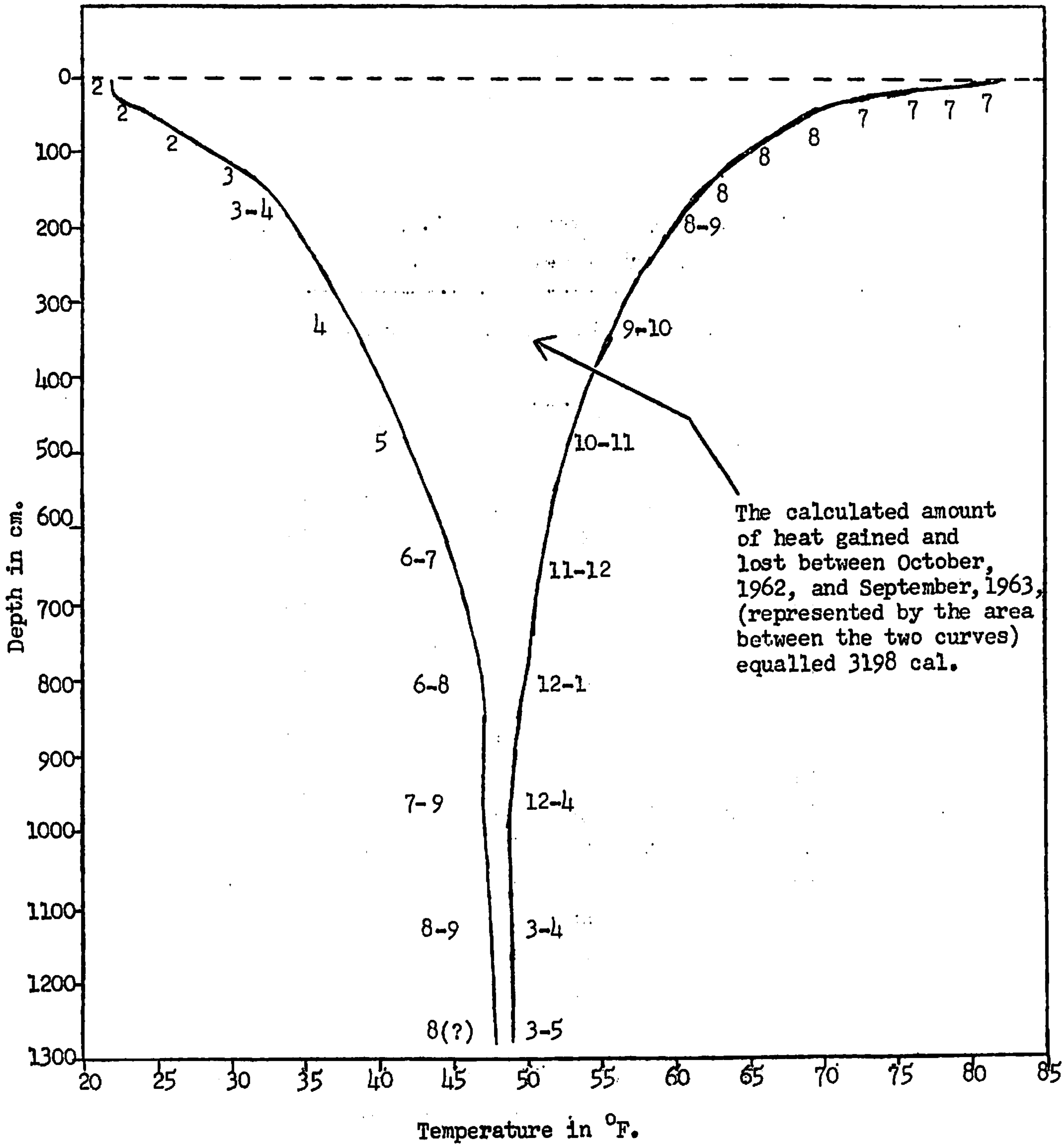

Fig. 1. Maximum and minimum average monthly soil temperatures under sod during the period October, 1962, to September, 1963. The numbers at each depth represent the month or months when the maximum or minimum average monthly temperature occurred (1 = January, 2 = February, etc.).

DGB; So. 133
1/64

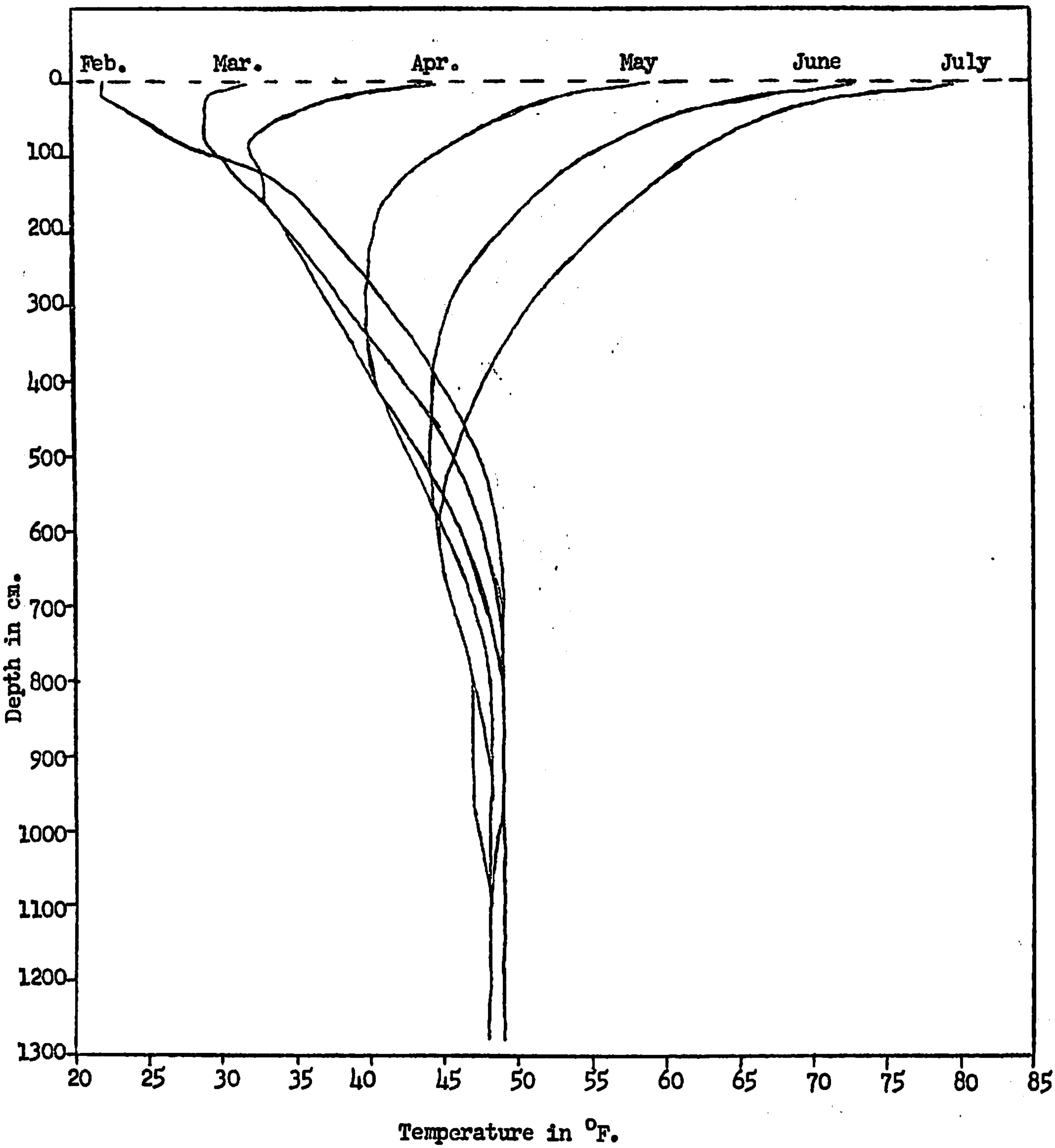

Figure 2. Average monthly soil temperatures under sod, February - July (from Oct., 1962 - Sept., 1963, data).

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1/64

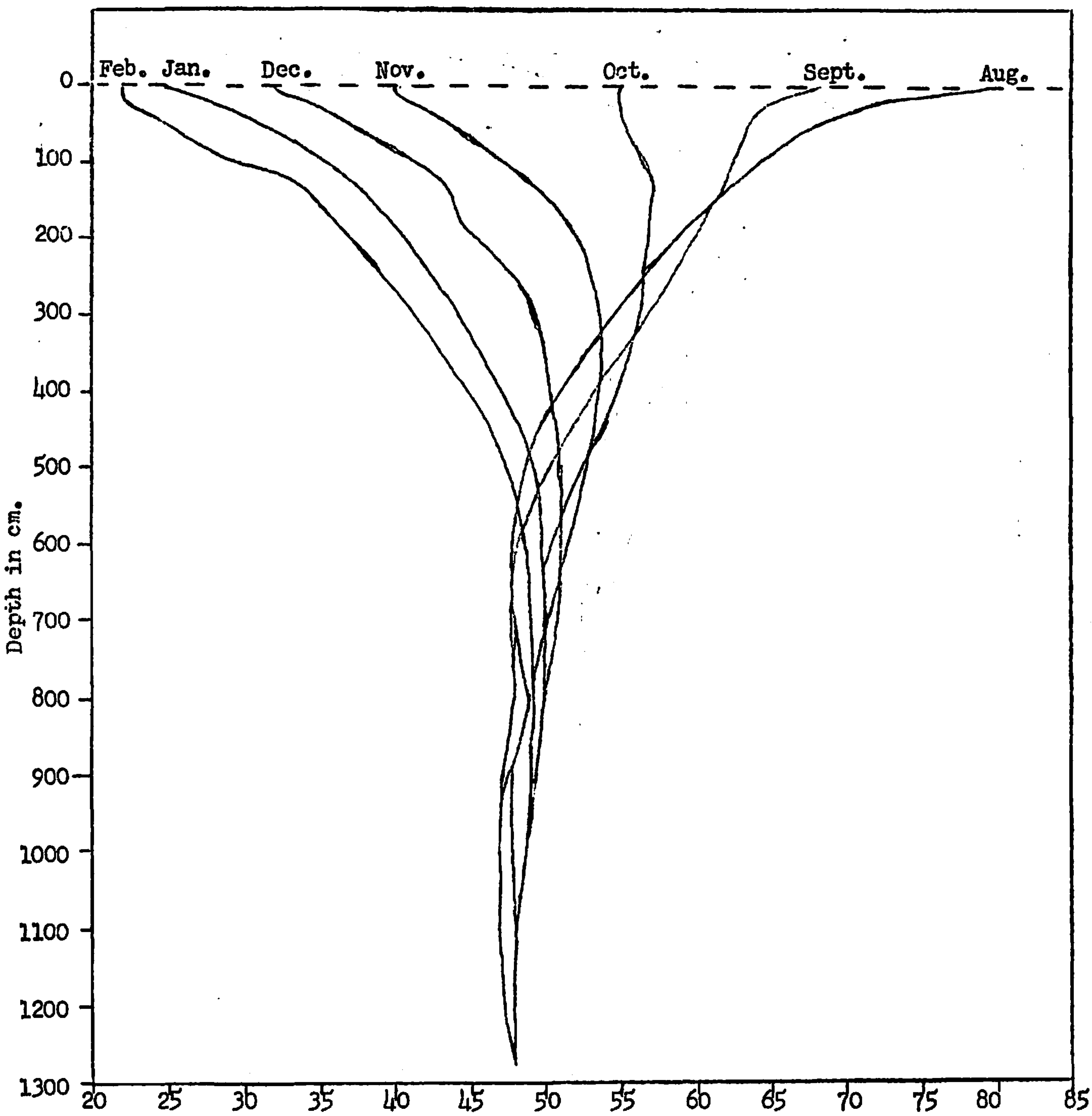


Figure 3. Average monthly soil temperatures under sod, August - February. (from Oct., 1962 - Sept., 1963, data).

DGB; So. 133
1/64

Air Temperatures in the Microclimate

For several years a daily record has been maintained of the minimum air temperature close to the earth's surface. The major objective was to determine how well the minimum temperatures as measured in the standard Weather Bureau shelter, which stands 5½ feet above the surface, agreed with minimum temperatures in the microclimate. As might be suspected the shelter temperatures are quite a bit higher as shown in Table 5. In December through February differences are not as great between the three microclimates and between them and the shelter due to snow cover. The minimum over a sod averages 5° F. lower and the bare soil only 3° F. lower than the shelter temperature. This is because when free of snow the bare soil loses more heat at night and thus prevents lower microclimatic temperatures from developing. The minimum temperatures in the soybean plot are not as low as over the sod because of protection offered by the soybean vegetative canopy.

Table 5. Comparison of average monthly minimum air temperatures, °F., October, 1962, through September, 1963, at St. Paul.

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Ave.
Shelter[1]	43	29	12	-3	6	26	38	45	59	63	59	53	36
Sod Soil[2]	36	25	11	-5	1	21	32	40	52	56	54	49	31
Soybean Soil[3]	38	26	11	-6	0	23	32	42	54	59	--	--	--
Bare Soil[4]	39	26	11	-4	3	22	33	42	55	60	56	50	33

1. Temperature measured within standard Weather Bureau shelter about 5½ feet above ground.

2. Temperature measured at top of grass blades during growing season or at 2 cm. above snow surface when snow present.

3. Temperature measured at 2 cm. above soil in soybean field during growing season or at 2 cm. above snow surface when snow present.

4. Temperature measured at 2 cm. above soil surface or at 2 cm. above snow surface when snow present.

General Climatology

Based upon Weather Bureau records the probability of occurrence in the spring and fall of certain low temperatures have been determined. Figures 4 and 5 illustrate some of the information obtained in that study.

A second study of similar nature was made with respect to defining agricultural seasons, determining when they began and ended and their average duration. Figures 6 and 7 are taken from that study.

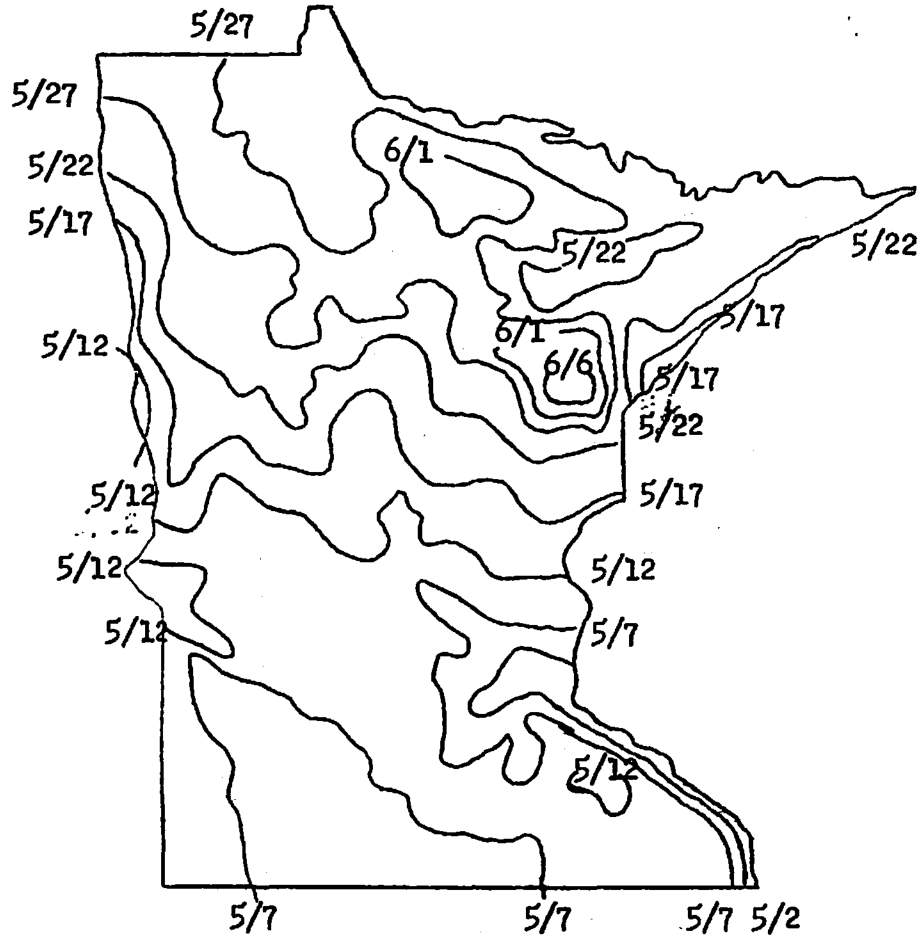


Fig. 4. Average date of last occurrence of 32° F. or lower in the spring.

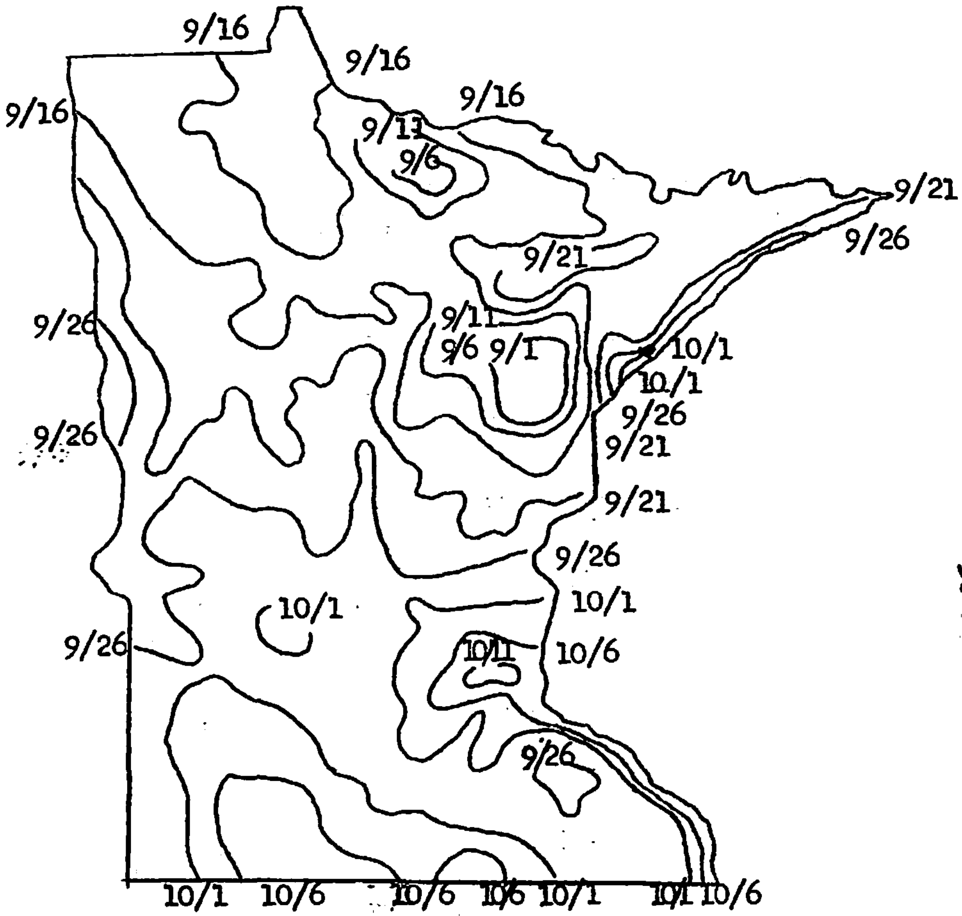


Fig. 5. Average date of first occurrence of 32° F. or lower in the fall.

(Both figures from: Baker, D. G., and Strub, J. H., Jr. 1963. Climate of Minnesota. Part I. Probability of occurrence in the spring and fall of selected low temperatures. Minn. Agric. Expt. Sta. Tech. Bull. 243.)

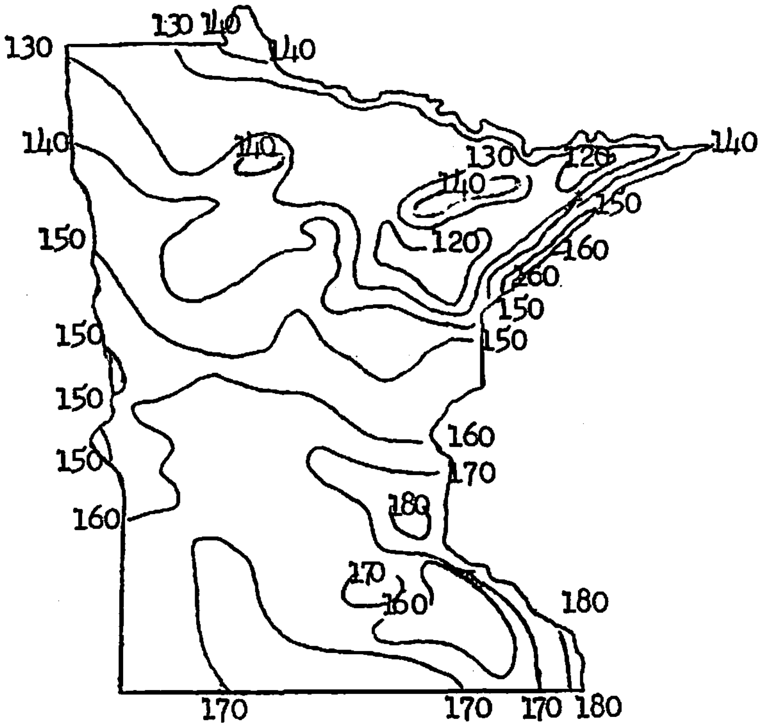


Figure 6. Average duration in days of the warm season crop (corn, soybeans) period -- late spring through late fall.

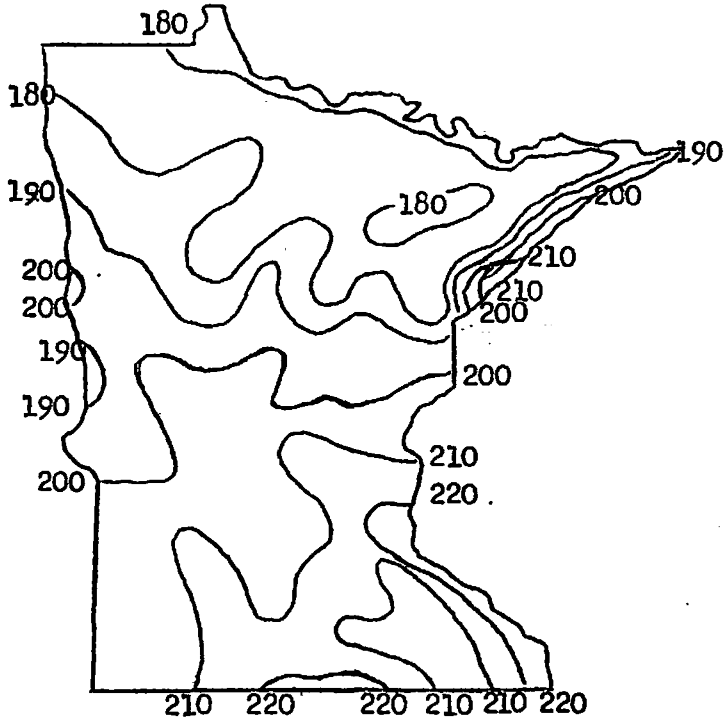


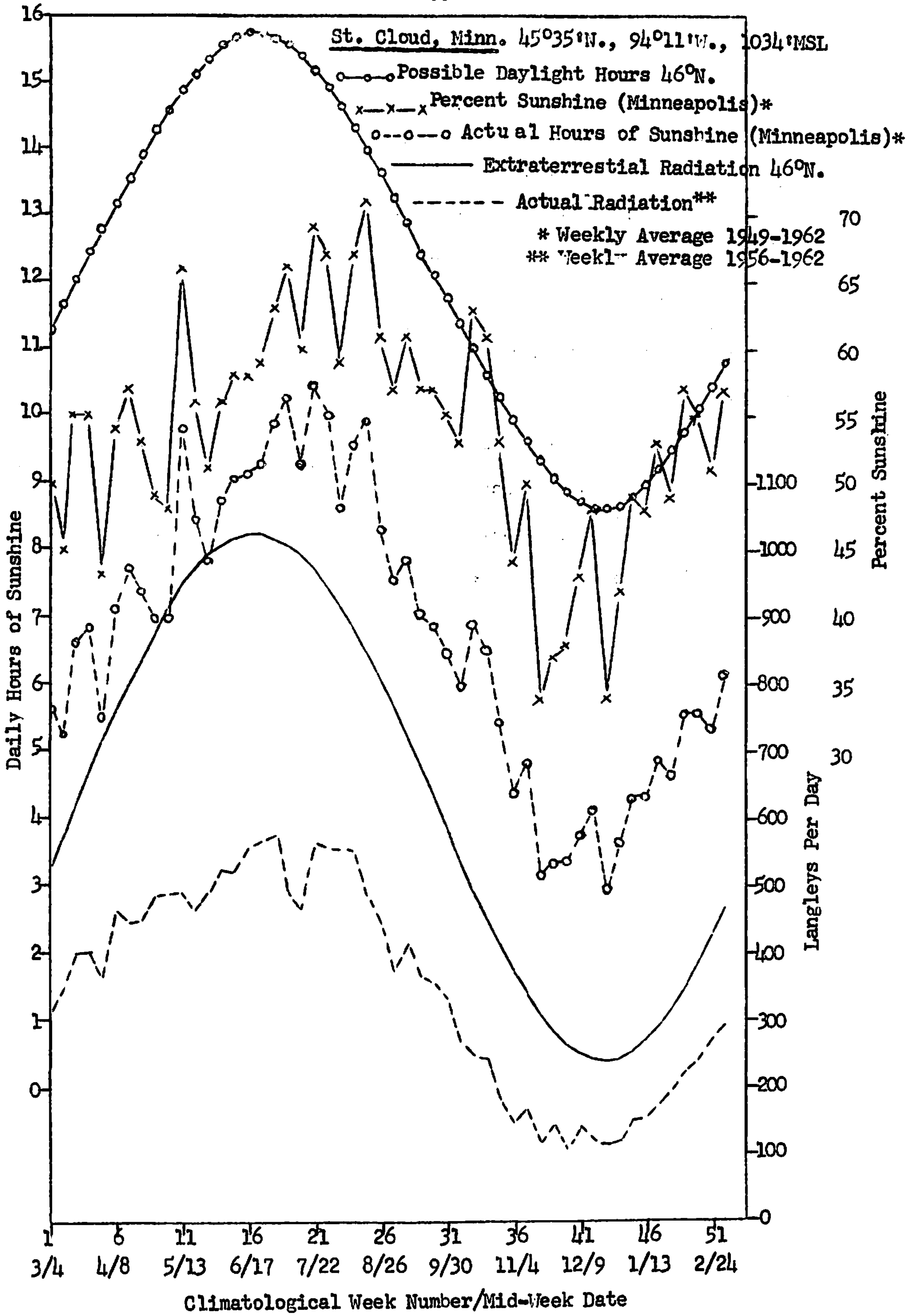
Figure 7. Average duration in days of the total crop season -- early spring through late fall.

(Both figures from: Baker, D. G., and Strub, J. H., Jr. 1963. Climate of Minnesota. Part II. The agricultural and minimum - temperature - free seasons. Minn. Agric. Expt. Sta. Tech. Bull. 245.)

Radiation

On a continual recording basis both solar radiation and net radiation are obtained at the Soils Department Weather Station. Detailed studies using these data are being made. Of a more general nature is a pilot study into the correlation between sunshine duration and solar radiation reception, as well as the distribution of each based upon climatological records.

The results obtained, though of preliminary nature, are interesting. The only item of this study to be presented here, however, is the following figure which shows the average weekly sunshine received at Minneapolis and the average weekly radiation received at St. Cloud. Incidentally, until a year ago these were the only stations in the state recording such data.


St. Cloud, Minn. 45°35'N., 94°11'W., 1034'MSL
Possible Daylight Hours 46°N.
Percent Sunshine (Minneapolis)*
Actual Hours of Sunshine (Minneapolis)*
Extraterrestial Radiation 46°N.
Actual Radiation**
* Weekly Average 1949-1962
** Weekly Average 1956-1962
Daily Hours of Sunshine
Langleys Per Day
Percent Sunshine
Climatological Week Number/Mid-Week Date
1 6 11 16 21 26 31 36 41 46 51
3/4 4/8 5/13 6/17 7/22 8/26 9/30 11/4 12/9 1/13 2/24

The Weather of 1963

The following summary was kindly provided by Mr. Joseph H. Strub, Jr., for inclusion in this outline.

Although January began quite warm, severe cold moved into the northern third of the State on the 10th and the rest of the State on the 11th. Daily minimum temperatures registered 0° F. or colder from then through January 31. Throughout February daily minimum temperatures were recorded 0° F. or colder for at least half of the month, but their occurrence was not consecutive as in January. Except for long-term mean precipitation over the southwest division during January and along the Canadian Border during February, January and February precipitation was much below the long-term mean. With the extended cold of January and February, and the lack of snowfall, frost penetration was much deeper this year compared to last year.

March temperatures were 4° to 9° above the long-term mean. Precipitation was near the mean. Although snowfall was near the mean, the above 32° F. temperatures the last 10 days of the month coupled with nighttime readings below 32° F. released the snow melt slowly so that there was no flood problem. Frost penetration came out rapidly. Record breaking temperatures in the sixties and seventies occurred the last 4 days of March. The last occurrence of 0° F. or colder occurred on March 22 at Gunflint Lake.

April temperatures continued warm with precipitation above the mean. Field work started throughout most of the State by mid-April. Seeding was well underway in the central and southern half of the State. Mississippi River navigation opened at Minneapolis-St. Paul on April 1 after a channel was made through Lake Pepin ice on March 31. The year's first storm of 3/4 inch hail occurred on April 1 in the Paynesville area.

What looked like the start of earlier-than-usual and an excellent agriculture season darkened somewhat as May turned out cool and wet. Western and southern Minnesota were hit hard by a freeze during the early morning hours of the 21st, 22nd, and 23rd as temperatures as low as 21° in some areas damaged soybeans, corn, peas, garden crops, and fruit trees. Greatest damage was sustained the morning of the 22nd. For many areas the temperature recorded was the coldest temperature of record for so late in the season. Regardless, planting and seeding were completed in most areas by May 31.

With the return of warm temperatures in June severe weather began to occur throughout the State. The season's first damaging windstorm covered southeastern Minnesota on June 8. The first 1963 tornado was observed at Janesville on June 9. The first occurrence of a temperature of 100° F. or more was recorded at Canby on June 29, 101°F.

June temperatures were below the long term mean with precipitation also below the mean with the exception of the southwest, south central, and parts of the north central and northeast divisions, where it was above. For all of the State there was little or no rainfall from June 10 through 27. This lack of rainfall aggravated by temperatures generally in the upper eighties and nineties the last 9 days of the month dried the State out. Although agricultural interests had sufficient moisture to continue growth, urban areas such as Minneapolis-St. Paul were suffering moisture to continue growth, urban areas such as Minneapolis-St. Paul were suffering as supplement watering was needed to sustain grass, shrubbery, ornamental trees, and truck gardens. Watering bans were in effect throughout many suburban areas by the end of the month.

The first eleven days of July were void of effective rainfall except for the southwestern and south central divisions. July rainfall ranged from 0.97 inch at Duluth to 13.61 inches at Canby. This July rainfall at Canby was more than the total seven month precipitation at Minneapolis-St. Paul, 12.62 inches. For the most part rainfall was heavy over the southern third of the State.

August rainfall was below the long-term mean but what fell was timely. September precipitation was above except for the northern third of the state and the southeast division. The remaining four months of the year were below the long-term monthly mean.

July temperatures were near the long-term mean with August below. September returned to above the long-term mean with October and November much above. The October-November months combined were the second warmest such period of record for many locations. Surprisingly, the warmest October-November for much of the state was that of 1953. Although a temperature of 32° or colder was reported in numerous areas in September, it wasn't until October 29 when temperatures were lower than 32° F. statewide that the growing season ended.

December ended 1963 the way it began in January with temperatures much below the long-term mean and precipitation also below except for north central Minnesota and along the Canadian border where it was above the long-term mean. For most of the state December was the fourth coldest of record. There were at least twelve consecutive days with a minimum temperature 0° F. or colder. On the 15th-16th and again for the period of the 19th through the 21st, the maximum, as well as the minimum temperatures, did not go higher than 0° F.

There was no snow in October except for a trace at Babbitt. November snowfall was light with the first measurable amounts falling on the 11th. Minneapolis-St. Paul had only a trace of snow during November. This had only happened once before in 1928. Winter came to Minnesota in a hurry on December 8-9 as 3 to 9 inches of snow fell throughout the state followed by sub-zero temperatures on the 11th. The first occurrence of -10° or colder was on December 11; of -20° or colder on December 15; and of -30° or colder on December 16.

With the snow and cold arriving in December as it did, winter agricultural routine and sporting activities went into high gear. Ice fisherman were on the lakes by the 10th as lakes over most of the state were ice covered by December 1. The subzero temperatures broke on the 22nd allowing Christmas shoppers to complete their buying.

The Mississippi River navigation season ended at Minneapolis-St. Paul on December 9 and at La Crescent-La Crosse on December 14. Lake Superior navigation terminated at Duluth on December 14.

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

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

The effect urea and ammonium nitrate as sources of nitrogen on the yield and composition of corn is being studied. The nitrogen materials are being plowed down and surface applied. The plowed down treatments are fall applications. The surface treatments were applied in fall, spring and a late sidedressing. This study was started in 1960.

Each experimental plot is 77.5 feet long and six corn rows wide. Each treatment is replicated four times. Sufficient phosphorus and potassium is applied as broadcast and starter applications. A plant population of 18,000 plants per acre is established. The primary objectives of this field project is to investigate:

1) The relative effectiveness of equal amounts of nitrogen as urea or as ammonium when applied to this soil at different rates.
2) The relative efficiency of such nitrogen forms when they are applied in the late fall, in the spring at time of planting, or as late sidedressing in late June or in early July.
3) The relative values of fall plowing down of two sources in comparison to overwintering of the nitrogen fertilizer on the surface of the fall plowed soil.
4) To find if there was any possible fertilizer nitrogen accumulation in the soil, the relative amounts removed by the corn crop and losses sustained through leaching, losses to the air, or losses by soil erosion.

For the first few years, all data was obtained by harvesting and analyzing the corn plants, and computing the nitrogen removal and relative efficiency based on amounts actually present in the corn plants. The plant parts were divided into ears, leaves, upper stalk and lower stalk. Soil samples were collected from some treatments during 1962 and 1963. The depths sampled were 0-6", 6-12" and 12-24".

The yield of corn in 1960 was quite low for all treatments. The 1961 yields were much higher than the 1960 yields and could be related to amount of applied nitrogen. In 1962 the weather was cold and wet and only sidedress applications indicate strong response to application of nitrogen.

The effect of nitrogen source, rate and time of application of urea and ammonium nitrate on the yield of continuous corn is presented for the 4 years (1960-63) in Table 1.

Table 1. The Effect of Nitrogen Source, Rate and Time of Application on the Yield of Continuous Corn at Lamberton from 1960-63.

(Ranked according to 1963 yield - average of 4 replicates)

Rank	Treatment (Lbs. N Per Acre)	Yield of Ear Corn (Bu./acre) 1960	1961	1962	1963*
1	80 as Urea plowed under fall	61.7	76.9	36.7	154.5
2	160 " Urea " " "	79.4	112.5	43.5	152.8
3	40 " NH_4NO_3 at planting	66.2	92.0	45.4	152.2
4	160 " NH_4NO_3 late sidedressing	40.7	97.4	77.7	151.7
5	80 " NH_4NO_3 plowed under fall	67.4	97.9	43.6	149.6
6	80 " Urea at planting	57.7	99.1	40.5	149.3
7	80 " NH_4NO_3 " "	59.3	90.0	32.7	149.2
8	40 " Urea plowed under fall	55.1	78.2	29.1	148.8
9	40 " NH_4NO_3 late sidedressing	63.6	92.6	39.5	148.6
10	40 " NH_4NO_3 plowed under fall	42.3	87.5	30.9	148.6
11	160 " NH_4NO_3 " " "	69.8	97.9	46.7	147.7
12	40 " Urea at planting	45.4	91.1	31.4	147.6
13	80 " Urea late sidedressing	76.9	86.4	48.2	143.8
14	40 " Urea " "	57.7	95.6	24.9	142.3
15	80 " NH_4NO_3 " "	50.4	98.4	46.7	140.7
16	40 " Urea left on plowed surface	62.3	101.3	37.0	140.7
17	40 " NH_4NO_3 " " " "	49.0	96.7	29.6	140.1
18	Check	49.5	88.2	26.1	132.6

* Duncan's New Multiple Range test = 0.05

The yields in table 1 are ranked according to the results obtained in 1963. These yields would not be ranked the same each year. The 1963 yields were not significantly different from each other as is drawn by Duncan's multiple rank test. However many treatments are significantly higher in yield than the check. The check as expected was the lowest yielding plot.

The total yield obtained over the 4 years of this field experiment, the total increase in yield and the calculated pounds of nitrogen applied per increase in yield of continuous corn as influenced by nitrogen source, rate and time of application is presented in Table 2.

Table 2. The Total Yield of 4 Years, Increase and Pounds of Nitrogen Applied Per Bushel Yield Increase of Continuous Corn as Influenced by Nitrogen Source, Rate & Time of Application at Lamberton (1960-63)

(Ranked according to 4 year total - average of 4 replicates)

Rank	Treatment (Lbs. N. per acre)	Total 4 yr. Yield	4 yr. Increase in Yield	Nitrogen Applied 4 yr.	Nitrogen Applied Per Increase Yield
		Bu/A.	Bu/A.	lbs./A.	lbs./bu.
1	160 as Urea plowed under fall	388.8	92.4	800	8.7
2	160 " NH_4NO_3 late sidedressing	367.5	71.1	800	11.3
3	160 " NH_4NO_3 plowed under fall	362.1	65.7	800	12.2
4	80 " NH_4NO_3 " " "	358.5	62.1	320	5.1
5	40 " NH_4NO_3 at planting	355.8	59.4	120	2.0
6	80 " Urea late sidedressing	355.3	58.9	320	9.0
7	80 " Urea at planting	346.6	50.2	320	6.4
8	40 " NH_4NO_3 late sidedressing	344.3	47.9	120	2.5
9	40 " Urea left on plowed surface	341.3	44.9	120	2.7
10	80 " NH_4NO_3 late sidedressing	336.2	39.8	320	8.0
11	80 " NH_4NO_3 at planting	331.2	34.8	320	9.2
12	80 " Urea plowed under fall	329.8	33.4	320	9.6
13	40 " Urea late sidedressing	320.5	24.1	120	5.0
14	40 " Urea at planting	315.5	19.1	120	6.3
15	40 " NH_4NO_3 left on plowed surface	315.4	19.0	120	6.3
16	40 " Urea plowed under fall	311.2	14.8	120	8.1
17	40 " NH_4NO_3 " " "	309.3	12.9	120	9.3
18	Check	296.4	----	----	----

The highest total yields were obtained on plots receiving 160 pounds of nitrogen and is independent of source, placement and time. The rank of total yields appear to very closely follow rate of nitrogen application. The late sidedressing and at planting time applications appear to be ranked higher for all of the increments of nitrogen that were applied. Generally the 40 pounds of nitrogen per acre application showed the least nitrogen required for increased yield of corn. These results indicate the 160 pounds of nitrogen per acre would be the least economic production in relation to nitrogen required for bushel increase in yield.

The effect of nitrogen source, rate and time of application on the total nitrogen content of 1963 continuous corn plots is presented in Table 3.

Table 3. The Effect of Nitrogen Source, Rate and Time of Application on the Total Nitrogen Content of 1963 Corn of the Continuous Corn Plots at Lamberton

(Total above ground plant parts - average of 4 replicates)

Treatment (lbs. N. Per acre)	Nitrogen in Plant Parts Leaves lbs N/A	Ears lbs N/A	Upper Stalks lbs N/A	Lower Stalk lbs N/A	Total Nit. lbs N/A	Inc. in Nit. lbs/A
Check	18.9	76.1	4.1	2.2	101.3	---
40 as NH_4NO_3 plowed down fall	24.9	71.3	4.9	3.7	104.8	3.5
40 " Urea " " "	23.7	92.3	5.4	4.9	126.0	24.7
40 " NH_4NO_3 left on surface fall	25.0	78.1	5.1	4.0	112.2	10.9
40 " Urea " " " "	22.7	87.0	4.6	4.4	118.7	17.4
80 " NH_4NO_3 plowed down fall	21.9	82.3	5.1	5.5	114.8	13.5
80 " Urea " " "	28.1	81.3	4.4	5.3	119.1	17.8
160 " NH_4NO_3 " " "	24.8	90.9	4.6	4.5	124.8	23.5
160 " Urea " " "	20.0	77.2	4.4	5.0	106.6	5.3
40 " NH_4NO_3 at planting	21.1	79.6	4.7	5.3	110.7	9.4
40 " Urea " "	23.5	61.6	4.2	3.8	93.1	-8.2
80 " NH_4NO_3 " "	18.6	74.5	3.7	5.8	102.6	1.3
80 " Urea " "	26.6	73.8	4.1	3.4	107.9	6.6
40 " NH_4NO_3 late sidedressing	20.5	71.8	4.1	4.0	100.4	-0.9
40 " Urea " "	29.7	70.2	4.4	3.8	108.1	6.8
80 " NH_4NO_3 " "	24.5	67.0	4.1	4.0	99.6	-1.7
80 " Urea " "	28.3	80.1	6.1	5.9	120.4	19.1
160 " NH_4NO_3 " "	20.0	80.1	6.1	5.9	114.3	13.0

The highest quantity of nitrogen in the above ground plant parts is generally from the plots where nitrogen was plowed down in the fall. The nitrogen yield did not appear to follow the rate of application or does it appear to be related to source of nitrogen. During the four years of this experiment the increase of nitrogen yield over the check was the lowest during 1963. Since all but ears are returned to the soil it would be anticipated that an increase in nitrogen yields would increase rather than decrease for the higher nitrogen rates. With adverse conditions for corn growth in 1963 the organic nitrogen may have been held and then released by the very favorable conditions existing in 1963. The analysis of soil from some of fertilized plots indicated exchangeable ammonia to be high in fall after treatment and nitrates to be high the following spring. Spring and sidedress plots were low in exchangeable ammonia and nitrates during entire growing season. The fall treatments were again low in exchangeable ammonia and nitrate by early summer and remained low all season. This would indicate available nitrogen was being utilized by the corn.

The Effect of Five Nitrogen Sources on the Yield of Corn at Lamberton

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

The influence of five nitrogen sources on the production of corn growing on Webster clay loam was investigated at Lamberton. Two fields were used in this experiment. These fields had corn following corn and corn following alfalfa. 175 lbs./acre of 8-24-12 was applied as a starter fertilizer.

The nitrogen sources, yields and yield increases is presented in Table 1.

Table 1. The effect of nitrogen source on yield of corn where corn follows corn and corn follows alfalfa on Webster clay at Lamberton

(Average of 4 replicates - 50 lbs. nitrogen/per acre applied)

Source of nitrogen	Corn following corn		Corn following alfalfa	
	Yield of corn	Increase over check	Yield of corn	Increase over check
	Bu/A	Bu/A	Bu/A	Bu/A
Check	63.7	--	88.5	--
33.5 - 0 - 0	81.0	17.3**	81.3	-7.2
Urea	82.3	18.6**	78.8	-9.7
Anhydrous	81.3	17.6**	80.7	-7.8
Liquid 20.5%	83.6	19.9**	87.1	-1.4
Liquid 37%	78.8	15.1*	80.7	-7.8

175 lbs/acre 8-24-12 starter fertilizer
* Significant 5% L.S.D.
** Significant 1% L.S.D.

All the sources of nitrogen significantly increased the yield of corn for the field where corn followed corn. There was a nonsignificant decrease in yield with nitrogen application for the field where corn followed alfalfa.

The Effect of High Rates of Phosphorus Application on the Growth and Composition of Corn and Soybeans

A. C. Caldwell and W. W. Nelson

In 1962 an experimental plot was established at Lamberton to study the effects of extremely high rates of phosphorus application on the yield and chemical composition of crops. Concentrated superphosphate was applied by broadcast application at rates up to 800 pounds of P per acre. In 1962 corn was grown on all of these plots. The treatments consisted of rates of broadcast phosphorus from 0 to 800 pounds per acre P with and without an additional starter fertilizer application of 40 pounds of P per acre. Corn was grown on these same treatments in 1963 and the results of both years shown in table 1. In 1963 soybeans were grown on those plots which received starter phosphorus in 1962.

In general, the data in table 1 indicate that the yield of corn was increased by the first increment of phosphorus added and no further increases found with increasing rate of application.

The phosphorus content of 6th leaf of untreated corn was below the critical level, but after application of 100 pounds per acre P the phosphorus content was above the critical level. The data also indicate that the manganese content was increased at higher levels of phosphorus application.

Data in table 2 show that the yield of soybeans was increased slightly due to the residual effect of phosphorus application. Phosphorus content of the soybean tissue increased with increasing rate of phosphorus application to the soil. Both zinc and aluminum contents of the plants were reduced by the application of high rates of phosphorus the previous year.

Table 1. Effect of phosphorus on the yield and nutrient composition of corn at Lamberton.

Broadcast fertilizer		Starter fertilizer	Shelled corn yield		Nutrient content of 1962 6th leaf samples[1]					
			1962	1963	P	Ca	Mg	Mn	Zn	Al
pp2m P	pp2m K	pp2m P	bu./acre		---------%------			-----ppm------		
0	0	0	53	138	.25	.24	.29	34	25	76
0	0	40	60	152	.26	.28	.33	46	27	88
50	0	0	58	144						
50	0	40	65	147						
100	0	0	60	148	.29	.29	.34	44	27	105
100	0	40	62	147	.31	.29	.33	47	34	128
100	100	0	70	148						
100	100	40	72	150						
200	0	0	72	142						
200	0	40	77	144						
200	200	0	67	155	.36	.27	.27	48	26	77
200	200	40	73	149	.31	.23	.23	45	24	71
400	0	0	56	148	.40	.30	.34	47	25	84
400	0	40	65	145	.38	.32	.36	61	40	133
800	0	0	74	147	.51	.30	.31	56	27	83
800	0	40	69	153	.60	.37	.38	71	24	87
L.S.D. (.05)			6	11						

[1]All analytic data analyzed from a composite sample analyzed by Ohio State University Spectrographic Laboratory.

Table 2. Yield and composition of soybeans as effected by phosphorus fertilization at Lamberton in 1963.

Fertilizer broadcast in 1962[1]		Yield of soybeans	Nutrient content of soybean tissue[2]					
			P	Ca	Mg	Mn	Zn	Al
pp2m P	pp2m K	bu./acre	---------%---------			-------ppm--------		
0	0	29	.24	1.55	.69	39	123	180
50	0	32						
100	0	33	.33	1.60	.77	39	83	148
100	100	32						
200	0	33						
200	200	32	.32	1.50	.57	37	54	120
400	0	32	.38	1.60	.77	39	72	110
800	0	31	.52	1.65	.80	39	65	115
L.S.D. (.05)		2.2						

[1]Also 40 pp2m P was applied to all plots as starter fertilizer in 1962.

[2]Chemical analysis run by the Ohio State University Spectrographic Laboratory.

Comparison of Phosphorus Sources

A. C. Caldwell and E. C. Seim

A phosphorus source experiment was established at Rosemount in 1951. Twelve treatments of various phosphate materials were replicated 4 times across a regular rotation of corn, wheat, and 2 years of alfalfa. In 1959 the rotation was changed to corn, soybeans, wheat, and alfalfa. Potassium has been applied as required according to soil test. Lime was applied to 2 replicates in the fall of 1961. Corn yields were significantly increased by phosphate treatments over the check but the differences between sources were not substantial and do not follow a consistent pattern over the years. Soybean yields in 1963 showed small but consistent increases to the phosphate treatments. No specific phosphate treatment has been consistently better over the years. Wheat yields were disappointingly low in 1963 because of late planting and dry weather immediately thereafter. As in past years large increases in the yield of alfalfa resulted from all sources whether or not the phosphorus was readily available.

Effect of various phosphate fertilizers on yield of corn, soybeans, wheat, and alfalfa.

(Rosemount, 1963)

Treatments	P_2O_5/A/Yr. Lbs.	Corn Bu/A	Soybeans Bu/A.	Wheat Bu/A.	*Alfalfa Tons/A.
None		94.4	26.8	11.5	1.42
Ord Super	40	119.3	26.7	13.5	2.50
Conc Super	40	108.7	27.6	15.4	2.50
Cal Meta	40	122.9	28.4	12.4	2.68
Phos. Acid	40	112.8	27.9	13.1	2.32
Fused trical. Phos	40	112.3	30.1	16.3	3.05
Fl. Rock & Ord. Super	20+20	115.2	29.4	14.7	2.60
Fl. Rock	100	109.1	27.2	13.6	2.04

(Cont.)

Effect of various phosphate fertilizers .... (Cont.)

Treatments	P_2O_5/A/4 Yr.	Corn	Soybeans	Wheat	*Alfalfa
Fl. Rock	1000	117.7	28.3	15.6	2.03
Western Rock	1000	115.7	29.3	14.7	1.90
Cal. Clay Rock	1000	99.0	27.6	13.6	2.19
Tunis. Rock	1000	120.6	29.0	11.4	2.19
* Only two replications					
Std error		3.3	1.7	2.1	.43
Lsd (.05)		9.5	NS	NS	NS
Hsd (.05)		16.7	NS	NS	NS

Yield and potassium content of alfalfa as affected by potassium applications

(Northeast Experiment Station)

H. J. Hopen, R. S. Grant and A. C. Caldwell

The residual effects of potassium applied in 1961 were still evident on the yield and potassium content of alfalfa in 1963. This soil is classed as one very low in exchangeable potassium. Levels of potassium in plants below 1.5% are considered deficient. Stand counts showed over twice as many alfalfa plants on the heavily fertilized plots.

Table 1. Yield and potassium content of alfalfa

Treatment lbs. K_2O/A	1st Harvest Yield tons/A.	1st Harvest K %	2nd Harvest Yield tons/A.	2nd Harvest K %
None	1.8	1.27	0.6	1.34
100	2.2	1.39	0.9	1.33
200	2.6	1.68	1.1	1.46
400	2.7	2.33	1.2	1.87
800	3.0	2.97	1.3	2.59

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

A. C. Caldwell and E. C. Seim

The purpose of this experiment, started in the fall of 1951, is to study the long time effects of lime on (1) the yields of some common crops and (2) on the physical and chemical properties of the soil. Treatments were 0, 3, 6, 12, and 24 tons of dolomitic lime per acre, replicated 4 times. A rotation of corn, oats, and 2 years of alfalfa was set up. Each year corn and oats have received 200 pounds of 5-20-20 per acre. The alfalfa has received P and K as needed according to soil tests. Since 1959 soybeans have replaced one year of alfalfa in the rotation. The beans receive 100 pounds of 5-20-20 per acre as a starter fertilizer.

In 1960, molybdenum (as $(NH_4)_2 MoO_4$) was applied at the rate of 8.7 ounces per acre on one of the check plots in each replicate.

Effect of the different treatments on yields are shown in the Table. Alfalfa yields have been most affected by lime, as has been the case in the past. Six tons of lime gave the greatest yield but 3 tons were nearly as effective as six tons in increasing the yield. Molybdenum was also effective in increasing alfalfa yields in 1963 as it was in 1962.

Oat yields were increased by all treatments, significantly so by 3 tons of lime and by the Mo treatment. This is what has been found in most other years except 1962 when the yields were erratic.

Increases in corn yields were not significant in 1963. In past years all treatments have generally increased corn yields. The diminished response to lime and molybdenum in 1963 may be attributed to the lower yields which reflect the effect of a period of drougth in midsummer.

There were no major effects of lime on soybeans.

Effect of lime and molybdenum on yields of alfalfa, oats, corn and soybeans

(Rosemount 1963)

Lime Treatment Tons/A.	Alfalfa (2 cuttings) Tons/A.	diff	Oats Bu/A.	diff	Corn Bu/A.	diff	Soybeans Bu/A.	diff
0	0.95	--	38.5	--	109.0	--	26.1	--
3	2.11	+1.16	48.2	+9.7	104.0	-5.0	27.7	+1.6
6	2.62	+1.67	40.1	+1.6	111.0	+2.0	26.7	+0.6
12	2.43	+1.48	40.4	+1.9	113.7	+4.7	27.2	+1.1
24	2.46	+1.51	39.8	+1.3	117.1	+8.1	26.8	+0.7
0 + 8.7 oz. Mo/A.	1.91	+0.96	44.2	+5.7	106.2	-2.8	26.1	--
Standard error		1.25		4.16		5.1		
Hsd (.05)		.55		N.S.		22.3		N.S.
Hsd .01		.70		N.S.		28.7		N.S.

Sulfur Investigations on Soils and Crops

A. C. Caldwell, Paulina Li, E. C. Seim,
George Rehm and W. P. Martin

Department of Soil Science
University of Minnesota

An active research program on sulfur has been conducted in Minnesota in 1963. Studies have been made in the field and laboratory. Major investigations have included effects of rates and kinds of sulfur - bearing materials on field crops, sulfur in the atmosphere, oxidation of elemental sulfur in the soil, and development of a satisfactory method of determining total sulfur in plants. Some of the results of these investigations are given below.

Field Research

One of the major areas of investigation of sulfur in soil was the field research conducted on an experimental area near Park Rapids. Alfalfa planted in 1962 received various rates of elemental sulfur and gypsum. About 1/2 of the plots were to receive no more sulfur and would serve as a measure of the residual effects of sulfur treatments; additional sulfur was added in 1963 to the remaining plots. All alfalfa plots were sampled for yield and tissue collected for analysis. Stand counts were made also. The plot area that had been in corn in 1962 was planted to alfalfa in 1963. Additional sulfur was applied to all plots except the control and two other sets that had gotten sulfur in 1962. Barley was planted and sulfur as elemental sulfur, gypsum and potassium sulfate was applied with the seed at planting time. Sulfur as sodium sulfate was broadcast for corn at rates of 5, 15 and 25 pounds of sulfur per acre. Treatments on soybeans consisted of broadcast applications of elemental sulfur at 25 and 50 pounds per acre and gypsum at the rate of 50 pounds of sulfur per acre. Barley, corn and soybeans were sampled for yield and tissue samples collected for analysis.

Yields of alfalfa on the Park Rapids sulfur experimental field showed no difference between plots which had gotten sulfur in 1962 and 1963, and those which had treatment only in 1963. Yields were greatly increased over the control by sulfur treatments however (table 1). There were no significant differences between the effects of elemental sulfur or gypsum. Generally elemental sulfur at 25 pounds of sulfur per acre was not as effective as 50 and 100 pounds. A spring plant count showed over twice as many plants on the sulfur treated plots as on the controls.

A nitric-perchloric digestion of alfalfa tissue collected in 1962 showed recovery of about 35% more sulfur than a dry combustion method previously used. Plants from control plots, for example, increased from .117 to .179% S (young plants). All sulfur treatments resulted in a large increase in the sulfur content of young and mature alfalfa plants. Gypsum was a more efficient form of sulfur in this respect than elemental sulfur.

Drouth hurt barley yields badly, differences between treatments were small, so no significant effects from sulfur were apparent. Applications of sulfur did result in increased sulfur in the plants however. Gypsum and potassium sulfate were more efficient in getting sulfur into the plant than was elemental sulfur. There were no significant effects of sulfur treatments on corn or soybeans.

Spectroscopic analysis of alfalfa, oat and corn tissue (1962 samples), showed no effects of sulfur on the content of other elements measured, including K, P, Ca, Mg, SiO_2, Mn, Fe, B, Cu, Zn, Al, Sr, Na and Ba.

Sulfur in the Atmosphere

Sulfur in the rainfall and SO_2 in the atmosphere were determined at 4 major sites, St. Paul, Duluth, Park Rapids and Lamberton. These sites are at the corners of a square approximately 200 miles on each side in an area of central Minnesota. Collections were made once a month and samples analyzed for total sulfur.

Estimates of sulfur as SO_2 and that in precipitation showed much greater amounts of both at St. Paul than any other station (table 2). At St. Paul the amount of sulfur in precipitation was 13.3 pounds per acre compared to 3.1 pounds at Park Rapids. Also there was 5 times more SO_2 in the atmosphere at St. Paul than in the air at Park Rapids.

Oxidation of Elemental Sulfur in Soils

Work was continued in 1963 on the oxidation of elemental sulfur in soils. Under investigation was the effect of particle size, rate of application, length of time of incubation, and temperature on sulfur oxidation. The effects of rate, particle size and time on the oxidation of elemental sulfur incorporated into 3 fertilizer materials were also studied.

Data on the oxidation of elemental sulfur showed that the amount of sulfur oxidized increased with decrease in particle size. Greatest oxidation occurred with particle sizes of less than 100 mesh. Oxidation reached a peak at 60 days of incubation time. The amount of sulfur applied to the soil did not seem to affect the fraction oxidized. Little sulfur was oxidized at 4° C., some at 10° C. (graph). Temperatures of 30° C. and 40° C. were more effective than 23° C. and lower. In studies with sulfur-fertilizer mixtures it was shown that maximum oxidation of fine and medium particle sizes (-10+30 and -30 mesh) occurred after 60 days of incubation, after which the amount oxidized declined (table 3). With larger particle sizes sulfur oxidation kept increasing slightly with time. Sulfur was oxidized to a greater extent in the nitric phosphates and diammonium phosphates than in the triple superphosphates.

The addition of sulfur to fertilizers did not affect water soluble or Bray No. 1 available phosphorus in triple superphosphate or diammonium phosphate. Sulfur did reduce both kinds of phosphorus in the nitric phosphates.

Determination of Sulfur in Plant Material by Nitric-Perchloric Digestion

A major effort was made to fashion a more satisfactory method for determining the sulfur content of plant tissue. Particular attention was given to the initial step of oxidizing plant material to see that complete oxidation of difficultly oxidizable sulfur compounds occurred, and to see that sulfur was not lost in some gaseous form. To check on completeness of oxidation, methionine (a difficultly oxidizable material) was digested. A major shift in method was going to a nitric-perchloric digestion rather than furnace combustion of a salt-organic material mixture.

It is our belief that we have now developed a satisfactory method of determining total sulfur in plant tissue. It was reported above that the amount of sulfur recovered in alfalfa by a nitric-perchloric digestion was up to 35% greater than a dry combustion procedure. Studies with methionine indicated an average of 98% recapture of this difficultly oxidizable material.

Table 1. Effect of sulfur bearing materials on stand and yield of alfalfa.

Material	Rate lbs. S/ac.	Stand plants per sq. ft.	Yield[1] S app'd. '62 only tons/ac.	Yield[1] S app'd. '62 & '63 tons/ac.
None	0	7	.46	.53
Sulfur	25	15	1.04	1.03
"	50	15	1.08	1.23
"	100	18	1.27	1.29
Gypsum	50	19	1.18	1.10
"	1000	14	1.04	
L.S.D.			.24	.25

[1] Two cuttings

Table 2. Sulfur dioxide in the atmosphere and sulfur in precipitation at four locations in Minnesota from Oct. '62 to Oct. '63.

Location	SO_2 lbs. S/ac.*	S in precip. lbs. S/ac.	Precip. inches
St. Paul	33.8	13.3	20.7
Duluth	9.3	6.9	19.2
Park Rapids	6.5	3.1	19.7
Lamberton	5.6	6.4	26.6

* Per acre of exposed surface of PbO_2 coated fabric.

Table 3. Oxidation of elemental sulfur in granulated fertilizers

Base Material	%S	Particle Size	Incubation Time, Days 10	60	120
			S oxidized, ppm		
14-14-14	5	-10 +20	9	16	27
14-14-14	6	-35	45	76	62
0-42-0	15	-10 +20	5	12	10
0-42-0	17	-35	21	56	34
18-45-0	13	-10 +20	10	42	26
18-45-0	18	-35	25	61	30

L.S.D., 0.05 = 10

* Added to soil at rate of 100 ppm S

Table 4. Sulfur recovery of thiourea and methionine by digestion with nitric-perchloric acids.

Thiourea Added ppm S	Thiourea Recov'd. %	Methionine Added ppm S	Methionine Recov'd %
40	94	40	98
"	96	"	98
"	96	"	98
"	96	"	94
"	98	"	96

FOLIAR, SOIL AND SEED TREATMENTS WITH IRON ON SOYBEANS IN 1963

by

J. M. MacGregor

Soybeans growing on some calcareous soils developed a yellowed leaf condition caused by a deficiency of iron inducing insufficient chlorophyll development. This yellowed condition of soybeans usually occurs in more or less scattered areas in the affected fields, and seldom is an entire soybean field affected. Some soybean varieties are more seriously affected than others, and cool, moist growing seasons favor the condition. In serious cases, soybean yellowing may be apparent from the time of plant emergence late in May or early June, but it usually becomes more noticeable in mid-June. Since mineral soils usually contain at least 1% iron (which would mean some 10 tons of iron per acre six inches of soil) and plants need only 1 or 2 pounds of iron per acre to grow a crop, it is obvious that any iron deficiency of plants must be due to limited iron availability rather than total supply present in the soil.

Research on the problem has shown that the yellowing of plants condition is the result of many interacting soil factors, of which the presence of free lime in the soil is probably the most important. Since it is economically impractical to remove the free lime from calcareous agricultural soils, the problem becomes one of increasing iron availability. Iron occurs in soils in two forms, the proportion of each depending upon the relative soil acidity and alkalinity.

1. Ferric iron which is relatively insoluble in water (FeO or iron rust is an example) and becomes even more so as the pH passes neutrality and becomes alkaline. In alkaline soils, essentially all solid iron occurs in the ferric (unavailable) form.

2. Ferrous iron, which is soluble in water and may become so abundant in strongly acid soils as to create toxic conditions for plant root growth. Soil acids dissolve iron bearing minerals at a relatively rapid rate to produce a soil water solution relatively high in ferrous (available) iron, and this soluble iron excess also tends to limit phosphorus availability. However, strongly acid soils high in quartz sand may actually be deficient in total iron.

Mineral soils which are approximately neutral in reaction usually contain relatively small amounts of ferrous iron, but since most plants require only one or two pounds of iron per acre for normal growth, iron availability is seldom a problem. As soil pH rises, and eventually free lime is present, more and more of the ferrous iron is oxidized to the ferric form, until some plant species are unable to obtain sufficient soluble iron to support normal chlorophyll formation. One can lime an acid soil to improve soil reaction, but it is impractical to attempt to remove excess free lime from a soil by any chemical means now available. The problem of correcting iron chlorosis of plants becomes one of either adding iron to the soil or plant in a form which will remain available for much of the growing season, or adding some substance which will render the unavailable soil iron more available.

A. 1963 Seed or Soil Treatments

Field experiments in which various iron compounds have been banded along the soybean row near the yellowed seedlings have been carried on for several years with generally unsatisfactory results. The only treatment which corrected the soybean chlorosis in every trial, was the banded application of Chelate-138 HFe (HFe EDDHA) when banded at the rate of 100 pounds per acre. Since the cost of such a treatment would approach three hundred dollars per acre, this is obviously an impractical corrective treatment for field crops such as soybeans.

In 1963, several possible available iron containing materials were either stuck to the soybean seed coat, or were applied in the row at planting time in contact with the seed. This was done on two farm soybean fields known to have a chlorotic soybean problem, using two soybean varieties, Lindarin and Chippewa. One field was located near Gaylord in Sibley County, while the second was planted much later in Kandiyohi County near Pennock. The Pennock field was not harvested because of an uneven stand and serious weed competition. Each of four replicates consisted of three rows 20 feet in length, of which 15 feet of the center row was harvested in October to determine yield and treatment effect.

Growth observations were made each week on both fields, but at no time was there significant difference in the degree of chlorosis on the different treatments. The yields obtained on the Sibley County field are shown in Table 1.

Table 1. The Effect of Iron Treatments on Seed or to a Calcareous Soil on the 1963 Soybean Yield at Gaylord (Harpster clay loam-pH of 8.0)

No.	Iron Treatment	Lindarin	Chippewa
		(Bushels per acre)	
1	None	11.6	12.7
		Yield increase for iron treatment	
2	Kalo seed treatment	-2.6	1.9
3	Fe Chelate 138@1#/A (0.06#Fe/A)	-4.4	-3.0
4	Fe " " @20#/A (1.2#Fe/A)	1.1	----
5	Chelate 138@20#/A (no Fe)	-3.4	----
6	" " on vermiculite 2.5#/A or 0.06#Fe	-1.8	----
7	Versenol Fe on vermiculite @1#/A or 0.06#Fe	-3.6	----
8	Grace 7-35-0 (Fe amm. phos) 78#Fe/A	-1.5	-0.4
9	ADM Chelate 138Fe + $FeSO_4$ (21.2%Fe) @0.954#/A	-3.7	0.2
10	ADM coated $FeSO_4$ (21.2%Fe) @0.954#/A	1.9	1.4
	Significant (5%)	3.8 bu.	5.5 bu.

It is obvious that none of the nine treatments had a favorable effect on the yield of either soybean variety. Treatment 5 was the only one which contained no iron with the intention that some of the soil iron might be made available to the growing soybeans.

B. 1963 Iron Spraying of Chlorotic Soybeans

Since calcarious soils quickly oxidize the available ferrous iron to the unavailable ferric iron, many investigators have recommended the spraying of chlorotic soybean plants with ferrous iron compounds, based on the theory that the iron would be absorbed into the leaves and never come into contact with the soil. In 1948, the Iowa Agricultural Extension Service recommended the spraying of chlorotic soybeans with ferrous sulfate at the rate 10 pounds per acre after dissolving in 50 gallons of water. This would have a material cost of some 40 cents per acre. Some Minnesota county agents have investigated this treatment with generally unsatisfactory results.

The Tennessee Corporation of Atlanta, Georgia manufactures a compound "Nu-Iron" containing 30% iron readily absorbable by plants.

In the latter part of June, three chlorotic soybean field areas were selected for iron spray treatments -- the first field being located one mile west of Lake Lillian on Highway 7 in Kandiyohi County, the second approximately midway between Willmar and Raymond on Highway 23 in Kandiyohi County, and the third field was 8 miles east of Montevideo on Highway 7 in Chippewa County. Each treatment was replicated four times on the three fields, with one row plots 20 feet in length.

Since the sprays were to be applied by hand, it was considered that this would be more efficiently applied than with power spraying equipment, so both the recommended treatment rate and one-tenth the recommended treatment rate were applied on June 21, and a second application was sprayed on as a second treatment on half the plots eleven days later (July 2).

The chlorotic plants on the differently sprayed treatments were observed at weekly intervals, and while some leaf scorching was noted on the heavier (recommended) rate treatments, considerable leaf greening occurred during early July. The entire chlorotic area of the Chippewa county field recovered its green color at this time, but this recovery was irrespective of any spray treatment. Soybean plants on both of the Kandiyohi field areas remained largely chlorotic, and eventually the plants on several feet of both sprayed or unsprayed soybean rows died completely, and only stubs of the soybean stems remained. The three fields were harvested in early October, and the calculated yields are shown in Table 2. (Next page)

Calcareous soils on which soybean chlorosis occurs are extremely variable, and relatively large increases or decreases in yield are necessary for mathematical significance effect. None of the increases or decreases shown in Table 2 are consistent or are sufficiently large to attribute as due to iron spray effect alone.

Conclusions

None of the 1963 seed coating, soil, or spraying treatments with iron compounds to correct iron chlorosis were effective for improving soybean chlorosis or yield, and hence cannot be recommended for farm use.

Table 2. The Effect of Spraying Chlorotic Soybeans with Ferrous Sulfate and Nu-Iron on 1963 Yield

Location Soybean variety	Lake Lillian Chippewa	Raymond Chippewa	Montevideo Harmon	Ave.
Treatment	Yield in bushels per acre			
None	13.5	14.8	27.4	18.6
	Yield increase for iron spray			
$FeSO_4$ 1#/A June	2.3	0.6	1.8	1.6
$FeSO_4$ 1#/A June + July	2.5	1.7	-0.5	1.2
$FeSO_4$ 10#/A June	4.0	4.3	-3.0	1.6
$FeSO_4$ 10#/A June + July	5.3	4.8	-1.2	3.0
Nu-Iron (1/10 rec. rate) - June	5.1	-1.7	-1.7	0.6
Nu-Iron (1/10 rec. rate) - June + July	2.4	0.1	-1.5	0.3
Nu-Iron (rec. rate) - June	-3.0	1.8	-3.3	-1.5
Nu-Iron (rec. rate) - June + July	-1.0	6.0	-3.8	0.4
Significant (5%)	8.0 bu.	7.4 bu.	5.7 bu.	

State Survey of Zinc in Corn

D. F. Bezdicek and John MacGregor*

Zinc deficiency in corn was first reported from central Minnesota in 1961. Soils in this area are believed to contain adequate total zinc, but conditions brought about by high soil pH and high lime reduce the amount available for normal plant growth.

A state survey of corn conducted in 1962 showed that zinc deficiency occurred in Meeker, Swift, and Kandiyohi Counties.

A more thorough survey was conducted in 1963 to study the relationship between leaf zinc concentration and observed deficiency symptoms, soil pH, and soil type. Results from 100 samplings showed a probable zinc deficiency in twelve Minnesota counties. A general relationship between leaf zinc concentration and the degree of observed zinc deficiency was found. Visual deficiency symptoms began to appear when the leaf zinc concentration fell below 15 to 17 parts per million (ppm). This value is near the minimum critical level of leaf zinc reported by other investigators.

Table 1 shows the relationship between leaf zinc coneentration and great soil group and soil series. Some of the soils of the Calcium Carbonate Solonchak, Chernozem, and Humic Gley are at a critical minimum available zinc level based on leaf zinc concentration.

Several soils were further classified as being available zinc deficients on the basis that the leaf samples taken contained less than 15 ppm zinc and that zinc deficiency symptoms were observed. These appear in Table 2.

Corn grown on these soils may not necessarily respond to zinc fertilization. However, there is a greater probability of zinc response to corn on these soils and also to other high lime soils not included in the survey.

* The cooperation of the Soil Conservation Service personnel for their assistance in the soil classification is hereby acknowledged.

Table 1. The average Zn content of "index leaf" samples taken from corn growing on various soil series of great soil groups included in 1963 Minnesota zinc survey.

Great soil group and series	Average "index leaf" Zn content ppm		Number of fields sampled	
Gray-Brown Podzolic	20.9		3	
Hayden		19.3		1
Seaton		21.1		1
Fayette		22.4		1
Gray-Brown Podzolic-Brunizem	26.9		7	
Lester		16.6		2
Downs		21.2		1
Racine		29.6		2
Kasson		33.6		1
Mt Carroll		33.9		1
Brunizem	21.9		6	
Waukegan		12.8		1
Kingston		12.3		1
Kenyon		18.1		1
Nicollet		20.3		1
Port Byron		31.8		1
Ostrander		36.0		1
Humic Gley	20.6		15	
Parnell		9.6		1
Harpster		15.2		1
Lura		15.4		1
Marna		16.5		1
Webster		16.9		2
Flom		18.0		3
Hatfield		19.5		2
Floyd		20.7		1
Glencoe		22.8		1
Lamoure		33.8		1
Blue Earth		37.9		1
Chernozem	17.5		11	
Kranzburg		13.6		1
Barnes		15.6		4
Brookings		16.6		1
Aastad		17.9		4
Estelline		24.0		1

(Cont.)

Table 1. (Cont.)

Great soil group and series	Average "index leaf" Zn content ppm		Number of fields sampled	
Calcium Carbonate Solonchak	15.0		31	
Ulen		10.7		1
Borup		11.8		1
Colvin		14.3		14
Bearden		14.8		4
Vallers		18.3		9
Hamerly		20.3		2

Table 2. Predicted "available zinc deficient" soil series of the 1963 survey on the basis that leaf samples taken form the soil sampling area exhibited both zinc deficiency symptoms and contained 15 ppm Zn or less in the "index leaf" at silking.

1. Aastad	7. Colvin	13. Ulen
2. Barnes	8. Hamerly	14. Vallers
3. Bearden	9. Harpster	15. Webster calcareous variant
4. Beauford	10. Kranzburg	16. 36-H*
5. Borup	11. Lura	*Swift County Soil Conservation Service
6. Buse	12. Parnell	

Fertilizer Rotation Experiment

West Central Experiment Station

S. D. Evans and A. C. Caldwell

An NPK factorial experiment involving the three nutrients alone and in all combinations applied across a 5 year rotation and continuous corn has been in existence for 8 years. The 5 year rotation crops are flax, alfalfa, corn, corn and soybeans. Treatments and rates are as given in the tables.

The experiments were started by Soil Science personnel but are handled now by help at the station led by Dr. Evans.

N-P-K EXPERIMENT - 1963

Table 1. Yield of Continuous Corn

Treatment	$N-P_2O_5-K_2O$ Lbs/A	Average Yield Bu/A	Diff. from Untreated	Treatment Effect
None	0+0+0	46.62	- -	- -
N	160+0+0	57.91	+11.29	+20.87*
P	0+140+0	45.28	- 1.34	- 4.32
K	0+0+40	51.02	+ 4.40	- 3.11
NP	144+140+0	70.93	+24.31	+ 6.93
NK	160+0+40	67.61	+20.99	+ 2.41
PK	0+140+40	29.85	-16.77	-10.16
NPK	144+140+40	59.83	+13.21	- 0.24
NPK+	304+320+80	59.83	+13.21	- -

Table 2. Yield of First Year Corn

Treatment	$N-P_2O_5-K_2O$ Lbs/A.	Average Yield Bu/A.	Diff. From Untreated	Treatment Effect
None	0+0+0	88.28	- -	- -
N	60+0+0	76.16	-12.12	- 5.45
P	0+20+0	94.52	+ 6.24	+12.91*
K	0+0+40	78.58	- 9.70	+ 0.16
NP	44+20+0	88.53	+ 0.35	+ 0.42
NK	60+0+40	78.96	- 9.32	+ 3.60
PK	0+20+40	97.33	+ 9.05	- 3.60
NPK	44+20+40	93.25	+ 4.97	- 2.65
NPK+	84+100+80	84.70	- 3.58	- -

Table 3. Yield of Second Year Corn

Treatment	Lbs/A $N-P_2O_5-K_2O$	Bu/A Average Yield	Diff. From Untreated	Treatment Effect
None	0+0+0	64.42	- -	- -
N	80+0+0	67.73	+ 3.31	+ 6.43
P	0+60+0	70.16	+ 5.74	+14.05**
K	0+0+40	55.87	- 8.55	- 3.42
NP	64+60+0	81.01	+16.59	+ 2.60
NK	80+0+40	60.21	- 4.21	- 0.65
PK	0+60+40	73.03	- 8.61	- 4.54
NPK	64+60+40	80.24	-15.82	- 1.16
NPK+	104+100+80	90.19	+25.77	- -

Table 4. Yield of Soybeans

Treatment	Lbs/A $N-P_2O_5-K_2O$	Bu/A Average Yield	Diff. From Untreated	Treatment Effect
None	0+0+0	32.02	- -	- -
N	20+0+0	33.95	+ 1.93	+ 0.21
P	0+40+0	31.56	- 0.46	- 0.81
K	0+0+40	31.76	- 0.26	- 0.63
NP	20+40+0	32.59	+ 0.57	- 1.26
NK	20+0+40	31.50	- 0.52	- 1.27
PK	0+40+40	31.84	- 0.18	+ 0.09
NPK	20+40+40	29.98	- 2.04	- 0.17
NPK+	40+80+80	33.01	+ 0.99	- -

Table 5. Yield of Flax

Treatment	Lbs/A $N-P_2O_5-K_2O$	Bu/A Average Yield	Diff. From Untreated	Treatment Effect
None	0+0+0	27.88	- -	- -
N	60+0+0	26.71	- 1.17	- 0.82
P	0+40+0	28.87	+ 0.99	+ 0.65
K	0+0+20	24.42	- 3.46	- 0.63
NP	60+40+0	25.54	- 2.34	- 1.65
NK	60+0+20	27.41	- 0.47	+ 1.43
PK	0+40+20	28.20	+ 0.32	+ 0.74
NPK	60+40+20	26.43	- 1.45	- 0.57
NPK+	120+80+40	26.39	- 1.49	- -

Table 6. Yield of Alfalfa

Treatment	Lbs/A $N-P_2O_5-K_2O$	Tons/A Average Yield	Diff. From Untreated	Treatment Effect
None	0+0+0	3.32	- -	- -
N	20+0+0	3.23	- 0.09	+ 0.25
P	0+80+0	5.19	+ 1.87	+ 1.92**
K	0+0+40	2.59	- 0.73	- 0.31
NP	20+80+0	4.75	+ 1.43	+ 0.15
NK	20+0+40	3.80	+ 0.48	+ 0.51
PK	0+80+40	5.19	+ 1.87	+ 0.23
NPK	20+80+40	5.51	+ 2.19	- 0.13
NPK+	20+160+80	4.71	+ 1.39	- -

THE NICOLLET COUNTY PLOTS: Webster soils of southern Minnesota

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

Yield Results 1963

See 1962 results, p. 34 in Soil Fertility "blue book."

CONTINUOUS CORN: Rate and time of application (Started 1954)

Nitrogen treatments:		Yield results:	
Total	Time*	Starter only**	+PK broadcast***
None	0-0-0	107 bu./acre	95 bu./acre
40 lbs.	1-0-0	152	144
80	1-1-0	147	159
120	1-1-1	151	156
80	1-0-1	154	161
80	0-1-1	147	153
40	0-0-1	145	149
40	0-1-0	143	148
80	2-0-0	151	141
120	3-0-0	156	154

* Refers to time of application as between planting time-first cultivation-second cultivation; example: 1-0-0 means 40 lbs. N at planting time.
** 200 lbs. 6-24-12 in the row at planting time.
*** Starter plus 300 lbs. 0-20-20 broadcast.

CORN-OATS, with and without legume green manure (Started 1948)

	Corn:	(with legume)	Oats:	(with legume)
1. Check	75 bu/ac.	69 bu/ac.	45 bu/ac.	59 bu/ac.
2. N on oats	98	81	77	82
3. NP on oats	129	98	84	85
4. NPK on oats	129	101	97	99
5. P plowdown	136	96	56	70
6. NPK in hill	114	99	43	74
7. N plowdown	81*	100*	60*	56*
8. N sidedress	136*	115*	67*	67*

* One replication only vs three.

NICOLLET COUNTY PLOTS CONTINUED

CORN-SOYBEANS-CORN-OATS-HAY (with regular and extra-heavy fertilization treatments)
(Started 1948 as 4-year rotation; soybeans added in 1958)

Standard Treatment	Corn bu./ac.	(*)	Soybeans bu./ac.	(*)	Corn bu./ac.	(*)	Oats bu./ac.	(*)	Hay tons/ac.	(*) **
6. Check	122	147	43	44	114	148	83	93	1.4	2.1
1. P on oats	130	132	42	41	109	122	82	95	1.7	2.1
2. PK on oats	148	144	44	43	116	130	92	97	2.2	2.5
7. NP on oats	129	142	43	45	126	123	98	100	1.9	1.8
3. NPK on oats	139	145	48	40	129	128	98	94	1.5	2.0
10. P on oats & corn	128	144	41	41	127	128	84	95	1.7	2.1
4. Manure on corn	144	141	45	46	144	157	82	92	1.8	2.3
8. Manure & P on corn	150	144	43	47	140	157	88	96	1.9	2.2
5. Manure & NPK on corn	148	142	44	48	141	153	90	98	2.0	2.2

(*) Denotes extra-heavy fertilizer treatments.
** Only one hay cut salvaged because of wet weather.

CONTINUOUS CORN-HIGH FERTILITY EXPERIMENT
Rosemount Experiment Station
Soils

W. P. Martin and H. W. Kramer

Yield results 1963 (For experimental design and past years results see p. 47 in mimeographed "blue book", Feb., 1963).

		16,000 plants	20,000 plants
1.	Check	80 bu./acre	84 bu./acre
2.	H*	80	92
3.	H S1	82	98
4.	H S2	90	99
5.	B1 H	79	87
6.	B1 H S1	83	99
7.	B1 H S2	89	98
8.	B2 H	83	96
9.	B2 H S1	86	95
10.	B2 H S2	89	95

* H = 200 lbs. 10-20-20 hill drop.
S1 = 100 lbs. 33-0-0 sidedress.
S2 = 200 lbs. " "
B1 = 400 lbs. 6-12-24 broadcast.
B2 = 800 lbs. " "

Controlled Availability Fertilizer on Corn

Rosemount Agricultural Exp. Station
1963

Paul M. Burson

In recent years many new forms of fertilizing materials have been appearing on the market. Of the more recent are fertilizers that have controlled availability or the nutrients are released to the plant at a controlled rate. Because of this controlled rate of release it is thought that the fertilizer would be more efficient, less danger of germination injury and could be applied at higher rates near the seed and roots.

A very limited amount of the controlled fertilizer material was made available to the Soil Science Department in 1963. This fertilizer had a formula of 10 + 20 + 10. This was compared with a regular commercial fertilizer of the same grade with each being applied at 200 lbs. per acre in a band on paired rows. The moisture supply was very limited in 1963. From June 10th there was no rain for 37 days.

The controlled availability was 30% on the nitrogen and 80% on the phosphorus with no controlled availability on the potash. The corn grown with the controlled fertilizer was slower in emergence and was never as advanced in growth throughout the season as was the corn fertilized with the regular grade. The following table gives the comparative yields and final stand.

Table 1. Controlled availability fertilizer on corn - Rosemount, 1963.

		10 + 20 + 10 - 200#/A. - Band	
	Check	Regular	Controlled[1]
Bu./acre	62.0	120.0	111.0
Stand[2]	18	20	20

[1] Availability
N - 30% with controlled availability
P_2O_5 - 80% with controlled availability
100#N sidedressed 1st cultivation

[2] Thousand

Pop-Up Fertilization of Corn

Rosemount Agricultural Experiment Station
1963
Paul M. Burson

Pop-up fertilization is a term given to the placing of a small amount of fertilizer with the seed at planting time in addition to the regular starter application. It is believed by some states this is important because it would give the corn a faster start at the time of planting and a more uniform emergence and stand. This idea would then seem to support the use of the split boot placement of the starter fertilizer because some of the starter will always come in contact with the corn seed. However, with the split boot method there is no way of knowing the amount and where the fertilizer will be placed. Some will be with the seed, some on the surface of the soil, some on the side of the row and generally none of the fertilizer will be placed at the proper depth. It has been found at Rosemount that with the split boot method the germination of corn was injured and the final stand and yields were reduced as compared to the band method.

In 1963 a corn planter with a band fertilizer attachment was equipped with an additional applicator calibrated so a positive amount of fertilizer could be put in with the corn seed along with the regular banded starter fertilizer. The band placement of the starter was 2 inches to the side and 2 inches below the seed. The banded starter fertilizer used on all pop-up plots was 6 + 24 + 12 at 200 lbs. per acre. Four pop-up fertilizers were used. They included 0 +45 + 0, 18 + 46 + 0, 6 + 24 + 12, and 6 + 12 + 24 compared with a check and the starter which had no pop-up fertilizer. Moisture was very limited in 1963. No rain occured for 37 days following June 10th but no more injury occurred on the pop-up than the regular method of application.

The following table gives the yield results with the various pop-up and starter combinations. No differences could be observed in the field except there was slightly more early growth on the 18 + 46 + 0 pop-up. However, on the 6 + 12 + 24 pop-up there was uneven emergence, poor stand and a retarded growth for the entire season.

These yield data would suggest there was a response to the nitrogen and the potash in the pop-up fertilizer providing these nutrients are not excessive in amounts.

Table 1. Pop-up fertilization of corn - Rosemount, 1963.

		6 + 24 + 12 - 200#/A. - Band					
	Check	0+0+0	6+24+12		0+46+0	18+46+0	6+12+24
Pop-up rate/A.	---	---	50#	100#	50#	50#	100#
Bu./A. yield	109.0	115.0	136.0	134.0	122.0	127.0	114.0
Stand[1]	19	20	20	20	20	20	18

[1]Thousand
No N sidedressed

PROFIT POSSIBILITY PLOTS 1963

C. J. Overdahl, John Grava, Lowell Hanson, Merle Halverson

Summary of Plot Results - 37 Plots
(Excluding westernmost counties)

There were 71 kits distributed, and 51 fields harvested by county agents. Average check plot yield was 97 bushels per acre which may explain in part why profits were so low. Average corn yield estimate for the state is 69 bushels per acre which is more than 9 bushels above the 1962 average and 12 bushels above the 1957-61 average which would indicate that 1963 was a good corn year.

I. Number of plots according to various soil test ranges of pH, P and K levels

	pH			P				K				
Soil test	<6	6 to 7	>7.1	L	M	H	VH	L	ML	MH	H	VH
No. plots	5	21	11	4	16	7	10	7	5	14	5	6

II. Number of plots in various yield increase ranges

	Unprofitable	Profitable to Very Profitable		
Nitrogen	< 4 bu.	4 to 10 bu.	11 to 20 bu.	>20 bu.
30 lbs. S.D.	15	7	13	2
	<7	(7 to 10 bu.)		
60 lbs. S.D.	15	6	10	6
	<11			
90 lbs. S.D.	18	--	10	9

Phosphate	< 4 bu.	4 to 10 bu.	11 to 20 bu.	>20 bu.
30 lbs. row	19	7	8	2
w	<7 bu.	(7 to 10 bu.)		
60 lbs. row	21	3	8	4

Potash	< 2 bu.	2 to 10 bu.	11 to 20	21 to 30	>30
30 lbs. row	14	9	8	2	3
	< 4 bu.	(4 to 10 bu.)			
60 lbs. row	16	4	11	3	3
	< 5 bu.	(5 to 10 bu.)			
90 lbs. row	18	5	3	5	5

Results were similar in the Barnes-Aastad soil area. Plots from this area were excluded because of plot design differences

Profits were considerably below those observed in 1962. The percentage of plots with profitable yield increases from 60 lbs. of N, 30 lbs. of P_2O_5, and 30 lbs. of K_2O were as follows:

Year	No. fields	Av. yield check plot	N (60 lbs.)	P_2O_5 (30 lbs.)	K_2O (30 lbs.)
1962	37	65	68%	59%	81%
1963	37	97	61%	47%	60%

Profits were less in 1963 from rates higher than 60+30+30. All the phosphate and potash was row applied plus a small amount of nitrogen for best phosphate uptake. (The 30 lb. rate of phosphate was applied as 9-36-0; the 60 lb. rate had 0-45-0 added to the 9-36-0).

We are indebted to the National Plant Food Institute for funds supplied to cover packaging and shipping costs. Sohio Chemical Company furnished urea nitrogen. Geigy Agricultural Chemicals supplied atrazine and diazinon for weed and soil insect control.

Lamberton Maximum Yield Corn and Soybean Demonstrations.

W. W. Nelson and Lowell Hanson

Two demonstration type trials were conducted at the Southwest Agricultural Experiment Station on corn and soybeans. The soil type was Nicollet clay loam and the soil tests were medium in phosphorus and high in potassium.

Corn Demonstration

Treatment	Plot	Row	Yield	Plants/Acre
30,000 - planting rate	1	3	134.6	22,600
300# 8-24-12		4	104.1	17,600
500# 0-30-15		9	117.8	24,000
200# N		10	109.7	22,500
			126	22,150
20,000 - planting rate	2	3	120.2	16,800
same fertilizer		4	119.2	18,000
as above		9	120.3	16,800
		10	127.2	19,300
			122	17,700
15,000 - planting rate	3	3	86.2	12,700
no fertilizer		4	83.0	11,900
		9	89.3	13,000
		10	91.2	12,400
			88	12,500
15,000 - planting rate	4	3	104.1	15,200
125# 8-24-12		4	105.2	14,100
40# N		9	105.8	13,900
		10	98.7	13,800
			103	14,250
20,000 - planting rate	5	3	95.1	14,600
same fertilizer as above		4	97.3	12,000
		9	102.4	14,500
		10	101.4	15,700
			100	14,300

Soybean Demonstration

Treatment	Yield, bushel/acre
40 inch row 60 lbs.seed per acre No fertilizer	30
18 inch row 120 lbs. seed per acre 200 lbs. 8-24-12, planter attach 200 lbs. 0-30-15, broadcast	42

Residual effects of fertilizer on soybeans grown continuously

A. C. Caldwell and E. C. Seim

An experiment was set up in 1957 to study the effects of P, K, and barnyard manure on the yields and plant composition of soybeans. Fifteen treatments were applied with 4 replications. In 1958 through 1963 no fertilizer was applied in order to study the residual effects of the fertilizer applied in 1957.

Yield results are shown in the accompanying Table. In the sixth year after treatment, the very heavy applications (0-400-400, and 0-400-400 + 6T man.) still gave significant increases in yield.

Effect of residual fertilizer on yield of continuous soybeans

(Rosemount, 1962)

Treatment $N-P_2O_5-K_2O$ lbs/A.	Yield Bu/A.	Yield Diff.
0-0-0	20.4	--
0-0-20	19.1	-1.3
0-0-80	19.5	-0.9
0-0-400	21.5	+1.1
0-20-20	19.3	-1.1
0-40-40	20.1	-0.3
0-60-60	19.6	-0.8
0-80-80	21.3	+0.9
0-400-400	27.0	+6.6
0-400-400 + 6T* Man.	24.9	+4.5
0-20-0	19.3	-1.1
0-80-0	19.4	-1.0
0-400-0	21.1	+0.7
0-20-0 + 6T* Man.	21.7	+1.3
6T* Man.	22.0	+1.6

6T* = 6 ton manure per acre.

Standard error =	1.1
Hsd (.05) =	5.5
(.01) =	6.3

Fertilizer Placement for Corn and Soybeans

Rosemount Agricultural Experiment Station

1963

Paul M. Burson

Three methods of fertilizer placement on corn and soybeans were tested on 3 fields to determine if any salt injury from fertilizer that would result in reduced germination and stand. All the fertilizer was applied as starter and consisted of three common grades. The grades and rates used are as follows:

6-12-24 at 200 lbs. per acre
6-24-12 at 200 lbs. per acre
11-48-0 at 100 lbs. per acre.

The first method with the split boot on the older type of corn planters is intended to place the fertilizer at seed level and on each side. However, the actual placement varies with the make of the machine, the tilth of the seedbed, the amount of residues in the seedbed and the physical condition of the fertilizer. These variable conditions may result in portions of the fertilizer being placed to the side, above or directly with the seed.

The second method of placement was with the split boot planter with the fertilizer divider removed so all the fertilizer was placed with the seed.

The third method was with the band type of placement where the position of the fertilizer is definitely determined by the mechanical adjustments. In this method the placement was 2 inches to the side and 2 inches below the seed so all the fertilizer was in exact position to the seed. Both planters had been previously calibrated for both seed and fertilizer rates. The 3 fields were located on Port Byron silt loam soil type with 9 to 12 inches of top soil on a 5 to 6 percent slope.

The planting rate for corn was about 23,000 kernels per acre with a final stand of about 20,000 plants. In table 1 the split boot method did allow some fertilizer-seed contact which reduced the stand and also yield. However, when all the fertilizer was in contact with the seed the stand was greatly reduced along with the yield.

TABLE 1. FERTILIZER PLACEMENT FOR CORN 1963

Fertilizer treatments	Fertilizer Lbs./A.	Band[1] Bu.	Sp. B.[2] Yield	W.S.[3] per acre
Check	----	115.0	98.0	----
Stand[4]	----	20	19	----
6-12-24	200	128.0	117.0	102.0
Stand		20	18	15
6-24-12	200	130.0	114.0	113.0
Stand		20	18	17
11-48-0	100	124.0	111.0	102.0
Stand		20	18	17

(1) 2" x 2"
(2) Split boot
(3) With seed
(4) Thousand

The soybeans in 1963, as was the apparent case in 1962, are much more sensitive to fertilizer contact than corn. To get a more uniform planting rate for soybeans an effort was made to get a more uniform grade size. A 4 mesh hardware cloth was used to get this more uniform grade. All beans that remained on this mesh were used for these trials. The planting calibration rate on the 2 planters was about 1 bu. per acre which was about 225,000 seeds per acre. Table 2 gives the final stand per acre along with the yield per acre. It will be noted that any fertilizer contact with the seed as in the case of the split boot and when all the fertilizer was placed with the seed the stand and yield was greatly reduced.

TABLE 2. FERTILIZER PLACEMENT FOR SOYBEANS
1963

Fertilizer treatments	Fertilizer Lbs./A.	Band[1] Bu.	Sp. B.[2] Yield	W.S.[3] per acre
Check	----	30.1	34.1	----
Stand[4]	----	170	163	----
6-12-24	200	33.0	30.0	11.9
Stand		170	97	53
6-24-12	200	33.8	27.9	24.9
Stand		170	133	95
11-48-0	100	32.5	33.3	33.5
Stand		170	169	140

(1) 2" x 2"
(2) Split boot
(3) With seed
(4) Thousand

It should be noted that potash was the most harmful to germination and stand when in contact with the seed. When the fertilizer is properly placed so there is no fertilizer--seed contact no salt injury was noted.

Proper placement is most important with the new high analysis fertilizer materials now on the market along with the use of higher rates of application. Still there is about 40% of the corn planters in use that are some form of the split boot. With this type of equipment extra care should be taken to prevent this salt injury by watching the fertilizer rate per acre and the analysis of the material used.

Phosphorus and Nitrogen Placement Experiment
Southwest Experiment Station

Lowell Hanson, W. W. Nelson, C. J. Overdahl, A. C. Caldwell

Two experiments were established in 1963 to test difference in effects of combinations of row and broadcast placement of phosphorus and nitrogen on corn. Plans are to continue the experiments for two additional years. The plots are located on Nicollet clay loam testing medium in phosphorus and high in potassium. The plot used for the nitrogen experiment was cropped to corn in 1962 and the phosphorus site was alfalfa in 1962.

None of the treatment effects of either experiment were significant at the 5 per cent level in 1963.

Nitrogen Placement Experiment --

Treatment	REPLICATES I	II	III	IV	Ave.
1. Check	124.2	123.0	136.8	117.3	125
2. 40* row, 0 bcst	132.2	94.3	130.0	133.4	122
3. 80 row, 0 bcst	117.3	138.0	112.7	139.1	127
4. 0 row, 40 bcst	119.6	132.3	130.0	149.5	133
5. 0 row, 80 bcst	132.2	135.7	142.6	123.1	133
6. 40 row, 40 bcst	133.4	138.0	141.4	118.4	133

* lbs. N per acre, all plots received 30 lbs. P in row and 30 lbs. K broadcast.

Phosphorus Placement Experiment --

Treatment	I	II	III	IV	Ave.
1. Check	114	106	138	112	118
2. 15* row, 0 bcst	115	128	137	122	125
3. 30 row, 0 bcst	134	110	115	129	122
4. 0 row, 15 bcst	108	148	114	140	128
5. 0 row, 30 bcst	129	139	96	144	127
6. 15 row, 15 bcst	98	126	132	128	121

* lbs. P per acre, all plots received 10 lbs. of N in row, 70 lbs. N broadcast and 30 lbs. K broadcast.

Effects of phosphorus and nitrogen-phosphorus fertilizers on wheat - (Red River Valley, 1963)

A. C. Caldwell and H. W. Kramer

Treatments*	Field I	Field II
	Yield, Bu./A.	
None	24.3	17.6
0-46-0	24.9	18.6
34-17-0	26.7	26.1
24-14-0	26.1	25.5
30-10-0	27.5	29.6

* Fertilizers applied at the rate of 30 lbs. P_2O_5 per acre.

It is apparent that a combination of nitrogen and phosphorus has resulted in consistently higher yields than phosphorus alone.

Kittson County Barley Demonstration - 1963

Winton Fuglie, Merle Halverson and Bob Munter

Soil type: Bearden silt loam
Per cent organic matter: 5.0 (high)
pH: 8.1

Extractable P: 23 (high)
Exchangeable K: 320 (very high)

Seeding date: May 6
Variety: Trophy

Sample size: 16' x 515' = 0.188 A (combine harvested)

Cropping History

1958 = Black fallow
1959 = Barley
1960 = Oats
1961 = Potatoes
1962 = Wheat

Effect of Phosphorus

(a) Treatments receiving no phosphorus

Replicate	Treatment	Yield bu./A.	% Plump Kernels	% Protein in Grain
1	0+0+0	29.5	59	10.6
2	0+0+0	31.2	57	10.6
	Average	30.4	58	10.6

(b) Treatments receiving phosphorus

Replicate	Treatment	Yield bu./A.	% Plump Kernels	% Protein in Grain
1	0+30+0	30.2	64	10.8
2	0+30+0	32.2	61	10.2
	Average	31.2	63	10.5

Apparent increases due phosphorus (b-a)

Yield:	+ 0.8 bu./A.
% Plump kernels:	+ 5 per cent
% Protein in grain:	(-) 0.1

Effect of Nitrogen

(a) Treatments receiving no nitrogen:

Replicate	Treatment	Yield bu/A.	% Plump Kernels	% Protein in grain
1	0+30+0	30.2	64	10.8
1	0+30+15	31.6	60	10.2
2	0+30+0	32.2	61	10.2
2	0+30+15	31.1	63	11.5
	Average	31.3	62	10.7

(b) Treatments receiving nitrogen:

Replicate	Treatment	Yield bu/A.	% Plump Kernels	% Protein in grain
1	30+30+0	41.0	62	11.5
1	30+30+15	44.4	65	11.5
2	30+30+0	41.0	60	11.4
2	30+30+15	40.7	60	11.6
	Average	41.8	62	11.5

Apparent increases due Nitrogen (b-a)

Yield:	+ 10.5 bu./A.
% Plump kernels:	None
% Protein in grain:	+ 0.8

Effect of Potassium

(a) Treatments receiving no potassium:

Replicate	Treatment	Yield bu/A.	% Plump Kernels	% Protein in grain
1	0+30+0	30.2	64	10.8
1	30+30+0	41.0	62	11.5
2	0+30+0	32.2	61	10.2
2	30+30+0	41.0	60	11.4
	Average	36.1	62	10.7

(b) Treatments receiving potassium:

Replicate	Treatment	Yield bu/A.	% Plump Kernels	% Protein in grain
1	0+30+15	31.6	60	10.2
1	30+30+15	44.4	65	11.5
2	0+30+15	31.1	63	11.3
2	30+30+15	40.7	60	11.6
	Average	37.0	62	11.2

Apparent increases due potassium (b-a)

Yield:	+ 0.9 bu./A.
% Plump kernels:	No effect
% Protein in grain:	+ 0.5

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

W. P. Martin, A. C. Caldwell, M. V. Halverson, N. H. Grimsbo

This experiment was started in 1962 with potatoes, and oats were to be planted the second year to check on nitrogen residuals and particularly when large quantities of nitrogen were applied with sawdust. Details of the experiment can be found in the 1962-yield results mimeograph on page 76 together with potato yields which were generally depressed by sawdust even in the presence of high rates of nitrogen.

Woodchips (or sawdust) Wo = none; W1 = 5 tons/acre; W2 = 15 tons/acre. (1962 only).

Nitrogen in addition to 335 lbs. 12-24-12 band placed at planting time throughout: No = none; N1 = 360 lbs. 33.3-0-0 applied preplant and plowed down; and N2 = 540 lbs. 33.3-0-0 plowed down and 540 lbs. also applied sidedress 3 weeks after emergence. All the plots received in addition 250 lbs. 0-0-60. (No fertilizer applied in 1963-all in 1962).

1963 oat yields in bushels/acre for the nine combination treatments which are an average of five replications (45 plots):

	No	N1	N2	Ave.
Wo	66	88	76	77
W1	68	58	72	66
W2	58	68	74	67
Ave.	64	71	74	70

THE EFFECT OF PASTURE FERTILITY AND MANAGEMENT ON BEEF PRODUCTION

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

Pasture crops are the forgotten crops when compared to other crops grown on the farm. Pasture crops are similar in nutrient needs as compared to other crops produced on the farm. High quality pasture crops provide one of the cheapest sources of high quality livestock feeds. Pasture crops are extremely responsive to lime and fertilizer, hence their application will increase the production of beef per acre. Land that is too rolling and steep for the production of cultivated crops is most efficient in the production of beef through the proper utilization of the pasture and forage crops. Pastures properly fertilized and properly managed will produce more pounds of beef and animal products per acre.

Procedure

On May 14, 1963, "medium" grade yearling Holstein steers were lotted as uniformly as possible and turned onto pasture. Prior to 1962 one-half of each pasture was fertilized and the other one-half not fertilized. Beginning in 1962 all of the pasture area was fertilized except for a one rod strip adjacent to the center fence in the original unfertilized area. On this area a basic treatment of 500 lb. per acre of 0-20-20 was applied at the time of renovation. No other treatment of phosphate and potash will be made until it is renovated again. On the original fertilized area the usual annual application of 200 lb. per acre of 0-20-20 was made. Since pastures B and C have not been renovated for several years no treatments of phosphate and potash were made on the old unfertilized areas but 120 lb. of actual N were applied in 1962. On the original fertilized areas the annual application of 200 lb. of 0-20-20 was applied with nitrogen. In all cases the nitrogen was applied as a topdressing at two different times as follows: (1) all in early spring, (2) all in early June, (3) 1/2 early spring and 1/2 in July, and (4) 1/2 early June and 1/2 in July.

Results and discussion

The 1963 pasture growing season from April 1 through Aug. 31 was probably the most extreme and most critical of any pasture season in the history of this project. During this period there was 13.31 inches of rainfall as compared to 15.49 inches which is normal according to the U. S. Weather Bureau. For this period there was only 2.18 inches less than normal. However, there was no rainfall during the normal peak pasture period which generally determines the extent of pasture production for the remainder of the pasture season.

This critical period in 1963 lasted for 37 days from June 11 through July 16. Even though the last half of July was about normal for the month the Aug. rainfall was 1.43 inches below normal resulting in practically no pasture growth recovery for the remainder of the 1963 pasture season. Because of this extreme variation in rainfall during critical periods it was not possible to carry out the original pasture plans for 1963. Steers had to be removed from pastures because of reduced carrying capacity

The production of beef per acre for 1963 (table 1) again reflects these potential soil fertility differences even though the grazing-management practices were the same on all pastures. Pasture B and C (south) with 120 lb. of N per acre, produced 314 lb. of beef per acre as compared to pasture B and C (north) with 60 lb. of N produced 356 lb. of beef to 354 lb. of beef per acre on pasture E renovated in 1961.

The carrying capacity as shown by steer-days per acre ranged from 102 on the B and C (north) pasture to 136 on the renovated E pasture. It should again be remembered that there is a big difference in pastures B and C (north) and B and C (south) in natural fertility levels, type of soil, the need for lime, the steepness of slopes, the extent to which erosion has previously occurred and the depth of topsoil. On the basis of these soil characteristics pasture B and C (north) could be classed as "fair to good", pasture B and C (south) "poor to fair" while pasture E could be classed as "good to very good".

These data seem to bear out the principle that more beef per acre, the same as any other agricultural crop, can be produced on those soils that are higher in fertility, even though they are too steep and erosive to use in the production of tillable agricultural crops. However, because of the lack of the necessary rainfall during the critical pasture periods the differences in fertility and management are not as great as has been shown during the pasture seasons of normal rainfall conditions.

Table 1. Beef produced with yearling steers on fertilized pastures grazed in rotation May 14 to September 3, 1963 (112 days). a

Treatments Pasture	120# N B & C south	60# N. B & C north	Renovated Annual 0-40-40 E
No. acres	7.2	7.4	7.8
No. steers-at start[a]	10	10	12
Av. initial wt., lb.	747	741	744
No. steers-at finish[b]	4	4	8
Av. final wt., lb.	1015	1015	1020
Total gain, lb.	2259	2635	2764
Av. daily gain, lb.	3.00	3.50	2.61
Total No. steer days	752	752	1057
Steer-days/acre	104	102	136
Beef produced/acre	314	356	354
Value of beef produced per acre @$18.00 cwt	$56.52	$64.08	$63.72
Tillage and seed/acre			$6.64
Fertilizer and lime cost/acre[c]	$11.05	$6.01	$5.25
Return over lime, fertilizer, seed and tillage costs	$45.47	$58.07	$51.83

a All steers implanted with 24 mg. stilbesterol and one half were given 20 gram cobalt bullets on May 12, 1963.

b Steers were removed as carrying capacity decreased.

c Fertilizer and lime treatments: 0-40-40 (P, $.09/lb., 20% carry-over; K, $.07/lb., 50% carry-over), nitrogen, $.12/lb., 30% carry-over; Lime, all pastures @ 3 tons per acre, cost $.97 per acre per year over a 10 year period,

E pasture: Renovated in 1960-61.

BEEF PRODUCTION FROM RENOVATED AND FERTILIZED GRASS PASTURES AND PERFORMANCE OF PASTURE MIXTURES IN SMALL PLOTS

A. R. Schmid[1], Agronomy; P. M. Burson, Soils; A. L. Harvey
and O. E. Kolari, Animal Husbandry

Four types of pasture were compared on "G" consisting of grass with no fertilizer, grass with manure, grass with nitrogen and a newly renovated pasture. All pastures were limed in the fall of 1956 with 3 tons of ground limestone per acre. The area for renovation was cultivated three times in the fall and one time in the spring with a deep tiller. Then it was disked and seeded to a mixture of Vernal alfalfa 5 lbs. per acre, alsike clover 1, Lincoln bromegrass 6, and orchardgrass 2.

For the manure treatment on grass applications were made each fall. Commercial fertilizer used on the various treatments was applied in the spring. The rates of fertilization, manure and lime are shown in table 2.

Results and discussion

Data for G pastures are shown in table 1. The pastures (G3, G8) renovated in 1960-61 were the most productive. They consisted of alfalfa-clover-orchard grass and bromegrass about 50% legume and 50% grass. For the grazing season 514 steer days, they produced the greatest amount of beef per acre, 456 lb. with the greatest return per acre, $70.19 after deducting lime, fertilizer, tillage, and seed costs. Total steer days, beef produced per acre and returns per acre for the nitrogen treated, (G2, G5) manure treated (G1, G7) and controls (G4, G6) were: 428 days, 444 lb. per acre, $67.95; 514 days, 387 lb. per acre, $57.69; 281 days, 244 lb. per acre, $43.92, respectively.

The treatments resulted in following increase in value of beef produced per acre as compared to the control pastures: Renovated 63%, nitrogen 58%, manure 34%.

Pasture Mixtures in Small Plots

When renovated pasture "E" was seeded in 1961 small plots of different mixtures were seeded by hand in part of the pasture to obtain agronomic data prior to each grazing. Clipping yields and percent composition of these mixtures are shown in table 2. The addition of 2 lbs. of orchardgrass to the first three mixtures effectively increased the grass percentage to those mixtures in 1962. But due to the great amount of winter injury, orchardgrass in 1963 did not contribute so much to the percent composition. Approximate contribution of the two grasses at the first harvest were as follows:

	1962	1963
Orchardgrass	67%	20%
L. Brome	33	80

Also the volunteer clover taken out of the plots due to the winter injury, and the percentage of Empire trefoil has greatly decreased.

[1]A. R. Schmid was on leave for 3 months. These experiments were supervised during the summer of 1963 by Charles H. Cuykendall, Department of Agronomy and Plant Genetics

Table 1. Beef produced from brome-timothy and renovated pastures (2 pasture rotational grazing). May 14 to September 3, 1963 (112 days).[a]

Treatment Pasture	Control (G4, G6)	Manure[e] (G1, G7)	Nitrogen[f] (G2, G5)	Renovated[g] (G3, G8)
No. acres	3.2	3.2	3.2	3.2
No. steers at start	4	6	6	6
Av. initial wt., lb.	748	741	740	741
No. steers at finish	2[d]	4[c]	4[d]	4[c]
Av. final wt., lb.[b]	948	915	1052	971
Total gain, lb.	782	1238	1421	1460
Av. daily gain, lb.	2.78	2.41	3.32	2.84
Total No. steer days	281	514	428	514
Steer days/acre	88	161	134	161
Beef produced/acre	244	387	444	456
Value of beef produced/acre@$18.00 cwt.	$43.92	$69.66	$79.92	$82.08
Fertilizer, lime and manure cost/acre[h]	$ 0.97	$11.97	$11.97	$ 5.25
Tillage and seed cost				$ 6.64
Value of beef produced/acre less lime, fertilizer, tillage and seed costs	$42.95	$57.69	$67.95	$70.19

[a]Medium grade yearling Holstein steers all were implanted with 24 mg. stilbestrol, and one half were given 20 grams cobalt bullets on May 14, 1963.
[b]All steers weighed and removed from pastures July 16, 1963 - pasture dried up.
[c]Put back on pasture July 31, 1963.
[d]Put back on pasture August 13, 1963.
[e]Manure, 8 tons/acre annually, value $9.60 (charge per acre $6.72 assuming 30% carry-over). Also 200 lbs./acre 0-20-20 (charge per acre $2.12 assuming 9¢ lb. for P, 7¢ lb. for K and 20 and 50% carry-over respectively.
[f]Nitrogen, 80 lbs. N/acre annually, cost $9.60 (charge per acre $6.72 assuming 30% carry-over). Also same amount 0-20-20 as on manure.
[g]Renovated 1960-61, four workings with a deep tiller and once with disk, cost at $3.00 per operation per acre $15.00 or $5.00 per year over 3 years. Also same amount 0-20-20 as on manure. Seed was Vernal alfalfa 5 lbs./acre, alsike 1, Lincoln bromegrass 6, orchardgrass 2; cost $4.92 or $.64 per year over a 3 year period.
[h]Lime, all pastures @ 3 tons per acre, cost $0.97 per year over 10 year period.

Table 2. Yield and composition of pasture mixtures in small plots seeded in spring of 1961 in pasture E. Four replications 1962-63.

Mixture and lb./acre	Tons/acre at 15% M.						Ave. % Composition							
	Total	1963					Alf.		Clover[1]		Tref.		Grass	
	1962	1st	2nd	3rd	4th[2]	Total	'62	'63	'62	'63	'62	'63	'62	'63
1. V. alf 6, L. brome 6, Orch. G. 2, E tref. 3	3.92	.47	1.06	.21	.30	2.04	30.5	45.0	6.8	---	.2	---	62.5	55.0
2. Rambler alf. 6, L. brome 6, Orch. G. 2, E. tref. 3	3.35	.31	.93	.11	.27	1.62	18.0	33.4	9.3	.3	.2	---	72.5	66.3
3. Teton alf. 6, L. brome 6, Orch G. 2, E. tref. 3.	3.33	.51	.80	.11	.29	1.71	18.5	30.6	11.5	---	---	---	70.0	69.4
4. Teton alf. 6, L. brome 6, E. tref. 3	3.36	.37	.64	.21	.15	1.37	29.3	35.3	22.5	---	.7	---	47.5	64.7
5. V. alf 6, L. brome 6, R. canary 3, E. tref. 3	3.66	.44	.70	.29	.32	1.75	33.3	38.4	12.0	---	---	---	54.7	61.6
6. V. alf. 6, L. brome 6, Tim. 2, E. tref. 3	3.55	.28	.69	.23	.15	1.35	37.3	34.7	11.7	===	.5	---	50.5	65.3
7. E. tref 6, Park bluegrass 6	3.04	.33	.76	.31	.32	1.72	6.0	4.2	28.0	---	8.7	3.7	57.3	92.1
8. E. tref 6, L. brome 6	3.06	.43	.69	.20	.18	1.50	8.2	8.2	29.0	---	5.3	3.2	57.5	88.6

[1]Volunteer clover

[2]A fifth time the plots were grazed but due to the low rainfall there was not sufficient regrowth for harvest yields.

Grass Seed Production
1963

J. M. MacGregor, P. M. Burson, Wayne Carlson and H. W. Kramer

Grass seed production like legume seed production is located in northern Minnesota covering an area of about 15 counties along the Canadian border. This area extends west from Lake County to the western boundary of Minnesota. Ten years ago very little grass seed such as bluegrass and timothy were grown and seed produced. Practically no seed was certified. With the development of new and improved varieties of Park and Marion bluegrass and Climax and Itasca timothy the acreage and seed production has increased many times. During this period the northern Minnesota Bluegrass Growers Association made up of producers was organized. The most modern cleaning plant of its kind was constructed at Roseau to clean and prepare the bluegrass seed for marketing. In the case of timothy a similar plant was constructed at Gully in East Polk County to clean and prepare the timothy seed for marketing. In Minnesota in 1960 and again in 1962 bluegrass seed production ran over 1,000,000 lbs. per year with practically all grown under management practices which would make the seed eligible for certification. In 1962 Minnesota produced 2,000,000 lbs. of timothy seed which was all cleaned and prepared for marketing at the Gully plant. In 1963 the grass seed certification program made real advances with a total of about 5000 acres of certified bluegrass and about 4000 acres of certified timothy seed. With both crops the seed certified was the new improved name varieties.

During the period prior to 1959 the problem of fertilization began to appear. What kind of fertilizer should be used? How much of nitrogen, phosphorus and potash should be applied per acre for most economical yields and returns per acre? What fertilizers should be used on mineral soils as compared to organic (peat) soils? In 1960 the Soils Department put out field experimental plots to try to answer these questions that were raised by the bluegrass and timothy seed growers in the area.

Park Bluegrass Seed

The fertilizer treatments were made on two newly seeded peat soil fields and on three newly seeded mineral soils. One additional field on peat soil was selected that had been in seed production for three years and was considered to be in a so-called "sod-bound" condition and very low in production. These fields were studied during the seasonal years of 1960, 61, and 62. Fall and spring applications and winter (February) versus early spring (April) applications were studied. The year 1961 was very dry and was not a representative year for this area. On the two peat soil fields all three nutrients, nitrogen, phosphorus and potassium, were studied and all three nutrients increased seed yields. Fall and spring treatments were variable. For the three years the total production of seed ranged from 530 lbs. per acre with no fertilizer to over 1100 lbs. per acre where all three nutrients were used. On the 4 year old "sod-bound" field seed yields ranged from 315 lbs. with no fertilizer to over 700 lbs. where all three nutrients were used (Note: Report on Field Research in Soils, February, 1963).

On the two mineral soil fields during this same period nitrogen and phosphorus were the two most effective nutrient treatments with practically no difference between fall and spring applications. The seed yields ranged from 154 lbs. on the no fertilizer to over 500 lbs. per acre with nitrogen and phosphorus. On the one mineral soil field where winter (February) fertilizer application was made as compared to early spring (April) the April treatment was the best. (Note: Report on Field Research in Soils, February, 1963).

Timothy Seed

The three timothy fields for 1960, 61 and 62 were on mineral soils. In 1960 the seed yields ranged from 159 lbs. to almost 900 lbs. per acre with nitrogen, phosphorus and potassium. However, nitrogen and phosphorus were the two most essential nutrients. Spring application gave greater production of seed at 531 lbs. per acre as compared to 431 lbs. when the fertilizer was applied in the fall. (Note: Report on Field Research in Soils, February, 1963).

Park Bluegrass Seed - 1963

In 1963 the three peat fields were planned for study but the two new fields that were selected in 1960 winter killed and had to be reseeded in 1963 for seed production in 1964. The original old field selected for 1960 came through the winter in satisfactory condition. The results on this field for 1963 are found in table 1.

Table 1. The effect of different fertilizer treatments on the 1963 Park bluegrass seed yields on peat soil (fall-spring-winter). Stanley Roadfeldt farm - Badger (shallow peat - 1957 seeding).

Nutrient lbs./acre	Pounds of harvested seed per acre Fall 1961	Spring 1962
0 + 0 + 0	216	216
0 + 80 + 0	309	315
0 + 80 + 80	360	379
30 + 80 + 0	287	301
30 + 80 + 80	270	372
60 + 80 + 80	346	297
90 + 80 + 80	360	281
	February 14, 1963	March 28, 1963
0 + 0 + 0	210	210
60 + 0 + 0	217	222
60 + 80 + 80	331	291

All treatments on this field gave a good response with more consistent increase in yields in favor of the spring application over the fall. Winter application was not as good as the spring application.

Two fields were studied on mineral soils in 1963. The yields on the Foss field are given in table 2. No fertilizer treatments were made in 1963. This was a very poor field and there was a question if it should be harvested. No visible difference could be noticed between the different fertilizers because there was no apparent carry-over of the previous fertilizer treatments. Also this field was very wet. This would indicate also if the soils are too wet fertilizer treatments will not be effective.

Table 2. The effect of different fertilizer treatments on the 1963 Park bluegrass seed yields on mineral soils. Clifford Foss farm - Badger

Nutrients lbs./acre	Pounds of harvested seed per acre Fall 1961	Spring 1962
0 + 0 + 0	57	57
0 + 80 + 0	106	104
0 + 80 + 80	93	72
30 + 80 + 0	92	80
30 + 80 + 80	68	88
60 + 80 + 80	72	81
90 + 80 + 80	52	70
90 + 0 + 0	77	87

On the Roy Rice bluegrass field the 1963 yields would represent the response to an annual treatment. The two winter applications were not as high in yield as the regular spring treatment. On this field the nitrogen and phosphorus treatment gave the highest yield. Also, on this field there was considerable injury from a "thrip" insect. This insect's life history according to entomologists is not well known at present as related to bluegrass seed production. This insect injures the seed stem causing immature white heads that can easily be seen throughout the field. On this field the injury was the greatest on the plots having 60 lbs. or more of nitrogen per acre. None appeared on the 30 lb. rate or on the unfertilized plots.

Table 3. The effect of different fertilizer treatments on the 1963 Park bluegrass seed yield on mineral soils. Roy Rice farm- Pine Creek.

Nutrient lbs./acre	Pounds of harvested seed per acre Spring 1963	February 14, 1963	March 28, 1963
0 + 0 + 0	97	133	133
30 + 0 + 0	164	---	---
30 + 40 + 0	257	---	---
30 + 40 + 40	322	---	---
30 + 80 + 0	259	---	---
30 + 80 + 80	291	---	---
30 + 80 + 40	274	---	---
60 + 0 + 0	189	199	217
60 + 40 + 0	314	---	---
60 + 40 + 40	269	---	---
60 + 80 + 0	379	---	---
60 + 80 + 80	322	292	320
60 + 80 + 40	230	---	---

Timothy Seed - 1963

The 1963 timothy yields on the Clifford Foss field were low because of wet soil conditions and no fertilizer treatments in 1963. These yields would again indicate there is no carry-over of previous fertilizer treatments and a probable need for an annual fertilizer application, especially nitrogen.

Table 4. The effect of fertilizer on yield of Climax timothy seed on mineral soils. Clifford Foss farm - Badger.

Nutrients lbs./acre	Pounds of harvested seed per acre Fall 1961	Spring 1962
0 + 0 + 0	147	147
0 + 80 + 0	172	185
0 + 80 + 80	184	153
30 + 80 + 0	70	73
30 + 80 + 80	128	111
60 + 80 + 80	54	77
90 + 80 + 80	71	73

In summary, the most generally and essential nutrients are nitrogen and phosphorus in this area. Soils tests should always be made to determine the nutrient needs. Further work needs to be done to determine the time and the rate of fertilizer application. Investigations should continue on the study of the "thrip" as related to rates of nitrogen per acre.

Legume Seed Production
1963

Paul M. Burson and H. W. Kramer

Northern Minnesota is a natural forage crop area because of the soil, climate, seasonal weather conditions and the type of agriculture adaptable to that part of the state. This major forage crop area covers about 15 counties along the Canadian border, extending west from Lake County to the eastern edge of the Red River Valley. Twenty-five years ago this general area was one of the best forage seeded producing areas in the nation. This was especially true of the legume seeds of alfalfa, alsike clover, medium red clover and biennial sweet clover. Out of the 18 legume seed producing states Minnesota consistently ranked in the top eight states. However, during this same period Minnesota consistently remained among the top three states in the production of alsike clover and biennial sweet clover seed. Following this peak period of production the legume seed yields began to rapidly decline until this once highly profitable industry had reached a point of such low return that farmers were forced to look for some other crop. Yields had dropped until the alfalfa and medium red clover were well below 100 lbs. per acre while the maximum production of alsike clover seed ranged from 100 to 125 lbs. per acre. These yields are according to the USDA seed crop estimates and Minnesota crop production census figures.

Beginning in 1951 the Minnesota Agricultural Experiment Station with the cooperation of the local farmers and county agents in the area, developed plans for extensive field experiments to be started in 1952. A coordinated research team was made up of representatives of Soils, Agronomy, Entomology, and Plant Pathology Departments. The answer for the production of alsike clover, medium red clover and biennial sweet clover is pretty well established but for alfalfa further work needs to be conducted. However, alfalfa seed production is not well adapted to the general soil conditions of this area. The following practices were found to be essential to the successful production of legume seed. Also see the attached reprints:

1. Selection of the soil condition for the specific legume seed crop.
2. Use adaptable and recommended varieties.
3. Proper fertilization based on the soil test.
4. Supply adequate pollination for each field.
5. Control harmful insects on each field.

All of these five production practices must be coordinated on each legume seed field.

From the more than 40 field experiments over the years the practices outlined above have given the following seed yield ranges.

Crop	State Ave	No fertilizer	Fertilizer (lbs./acre)
Alsike clover	114	156	~~800~~ 808
Medium red clover	59	125	~~700~~ 824
Biennial sweet clover	180	175	~~1500~~ 2100 760

In the last two years the production of legume seed has practically disappeared in this area. Land that formerly produced legume seed is now in the soil bank with more intensive use of the remaining acres for the production of feed grain crops. Other farmers have turned their attention to growing of Park Bluegrass and Climax Timothy seeds. Also, many bee keepers have gone out of the area leaving a problem whereby farmers are unable to find adequate pollination.

In 1963 only one field of medium red clover was available for research field plots. The few available alsike and red clover fields were lacking in uniformity of growth and stand because of the variable soil conditions or were too weedy. Winter killing was quite severe in 1963 which also limited the number of available fields suitable for study.

The following yields for the 1963 medium red clover seed represents what can be expected under normal weather conditions if all the recommended production practices are applied and carried out by the farmer.

Fertilizer treatment (lbs./acre)	Yield of seed (lbs./acre)
No fertilizer	355
300 lbs. 0-20-0 (phosphate only)	776
500 lbs. 0-20-0	824
300 lbs. 0-20-20 (phosphate and potash)	787
500 lbs. 0-20-20 (phosphate and potash)	787
300 lbs. 0-20-40 " "	777
500 lbs. 0-20-40 " "	820
500 lbs. 0-0-40 (potash only)	328

The most essential nutrient for legume seed production in this area is phosphate. This has been true since the project was started.

These data show an increase of 421 lbs. of seed for 300 lbs. of 0-20-0 over the no fertilizer plots at a fertilizer cost of $6.30 per acre. The increase of 421 lbs. per acre valued at $.30 per lb. of clean seed on the farm would bring a total gross income of $126.30 or $120.00 per acre over the fertilizer cost. This field is one of many typical illustrations that the legume seed production program could become a million dollar industry for northern Minnesota.

The forage seed production program has a definite place in this northern Minnesota agriculture. More farmers in this area are becoming interested in the beef cow herd to produce feeder calves for the corn belt located just south of this area in southern Minnesota and Iowa. Also ranchers are moving in from the southwest range country bringing in sizeable herds of beef cows. All of these beef cattle producers are building their operations around legume forages. Such a program on an individual farm can include the production of legume seeds, at least for their own needs, production of haylage, legume silages, and hay to go along with their feed grain program. This appears to be what is developing for the future in northern Minnesota.

Clearwater County Sunflower Demonstration - 1963

Arnold Heikkila and Merle Halverson
Cooperator - John Brooks, Jr., Gonvick, Minnesota

Soil texture: silt loam
Percent organic matter: 7.5 (high)
pH: 7.1

Extractable P: 20 lb/A. (high)
Exchangeable K: 320 lb/A. (very high)
History: Black fallowed in 1962

Seeding date: May 10, 1963
Seeding rate: 6 lb/A.

Sample size: 2-40 inch rows x 1760 ft.
= 11,721.6 ft.^{2} = 0.27 acres
(combine harvested)
Treatments not replicated

Effect of Nitrogen

(a) Treatments receiving no nitrogen:

Treatment	Yield lb./A.
0+0+0	1140
0+30+0	Missing
0+0+30	890
0+30+30	1188
Average	1073

(b) Treatments receiving 30 lb. nitrogen/A.

30+0+0	1070
30+30+0	976
30+0+30	1203
30+30+30	1272
Average	1130

Apparent increase due nitrogen (b-a) = 57 lb. clean seed/A.

Effect of Phosphorus

(a) Treatments receiving no phosphorus

Treatment	Yield lb./A.
0+0+0	1140
0+0+30	890
30+0+0	1070
30+0+30	1203
Average	1076

(b) Treatments receiving 30 lb. P_2O_5/A.

0+30+0	Missing
0+30+30	1188
30+30+0	976
30+30+30	1272
Average	1142

Apparent increase due phosphorus (b-a) = 66 lb. clean seed/A.

Effect of Potassium

(a) Treatments receiving no potassium:

Treatment	Yield lb./A.
0+0+0	1140
0+30+0	Missing
30+0+0	1070
30+30+0	976
Average	1062

(b) Treatments receiving 30 lb. K_2O/A.

0+0+30	890
0+30+30	1188
30+0+30	1203
30+30+30	1272
Average	1138

Apparent yield increase due potassium (b-a) = 76 lb. clean seed/A.

Apparent yield increase due 30+30+30 treatment (main effects only)

= 57+66+76+199 lb. clean seed/A.

NITROGEN FERTILIZATION OF TURF - 1963

R. S. Farnham

Nitrogen fertilization studies on bluegrass turf on the St. Paul campus have been conducted over the past five years. In 1963 several new coated nitrogen materials produced by Archer-Daniels Company were added. In addition a new lignite-base organic nitrogen fertilizer produced by American Humates was used as a comparison.

The objectives of these studies were as follows:

1) To compare the effectiveness of several slow-release nitrogen materials on yield and color of bluegrass turf.

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

3) To compare the effectiveness of these slow-release nitrogen fertilizers in supplying nitrogen to grass during the growing season.

MATERIALS AND METHODS:

The plots were located between Agronomy and Plant Pathology building on the campus. Plots were 5' x 10' in size. Thirty-two treatments were applied and clippings were made at two week intervals from June to October. Color comparisons were made periodically during the season.

Nitrogen fertilizer materials included in the 1963 study were ammonium sulphate, ammonium nitrate, Urea, Urea-form, lawn grades of fertilizer both coated and uncoated such as 20-10-5 and 16-8-8, organics including Milorganite and American Humate materials, and several experimental products supplied by Spencer Chemical Co. The inorganic nitrogen forms were both coated and uncoated. The coated fertilizers were supplied by Archer-Daniels-Midland Company.

Nitrogen was applied at 4 and 8 pounds of N per 1000 square feet rates. P and K were applied on all plots. All materials were applied in May on dry turf and wet thoroughly immediately after application.

RESULTS AND DISCUSSION

Total clipping yields are shown in table 1. The following results were noted.

1) Many of the coated nitrogen materials were superior to any of the other nitrogen materials. The $(NH_4)_2SO_4$ coated were the highest yielders despite variation in release rate. The coated mixed fertilizers 20-10-2 and 16-8-8 performed well again this year.

2) The organic nitrogen forms such as Milorganite and American Humates were not as good as the coated inorganic nitrogen forms.

3) Most of the 4 lbs./1000 square feet rates were too low for satisfactory growth when using a single application.

4) The Urea-form again produces low yields in this climate. This is probably due to the very slow release caused by low night-time summer temperatures in Minnesota.

TABLE 1. 1963 TURF EXPERIMENTS-NITROGEN FERTILIZATION

Treatment	lbs/N 1000 ft.^{2}	Total clippings gms/1000 ft.^{2}	Rank
$(NH_4)_2SO_4$ (c) 5422-18-Y 19.1% leach	8	70,829	1
$(NH_4)_2SO_4$ (c) 5422-18-Y 2% leach	8	68,764	2
20-10-5 (c) 5422-20-C	8	67,288	3
16-8-8 (c) 5422-20-E	8	65,124	4
Urea (c) w/inhibitor	8	62,560	5
NH_4NO_3 (c) 5422-21-V 3%	8	61,638	6
NH_4NO_3 (c) 5422-21-V $\frac{1}{2}$:$(NH_4)_2SO_4$ (c)$\frac{1}{2}$ 19.6%	8	61,605	7
ADM 8459-0-2X (I Rep only)	8	61,183	8
Amer. Humates $\frac{1}{2}$, 16-8-8 (c)$\frac{1}{2}$	8	60,206	9
$(NH_4)_2SO_4$ (c) 5422-18-Y 19.1% leach	4	58,175	10
$(NH_4)_2SO_4$ (c) 5422-18-Y 2%	4	55,633	11
Spencer 30-10-0 (c)	8	54,701	12
20-10-5 (c) 5422-20-C	4	54,290	13
16-8-8 (c) 5422-20-E	4	54,068	14
16-8-8 (uc)	8	52,892	15
NH_4NO_3 (c) 5422-21-U 3%	4	52,692	16
Urea (c) w/inhibitor	4	51,915	17
Urea (med. c.)	8	50,982	18
Milorganite	8	50,927	19
Uramite	8	50,172	20
Urea (med. c.)	4	49,184	21
NH_4NO_3 (UC)	8	48,352	22
Amer. Humates 12-9-6	8	47,996	23
Amer. Humates 12-9-6	4	47,419	24
16-8-8 (UC)	4	47,264	25
Spencer S-4383	8	46,931	26
NH_4NO_3 (UC)	4	46,409	27
Milorganite	4	44,222	28
Spencer S-4383	4	42,469	29
Uramite	4	41,625	30
Check	0	27,006	31
Check	0	26,662	32

Structure-Nitrogen Study

Crookston, 1963

Wheat Yield Bu/A. and Bushel Weights

G. R. Blake, J. M. MacGregor and O. C. Soine

Crop Sequence (end second cycle)	No Fertilizer	20-40-20	10-40-20
		Yield of Wheat Bu./A.	
Wheat-wheat-wheat	17.2	27.6	27.8
Fallow-fallow-wheat	29.1	35.2	29.6
Ditto plus straw[1]	29.7	30.3	33.2
Corn-soybeans-wheat	27.4	29.4	32.0
		Bushel Weights	
Wheat-wheat-wheat	55	56	52
Fallow-fallow-wheat	53	53	52
Ditto plus straw[1]	54	54	54
Corn-soybeans-wheat	54	53	53

[1] Straw added to fallow at time of wheat harvest.

Structure-Nitrogen Study

Morris, 1963

Corn Yields

G. R. Blake, J. M. MacGregor and S. D. Evans

Seedbed preparation Handling of residues Fall or spring plowed	Fertilizer					
	0-40-40	40-40-40 fall	40-40-40	80-40-40	240-40-40	Ave.
Minimum-chop-spring	61.5	79.7	75.5	79.5	85.3	76.3
Minimum-not-chop-spring	62.3	68.7	86.0	77.1	75.5	73.9
Minimum-chop-fall	61.8	90.6	80.9	84.4	78.2	79.2
Conventional-chop-fall	67.9	82.3	87.7	81.7	86.0	81.2
Field Cultivate-chop-fall & spring	59.8	82.7	87.3	64.4	72.3	73.3
Averages	62.7	80.9	83.5	77.4	79.5	

Replication was significant at 1% level. Tillage was not significant. Fertilization was significant at the 1% level. Nothing else was significant. Residual effects of manure, rock and superphosphate from an earlier experiment on this land were not significant.

Structure-Nitrogen Study

Waseca, 1963

Corn Yields, Bu./A., and Moisture Content of Grain

Data Book 21:3-6

G. R. Blake, J. M. MacGregor and L. E. Ahlrichs

Seedbed preparation Handling of residues Fall or spring plowed	Mini. Chop Spring	Mini. Not chop Spring	Conventional Chop Fall	Mini. Chop Fall	Field culti- vated-Chop Fall & Spring	Ave.
0-0-0	136.6	133.2	143.1	149.4	146.8	141.8
0-40-40	146.6	130.9	141.6	156.6	133.9	141.9
40-40-40 (fall)	137.9	144.8	137.6	138.8	150.1	141.8
40-40-40	153.3	144.2	155.8	133.2	153.1	147.9
80-40-40	145.7	141.8	165.3	142.6	145.2	148.1
240-40-40	157.4	124.3	155.2	139.7	141.1	143.5
Averages	146.3	136.5	149.8	143.4	145.0	
Moisture Content of Grain	37.7	37.1	35.9	36.4	36.5	

Differences for tillage and fertilizers not significant. Moisture content of grain at harvest, L.S.D. (.05) 0.74 and (.02) 0.93.

Subsoil Regeneration Study

Lamberton, 1963

Corn Grain Yield (bu./A @ 15.5% water);

Percent Moisture in Grain,

and Alfalfa Yield (Lbs./A @ 20% water)

G. R. Blake and W. W. Nelson

	Date	Data Book	Packed		Not Packed	
	Harvested	Reference	Irrig.	Not Irrig.	Irrig.	Not Irrig.
Corn Yield	10/5/63	20:108-110	135.3	134.4	144.8	139.6
% Moisture	10/5/63	20:111-112	26.2	26.4	25.2	26.0
Alfalfa	6/6/63	20:100-102	1771	2120	2149	1975
Alfalfa	7/10/63	20:102-104	2759	2759	2701	2875
Alfalfa	8/21/63	20:105-107	2643	2817	2410	2788

The differences are not significant in the Corn Grain Yield and the Percent Moisture of the Grain.

Irrigation X Packing interaction was significant at 90% level for 1st cutting. Replication was signficant at 95% level for 2nd cutting. Irrigation was significant at 95% level for 3rd cutting. Nothing else was significant.

Subsoil Regeneration Study

Lamberton

Bulk Density

June 26, 1963

Data Book 20:114-137

G. R. Blake and W. W. Nelson

Depth Inches	Corn				Alfalfa				Significance[1]	
	Packed		Not Packed		Packed		Not Packed			
	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Crop	Packing
4-8	1.26	1.24	1.25	1.19	1.40	1.36	1.36	1.33	***	NS
8-12	1.43	1.42	1.22	1.21	1.40	1.48	1.21	1.26	NS	***
12-16	1.53	1.52	1.30	1.25	1.44	1.48	1.21	1.22	NS	***
16-20	1.53	1.44	1.37	1.29	1.37	1.37	1.29	1.23	**	***
20-24	1.46	1.44	1.37	1.32	1.33	1.38	1.31	1.27	NS	***
24-28	1.43	1.39	1.36	1.39	1.28	1.35	1.31	1.32	NS	NS
28-32	1.51	1.35	1.39	1.41	1.33	1.36	1.25	1.32	**	NS
32-36	1.44	1.47	1.46	1.47	1.39	1.43	1.36	1.31	NS	NS

[1] * = Significant at 10%, ** = Significant at 5%, *** = Significant at 1%, NS = Not Significant.

Irrigation was significant at 10% level at 16-20" depth. Irrigation X Crop was significant at 10% level at 28-32" dp. Irrigation tended to give lower bulk density in alfalfa, and higher in corn than no irrigation. Nothing else was significant.

Subsoil Regeneration Study

Lamberton

Soil Moisture Percentages

June 26, 1963

Data Book 20:138-149

G. R. Blake and W. W. Nelson

Depth Inches	Corn				Alfalfa				Significance[1]	
	Packed		Not Packed		Packed		Not Packed			
	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Irrig.	Not Irrig.	Crop	Irrig. X Crop
4-8	23.00	23.56	25.80	25.40	19.66	18.10	18.92	18.10	***	*
8-12	22.54	22.90	23.92	23.92	20.10	19.30	19.18	18.18	***	NS
12-16	20.98	24.00	23.12	23.44	20.34	18.64	19.36	18.84	***	***
16-20	19.98	22.82	22.16	23.24	19.44	18.18	18.98	19.42	NS	***
20-24	19.20	21.76	21.80	23.56	18.96	18.12	19.12	19.24	NS	NS
24-28	19.50	22.64	22.82	22.92	18.56	18.26	19.66	20.50	NS	NS
28-32	19.10	22.98	23.98	22.88	17.92	18.38	20.86	20.58	NS	NS
32-36	19.72	22.12	21.40	21.86	16.74	19.38	19.38	19.48	NS	NS

1 *** = Significant at 1% level, ** = Significant at 5% level, * = Significant at 10% level, NS = Not significant.

Irrigation was not significant.

Packing x Crop interaction was significant at 5% level at 4-8" depth and at 10% level at 8-12" depth. Irrigation x Packing interaction was significant at 10% level at 4-8" depth. Irrigation x Packing x Crop interaction was significant at 10% level at 12-16" depth. Packing was significant at 10% level at 28-32" depth. Nothing else was significant.

Soil Testing in Minnesota During 1963

John Grava

Currently the University of Minnesota Soil Testing Laboratory processes about 40,000 samples annually. The following data show the number of various types of samples analyzed in 1963:

Regular farm, garden and lawns samples	35,061
Florist (Greenhouse) samples	1,264
Limestone	136
Departmental research samples	4,132
Total	40,593

Pennington County won the fall soil sampling roundup award. A plaque was presented by "The Farmer" magazine to county extension agent Mr. Paul J. Stelmaschuk during the annual Soils and Fertilizer Shortcourse. The purpose of this recognition is to call attention to excellent cooperation among fertilizer dealers, extension agents and other agricultural leaders in promoting soil testing. The plaque was awarded for the highest number of soil samples per commercial farm received from a county by the Laboratory from July 1 to November 30.

Table 1. List of Top Ranking Counties with Outstanding Soil Testing Programs in Fall of 1963

County	Samples Per 100 Farms Number	Samples Per 100 Farms Rank	Total Number of Samples Number	Total Number of Samples Rank	Number of Farms*
Pennington	95.4	I	579	II	607
Roseau	42.2	II	548	III	1299
Carlton	35.0	III	362		1035
Freeborn	31.5		719	I	2281
Rice	30.9		533		1726
Chippewa	30.9		436		1410

* Adjusted by excluding (1) cropland acreage not harvested or pastured in 1959, and (2) excluding non-commercial farms (under 50 acres). Data according to 1959 U. S. Census of Agriculture.

Figure 1. Monthly distribution of soil samples received by the University of Minnesota Soil Testing Laboratory during 1963. (Total = 35,061).