The University of Minnesota

AGRICULTURAL EXPERIMENT STATION

GENERAL REPORT
NORTH CENTRAL EXPERIMENT STATION
GRAND RAPIDS, 1915-1919

UNIVERSITY FARM, ST. PAUL

THE BOARD OF REGENTS

The Hon. Fred B. Snyder, Minneapolis, President of the Board	1922
Marion LeRoy Burton, Minneapolis	*Ex Officio*
The President of the University	
The Hon. J. A. A. Burnquist, St. Paul	*Ex Officio*
The Governor of the State	
The Hon. J. M. McConnell, St. Paul	*Ex Officio*
The Superintendent of Education	
The Hon. John G. Williams, Duluth	1920
The Hon. George H. Partridge, Minneapolis	1920
The Hon. A. E. Rice, Willmar	1921
The Hon. Charles L. Sommers, St. Paul	1921
The Hon. Pierce Butler, St. Paul	1922
The Hon. C. W. Glotfelter, Waterville	1922
The Hon. W. J. Mayo, Rochester	1923
The Hon. Milton M. Williams, Little Falls	1923

THE AGRICULTURAL COMMITTEE

The Hon. A. E. Rice, Chairman	The Hon. John G. Williams
The Hon. Pierce Butler	The Hon. C. W. Glotfelter
The Hon. J. M. McConnell	The Hon. Milton M. Williams
The Hon. Charles L. Sommers	President Marion LeRoy Burton

ADMINISTRATIVE OFFICERS

R. W. THATCHER, M.A., D.Agr., Director
ANDREW BOSS, Vice Director
A. D. WILSON, B.S. in Agr., Director of Agricultural Extension and Farmers' Institutes
O. I. BERGH, B.S.Agr., Superintendent, North Central Substation, Grand
M. J. THOMPSON, M.S. Superintendent, Northeast Substation, Duluth
C. G. SELVIG, M.A., Superintendent, Northwest Substation, Crookston
Rapids
R. E. HODGSON, B.S. in Agr., Superintendent, Southeast Substation, Waseca
P. E. MILLER, B.S.A., Superintendent, West Central Substation, Morris
W. H. KENETY, M.S., Superintendent, Forest Experiment Station, Cloquet
CHARLES HARALSON, Superintendent, Fruit Breeding Farm, Zumbra Heights, (P. O. Excelsior)
W. P. KIRKWOOD, B.A., Editor
ALICE MCFEELY, Assistant Editor of Bulletins
HARRIET W. SEWALL, B.A., Librarian
T. J. HORTON, Photographer
R. M. West, B.S., Secretary
R. A. GORTNER, Ph.D., Chief, Division of Agricultural Biochemistry
ANDREW BOSS, Chief, Division of Agronomy and Farm Management
C. W. GAY, B.S.A., D.V.M., Chief, Division of Animal Husbandry
FRANCIS JAGER, Chief, Division of Bee Culture
C. H. ECKLES, M.S., Chief, Division of Dairy Husbandry
*JOHN T. STEWART, C.E., Chief, Division of Drainage
W. A. RILEY, Ph.D., Chief, Division of Entomology and Economic Zoology
WILLIAM BOSS, Chief, Division of Farm Engineering
E. G. CHEYNEY, B.A., Chief, Division of Forestry
W. H. ALDERMAN, B.S.A., Chief, Division of Horticulture
E. M. FREEMAN, Ph.D., Chief, Division of Plant Pathology and Botany
A. C. SMITH, B.S., Chief, Division of Poultry Husbandry
J. D. BLACK, Ph.D., Chief, Division of Research in Agricultural Economics
F. J. ALWAY, Ph.D., Chief, Division of Soils
C. P. FITCH, M.S., D.V.M., Chief, Division of Veterinary Medicine

STAFF OF NORTH CENTRAL EXPERIMENT STATION

OTTO I. BERGH, B.S. in Agr., Superintendent
EMIL OSTROM, Secretary
JOHN H. MOLLINS, Farm Foreman
JOSEPH N. FRISTEDT, Dairy Herdsman
JOHN HIRVONEN, In charge of Swine, Sheep, and Poultry

*On leave of Absence.

CONTENTS

ILLUSTRATIONS

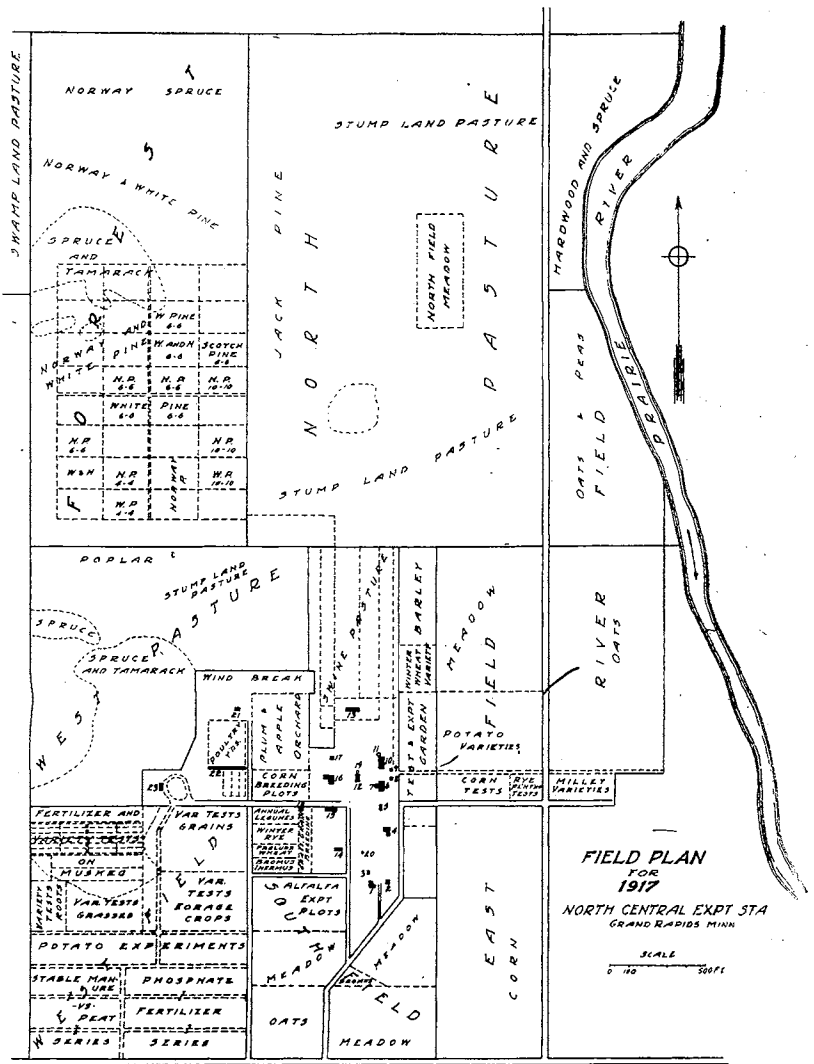

Fig. 1. Field Plans for 1917

GENERAL REPORT, NORTH CENTRAL EXPERIMENT STATION, 1915-1919

By O. I. Bergh, Superintendent

INTRODUCTION

In this report we have endeavored to present information bearing on the numerous experimental projects carried on at this station in as brief and concise a form as possible, eliminating a large amount of detail that it seemed unnecessary to include in so general a report. The reader should bear in mind that most of the projects reported on will be continued, therefore the data given should not be considered as final or conclusive.

The report is broadly a summary of the five years from 1915 to 1919, inclusive, covering the period that the writer has been in charge of the work. As the work in the various projects is completed, special reports will be published in which it will be described more in detail and the results discussed more fully

Fig. 2. Superintendent's Cottage From Entrance to Station

WEATHER

An observation station of the United States Weather Bureau is located here. Daily observations are reported to the weather bureau at Minneapolis each month. Table 1 shows the mean temperature as well as the absolute maximum and minimum for each month, beginning with December, 1914. The average mean is also given for the four seasons for each year. The average mean temperature for the three winter months for the five-year period was 6.50 degrees; for the spring months, 37.7 degrees; for the three summer months, 64.50 degrees; and for the three fall months, 39.30 degrees. The average yearly mean temperature for the five-year period was 37.10 degrees.

TABLE I

NORMAL MONTHLY, SEASONAL, AND ANNUAL TEMPERATURE, GRAND RAPIDS, 1915 TO 1919

Month	1915			1916			1917			1918			1919		
	Mean	Absolute Max.	Absolute Min.	Mean	Absolute Max.	Absolute Min.	Mean	Absolute Max.	Absolute Min.	Mean	Absolute Max.	Absolute Min.	Mean	Absolute Max.	Absolute Min.
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
December, 1914	7.6	42	—25	16.0	38	—15	2.3	43	—34	—0.6	38	—40	20.1	49	—20
January	4.5	39	—47	—3.4	32	—46	—3.1	41	—40	—3.5	24	—40	14.0	44	—38
February	18.5	40	—17	3.2	46	—38	—3.8	37	—33	3.8	54	—35	10.4	49	—36
Winter	10.2			8.9			—1.5			0.1			14.8		
March	24.6	49	—13	17.4	60	—35	21.1	59	—38	29.1	64	—7	23.0	63	—32
April	49.2	77	17	38.1	67	0	37.2	60	13	35.7	69	—1	40.0	74	11
May	49.0	80	21	49.8	77	26	49.8	82	20	48.9	70	11	53.5	97	20
Spring	40.9			35.1			36.0			37.9			38.8		
June	56.0	83	27	58.5	82	31	58.6	95	30	62.5	86	34	67.0	94	40
July	62.0	88	38	73.0	97	45	72.6	102	38	65.1	98	40	66.9	90	42
August	61.0	90	30	65.9	95	33	61.4	88	31	63.9	90	32	63.5	90	32
Summer	59.7			69.1			64.2			63.8			65.8		
September	56.0	86	30	53.5	83	22	53.6	82	22	38.1	76	12	56.5	84	32
October	44.0	71	20	40.7	73	13	32.8	64	—1	41.1	72	12	38.8	68	8
November	27.0	57	—3	26.6	67	—6	30.1	60	—9	31.3	56	9	19.1	44	—22
Fall	42.3			40.3			38.8			36.8			38.1		
Year	38.3	90	—47	38.4	97	—46	34.6	102	—40	34.7	98	—40	39.4	97	—38

The seasonal temperatures have a wide range. The lowest was 47 degrees below zero, in January, 1915, and the highest 102 degrees above zero, in July, 1917. Altho the winter temperatures drop very low, the weather is not so unbearable as it may seem, as the low temperatures usually occur in still, dry weather. The summer is marked by cool nights and warm days.

The ground is usually covered with snow from the middle of November to the latter part of March or the first of April. Field work usually begins in April. In 1915 the first grain planting was done April 16; in 1916, May 3; in 1917, May 4; in 1918, April 5; and in 1919, April 19.

Table 2 shows the latest dates of killing frost in the spring and the earliest dates of killing frost in the fall. The dates of slight frosts are also indicated but are not considered in determining the length of the growing season as the frosts were either local or not severe enough to cause damage. The shortest growing season was in 1916, 89 days, and the longest in 1919, 149 days. The five-year average was 112.8 days.

TABLE 2

LENGTH OF GROWING SEASON, 1915–1919 INCLUSIVE

Year	Latest killing frost in spring	Earliest killing frost in fall	Length of growing season	Slight frost, spotted, not killing
			Days	
1915	June 9.....	October 5.....	118	August 26, September 11 and 15.
1916	June 5.....	September 2..	89	None
1917	May 28.....	September 10.	105	June 5, August 29, September 2
1918	May 23.....	September 4..	103	August 11
1919	May 11.....	October 7.....	149	May 22, September 26

Table 3 shows the precipitation by months during the five-year period. The five-year average annual precipitation was 22.57 inches. It should be noted, however, that 1917 and 1918 were years of unusually low precipitation (14.71 and 20.78 inches, respectively) causing the five-year average to be lower than the average for a longer period, which is borne out by the records of the United States weather station, at Pokegama Falls, five miles west, where the average annual precipitation for a period of 33 years is 27.38 inches. It should be noted also that the greater part of the precipitation occurs during the growing season.

Table 4 shows the distribution of the precipitation throughout the year. There were 182 clear days, 67 partly cloudy, and 116 cloudy.

Table 5 shows the maximum and minimum temperatures for the growing season of 1919, May to October, inclusive, at two stations. One thermometer was located on mineral soil near the buildings and the other on the peat land of the muskeg. Both were four feet above the ground. The temperatures on the muskeg averaged from one to two degrees lower than those on the upland. Summer frosts are more frequent and more severe on peat than on the upland. It should be noted that two killing frosts occurred on the peat in August when none occurred on the upland. For this reason such tender crops as corn or potatoes can not be recommended for peat soils in this district. However, under proper management and fertilizer treatments the following crops can be successfully grown: For hay, oats and peas, timothy and clover; for pasture, Kentucky bluegrass, redtop, timothy and clover; for soiling and temporary pasture, rape; for stock and table vegetables, rutabagas, turnips, carrots, cabbage, onions, celery, and lettuce.

Table 6 gives a monthly summary of weather for 1919.

TABLE 3

PRECIPITATION BY MONTHS, 1915–1919

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1915	0.48	0.58	0.16	0.94	3.75	7.78	3.02	2.10	1.71	2.78	1.53	0.48	25.31
1916	1.66	0.24	1.38	3.52	3.80	3.87	1.89	4.22	2.87	1.80	0.16	0.76	26.17
1917	0.22	0.91	1.00	1.40	0.12	1.45	2.27	2.48	1.51	2.64	0.18	0.53	14.71
1918	0.23	0.18	0.12	2.10	2.75	0.78	2.24	4.29	0.82	2.92	2.18	2.17	20.78
1919	0.10	1.40	0.41	0.91	2.05	6.29	4.25	4.47	1.50	1.63	2.43	0.46	25.90
5-year average	0.54	0.66	0.61	1.77	2.49	4.03	2.73	3.51	1.68	2.35	1.30	0.88	22.57
33-year average at Pokegama Falls	0.75	0.70	1.36	2.00	3.37	4.26	4.14	3.70	3.07	2.02	1.18	0.83	27.38

TABLE 4

DAILY RAINFALL AND MELTED SNOW AT NORTH CENTRAL EXPERIMENT STATION, 1919

Date	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1		T	0.07			0.55			T	0.10			
2		0.60	0.01			0.01			0.08	0.02	0.08		
3		0.20	0.05		T	0.01	1.45	0.80	T		0.49		
4					0.84	0.50		0.05		0.10			
5				0.02		0.13		0.05	0.21	0.01		T	
6	0.03			0.10	0.58	0.23		0.66				0.06	
7			0.01	0.25	0.11	0.01		0.10	0.04			0.05	
8				0.15		0.23							
9				0.04	0.13	0.58				0.24			
10				0.25		0.04		0.04			0.50		
11		0.10		0.02		T	0.01	0.16		T	0.10	0.03	
12						0.66		0.50			0.05	0.17	
13				0.08				0.42	0.46	0.01			
14		0.10			0.05	0.15	0.46			0.15			
15			T		T	0.40		0.05					
16					0.19			0.25				T	
17		0.05										0.02	
18	0.03					0.02		T	0.10			T	
19		0.05		T			0.75		0.05			T	
20							0.25	0.13	0.05	0.30			
21							0.02			0.02			
22	0.04					1.00				0.10			
23				T	0.04	2.00				0.23		T	
24		0.30			0.01				0.01	0.35	0.55		
25			0.02				0.12				0.02		
26			0.25										
27	T			T						T			
28										0.10	0.08		
29							0.55	1.43	0.50		0.40	0.13	
30				T			0.38	0.03			0.06		
31					0.10		0.03						
Total	0.10	1.4	0.41	0.91	2.05	6.29	4.25	4.47	1.50	1.63	2.43	0.46	25.9
Daily average	T	0.05	0.01	0.03	0.07	0.21	0.13	0.14	0.05	0.05	0.08	0.02	0.07
Days partly cloudy	4	3	8	9	4	3	5	9	12	5	3	2	67
Days cloudy	7	8	10	10	10	12	6	7	8	10	11	17	116
Days clear	20	17	13	11	17	15	20	15	10	16	16	12	182

TABLE 5

TEMPERATURES ON DATES WHEN FROST OCCURRED ON PEAT SOIL DURING GROWING SEASON, 1916–1919

	1916			1917			1918			1919		
	Date	Mineral soil	Peat soil	Date	Mineral soil	Peat soil	Date	Mineral soil	Peat soil	Date	Mineral soil	Peat soil
		Deg.	Deg.		Deg.	Deg.		Deg.	Deg.		Deg.	Deg.
	June 5	*31**	30*	May 27	*23**	16*	May 23	*28**	21*	May 11	*20**	20*
	June 19	35	31	May 28	30†	24*	May 29	38	31	May 12	34	30
	June 20	33	29*	May 31	44	26*	May 30	44	32	May 18	30†	30†
	June 22	33	*28**	June 1	34	26*	June 7	38	32	May 19	32†	30†
				June 2	33	25*	June 21	35	*32†*	May 20	30†	*28**
				June 5	32†	24*	June 22	34	*28**	May 21	34	32
				June 15	30†	24*				May 22	30†	30†
				June 20	31	28*						
				June 22	35	*28**						
	Aug. 13	32	*29**	July 4	38	31†	Sept. 4	*22**	*20**	Sept. 24	34	*26**
	Aug. 30	33	30†	Aug. 6	36	*28**				Sept. 25	32†	30†
	Sept. 2	*29**	25*	Aug. 25	35	28*				Oct. 7	*24**	20*
				Aug. 29	31†	26*						
				Sept. 2	31†	24*						
				Sept. 4	32†	26*						
				Sept. 6	32†	26*						
				Sept. 9	32†	31†						
				Sept. 10	*22**	16*						
Length of growing season free from killing frost	.....	89 days	52 days	.....	105 days	45 days	.....	103 days	74 days	.....	149 days	127 days

Four-year average growing season on mineral soil, 111.5 days.

Four-year average growing season on peat soil, 74.5 days.

* Killing frosts.

† Slight frosts, heavy dew during night.

TABLE 6

MONTHLY SUMMARY OF WEATHER RECORDS, 1919

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Average
Mean maximum temperature, degrees	27.8	24.2	38.2	52.9	70.9	80.6	83.2	77.6	69.7	49.6	28.4	12.7	.....	51.3
Mean minimum temperature, degrees	0.6	—3.3	7.8	27.1	36.1	53.5	50.7	49.4	43.3	28.0	9.9	—7.6	.....	24.5
Mean temperature, degrees	14.0	10.4	23.0	40.0	53.5	67.0	66.9	63.5	56.5	38.8	19.1	2.6	.....	37.9
Maximum temperature, degrees	44.0	49.0	63.0	74.0	97.0	94.0	90.0	90.0	84.0	68.0	44.0	42.0	.....	97.0
Minimum temperature, degrees	—38.0	—36.0	—32.0	11.0	20.0	40.0	42.0	32.0	32.0	8.0	—22.0	—34.0	.....	—38.0
Days clear	20	17	13	11	17	15	20	15	10	16	16	12	182	15.2
Days partly cloudy	4	3	8	9	4	3	5	9	12	5	3	2	67	5.5
Days cloudy	7	8	10	10	10	12	6	7	8	10	11	17	116	9.7
Days with 0.01 inch or more precipitation	3	7	6	8	9	15	11	15	9	12	11	6	112	9.3
Total precipitation	0.1	1.4	0.4	0.9	2.1	6.3	4.3	4.5	1.5	1.6	2.4	0.5	25.9	2.2
Snowfall	4.0	14.0	3.5	2.0	T	0	0	0	0	7.5	21.25	5.75	58.0	4.9

Maximum 97.0 degrees, May 29.
Minimum —38.0 degrees, January 3.

FARM CROP INVESTIGATIONS

The work with grains, legumes, and grasses includes variety testing, time of planting, rate of planting, and production of pedigreed seeds for distribution. Breeding work is being carried on with corn and clover.

The production of pedigreed seeds is carried on in cooperation with the Central station, at St. Paul, and the substations at Crookston, Duluth, Morris, and Waseca, as well as with farmers throughout the state who desire to join in the work.

VARIETY TESTS OF WHEAT

Table 7 gives the results from the variety tests of spring wheat, 1915 to 1918, inclusive. The results for 1919 are given separately (Table 8) as several of the varieties grown in the previous years were dropped and new varieties added in order to harmonize with and supplement similar work at the other stations.

TABLE 7

VARIETY TEST OF WHEAT
AVERAGE YIELD PER ACRE FROM THREE PLOTS, 1915 TO 1918

Variety	Number	1915	1916	1917	1918	4-year average
		Bu.	Bu.	Bu.	Bu.	Bu.
Minnesota (durum)	951	27.4	10.0	13.4	47.50	24.58
Kubanka (durum)	.....	25.1	5.5	16.1	44.17	22.72
Red Chaff (fife)	.....	28.5	4.5	17.6	38.35	22.24
Prelude (bearded spring)	3,323	30.6	9.2	14.3	35.08	22.30
Hyde (bearded spring)	.....	24.6	3.2	19.8	34.70	20.58
Marquis (fife)	1,239	30.5	4.5	11.5	35.42	20.48
Minnesota (fife)	163	27.3	2.7	11.8	37.12	19.73
Haynes (bluestem)	169	30.3	3.0	13.6	29.59	19.12
White (fife)	.....	22.8	2.5	15.9	33.80	18.75
Alaska (poulard)	.....	20.8	3.0	10.6	38.15	18.14
Powers (fife)	.....	21.6	3.2	13.3	31.24	17.34
Red (fife)	.....	24.3	1.5	10.6	22.49	14.72

TABLE 8

VARIETY TEST OF WHEAT
AVERAGE YIELD PER ACRE FROM THREE PLOTS, 1919

Variety	Number	One-year average
		Bu.
Emmer	.....	21.48*
Acme (durum)	1,967	10.41
Mindum† (durum)	470	5.50
Kubanka (durum)	.....	4.35
Prelude (bearded spring)	3,323	2.68
Kubanka (durum)	2,102	2.68
Marquis (fife)	1,239	1.31
Preston (bearded spring)	924	0.78
Humpback (bearded spring)	1,598	0.16
Arnautka (durum)	2,103	0.13

* Emmer is figured at 60 pounds per bushel after deducting 20 per cent for hulls in order to give yield comparable with wheat.

† Mindum No. 470 is a selection from Minn. No. 951.

The very poor yields in 1916 and 1919 were due to black stem rust. Yields of the different varieties for those two years give a very fair indication of relative rust resistance. It will be noted that some of the durum wheats show a stronger resistance to rust than either the fifes, bluestems, or bearded springs, while other durums are very susceptible to this disease. Among the latter, Prelude, a very early short-strawed variety, surpasses the fifes and also the bluestems in hardiness. This can be recommended as one of the best hard spring wheats for this district on account of its quick growth and the short stiff straw which insures it against lodging on farms where a short rotation is practiced and where grain is to be planted as a nurse crop for grasses following potatoes or corn, and where the land has been heavily manured, as is usually the case on dairy farms in this district. This variety can not be recommended where grain is grown continuously or in a long rotation, or for any region where the average annual rainfall is less than 25 inches.

The milling test of this variety is shown in Table 9 in comparison with three other varieties: Minnesota No. 169 (bluestem), Powers Fife, and Marquis. The results indicate that Prelude is fully as good as any of the common varieties. It has the highest total flour and the greatest expansimeter test; the largest loaf volume, and a perfect color score; and is highest in crude protein content. Prelude was originated at Ottawa, Canada, and imported to this station in 1915.

TABLE 9

RESULTS OF TESTS FOR MILLING QUALITY, SPRING WHEATS, 1915 CROP

Variety	Total flour	Expansimeter test	Loaf volume	Water used	Color score	Moisture	Crude protein
	Per cent	cc.	cc.	Per cent		Per cent	Per cent
Minn. No. 169	70.3	910	1,510	59.1	98	12.28	9.93
Marquis	68.8	800	1,420	59.5	99	11.55	10.61
Prelude	72.7	930	1,580	63.5	100	10.40	12.31
Powers Fife	59.4	670	1,340	64.0	97	8.14	11.06

VARIETY TEST OF OATS

Tables 10 and 11 give the results from variety tests of oats. The yields obtained indicate that it is one of the best grain crops for this district for the production of feed, both grain and roughage, for livestock. Kherson and Iowa No. 103, both early varieties, give promise. Victory, Ligowa, Banner, and Lincoln can also be recommended.

TABLE 10

AVERAGE YIELD OF OATS PER ACRE FROM THREE PLOTS, 1915 TO 1918

Variety	Number	1915	1916	1917	1918	4-year average
		Bu.	Bu.	Bu.	Bu.	Bu.
Kherson		106.30	61.90	35.40	103.40	76.75
Banner	507	97.90	61.20	25.10	116.77	75.24
Lincoln	505	95.60	46.60	30.03	126.13	74.59
Early Gothland	295	87.00	52.20	32.30	123.90	73.85
New Market		88.60	57.50	28.10	119.07	73.32
Trifolium		91.70	40.90	32.75	126.93	73.07
White Russian		100.00	57.80	28.15	96.40	70.09
Danish Island		84.40	56.90	28.55	109.68	69.88
Golden Beauty		86.80	57.50	28.60	103.40	69.08
Abundance		83.90	52.80	22.60	115.53	68.56
Swedish Select		79.60	50.60	28.50	105.00	65.93
60 Day		110.60	40.00	26.45	.....	59.02*

* Three-year average.

Fig. 3. Oats in Variety Test
Seventy-five bushels of oats per acre is not unusual.

TABLE 11

AVERAGE YIELD OF OATS PER ACRE FROM THREE PLOTS, 1919

Variety	Number	Average yield
		Bu.
Iowa No. 103	531	45.67
Norway		35.72
Nursery Selection	358	34.25
Victory	514	34.25
O. A. C. 72	500	32.41
Imp. Ligowa	281	31.43
Lincoln	505	30.93
Swedish Select		27.78
Early July		26.88
Silvermine	506	26.15
White Russian	339	23.32

VARIETY TEST OF BARLEY

Barley ranks with oats as a grain crop for feed. As a rule the six-rowed varieties are heavier producers than the two-rowed varieties. Among the best six-rowed varieties are Minsturdi, Odessa, Manchuria, and Blue Ribbon. Austrian Hannah, Swedish Chevalier, and Svansota are good two-rowed varieties. So far we have been unable to find a hull-less variety giving a yield sufficiently large to recommend it in preference to the best bearded varieties.

TABLE 12

AVERAGE YIELD OF BARLEY PER ACRE FROM THREE PLOTS, 1915–1918

Variety	Number	Type	1915	1916	1917	1918	4-year average
			Bu.	Bu.	Bu.	Bu.	Bu.
Odessa	.....	6-rowed	63.30	13.50	25.10	52.83	38.68
Austrian Hannah	.....	2-rowed	47.70	21.80	25.00	55.66	37.54
Blue Ribbon	.....	6-rowed	62.00	16.25	26.20	45.66	37.53
Manchuria	184	6-rowed	61.70	13.70	20.70	50.33	36.61
O. A. C. 21	.....	6-rowed	63.90	12.10	18.10	47.83	35.48
Huston G. Queen	.....	6-rowed	58.10	12.70	17.40	47.66	33.97
French Chevalier	230	2-rowed	43.10	15.20	23.90	49.00	32.80
Oderbrucker	.....	6-rowed	54.60	11.70	20.90	39.00	31.55
Champion of Vermont	.....	2-rowed	55.60	12.90	15.20	40.60	31.08
Swedish Chevalier	.....	2-rowed	36.20	12.90	21.10	46.33	29.13

TABLE 13

AVERAGE YIELD OF BARLEY PER ACRE FROM THREE PLOTS, 1919

Variety	Number	Type	Average yield
			Bu.
Minsturdi	439	6-rowed	40.27
Odessa	.....	6-rowed	38.32
Manchuria	184	6-rowed	37.48
Swedish Chevalier	.....	2-rowed	34.79
Lion × Manchuria	438	6-rowed	32.41
Svansota	444	2-rowed	31.98
Austrian Hannah	.....	2-rowed	29.68
White Hull-less	.....	6-rowed	18.33

Fig. 4. Barley Field
Barley is a dependable crop for northern Minnesota.

TABLE 14

AVERAGE YIELD OF WINTER WHEAT PER ACRE FROM THREE PLOTS, 1916–1919

Variety	Minn. No.	Nursery stock No.	Type	Yield per acre				General average yield	Two-year average yield 1916–1919
				1916	1917	1918	1919		
				Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Turkey × Odessa	1507	II–02–280	White, bearded	26.8	8.4	6.6	22.7	16.2	24.7
Turkey × Odessa	1493	II–02–14	Red, awnless	23.9	10.1	4.4	22.0	15.1	23.0
Turkey	1487	Check	White, bearded	20.2	7.7	3.2	21.8	13.2	21.0
Odessa × Turkey	1497	II–02–41	Red, bearded	25.1	11.1	5.0	13.0*	13.9	19.1
Crimean	845	III–16	White, bearded	22.3	13.7	5.6	15.3	14.3	18.8
Odessa	1471	I–01–3	Red, awnless	20.7	10.4	2.8	13.8	12.0	17.3
Turkey × Odessa	1506	II–02–239	White, awnless	19.6	7.7	3.7	14.0	16.8	11.3
Big Frame	1481	I–06–6	White, awnless	19.7	14.4	2.0	13.2	12.4	16.5
Turkey × Odessa	1505	II–02–195	White, awnless	18.8	10.0	4.0	14.2	11.8	16.5
Turkey (N. K. & Co.)	1488	I–03–120	White, bearded	16.2	13.8	7.0	14.0	12.8	15.1
Padui	1491	I–03–229	Red, bearded	19.4	8.2	2.7	10.7	10.3	15.1
Odessa × Turkey	1498	II–02–67	White, bearded	17.3	11.4	7.3	11.6	12.0	14.5
Odessa × Turkey	1509	II–02–334	White, bearded	18.1	11.1	5.3	8.6	10.6	13.4
Odessa × Turkey	1496	II–02–30	White, bearded	17.1	8.7	5.3	8.9	10.0	13.0
Odessa × Turkey	1484	II–01–7	Red, bearded	17.5	10.9	9.1	6.0	10.9	11.7
_____ × Turkey	552/829	II–02–521	White, bearded	.....	10.3	3.3	16.0	19.9	.....
Crimean	832	I–15–36	White, bearded	.....	7.5	5.0	11.1	7.9	.....
Turkey × Bearded	829/550	II–02–618	White, awnless	.....	.....	4.1	16.3	10.2	.....
Crimean	845	I–17–133	.....	.....	.....	.....	15.6	15.6	.....
China	1576	III–16	.....	.....	.....	.....	12.1	12.1	.....
Buffins No. 17	1651	III–18	.....	.....	.....	.....	10.9	10.9	.....
Kansas P 1068	.....	III–19	.....	.....	.....	.....	9.5	9.5	.....

VARIETY TEST OF WINTER WHEAT

Variety testing of winter wheats has been carried on since 1916. Forty-two varieties have been included in these tests. However, twenty of the varieties have been eliminated and others included in their place. Table 14 gives the results from the varieties still in the test. No results are given for those dropped out. The table shows the general average for four years as well as a two-year average for 1916 and 1919. The yields for 1917 and 1918 are eliminated, as the determining factor for those two years was lack of moisture rather than winter hardiness.

The yields obtained in 1916 and 1919 are fair indications of winter hardiness and yielding ability of the varieties under test, as during those two years no determining factor other than winter hardiness entered into the results except that of rust in 1919. There seems to be no evidence that the bearded varieties are better yielders than the awnless, as is apparently the case with barleys.

VARIETY TEST OF RYE

Variety tests with rye were started in 1919. The yields from the different varieties are given in Table 15. While one year's test is not sufficient on which to base a safe conclusion, the information obtained may be of some practical value to farmers of this district. Swedish No. 2 and Rosen showed no evidence of winter-killing. Abruzzes seems to be the least hardy of the winter varieties. Swedish No. 2 has a longer straw than any of the other varieties under test. Rosen has the shortest straw among the winter varieties. Spring rye yielded only about one third as much as the winter varieties and the grain was of much poorer quality. Rosen and Swedish No. 2 can be recommended as good varieties for this district.

TABLE 15

AVERAGE YIELD PER ACRE IN VARIETY TESTS OF WINTER RYE, 1919

Variety	Yield per acre	
	Grain	Grain and straw
	Bushels	Pounds
Swedish No. 2	29.1	4,191
Wis. Pedigree	28.1	3,020
Rosen	31.7	4,069
Abruzzes	26.2	3,619
Spring rye	10.5	2,176

RATE OF PLANTING WINTER WHEAT AND WINTER RYE

The results from the rate of planting test indicate that six pecks per acre is the minimum amount of seed that can be recommended for both winter rye and winter wheat. Further tests will be necessary to determine whether a larger amount should be used. In 1919 six pecks per acre gave the maximum yields when the seeding was done between August 20 and September 1. If sown later, more seed is probably necessary for best results.

TIME OF PLANTING WINTER WHEAT AND WINTER RYE

Results from the time of planting tests of winter wheat and winter rye are given in Tables 16 and 17. These plantings were made on corn land, the first two before the corn was harvested. A single-horse disk drill was used.

It is evident that winter grains should be planted previous to September 15. However, winter rye may be safely planted later than winter wheat. The latter should be planted in August in order to get well established before the ground freezes. With both winter rye and winter wheat the August plantings surpassed in yield all later plantings.

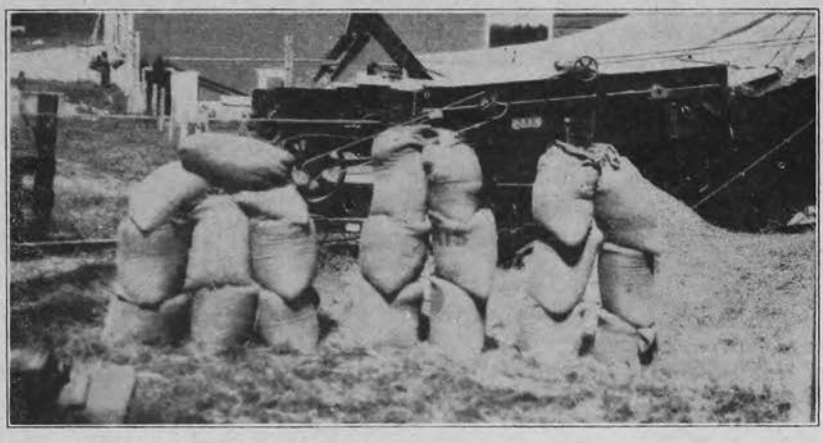

Fig. 5. Yield of Winter Rye (Minn. No. 2)
From left to right: Rye sown Sept. 1—yield, 31.3 bushels per acre. Rye sown Sept 15—yield, 26.1 bushels per acre. Rye sown Oct. 1—yield, 23.0 bushels per acre.

TABLE 16

YIELD PER ACRE OF TURKEY RED WINTER WHEAT IN TIME-OF-SEEDING TEST, 1917–1919

Date seeded	1917	1918	1919	Three-year average
	Bu.	Bu.	Bu.	Bu.
August 15	.....	24.9	24.08	24.49*
September 1	12.1	17.5	22.54	17.38
September 15	6.6	Winter-killed	20.06	8.88
October 1	2.8	Winter-killed	16.88	6.56

* Two years only.

TABLE 17

YIELD PER ACRE OF MINN. NO. 2 RYE IN TIME-OF-SEEDING TEST, 1916–1919

Date seeded	1916	1917	1918	1919	Four-year average
	Bu.	Bu.	Bu.	Bu.	Bu.
August 15	.....	.....	44.0	22.5	33.25*
September 1	32.1	31.3	35.9	22.4	27.75
September 15	22.1	26.1	32.9	20.3	23.70
October 1	21.3	23.0	23.5	20.3	21.60

* Two-year average.

FIELD PEAS

Field peas have been grown at this station for both grain and hay. A mixture of field peas and oats seeded at the rate of 2 bushels of peas and 1 bushel of oats per acre is one of the best paying annual hay crops for this district.

In normal seasons the yield is between two and three tons of hay per acre. In nutritive value for dairy cows, this hay compares well with timothy and clover hay. Heavy soils are better adapted to field peas than light sandy soils, especially for the purpose of growing them for hay. Large crops of oats and peas hay have also been produced on the peat land when this has received the proper treatment. As an annual hay crop on peat land a mixture of oats and peas can be recommended. There is little danger of damage to this crop by summer frosts on such land. Table 18 gives the grain yield in bushels per acre of the varieties of field peas grown on mineral land.

TABLE 18

YIELD OF GRAIN PER ACRE IN VARIETY TEST OF FIELD PEAS

Variety	Yield per acre Bu.
Wisconsin No. 508	30.5
Green No. 208	25.8
Green Canada	24.6
Green No. 108	18.6
Ped. Marrowfat	18.3
Bangalia	14.3
Yellow Canada	14.3
Arthur	14.3

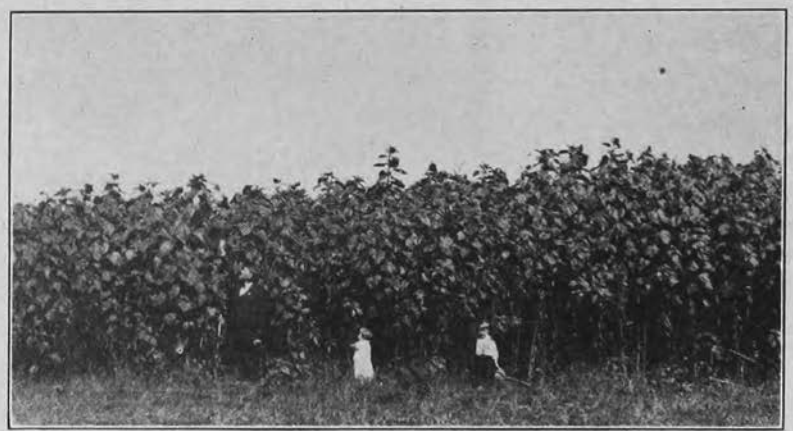

Fig. 6. Sunflowers for Silage
They were grown on low-lime peat land, limed and manured.

CORN, SUNFLOWERS, AND SOY BEANS FOR SILAGE

Corn is grown mainly for silage. Other crops used for silage are the sunflower and the soy bean. A mixture of corn, sunflowers and soy beans in the proportion of three parts of corn and one part each of sunflowers and soy beans drilled in rows 40 inches apart at the rate of 20 pounds of seed per acre has given very satisfactory results both in yield and in quality of silage. The varieties used are Minnesota No. 13 corn, Mammoth Russian sunflowers, and Chestnut and Early Black Wisconsin soy beans. Early Black Wisconsin soy bean is a small variety and appears to be too early for this purpose. A larger and later variety is more satisfactory.

CORN IMPROVEMENT

A breeding plot of Minnesota No. 13 corn has been maintained since 1915. The object has been to select for earliness and to reduce the number of rows of kernels on the ear in order to obtain ears of smaller diameter without sacrificing

depth and shape of kernels. The results have been very encouraging and seed from this improved corn is being distributed. This corn is sufficiently early to produce seed in normal seasons, and being large and leafy it is one of the best for fodder and silage. We do not recommend it to be grown for ripe grain in this district except on farms that are very favorably located. Early flint varieties are preferable for ear corn and for hogging off, the common Squaw Flint corn being generally recommended.

Table 19 gives the results of variety tests with corn in 1919. It should be stated, however, that the year was unusually favorable for corn.

Fig. 7. Harvesting Crop of Soy Beans, Corn, and Sunflowers
These were drilled in, in rows, at the rate of 20 pounds of seed per acre in the following proportion: 3 parts corn, 1 part soy beans, and 1 part sunflowers.

ALFALFA

Table 20 gives the results of the experimental work with alfalfa. It will be noted that Minnesota Grimm has consistently given the most satisfactory yields. Inoculation with soil from an old alfalfa field has given a marked increase in yields, and its beneficial effect was apparent in the vigor and color of the plants receiving such treatment as compared with those not inoculated. An application of lime at the rate of one ton per acre gave no apparent beneficial effect.

Alfalfa has also been grown in the regular field rotations. Planted early in the spring with a nurse crop of wheat on corn land previously manured and inoculated, alfalfa has given fully as large yields of hay as the clovers. Grimm alfalfa planted in April, 1918, with Prelude wheat as a nurse crop, yielded 11,446 pounds of hay per acre in 1919 in two cuttings, as follows: June 30, 6,829 pounds per acre, and August 21, 4,617 pounds per acre. The corn land was disked and harrowed but not plowed. Alfalfa has also been used in our general grass mixtures for meadows, replacing in part the medium red clover. Considering the relative price of seed, the following mixture can be recommended where meadows are to be used for hay more than one year: Timothy, 3 parts; alfalfa, 1 part; medium red clover, 1 part; and alsike clover, 1 part.

Two varieties of sweet clover were also added in our trials with meadow mixtures in 1919 and showed promising growth during the season.

TESTS OF GRASSES

Table 21 gives the results from tests of grasses grown for hay on the ordinary or mineral soil. This project was seriously affected by drought in 1917 and 1918. Italian rye grass was also included in this project but was entirely winter-killed.

Fig. 8. Picking Seed Corn, 1919
Minnesota No. 13 corn, 14 rows of kernels to the ear.

TABLE 19

YIELD OF CORN VARIETIES, 1919*

Variety	Height of stalk	Date tasselling	Date in silk	Date ripe	Field weight of ears per plot	Percentage of		Shelled corn per acre	
						Shrinkage	Shelled corn	Field cured	Air-dry basis
	Feet	July	July	Sept.	Lbs.			Bu.	Bu.
Cass Lake Squaw Flint	8.5	13	17	2	60.8	31	93	40.5	27.5
Squaw Flint	8.5	18	24	6	84.0	35	91	56.5	36.0
Dakota White Flint	8.8	20	23	3	52.0	33	84	32.5	21.5
Gehu Flint	8.0	19	22	5	52.5	34	86	35.5	23.0
Minnesota No. 23	7.0	20	23	15	79.5	36	79	53.0	34.0
Northwestern Dent	9.5	23	28	22	124.5	43	81	83.0	47.5

* Planted May 21.

TABLE 20

YIELD PER ACRE OF ALFALFA, FIELD CURED, 1916 TO 1918

Plot	Variety	1916			1917			1918			Three-year average		
		First cutting	Second cutting	Average	First cutting	Second cutting	Average	First cutting	Second cutting	Average	First cutting	Second cutting	Yearly Average
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	Minn. Grimm	5,028	1,029	6,057	416	232	648	3,060	1,600	4,660	2,835	954	3,789
2	Disco No. 52	2,514	800	3,314	171	95	266	3,460	700	4,160	2,048	532	2,580
3	Turkestan	2,971	1,829	4,800	306	170	476	3,080	1,200	4,280	2,119	1,066	3,185
4	Imp. N. K. & Co	2,971	2,171	5,142	172	95	267	2,440	1,020	3,460	1,861	1,095	2,956
5	N. W. Experiment Station	4,114	2,400	6,514	409	227	636	2,640	1,200	3,840	2,388	1,275	3,663
6	Dakota	2,286	2,743	5,029	166	92	258	2,000	1,000	3,000	1,484	1,278	2,762
7	Disco No. 28—South Dakota	3,200	1,829	5,029	108	60	168	2,200	1,000	3,200	1,836	963	2,799
8	Kansas	3,200	2,514	5,714	205	114	319	2,520	800	3,320	1,975	1,143	3,118
9	Montana	3,200	1,829	5,029	209	116	325	2,160	1,000	3,160	1,856	982	2,838
10	Turkestan	3,200	2,743	5,943	155	86	241	2,600	1,000	3,600	1,985	1,276	3,261
11	Grimm	3,771	2,400	6,171	522	290	812	2,440	1,200	3,640	2,244	1,296	3,540
12	Disco No. 52	2,514	2,629	5,143	187	104	291	2,040	600	2,640	1,580	1,111	2,691
	Average, all varieties	3,247	2,076	5,323	252	141	393	2,553	1,027	3,580	2,018	1,081	3,099
13	Turkestan, no treatment	3,291	1,920	5,211	384	213	597	3,264	1,656	4,920	2,313	1,263	3,576
14	Turkestan, limed 2,000 lbs. per acre	2,834	1,645	4,479	296	164	460	3,280	1,520	4,800	2,133	1,110	3,243
15	Turkestan, limed 2,000 lbs. per acre, seed treated with Govt. bacteria culture	3,749	1,920	5,669	475	264	739	3,760	1,256	5,016	2,661	1,147	3,808
16	Turkestan, seed treated with bacteria culture	3,200	2,012	5,212	300	167	467	3,440	1,360	4,800	2,313	1,180	3,493
	Average, all plots	3,269	1,874	5,143	364	202	566	3,436	1,448	4,884	2,355	1,175	3,530

Fig. 9. Alfalfa Field
Alfalfa can be grown successfully under proper management.

TABLE 21

AVERAGE YIELD PER ACRE OF FIELD CURED HAY, IN ONE CUTTING
DUPLICATE PLOTS, 1916-1918

Variety	1916	1917	1918	Three-year average
	Tons	Tons	Tons	Tons
Meadow fescue	2.50	0.78	0.64	1.32
Bromus Inermus	2.05	0.97	0.66	1.22
Western rye grass	2.25	0.50	0.58	1.11
Orchard grass	1.15	0.62	0.38	0.72
English rye grass	0.58*	0.82	0.64	0.68

* Winter-killed.

POTATO INVESTIGATIONS

Both the climate and the soil of north central Minnesota are favorable for potatoes. The potato crop is the main crop grown for market on most farms in the territory. Grown on land newly cleared or on land previously in clover, the yields are large and the quality unexcelled, so that on most farms the potato crop is given a place among the major field crops in the rotation.

Investigational work with potatoes has therefore been given due attention. This work may be summarized under the following headings: (1) Variety testing; (2) potato improvement; (3) fertilizer treatments; (4) cultural methods; and (5) field practice.

VARIETY TESTING

Variety testing has been carried on for the last twenty years, and has included a large number of varieties. The results from these tests have been reported from time to time in station bulletins. The most promising varieties, however, include those adopted in 1916 by the Minnesota Potato Growers' Association as the standard varieties for Minnesota. Since then the work has been limited to these eight standard varieties and one other, the "Itasca", a Green Mountain seedling propagated from seed gathered at this station by Geo. F. Kremer of Grand Rapids. The results are summarized in Table 22.

TABLE 22

YIELD PER ACRE OF POTATO VARIETIES

Variety	1917	1918	1919	Three-year average	U.S. grade No. 1*	Yield per acre U.S. grade No. 1*
	Bu.	Bu.	Bu.	Bu.	Per cent	Bu.
Green Mountain	373.58	374.7	414.2	354.16	92.9	329.02
Burbank	254.63	415.3	307.5	325.81	74.2	241.75
King	275.58	318.7	340.1	311.46	94.1	293.08
Irish Cobbler	300.83	318.3	398.0	305.71	89.7	274.22
Burbank Russet	270.17	354.7	289.7	304.86	77.6	236.57
Rural New Yorker	211.83	318.0	342.8	290.87	91.8	267.22
Bliss Triumph	258.67	254.4	257.1	256.71	91.6	235.15
Early Ohio	299.66	250.0	209.0	252.88	87.7	221.78
Itasca (Green Mountain seedling)	.....	381.3	376.2	378.75†	89.6	339.36

* Graded over Bogg grader, 1⅞-inch mesh revolving screen.

† Two-year average.

All varieties under test, except Green Mountain and the Green Mountain seedlings, were purchased from growers in the state in 1916 and 1917 and were from the very best stock obtainable. The Green Mountain potatoes are from stock grown at this station for many years. Throughout the testing work this variety ranked as one of the largest yielders and is a most satisfactory all-round late potato. The Green Mountain seedling, the Itasca, is quite similar to its parent in color of blossom, leaves, and tubers. The vines, however, are less spreading. The tubers set closer together in the hill and seem to be slightly earlier. The tubers are smoother than those of the true Green Mountain and the ends are more rounded. There are fewer over-grown, rough tubers. The eyes are somewhat shallower. The flesh is uniform and firm. The cooking quality is excellent and the flavor pleasing.

POTATO IMPROVEMENT

The potato improvement work has for its main object the development of superior seed strains and their distribution to potato growers both in this state and in other states. This work is being done in cooperation with Dr. William Stuart, Chief of Potato Investigations in the United States Bureau of Plant Industry. The procedure in brief, is as follows: 100-pound lots of seed are obtained from growers in the state whose fields have previously been inspected and found to be of vigorous growth, producing tubers of good quality, true to variety, of good type, and free from disease. These are carefully sorted, treated for disease, and planted in plots on a field selected for its uniformity of soil and other factors. The plots are carefully gone over several times during the growing season by expert field men of the United States Department of Agriculture and notes are taken on each plot with reference to vigor of plants, purity as to variety, and the prevalence of disease. All diseased plants are removed. At harvest time the crop is again carefully checked over by one of the government field men. The yield from each plot is carefully ascertained and the quality and condition of the tubers observed and recorded. The crop from the best plot of each variety is then reserved to be planted on an increase plot the next year in order to produce seed for distribution. New lots are received and tested each year and compared with the best lot of the previous year. The varieties included in this seed-development work are Green Mountain, Rural New Yorker, Early Ohio, Triumph, and Cobbler.

FERTILIZER TREATMENTS

Fertilizer treatments for potatoes have been carried on for five years and include the comparison of manure vs. no manure; acid phosphate vs. rock phosphate, with and without stable manure; and the application of raw peat in varying quantities of from 10 to 40 tons per acre, in comparison with applications of stable manure of from 5 to 20 tons per acre once in three years in a rotation of oats, clover and timothy meadow, and potatoes. These experiments are described on pages 34 to 47. The yields are given in Table 23.

TABLE 23

EFFECT OF FERTILIZATION ON YIELD OF POTATOES

Rock Phosphate vs. No Treatment

Treatment	1915	1916	1917	1918	1919	5-year average
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Rock phosphate, 1000 lbs. in 1914	131.6	95.6	155.3	170.5	179.9	146.58
Check (No treatment)	124.3	106.3	157.7	136.3	126.0	130.12
Increase	7.3	—10.7	—2.4	34.2	53.9	16.46
Acid Phosphate vs. No Treatment						
Acid phosphate, 360 lbs. per acre once in rotation (3 years)	140.0	104.6	179.5	154.2	154.2	146.70
Check (No treatment)	124.3	106.3	157.7	136.3	126.0	130.12
Increase	16.7	—1.7	21.8	17.9	28.2	16.58
Rock Phosphate and Manure vs. Manure Only						
Rock phosphate, 1000 lbs. per acre in 1914 and manure, 10 tons	179.6	145.8	260.5	285.9	285.2	231.40
Manure only, 10 tons	180.9	169.7	253.6	257.4	292.6	230.84
Increase	—1.3	—23.9	6.9	28.5	—7.4	0.56
Acid Phosphate and Manure vs. Manure Only						
Acid phosphate, 360 lbs. and manure, 10 tons	183.3	163.6	266.2	272.6	321.2	241.38
Manure only, 10 tons	180.9	169.7	253.6	257.4	292.6	230.84
Increase	2.4	—6.1	12.6	15.2	28.6	10.54
All Manured Plots (9) vs. All Unmanured Plots (9)						
Manure	181.2	159.7	260.1	271.9	299.7	234.52
No manure	132.3	102.1	164.1	153.6	153.3	141.08
Increase	48.9	57.6	96.0	118.3	146.4	93.44
Average for All Treatments						
Check (no treatment)	124.3	106.3	157.7	136.3	126.0	130.12
Rock phosphate	131.6	95.6	155.3	170.5	179.9	146.58
Rock phosphate and manure	179.6	145.8	260.5	285.9	285.2	231.40
Manure	180.9	169.7	253.6	257.4	259.3	230.84
Acid phosphate and manure	183.3	163.6	266.2	272.6	321.2	241.38
Acid phosphate	141.0	104.6	179.5	154.2	154.2	146.70

The yield given in the table is in each case the average from three plots. The rock phosphate was applied at the rate of 2,000 pounds per acre in 1914. Stable manure at the rate of 10 tons per acre is applied once in the rotation (3 years), on the clover sod preceding potatoes. Acid phosphate is applied at the rate of 360 pounds per acre once in the rotation, on the potato land just before planting.

It will be noted that the only treatment showing a decided beneficial effect is the 10 tons of stable manure. The yields of the plots receiving manure and treated the same as those with no manure, show an increase in favor of manure of 118.3 bushels per acre in 1918 and 147.4 bushels per acre in 1919. In other words, with potatoes selling at $1 a bushel, the manure application gave a return in 1919 in increased yield of $14.74 for each ton of manure applied. This may be termed the indirect profit from livestock. Table 42 shows the effect of stable manure on the other crops in the rotation. The importance of livestock in relation to potato culture in this district can hardly be over-estimated. Dairying with potato growing appears to be an ideal farm system for this district. The growing of potatoes is not essential to successful dairying, but it is questionable whether potatoes can be grown successfully for many years without being supplemented by dairy cows, or other livestock.

CULTURAL METHODS

Trials were begun in 1915 to compare (a) mature and immature potatoes for seed; (b) size of seed; (c) rate of planting; (d) time of planting; and (e) seed from crop produced on mineral soil with seed produced on peat land. This work was discontinued during the war on account of scarcity of labor. Results so far obtained are hardly sufficient on which to base recommendations, but can in brief be summarized as follows:

(a) Immature seed gave fully as large yields as mature seed.

(b) The results from seed of different sizes, that is, potatoes planted whole, in halves, quarters, and as ordinarily cut, indicate that the yields increased directly with the size of the seed piece, whole potatoes giving the largest yield; halves, second; ordinary cut, third; and quarters the lowest yield. The percentage of marketable potatoes from the planting of seed pieces of different size, however, resulted in 88.4 per cent for the quarters; 88.0 per cent for the halves; 86.8 per cent for the whole tubers; and 86.7 per cent for the ordinary cut. These figures indicate that there was a larger percentage of small tubers produced where the whole tubers were planted.

TABLE 25

YIELD OF POTATOES PER ACRE IN SIZE-OF-SEED TEST

	Weight of seed pieces	Seed required per acre	Yield per acre			Return for each bushel of seed used
			Total	No. 1 grade U. S.	Less seed used	
	Oz.	Bu.	Bu.	Bu.	Bu.	Bu.
Whole tubers.....	6.0	40.0	336.1	294.0	254.0	8.40
Half tubers.....	3.0	20.0	272.7	240.1	220.1	13.63
Quarter tubers....	1.5	10.0	232.7	205.8	195.8	23.27
Ordinary cut.....	2.0	13.3	258.9	224.8	211.5	17.23

(c and d) Results from rate of planting and time of planting tests have so far been rather conflicting and indicate that field conditions and weather are to a large extent determining factors. A fertile field receiving plenty of rain allows

closer planting than a field deficient in fertility and lacking in moisture. Plots planted at different dates may give varying effects from the same cause, as drought or rain, the degree of injury or benefit being determined by the stage of growth the plant is in when so influenced.

(e) The crop from seed grown on peat land in 1915 was fully as good as the crop from seed produced on mineral soil, altho the seed tubers from the peat soil, on account of an early frost, were small and immature as compared with these produced on the mineral soil.

The price of seed stock is usually about two times higher than that received for the bulk of the crop. Even when a farmer is growing his own seed it will cost him, for shrinkage, culling, risks, and interest on investment, at least twice what he can get for the potatoes when they are dug. This should be considered in determining the size of seed pieces to be used. In the above table, even tho twice the amount of seed used is deducted from the total marketable potatoes the yield will show a surplus over seed requirements in favor of the larger seed pieces, the whole tubers yielding 214 bushels per acre, the half tubers, 200 bushels, the ordinary cut, 198.2 bushels, and the quarter tubers, 185.8 bushels.

FIELD PRACTICE

The practice at this station is to have clover precede potatoes in the rotation. The soil on most of the station fields is a sandy loam. If the meadow is infected with quack grass, it is plowed shallow after the hay crop has been harvested and left fallow without further tillage until late fall when it is thoroly disked and left open for the winter. Stable manure is applied during the winter and early spring and is incorporated with the soil either by disking or by harrowing with a spring-toothed harrow. Just before planting the field is again plowed from six to eight inches deep and harrowed into condition for planting.

On fields free from quack grass, the practice on light sandy soil is as follows: Manure is applied on the clover meadow, usually in the spring preceding the hay crop. The clover stubble is thoroly disked, either in the fall or in the spring. The field is plowed 6 or 8 inches deep, usually in the spring just before planting, and harrowed into condition. With heavy soil, fall plowing is recommended.

The field is given a deep blind cultivation after planting and as the sprouts begin to appear in the rows the field is harrowed crosswise, followed later by cultivation as needed. Level cultivation is practiced where the soil is loose and open, which it usually is here in years of normal rainfall. During wet years hilling is recommended, especially if the soil is firm and set, causing the tubers to appear above the surface.

The seed used is the very best obtainable. All diseased tubers are discarded, as well as those not true to variety and type. The seed is then treated, a bushel to a sack, by immersion for an hour and a half in a corrosive sublimate solution made by dissolving 4 ounces of corrosive sublimate (bichloride of mercury) in 30 gallons of water. The corrosive sublimate is put into the empty barrel and a pail of hot water poured over it. Enough cold water is then added to make 30 gallons.

After treating, the potatoes are poured out on the grass to dry before they are cut. The size of pieces averages from two to three ounces. These are then planted from 11 to 16 inches apart in rows 3 feet apart. Early varieties are usually planted closer in the row than late varieties. Early varieties, planted

for the summer market, of course, are planted as early in the spring as the weather and soil conditions will permit. Late varieties, as Green Mountain, King, and Burbank are planted from May 15 to June 1, and early varieties are planted still later when grown for seed.

The potatoes are sprayed as soon as bugs appear. If no bugs appear, as has been the case, sprayings is delayed until the buds begin to set unless there is evidence of early blight. For bugs, 4 pounds of lead arsenate or 2 pounds of paris green is added to 50 gallons of bordeaux mixture; but bordeaux mixture is used alone if there are no bugs. The potatoes are usually sprayed twice and more if necessary.

A farmer growing potatoes for seed for spring delivery should provide an outdoor cellar, preferably, built into a hillside with ample covering to insure against freezing and with ample ventilation to keep the cellar dry. Two such cellars at this station, built of stone and concrete, are giving very satisfactory service. Basement cellars are usually unsatisfactory on account of the uneven temperature.

ROOT CROPS

For the most successful and economical winter feeding of sheep and swine as well as dairy and beef cattle, a succulent feed is necessary. In the corn belt ensilage from Indian corn meets this demand, and where this crop can be grown with certainty, with yields of from 10 to 15 tons per acre of green fodder, there is little hope of finding any other crop that will equal it in either economy or quality. But there are large districts in Minnesota, especially in the north eastern section, where corn can be grown only with the greatest risk from summer frosts and other adverse conditions. Happily, however, other factors combine to make this section eminently the most ideal district in the state for dairying and sheep raising. The ample rainfall and cool summer nights together with the fertile soil protected by a heavy blanket of snow through the winter months, result in the most luxuriant growth of all kinds of grasses and legumes, making pastures unsurpassed for grazing from the time the snow goes off in the spring until the first snow in the fall, or producing an abundant hay crop of the finest quality. These same conditions are also most favorable for all kinds of root crops, a fact which is of utmost importance to the dairy and sheep husbandry of northern Minnesota.

Roots are nature's ready-made succulent feed for winter. From earliest times roots have formed the basis of successful winter feeding of livestock in all the most important dairy districts of northern Europe; and Canada, Denmark, Sweden, Germany, Holland, and the British Isles all depend on root crops for their succulent winter feed. A person from the corn belt of America traveling through these districts of Europe and Canada is struck by the absence of fields of Indian corn and the universal cultivation of root crops.

The feeding value of such roots as beets, mangels, and rutabagas, as compared with silage, is in the ratio of approximately four to three. A daily feed of 40 pounds of roots will take the place of about 30 pounds of corn silage; in other words 4 tons of roots are equivalent to 3 tons of corn silage. A yield of 16 tons of roots per acre furnishes about the same digestible nutrients in succulent form as an acre of corn yielding 12 tons of silage.

TABLE 26

AMOUNT OF DRY MATTER AND DIGESTIBLE NUTRIENTS IN 100 POUNDS OF ENSILAGE, POTATOES, AND ROOTS

	Dry matter	Digestible		
		Protein	Carbohydrates	Fat
	Lbs.	Lbs.	Lbs.	Lbs.
Corn silage	26.0	1.2	14.0	0.7
Potatoes	21.0	1.1	16.0	0.1
Sugar beets	13.0	1.3	10.0	0.1
Rutabagas	11.0	1.0	8.0	0.2
Common beets	11.0	1.2	8.0	0.1
Carrots	11.0	0.8	8.0	0.2
Flat turnips	10.0	0.9	6.0	0.1
Mangels	9.0	1.0	5.0	0.2

Among the different kinds of root crops grown as stock feed at this station, rutabagas have given the most satisfactory results. This is also the conclusion of the farmers in this district who have made trials with different roots covering a period of several years. Table 27 summarizes the results obtained.

TABLE 27

COMPARATIVE YIELDS OF DIFFERENT ROOT CROPS AT NORTH CENTRAL EXPERIMENT STATION, 1918

	Av. yield per acre
	Tons
Rutabagas, 6 varieties	24.50
Flat turnips, 8 varieties	19.15
Sugar beets, 4 varieties	10.60
Mangels, 9 varieties	13.12
Mastodon carrots	5.80

From these results it is apparent that as much succulent feed can be grown by an acre of roots in this district as can be produced by anacre of corn in districts where conditions are favorable to that crop, altho where corn is grown in large acreage with modern machinery, the ensilage from an acre of corn can be handled at less cost than an acre of root crops. However, where the acreage under cultivation is small and only a few cows are kept on each farm, modern machinery and a silo are out of the question at present, and it is here that root crops offer many advantages. Root crops, especially rutabagas, are suited to new land. The crop can be planted and cared for with ordinary garden machinery. A root cellar can be constructed with little cash outlay from materials on hand, or the crop may even be stored in temporary pits until fed. Root crops are much more certain than is corn. They can be planted later, thereby giving more time for preparing the ground. They make their main growth during the cool days of late summer and autumn and their harvest can be delayed until after potato digging time, thus relieving the rush of labor during September.

American Purple Top rutabagas can be recommended as one of the best varieties. Seed can be had from practically all seed houses. It is one of the hardiest varieties and a good yielder as is indicated in Table 28.

TABLE 28

COMPARATIVE YIELDS OF DIFFERENT VARIETIES OF RUTABAGAS

Variety	Yield per acre		
	1916	1918	Average
	Tons	Tons	Tons
American Purple Top	26.5	28.8	27.6
Prize Winner	29.8	22.5	26.1
Sweet Russian	23.2	24.2	23.7
Sweet German	22.4	23.5	22.9
Hearsts Monarch	24.9	18.0	21.4
Hardy Swede	20.2	16.5	18.3

Besides being the largest yielder among root crops rutabagas have several other advantages: (1) Seed is cheap. (2) Germination is better than with mangels or sugar beets, therefore insuring a more even stand. (3) Rutabagas sprout quicker and can be thinned and weeded sooner, which is a great advantage. (4) Being of quicker growth they are less likely to be damaged by insects when small. (5) They are the most hardy of the root crops. (6) They are the best keepers, especially as compared with the flat turnip, which is likely to grow hollow and rot in storage.

Rutabagas respond very markedly to an application of stable manure, and for best results the seedbed should be thoroly pulverized. They may be seeded broadcast on new breaking at the rate of from 4 to 6 pounds per acre. However, much larger yields will be obtained on well-tilled land by drilling in rowa about thirty inches apart for cultivation during the summer. If the seed is mixed with two or three times its quantity of dry sand and the drill set accordingly, a more even feed will be insured. When the plants are well sprouted and setting the second pair of leaves they should be thinned to from 9 to 14 inches apart. It is important that the thinning be not delayed until the plants are too large. Special hoes can be had for this purpose.

Various methods are used in harvesting. Many farmers prefer to use the potato digger after topping the rutabagas with a hoe, others prefer to pull them two rows at a time, laying them with tops opposite and topping with a corn knife, still others prefer to haul the roots as they are pulled, topping at the root cellar or pit.

In storing rutabagas, ventilation should be provided. However, the most important factor is a low temperature, 32 to 40 degrees. Moisture in the cellar is not so injurious to roots as to potatoes. Storing rutabagas without topping is not advisable, as the tops are almost certain to heat.

In feeding, a pulper or chopper may be used, tho this is not necessary unless one wishes to mix them with grain feed. When feeding rutabagas in considerable quantity to dairy cows, it is important that the feeding should be done after milking time as the aroma from the roots in the barn may taint the milk. A dairy cow will consume to advantage from 40 to 70 pounds daily, depending on her size and the amount of milk she gives.

TABLE 29

BALANCED RATION WITH RUTABAGAS, CLOVER HAY, GROUND BARLEY, OR OATS FOR A 1,200-POUND COW GIVING 40 POUNDS OF 3.5 PER CENT MILK DAILY (HOLSTEIN)

Feed	Amount	Protein	Carbohydrates	Fat
	Pounds	Pounds	Pounds	Pounds
Clover hay	12	0.85	4.53	0.21
Rutabagas	56	0.56	4.56	0.10
Oats, ground	5	0.53	2.51	0.19
Corn, ground	4	0.32	2.68	0.17
Barley, ground	4	0.34	2.62	0.06
Linseed meal	1	0.30	0.32	0.07
Nutrients provided		2.90	17.22	0.80
Nutrients required		2.81	17.20	0.88

TABLE 30

RATION FOR A 1,000-POUND COW GIVING 25 POUNDS OF 5 PER CENT MILK DAILY (GUERNSEY OR JERSEY)

Feed	Amount	Protein	Carbohydrates	Fat
	Pounds	Pounds	Pounds	Pounds
Clover hay	10	0.71	3.78	0.18
Rutabagas	50	0.50	4.05	0.10
Oats, ground	5	0.53	2.51	0.19
Corn, ground	4	0.32	2.68	0.17
Barley, ground	2	0.17	1.31	0.03
Nutrients provided		2.23	14.33	0.67
Nutrients required		2.21	14.12	0.71

SOIL FERTILITY INVESTIGATIONS

(In cooperation with the Division of Soils, University Farm.)

MANURE AND PHOSPHATE EXPERIMENT

A comparison of acid phosphate and ground rock phosphate on upland has been carried on in a three-year rotation of oats; clover and timothy meadow; potatoes, rutabagas, and corn. The phosphates were applied both with and without manure.

The diagram in Figure 10 shows the plan of this experiment and the crops on the three series in 1919. The plots have received the following treatments:

Plots

1-7-13 No manure or fertilizer.

2-8-14 Rock phosphate in 1914, 2,000 pounds per acre.

3-9-15 Rock phosphate in 1914, 2,000 pounds per acre; manure, 10 tons per acre every third year.

4-10-16 Manure, 10 tons per acre every third year.

5-11-17 Manure, 10 tons per acre, and acid phosphate, 360 pounds per acre every third year.

6-12-18 Acid phosphate, 360 pounds per acre every third year.

The manure and acid phosphate are applied in preparing the land for the cultivated crop. Table 32 gives the amounts and years of the different applications of manure and fertilizers made since the experiment was started.

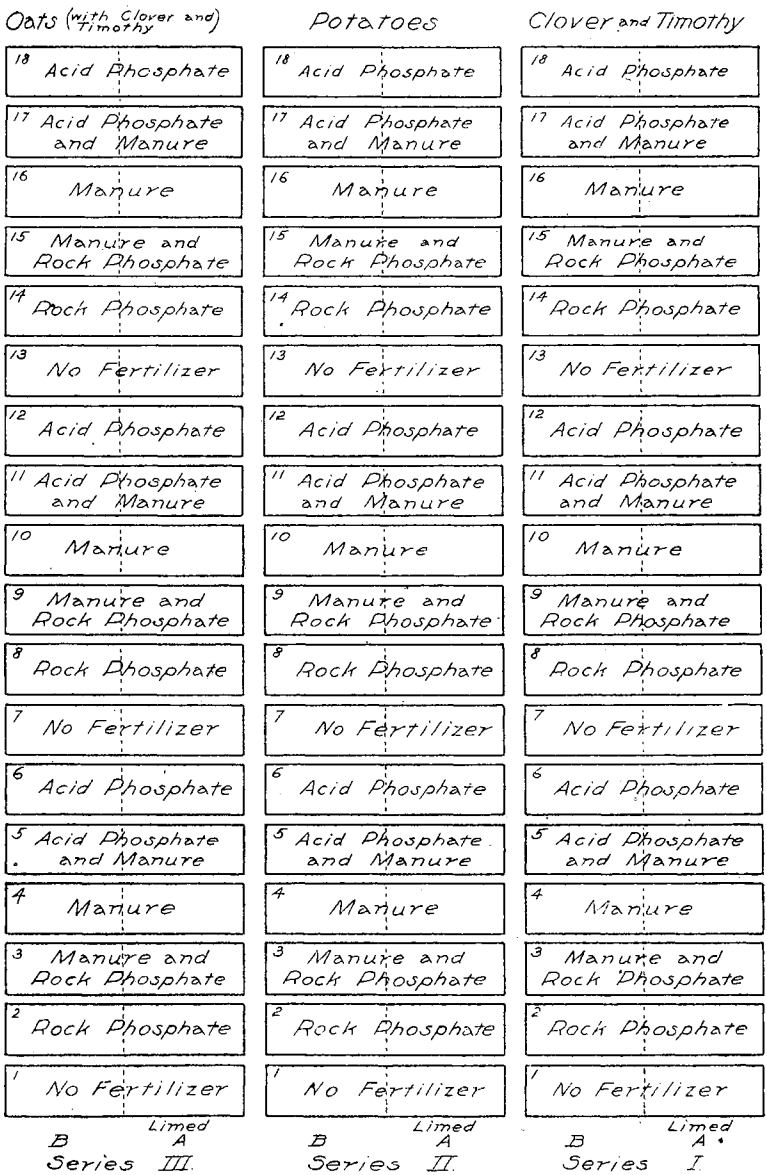

Fig. 10. Plan of Phosphate-manure Experiment, Showing Crops in 1919
The north half of each plot was limed in 1914.

TABLE 31

APPLICATION OF MANURE AND PHOSPHATES, 1914 TO 1919

Plots	Treatment	Rate per acre in the different years		
		Series I	Series II	Series III
1- 7-13	No fertilizer			
2- 8-14	Rock phosphate	1 ton in 1914	1 ton in 1914	1 ton in 1914
3- 9-15	Rock phosphate	1 ton in 1914	1 ton in 1914	1 ton in 1914
	and manure	10 tons in 1914 10 tons in 1917	6.6 tons in 1914 10 tons in 1916 10 tons in 1919	3.3 tons in 1914 10 tons in 1915 10 tons in 1918
4-10-16	Manure	10 tons in 1914 10 tons in 1917	6.6 tons in 1914 10 tons in 1916 10 tons in 1919	3.3 tons in 1914 10 tons in 1915 10 tons in 1918
5-11-17	Acid phosphate	360 lbs. in 1914 360 lbs. in 1917	240 lbs. in 1914 360 lbs. in 1916 360 lbs. in 1919	120 lbs. in 1914 360 lbs. in 1915 360 lbs. in 1918
	and manure	10 tons in 1914 10 tons in 1917	6.6 tons in 1914 10 tons in 1916 10 tons in 1919	3.3 tons in 1914 10 tons in 1915 10 tons in 1918
6-12-18	Acid phosphate	360 lbs. in 1914 360 lbs. in 1917	240 lbs. in 1914 360 lbs. in 1916 360 lbs. in 1919	120 lbs. in 1914 360 lbs. in 1915 360 lbs. in 1918

Ground limestone was applied at the rate of three tons per acre to the north half of each plot during the season of 1915, as indicated in Figure 10. The liming has so far shown no distinct effect on any of the crops, hence the data from the two halves of each plot are not reported separately in the tables.

The experiment has now completed two full three-year rotations—cultivated crop, oats, clover and timothy—and shows that on this soil phosphates 1919 are reported in Tables 23 and 33 to 37.

Using 1, 7, and 13 as control plots, the average increase per acre from the application of 10 tons of manure once in three years has been 94.8 bushels of potatoes, 7.3 bushels of oats, and 0.43 tons of hay. The addition of either acid or rock phosphate along with the manure has failed to increase the yield distinctly, and the same phosphates when applied without manure have shown little or no effect. Even the rutabagas, which are especially sensitive to any deficiency of phosphate, have shown little effect of the phosphate application. The seasons have been too unfavorable to corn for satisfactory yields under any treatment.

The relative value of phosphates and manure at Grand Rapids, so different from that at some of the other substations, shows how inapplicable may be the results of experiments conducted in some other part of the state.

TABLE 32

YIELD OF CORN AND RUTABAGAS PER ACRE IN MANURE AND PHOSPHATE EXPERIMENT, 1915-1918

Plot	Treatment	Green weight of corn for silage				Four-year average	Roots		Two-year average
		1915	1916	1917	1918		1917	1918	
		Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1	No fertilizer	0.83	4.33	1.11	5.32	.....	14.25	6.40	.....
2	Rock phosphate	1.10	3.99	1.37	5.37	.....	14.90	7.02	.....
3	Manure and rock phosphate	1.27	6.39	2.20	5.32	.....	16.00	9.57	.....
4	Manure	1.09	5.50	1.86	5.37	.....	19.20	7.50	.....
5	Manure and acid phosphate	1.20	8.18	2.76	6.50	.....	18.50	8.07	.....
6	Acid phosphate	0.70	5.43	1.44	4.25	.....	14.05	6.94	.....
7	No fertilizer	0.57	5.64	1.19	4.87	.....	11.35	7.15	.....
8	Rock phosphate	0.76	5.29	1.16	6.55	.....	12.55	7.05	.....
9	Manure and rock phosphate	1.11	9.21	1.34	9.12	.....	12.60	10.04	.....
10	Manure	0.90	9.62	1.45	9.85	.....	11.60	9.65	.....
11	Manure and acid phosphate	1.18	8.25	1.91	9.87	.....	13.50	9.27	.....
12	Acid phosphate	0.84	5.77	2.28	7.12	.....	10.35	9.12	.....
13	No fertilizer	0.62	5.57	1.84	7.15	.....	8.40	8.55	.....
14	Rock phosphate	0.91	6.74	1.89	7.25	.....	7.65	8.32	.....
15	Manure and rock phosphate	1.11	8.52	3.20	8.37	.....	10.40	10.45	.....
16	Manure	1.09	6.74	2.18	9.15	.....	9.95	10.15	.....
17	Manure and acid phosphate	1.21	6.74	3.03	9.50	.....	11.95	9.47	.....
18	Acid phosphate	0.85	5.77	3.20	7.20	.....	10.20	7.45	.....
Averages									
1- 7-13	No fertilizer	0.67	5.18	1.38	5.78	3.25	11.33	7.37	9.35
2- 8-14	Rock phosphate	0.92	5.34	1.47	6.39	3.53	11.70	7.47	9.58
3- 9-15	Manure and rock phosphate	1.16	8.04	2.25	7.61	4.76	13.00	10.02	11.51
4-10-16	Manure	1.03	7.29	1.83	8.13	4.57	13.58	9.10	11.34
5-11-17	Manure and acid phosphate	1.20	7.72	2.57	8.62	5.03	14.65	8.94	11.79
6-12-18	Acid phosphate	0.80	5.66	2.31	6.19	3.74	11.53	7.84	9.68

TABLE 33

YIELD OF POTATOES PER ACRE IN MANURE AND PHOSPHATE EXPERIMENT, 1915 TO 1919

Plot	Treatment	1915	1916	1917	1918	1919	Five-year average
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	No fertilizer	134.7	134.7	146.6	115.4	115.5	.....
2	Rock phosphate	151.0	108.2	159.6	175.0	177.8	.....
3	Manure and rock phosphate	201.3	161.8	273.3	244.6	249.6	.....
4	Manure	221.7	141.2	264.6	262.0	252.2	.....
5	Manure and acid phosphate	248.3	141.6	269.6	248.3	278.3	.....
6	Acid phosphate	162.0	104.0	177.9	136.2	165.7	.....
7	No fertilizer	125.0	124.2	158.3	145.8	118.4	.....
8	Rock phosphate	120.7	97.6	150.0	145.0	152.8	.....
9	Manure and rock phosphate	190.3	145.3	245.0	252.9	319.2	.....
10	Manure	180.0	154.9	227.5	249.6	336.9	.....
11	Manure and acid phosphate	161.7	185.2	243.7	221.2	291.3	.....
12	Acid phosphate	132.7	103.1	184.2	173.7	150.5	.....
13	No fertilizer	113.0	60.0*	168.3	148.7	144.2	.....
14	Rock phosphate	115.3	81.1*	156.7	191.7	209.4	.....
15	Manure and rock phosphate	147.0	130.2	262.9	260.4	286.8	.....
16	Manure	140.7	194.8	268.7	261.2	289.0	.....
17	Manure and acid phosphate	140.0	182.4	285.4	247.9	394.0	.....
18	Acid phosphate	128.3	106.8	176.2	152.9	141.7	.....
Averages							
1- 7-13	No fertilizer	124.2	129.4†	157.7	136.6	126.0	134.8
2- 8-14	Rock phosphate	129.0	102.9†	155.4	170.6	180.0	147.6
3- 9-15	Manure and rock phosphate	179.5	145.8	260.4	252.6	285.2	224.7
4-10-16	Manure	180.8	163.6	253.6	257.6	292.7	229.6
5-11-17	Manure and acid phosphate	183.3	169.7	262.2	239.1	321.2	235.9
6-12-18	Acid phosphate	141.0	104.6	179.4	154.3	152.6	146.4

* Not included in the averages.

† Average of two plots.

TABLE 34

YIELD OF OATS PER ACRE IN MANURE AND PHOSPHATE EXPERIMENT, 1915 TO 1919

Plot	Treatment	Grain					Grain and straw					Five-year average	
		1915	1916	1917	1918	1919	1915	1916	1917	1918	1919	Grain	Grain and straw
		Bu.	Bu.	Bu.	Bu.	Bu.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.
1	No fertilizer	57.8	31.6	23.7	27.7	33.7	3,950	2,950	1,475	2,088	2,870	.....	.....
2	Rock phosphate	59.8	44.7	27.3	28.9	40.0	3,300	2,900	1,665	1,899	2,550	.....	.....
3	Manure and rock phosphate	72.2	46.2	28.7	43.9	48.7	4,400	2,650	1,930	2,531	5,420	.....	.....
4	Manure	67.5	40.3	33.9	42.2	42.8	3,700	3,550	2,220	3,178	4,200	.....	.....
5	Manure and acid phosphate	71.2	49.4	37.2	49.5	39.1	4,300	3,350	2,585	3,563	4,000	.....	.....
6	Acid phosphate	54.4	40.0	37.3	30.8	41.6	3,850	3,350	2,490	2,026	4,560	.....	.....
7	No fertilizer	48.1	35.6	39.1	31.2	37.5	2,950	2,100	2,522	1,686	2,560	.....	.....
8	Rock phosphate	38.9	32.2	41.6	27.7	34.4	2,700	2,550	2,712	2,281	2,400	.....	.....
9	Manure and rock phosphate	48.7	47.8	42.8	31.7	41.4	2,950	2,450	3,037	2,208	4,620	.....	.....
10	Manure	39.4	39.1	50.1	32.9	49.4	2,200	2,650	3,425	2,621	3,660	.....	.....
11	Manure and acid phosphate	40.9	44.1	45.0	35.0	54.7	2,450	2,700	3,065	2,506	3,920	.....	.....
12	Acid phosphate	34.7	29.4	44.5	22.4	40.6	2,050	2,800	2,800	1,968	2,920	.....	.....
13	No fertilizer	35.8	22.5	37.3	28.5	39.1	2,350	1,600	2,522	1,111	2,840	.....	.....
14	Rock phosphate	33.6	25.9	42.5	28.4	39.2	2,000	2,200	2,570	1,940	3,110	.....	.....
15	Manure and rock phosphate	40.9	27.5	39.4	33.6	46.9	2,600	2,100	2,540	2,624	3,540	.....	.....
16	Manure	49.1	32.2	39.4	37.6	43.7	2,900	2,800	2,427	2,922	2,760	.....	.....
17	Manure and acid phosphate	50.0	40.0	37.5	38.8	54.1	3,150	2,400	2,500	2,987	4,180	.....	.....
18	Acid phosphate	36.4	32.8	30.3	33.8	37.8	2,300	2,600	1,880	2,761	4,000	.....	.....
Average													
1– 7–13	No fertilizer	47.2	29.9	33.3	29.1	36.8	3,083	2,217	2,173	1,628	2,757	35.3	2,372
2– 8–14	Rock phosphate	44.1	34.3	37.1	28.3	37.9	2,667	2,550	2,316	2,040	2,686	36.3	2,452
3– 9–15	Manure and rock phosphate	53.9	40.5	37.0	36.4	45.7	3,317	2,400	2,502	2,454	4,527	42.7	3,040
4–10–16	Manure	52.0	37.2	41.1	37.6	45.3	2,933	3,000	2,691	2,907	3,540	42.6	3,014
5–11–17	Manure and acid phosphate	54.0	44.5	39.9	41.1	49.3	3,300	2,817	2,717	3,019	4,033	45.8	3,177
6–12–18	Acid phosphate	41.8	34.1	37.4	29.0	40.0	2,733	2,917	2,390	2,252	3,827	36.5	2,824

TABLE 35

YIELD OF HAY PER ACRE IN MANURE AND PHOSPHATE EXPERIMENT, 1916 TO 1919

Plot	Treatment	1916	1917	1918	1919	Four-year average
		Tons	Tons	Tons	Tons	Tons
1	No fertilizer	0.92	0.85	0.68	1.84	.....
2	Rock phosphate	1.60	0.86	0.63	2.00	.....
3	Manure and rock phosphate	1.40	1.11	1.00	3.18	.....
4	Manure	1.95	1.31	0.95	3.23	.....
5	Manure and acid phosphate	2.22	1.37	0.90	3.05	.....
6	Acid phosphate	1.60	1.20	0.62	1.80	.....
7	No fertilizer	1.57	1.15	0.58	1.78	.....
8	Rock phosphate	1.67	1.21	0.72	1.54	.....
9	Manure and rock phosphate	1.62	0.99	1.05	2.29	.....
10	Manure	1.72	1.01	0.95	2.34	.....
11	Manure and acid phosphate	2.17	1.09	1.07	2.59	.....
12	Acid phosphate	1.57	0.69	0.71	1.87	.....
13	No fertilizer	1.70	0.69	0.89	1.68	.....
14	Rock phosphate	1.52	0.59	0.92	1.56	.....
15	Manure and rock phosphate	1.65	0.68	1.15	2.14	.....
16	Manure	1.95	0.69	1.07	2.43	.....
17	Manure and acid phosphate	1.20*	0.76	1.07	2.31	.....
18	Acid phosphate	1.75	0.66	0.60	1.54	.....
Averages						
1- 7-13	No fertilizer	1.40	0.90	0.72	1.77	1.20
2- 8-14	Rock phosphate	1.60	0.89	0.76	1.70	1.24
3- 9 15	Manure and rock phosphate	1.56	0.93	1.07	2.54	1.52
4-10-16	Manure	1.87	1.00	0.99	2.67	1.63
5-11-17	Manure and acid phosphate	2.19	1.07	1.01	2.65	1.73
6-12-18	Acid phosphate	1.64	0.85	0.64	1.74	1.22

* Not included in the average.

TABLE 36

YIELD OF OATS AND PEAS PER ACRE IN MANURE AND PHOSPHATE EXPERIMENT, 1915

Plot	Treatment	Grain and straw	Grain
		Lbs.	Lbs.
1	No fertilizer	2,500	1,072
2	Rock phosphate	2,200	822
3	Manure and rock phosphate	2,600	1,140
4	Manure	2,870	1,108
5	Manure and acid phosphate	3,330	1,172
6	Acid phosphate	2,100	855
7	No fertilizer	3,100	1,225
8	Rock phosphate	2,850	1,090
9	Manure and rock phosphate	3,200	1,175
10	Manure	2,800	1,160
11	Manure and acid phosphate	3,200	1,280
12	Acid phosphate	2,350	1,040
13	No fertilizer	2,950	1,220
14	Rock phosphate	2,750	1,190
15	Manure and rock phosphate	3,250	1,370
16	Manure	2,250	1,045
17	Manure and acid phosphate	2,850	1,270
18	Acid phosphate	2,050	890
Averages			
1- 7-13	No fertilizer	2,850	1,172
2- 8-14	Rock phosphate	2,600	1,034
3- 9-15	Manure and rock phosphate	3,017	1,228
4-10-16	Manure	2,640	1,104
5-11-17	Manure and acid phosphate	3,127	1,241
6-12-18	Acid phosphate	2,167	928

RATE-OF-MANURING EXPERIMENT

In the rate-of-manuring experiment stable manure is applied at three different rates, 5, 10, and 20 tons per acre, just before plowing the land for the cultivated crop. The yields are reported in Tables 37 to 41.

In the spring of 1915, in order to provide for this experiment, the three-series of tenth-acre plots laid out in 1914 for the phosphate-manure experiment (Figure 10) were extended to the west line of the farm. Of the thirteen additional plots in each series thus secured, three are used as checks and four for the manure applications, while the other six provide for the peat fertilizer experiment described below. The arrangement and treatment of the plots are shown in Figure 11.

The crops grown on each series in each season are the same as those on the first eighteen plots of the same series, and accordingly the yields on all thirty-one are comparable. The three check plots of the first group, 1, 7, and 13, are directly comparable with the three of the later group, 19, 25 and 31, and hence in the tables the average of all six, as well as the average of each set of three, is given. Plots 4, 10, and 16 provide the data on the effect of the 10-ton application of manure. Previous to 1914 the portion of the field containing plots 1 to 18 had been treated like that to the west, but in that season the latter, which was in clover meadow, received no manure, while on the former the pro-rated applications shown in Table 31 were made. Beginning with 1915, the same crops have been planted on all 31 plots of each series, but the 5-and 20-ton applications of manure were made on Series III first in 1915, on Series II first in 1916, and on Series I first in 1917, hence the data on oats and hay do not cover as many years as those on potatoes.

The year and rates of the applications on the 39 plots laid out in 1915 are shown in Table 37.

TABLE 37

RATE OF APPLICATION PER ACRE IN PEAT AND MANURE EXPERIMENTS

Plots	Treatment	Series I	Series II	Series III
19–25–31	No fertilizer			
20–26	Manure	5 tons in 1917	5 tons in 1916 5 tons in 1919	5 tons in 1915 5 tons in 1918
21–27	Manure	20 tons in 1917	20 tons in 1916 20 tons in 1919	20 tons in 1915 20 tons in 1918
22–28	Peat	10 tons in 1917*	10 tons in 1916 10 tons in 1919	10 tons in 1915 10 tons in 1918
23–29	Peat	20 tons in 1917*	20 tons in 1916 20 tons in 1919	20 tons in 1915 20 tons in 1918
24–30	Peat	40 tons in 1917*	40 tons in 1916 40 tons in 1919	40 tons in 1915 40 tons in 1918

* Spreader loads, approximately one ton of wet peat per load.

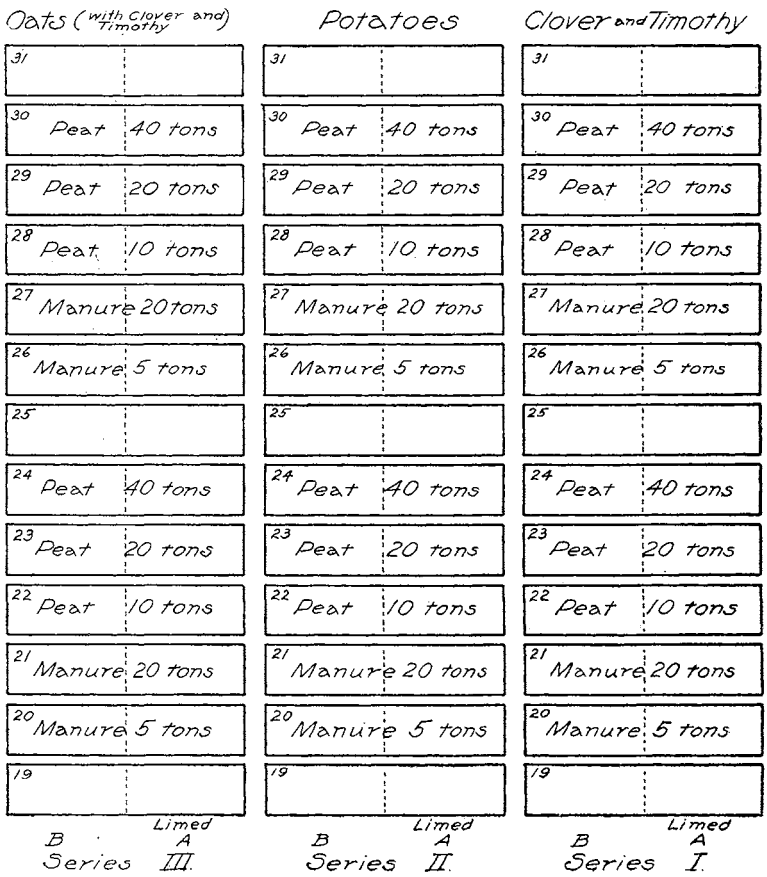

Fig. 11. Plan of Peat-Manure Experiment
The rate per acre of application is shown. The north half of each plot was limed in 1915.

TABLE 38

YIELD OF POTATOES PER ACRE IN RATE-OF-MANURING EXPERIMENT, 1915–1919

Plot	Treatment	1915	1916	1917	1918	1919	Five-year average
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	No manure	134.7	134.7	146.6	115.4	115.5	.....
4	10 tons	221.7	141.2	264.6	262.0	252.2	.....
7	No manure	125.0	124.2	158.3	145.8	118.4	.....
10	10 tons	180.0	154.9	227.5	249.6	336.9	.....
13	No manure	113.0	60.0*	168.3	148.7	144.2	.....
16	10 tons	140.7	194.8	268.7	261.2	289.0	.....
19	No manure	147.3	108.6	138.3	142.1	165.2	.....
20	5 tons	175.7	75.6	213.3	212.1	222.3	.....
21	20 tons	184.3	130.6	302.5	279.6	341.2	.....
25	No manure	127.7	85.7	158.7	142.5	174.3	.....
26	5 tons	172.0	130.2	230.0	209.5	224.3	.....
27	20 tons	121.7	165.9	308.7	320.0	354.3	.....
31	No manure	68.3*	122.3	107.5	89.2*	121.4	.....
Averages							
1–7–13	No manure	124.2	129.4†	157.7	136.6	126.0	134.8
19–25–31	No manure	137.5†	105.3	134.8	142.3†	153.6	134.7
1–7–13–19–25–31	No manure	129.5‡	115.1‡	146.3	138.9‡	139.8	133.9
20–26	5 tons	173.8	102.9	221.6	210.8	223.3	186.5
4–10–16	10 tons	180.8	163.6	253.6	257.6	292.7	229.6
21–27	20 tons	153.0	148.2	305.6	299.8	347.7	250.9

* Not included in average.

† Average of two plots.

‡ Average of five plots.

TABLE 39

YIELD OF CORN AND RUTABAGAS PER ACRE IN RATE-OF-MANURING EXPERIMENT, 1915 TO 1918

Plot	Treatment	Green weight of corn for silage				Four-year average	Roots		Two-year average
		1915	1916	1917	1918		1917	1918	
		Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1	No manure	0.83	4.33	1.11	5.32	.....	14.25	6.40	.....
4	10 tons manure	1.09	5.50	1.86	5.37	.....	19.20	7.50	.....
7	No manure	0.57	5.64	1.19	4.87	.....	11.35	7.15	.....
10	10 tons manure	0.90	9.62	1.45	9.85	.....	11.60	9.65	.....
13	No manure	0.62	5.57	1.84	7.15	.....	8.40	8.55	.....
16	10 tons	1.09	6.74	2.18	9.15	.....	9.95	10.15	.....
19	No manure	0.62	7.70	2.81	6.06	.....	13.75	7.07	.....
20	5 tons manure	1.56	8.66	2.90	7.17	.....	19.40	9.57	.....
21	20 tons manure	1.03	9.21	3.46	8.25	.....	20.75	11.05	.....
25	No manure	0.70	9.83	2.95	5.55	.....	11.75	8.67	.....
26	5 tons manure	1.04	10.24	3.19	7.07	.....	16.00	9.55	.....
27	20 tons manure	1.15	13.61	3.66	8.20	.....	22.00	9.62	.....
31	No manure	0.93	.....	2.95	4.52	.....	15.00	3.30	.....
Averages									
1–7–13	No manure	0.67	5.18	1.38	5.78	3.25	11.33	7.37	9.35
19–25–31	No manure	0.75	8.76*	2.90	5.38	4.50	13.50	6.35	9.92
1–7–13–19–25–31	No manure	0.71	6.61	2.14	5.58	3.76	12.42	6.86	9.64
20–26	5 tons manure	1.30	9.45	3.04	7.12	5.23	17.70	9.56	13.63
4–10–16	10 tons manure	1.03	7.29	1.83	8.13	4.57	13.58	9.10	11.34
21–27	20 tons manure	1.09	11.41	3.56	8.22	6.07	21.37	10.34	15.85

* Average of two plots.

TABLE 40

YIELD OF OATS PER ACRE IN RATE-OF-MANURING EXPERIMENT, 1916 TO 1919

Plot	Treatment	Grain				Grain and straw				Four-year average	
		1916	1917	1918	1919	1916	1917	1918	1919	Grain	Grain and straw
		Bu.	Bu.	Bu.	Bu.	Lbs.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.
1	No manure	31.6	23.7	27.7	33.7	2,950	1,475	2,088	2,870	.....	.....
4	10 tons manure	40.3	33.9	42.2	42.8	3,550	2,220	3,178	4,200	.....	.....
7	No manure	35.6	39.1	31.2	37.5	2,100	2,522	1,686	2,560	.....	.....
10	10 tons manure	39.1	50.1	32.9	49.4	2,650	3,425	2,621	3,660	.....	.....
13	No manure	22.5	37.2	28.5	39.1	1,600	2,522	1,111	2,840	.....	.....
16	10 tons manure	32.2	39.4	37.6	43.7	2,800	2,427	2,922	2,760	.....	.....
19	No manure	33.4	35.5	35.6	40.0	2,300	2,190	2,840	3,930	.....	.....
20	5 tons manure	39.4	35.5	44.1	52.5	2,900	2,170	5,150	3,980	.....	.....
21	20 tons manure	39.4	37.2	49.5	54.1	2,800	2,372	5,545	4,580	.....	.....
25	No manure	34.4	51.6	41.1	44.5	2,600	3,431	4,075	2,660	.....	.....
26	5 tons manure	36.6	48.7	48.7	39.7	3,050	3,080	4,240	3,100	.....	.....
27	20 tons manure	36.2	52.8	51.2	48.1	2,900	3,667	5,560	4,060	.....	.....
31	No manure	.....	32.8	33.4	38.4	1,600	2,485	2,930	2,880	.....	.....
Averages											
1–7–13	No manure	29.9	33.3	29.1	36.8	2,217	2,173	1,628	2,757	32.3	2,194
19–25–31	No manure	33.9*	40.0	36.7	41.0	2,450	2,702	3,282	3,157	37.9	2,898
1–7–13–19–25–31	No manure	31.5†	36.6	32.9	38.9	2,192	2,437	2,455	2,957	35.0	2,510
20–26	5 tons manure	38.0	38.0	46.4	46.1	2,975	2,625	4,695	3,540	42.1	3,459
4–10–16	10 tons manure	37.2	41.1	37.6	45.3	3,000	2,691	2,907	3,540	40.3	3,034
21–27	20 tons manure	37.8	37.8	50.4	51.1	2,850	3,019	5,552	4,320	44.3	3,935

* Average of two plots.

† Average of five plots.

TABLE 41

YIELD OF HAY PER ACRE IN RATE-OF-MANURING EXPERIMENT, 1917 TO 1919

Plot	Treatment	1917	1918	1919	Three-year average
		Tons	Tons	Tons	
1	No manure	0.85	0.68	1.84	.....
4	10 tons manure	1.31	0.95	3.23	.....
7	No manure	1.15	0.58	1.78	.....
10	10 tons manure	1.01	0.95	2.34	.....
13	No manure	0.69	0.89	1.68	.....
16	10 tons manure	0.69	1.07	2.43	.....
19	No manure	0.71	0.59	1.36	.....
20	5 tons manure	0.80	0.77	2.14	.....
21	20 tons manure	0.81	0.90	2.83	.....
25	No manure	0.89	0.74	2.00	.....
26	5 tons manure	1.05	0.78	2.34	.....
27	20 tons manure	1.04	0.92	3.23	.....
31	No manure	1.19	0.63	1.42	.....
Averages					
1–7–13	No manure	0.90	0.72	1.77	1.13
19–25–31	No manure	0.93	0.65	1.59	1.06
1–7–13–19–25–31	No manure	0.91	0.68	1.68	1.09
20–26	5 tons manure	0.92	0.77	2.24	1.31
4–10–16	10 tons manure	1.00	0.99	2.67	1.55
21–27	20 tons manure	0.92	0.91	3.03	1.62

To permit of a full comparison, the data on the check plots 1, 7, and 13, and those receiving ten tons of manure, 4, 10, and 16, given in earlier tables, are repeated in Tables 40 and 41.

In this experiment potatoes have proved the most satisfactory cultivated crop. The increase with all three rates is marked especially with potatoes. The greatest return per ton of manure applied has been obtained from the lowest rate, but the increased cost of application would more than offset this gain, should the comparison be confined to the 5-and 10-ton rates. Each ton of manure at the 5-ton rate shows an increase of 10.5 bushels of potatoes, 1.4 bushels of oats, and 88 pounds of hay; while at the 10-ton rate the increases are 9.6 bushels of potatoes, 0.5 bushels of oats, and 92 pounds of hay; and at the 20-ton rate 5.8 bushels of potatoes, 0.5 bushels of oats, and 53 pounds of hay per ton of manure. Table 42 gives a summary of the average yields of the three crops and shows the increase in yields over the control plots.

TABLE 42

AVERAGE YIELDS OF CROPS AND INCREASES WITH DIFFERENT RATES OF APPLICATION OF MANURE

Treatment	Potatoes		Oats		Hay	
	Five-year average	Increase over unmanured plots	Four-year average	Increase over unmanured plots	Three-year average	Increase over unmanured plots
	Bu.	Bu.	Bu.	Bu.	Tons	Tons
No manure	133.9	.....	35.0	.....	1.09	.....
5 Tons manure	186.5	52.6	42.1	7.1	1.31	0.22
10 Tons manure	229.6	95.7	40.3	5.3	1.55	0.46
20 Tons manure	250.9	117.0	44.3	9.3	1.62	0.53

USE OF PEAT AS A FERTILIZER

The value of peat as a fertilizer is being tested. Six one-tenth acre plots in each of the same three series as the phosphate and manure plots shown in Figures 10 and 11 receive applications of peat just before plowing the land for the cultivated crop. The rates of application and the separate applications made are given in Table 37. The crops each year on each series are the same as those grown in the phosphate-manure experiment. Tables 43 to 46 give the yields of the different crops. The yields on plots 28 to 31 have been affected somewhat by poor drainage.

The yields of the corn, rutabagas, and potatoes up to the present, are not to be regarded as satisfactory evidence of what the real effect of the different applications of peat may be. Insect pests caused differences in stand in the case of the rutabagas, frost killed the corn in both 1915 and 1917, and differences in drainage evidently affected the potatoes. The hay yields are a little better where peat has been applied than on the control plots. The same is also true in the case of oats. At the ordinary prices of crops the increases in yield have not been sufficient to pay for the labor of applying the peat.

TABLE 43

YIELD OF POTATOES PER ACRE IN EXPERIMENT WITH PEAT AS A FERTILIZER, 1915 TO 1919

Plot	Treatment	1915	1916	1917	1918	1919	Four-year average
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
19	No fertilizer	147.3	108.6	138.3	142.1	165.2	.....
22	10 tons peat	124.3	117.3	152.5	157.9	173.7	.....
23	20 tons peat	116.3	110.5	176.2	177.9	205.3	.....
24	40 tons peat	116.3	137.5	176.6	205.8	253.3	.....
25	No fertilizer	127.7	85.7	158.7	142.5	174.3	.....
28	10 tons peat	87.3*	117.3	101.2	105.8	174.0	.....
29	20 tons peat	52.3*	120.1	105.4	138.3	145.3	.....
30	40 tons peat	31.0*	97.6	131.2	129.1	120.7	.....
31	No fertilizer	68.3*	122.3	107.5	89.2*	121.4	.....
Averages							
19–25–31	No fertilizer	137.5†	105.3	134.8	142.3†	153.6	134.0
22–28	10 tons peat	.....	117.3	126.8	131.8	173.8	137.4
23–29	20 tons peat	.....	115.3	140.8	158.1	175.3	147.4
24–30	40 tons peat	.....	117.5	153.9	167.4	187.0	156.4

* Not included in the average.

† Average of two plots.

TABLE 44

YIELD OF CORN AND RUTABAGAS PER ACRE IN EXPERIMENT WITH PEAT AS A FERTILIZER, 1915 TO 1918

Plot	Treatment	Green weight of corn for silage				Four-year average	Roots		Two-year average
		1915	1916	1917	1918		1917	1918	
		Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
19	No fertilizer	0.62	7.70	2.81	6.06	.....	13.75	7.07	.....
22	10 tons peat	0.62	8.25	3.03	5.45	.....	13.55	9.07	.....
23	20 tons peat	0.58	7.01	3.09	6.87	.....	13.25	8.90	.....
24	40 tons peat	0.52	12.24	3.15	6.80	.....	15.75	9.72	.....
25	No fertilizer	0.70	9.83	2.95	5.55	.....	11.75	8.67	.....
28	10 tons peat	0.45	8.25	2.99	4.92	.....	11.55	4.90	.....
29	20 tons peat	0.57	8.59	3.07	3.82	.....	12.45	3.72	.....
30	40 tons peat	0.26*	9.90	3.23	6.12	.....	16.25	5.32	.....
31	No fertilizer	0.93	.....	2.95	4.52	.....	15.00	3.30	.....
Averages									
19–25–31	No fertilizer	0.75	8.76†	4.35	5.38	4.81	13.50	6.35	9.92
22–28	10 tons peat	0.53	8.25	3.01	5.18	4.24	12.55	6.99	9.77
23–29	20 tons peat	0.57	7.80	3.08	5.34	4.20	12.85	6.31	9.58
24–30	40 tons peat	0.52	11.07	3.19	6.46	5.31	16.00	7.52	11.76

* Omitted from averages.

† Average of two plots.

TABLE 45

YIELD OF OATS PER ACRE IN EXPERIMENT WITH PEAT AS FERTILIZER, 1916 TO 1919

Plot	Treatment	Grain				Grain and straw				Four-year average	
		1916	1917	1918	1919	1916	1917	1918	1919	Grain	Grain and straw
		Bu.	Bu.	Bu.	Bu.	Lbs.	Lbs.	Lbs.	Lbs.	Bu.	Lbs.
19	No fertilizer	33.4	35.5	35.6	40.0	2,300	2,190	2,840	3,930	.....	.....
22	10 tons peat	31.6	36.2	28.1	47.3	2,700	2,217	1,900	3,360	.....	.....
23	20 tons peat	34.7	42.6	38.1	44.5	2,350	2,537	3,980	3,220	.....	.....
24	40 tons peat	38.4	45.6	36.6	46.9	2,950	2,907	3,670	3,320	.....	.....
25	No fertilizer	34.4	51.6	41.1	44.5	2,600	3,431	4,075	2,660	.....	.....
28	10 tons peat	36.0	46.7	47.2	53.1	3,200	3,010	3,930	3,900	.....	.....
29	20 tons peat	23.7	45.0	45.9	51.6	2,000	2,802	4,210	3,940	.....	.....
30	40 tons peat	26.9	40.1	50.6	56.6	1,600	2,687	4,940	4,060	.....	.....
31	No fertilizer	.....	32.8	33.4	38.4	.....	2,485	2,930	2,880	.....	.....
Averages											
19–25–31	No fertilizer	33.9*	40.0	36.7	41.0	2,450*	2,702	3,282	3,157	37.9	2,898
22–28	10 tons peat	33.8	41.4	37.6	50.2	2,950	2,613	2,915	3,630	40.7	3,027
23–29	20 tons peat	29.2	43.8	42.0	48.0	2,175	2,669	4,095	3,580	40.7	3,130
24–30	40 tons peat	32.6	42.8	43.6	51.7	2,275	2,797	4,305	3,690	42.7	3,267

* Average of two plots.

TABLE 46

YIELD OF HAY PER ACRE IN EXPERIMENT WITH PEAT AS A FERTILIZER, 1917 TO 1919

Plot	Treatment	1917	1918	1919	Three-year average
		Tons	Tons	Tons	Tons
19	No fertilizer	0.71	0.59	1.36	.....
22	10 tons peat	0.90	0.78	1.87	.....
23	20 tons peat	0.68	0.81	1.82	.....
24	40 tons peat	0.82	0.99	2.12	.....
25	No fertilizer	0.89	0.74	2.00	.....
28	10 tons peat	1.24	0.74	1.71	.....
29	20 tons peat	1.09	0.66	1.78	.....
30	40 tons peat	0.82	0.79	1.86	.....
31	No fertilizer	1.19	0.63	1.42	.....
Averages					
19–25–31	No fertilizer	0.93	0.65	1.59	1.06
22–28	10 tons peat	1.07	0.76	1.79	1.21
23–29	20 tons peat	0.89	0.73	1.80	1.14
24–30	40 tons peat	0.82	0.89	1.99	1.23

EXPERIMENTS ON PEAT SOIL

On the station lands there are more than a dozen bogs generally known in this district by the Indian name "muskeg". These muskegs vary in area from a fraction of an acre to several acres. Two of the smaller muskegs which lie south of the station buildings have been under cultivation for several years. They have a peat layer about three feet deep. Besides an application of lime they have received the same treatment as the adjoining mineral soil. That is, they have been cropped to a three-year rotation, grain, clover and timothy

meadow, and a cultivated crop, receiving ten tons of manure once in a rotation. Under this management they have not produced crops of grain, potatoes, or corn equal to those produced on the adjoining mineral soil, but in some years the bogs have produced twice as much hay as the upland.

The muskeg just west of the station buildings, the largest on the farm, has an area of 15 acres. The peat on this varies in depth from a few inches to 23 feet. This muskeg has been tile drained, cleared, and a part put under cultivation and platted for experimental purposes. The experiments conducted are reported in the following pages. The most characteristic feature of this soil is its deficiency in lime, it being a typical low-lime peat and requiring, in addition to lime, applications of both phosphate and potash to make it productive, even of the clovers, while for non-leguminous crops a nitrogen fertilizer is also required. The treatments required on this muskeg, while typical of those needed on low-lime peats, are quite different from those that suffice on the high-lime peats which are characteristic of most of the bogs of Minnesota. A full discussion of the various peat soils and the treatments needed to make them productive, will be found in bulletin 188 of the Agricultural Experiment Station: Agricultural Value and Reclamation of Minnesota Peat Soils, by F. J. Alway.

TABLE 47

YIELDS OF HAY PER ACRE ON PEAT LAND MEADOW WITH VARIOUS TREATMENTS

Series I, Limed in 1915

Year	Mineral soil	Check (No treatment)	Potash	Phosphate and potash	Phosphate, potash, and nitrogen	Manure
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1917	3,408	932	2,132	2,708	3,864	3,208
1918	1,168	688	1,824	2,100	2,196	3,816
1919	2,840	1,600	2,440	2,880	3,520	4,020
Three-year average	2,472	1,073	2,132	2,563	3,193	3,681
Series II, Not Limed						
1917	1,324	264	984	2,784	2,928	2,376
1918	776	228	436	1,796	2,872	2,752
1919	2,440	200	800	2,480	2,400	3,520
Three-year average	1,513	231	740	2,350	2,733	2,883
Series III, Limed in 1915						
1917	1,392	868	1,732	2,800	3,804	4,444
1918	1,128	328	1,088	1,988	4,048	4,280
1919	3,080	1,080	3,080	3,680	4,080	4,560
Three-year average	1,833	759	1,967	2,823	3,977	4,428
Series IV, Not Limed						
1917	1,084	448	884	2,424	3,892	2,528
1918	1,056	296	696	1,872	3,380	3,384
1919	2,480	720	1,160	2,680	3,160	4,120
Three-year average	1,540	488	913	2,325	3,477	3,344

Fig. 12. Oats on Peat Land, 1915

Three plots at left received lime, two at right were unlimed. Treatments from left to right are as follows:

Plot 22. Lime and phosphate
Plot 21. Lime and phosphate
Plot 20. Lime, phosphate, and potash
Plot 19. Phosphate and potash
Plot 18. Check, no fertilizer

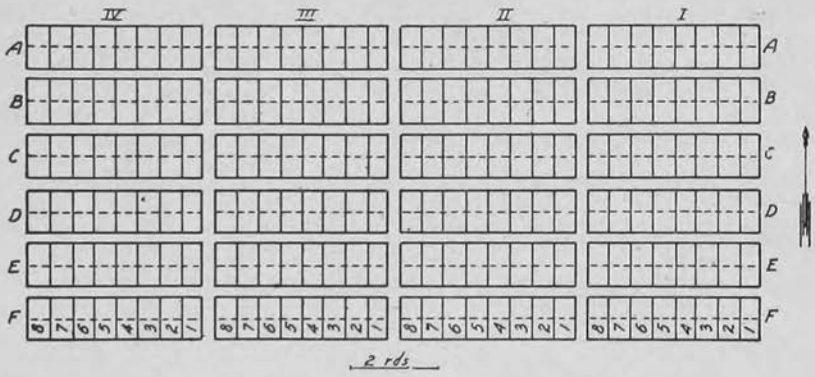

Fig. 13. Fertilizer Treatments on Grasses and Clover on Muskeg.

Crops sown in 1916 were:

1. Timothy
2. Redtop
3. Meadow fescue
4. Perennial rye grass
5. Bromus inermus
6. Alfalfa, white clover, and Kentucky bluegrass
7. Medium red clover, alsike clover, and timothy
8. Alsike clover, mammoth red clover, and timothy

A. Mineral soil: 200 tons per acre in 1915.

B. No application.

C. Potash: 1916, 400 pounds per acre of muriate; 1917, 200 pounds; 1918, 200 pounds.

D. Potash and phosphate:
Phosphate—800 pounds per acre of steamed bone meal in 1916, 400 pounds of acid phosphate in 1917 and 1918.
Potash —400 pounds per acre of muriate in 1916; 200 pounds in 1917, and 200 pounds in 1918.

E. Potash, phosphate, and nitrogen:
Nitrogen —400 pounds in 1915. 200 pounds in 1917 and 1918.
Phosphate—800 pounds per acre of steamed bone meal in 1916, 400 pounds of acid phosphate in 1917 and 1918.
Potash —400 pounds per acre of muriate in 1916, 200 pounds in 1917, and 200 pounds in 1918.

F. Stable manure:
20 tons per acre in the spring of 1916, and 10 tons per acre in the spring of 1917 and of 1918.

Table No. 48 shows the three-year average from each treatment. The limed series, Nos. I and III are combined, as are also the unlimed series, Nos. II and IV. The three-year average yield of hay for all treatments on the limed series is 2,575.1 pounds per acre as against 1,878.3 pounds per acre on the unlimed. The average yield for all treatments from the limed series shows an increase of 696.8 pounds per acre from the application of 4,000 pounds of ground limestone in 1915. The percentage of weeds in the hay crop from each treatment was also determined and the results are given in the same table. It should be noted that where lime was used the hay crop contained only 12 per cent of weeds, while on the unlimed series it contained 53 per cent. The weeds were mainly sheep sorrel (*Rumex acetosella*), Marsh fivefinger (*Potentilla palustris*), Cinquefoil (*Potentilla monspeliensis*). The difference in the yield of hay from the limed as compared with the unlimed series was not 696.8 pounds per acre, but 1,383.3 pounds, after eliminating the weeds. Stated differently, the yield of hay from the limed series was approximately three times that on the unlimed series. It should be noted that the peat on the area under treatment has a depth of from five to twenty feet, probably averaging more than 10 feet. The bog is tile drained.

TABLE 48

AVERAGE YIELD PER ACRE AND PROPORTION OF WEEDS AND HAY, EXPRESSED IN PERCENTAGE OF WEIGHT, 1917–1919

Treatment	Limed			Unlimed		
	Yield per acre	Per cent weeds	Per cent hay	Yield per acre	Per cent weeds	Per cent hay
	Lbs.			Lbs.		
Mineral soil	2,152.5	8	92	1,526.5	17	83
No treatment	916.0	20	80	359.5	89	11
Potash	2,049.5	15	85	826.5	90	10
Phosphate and potash	2,693.0	7	93	2,339.0	45	55
Phosphate, potash, and nitrogen	3,585.0	12	88	3,105.0	24	76
Manure	4,054.5	10	90	3,113.5	53	47
Average	2,575.1	12	88	1,878.3	53	47

Table 49 gives yields from the different grasses and legumes, some planted singly and others in mixtures. The yields are given in pounds per acre and are the average for three years, 1917, 1918, and 1919. The percentage of weeds in the crop from the different plantings is given and the marked effect from the application of lime should be noted. Where lime was not applied the legumes such as clover and alfalfa were entirely absent, while where lime was applied good stands were obtained. It also appears that a mixture of timothy, medium red clover, and alsike gave the largest returns. Kentucky bluegrass gives much promise as a pasture grass on peat land and grows luxuriantly with proper fertilization.

TABLE 49

YIELD OF HAY PER ACRE OF DIFFERENT VARIETIES AND MIXTURES ON THE PEAT LAND OF THE MUSKEG

Treatment	Timothy	Redtop	Meadow fescue	Perennial rye grass	Bromus inermus	Kentucky blue grass, white clover and alfalfa	Timothy, alsike, and mammoth clover	Timothy, alsike, and mammoth red clover	Average
				Unlimed					
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Mineral soil	1,696	1,840	848	736	1,056	688	1,072	1,696	1,204
No treatment	448	368	304	352	176	112	464	624	356
Potash	912	1,296	992	896	704	640	864	1,168	934
Phosphate and potash	2,448	2,688	1,744	1,648	1,856	2,144	4,384	3,920	2,604
Phosphate, potash, and nitrogen	4,400	5,088	3,776	2,112	3,392	3,824	4,688	4,000	3,910
Manure	2,592	2,768	1,936	1,712	1,376	2,176	3,728	3,328	2,452
Total average	2,083	2,341	1,600	1,243	1,427	1,597	2,533	2,456	1,910
Per cent weeds	57	43	57	77	64	34	47	43	53
Per cent hay	43	57	43	23	36	66	53	57	47
				Limed					
Mineral soil	2,320	2,320	1,456	944	1,392	608	1,360	2,032	1,554
No treatment	1,648	1,600	928	784	832	304	464	640	900
Potash	2,272	2,272	2,512	1,376	2,016	912	1,536	2,560	1,932
Phosphate and potash	3,504	2,816	2,672	1,456	1,840	2,016	2,848	4,880	2,754
Phosphate, potash, and nitrogen	4,864	4,736	3,776	2,656	3,184	3,504	3,088	4,864	3,834
Manure	3,856	3,904	3,712	3,424	2,896	3,744	4,560	4,512	3,826
Total average	3,077	2,943	2,510	1,774	2,027	1,848	2,309	3,248	2,467
Per cent weeds	6	6	11	42	8	6	8	9	12
Per cent hay	94	94	89	58	92	94	92	91	88

VEGETABLE INVESTIGATIONS

Investigations with vegetables have been limited almost exclusively to variety tests. These tests have been carried on for five years and include a large number of varieties. The varieties listed have given the most satisfactory results.

Bean.—Choice Navy, Brown Swedish (short season, very hardy), Boston Yellow Eye; Wax: Improved Golden Wax, Davis Kidney Wax, Curries Black Wax; Kidney: Burpees Kidney, Red Kidney; Lima: New Wonder Bush.

Beet.—Sterling, Detroit Dark Red, Early Blood Turnip, Crimson Globe.

Cabbage.—Early: Washington Wakefield, Early Spring, Danish Ballhead; Late: Hollander, All Seasons, Autumn King.

Carrot.—Half Long Scarlet, Chantenay, Danvers Half Long.

Cauliflower.—Drought Resistant, Snowball, Model.

Celery.—Golden Heart, Winter Queen, Kalamazoo.

Citron.—Have given good results and are recommended for preserves.

Corn, Sweet.—Golden Bantam, Peep O'Day, Extra Early White Cory, Portland.

Cucumber.—Siberian, Early Green Cluster, White Spine, Green Prolific, Pickling.

Kohl Rabi.—White Vienna.

Lettuce.—Black Seeded, Grand Rapids; Head: Golden Queen, All Seasons, Crisp as Ice, Hanson Head.

Mangel.—Improved Mammoth Red Long, Yellow Globe, Mammoth Golden Giant, Danish Sludstrup.

Muskmelon.—Improved Yellow Cantaloupe, Long Island Beauty, Extra Early Hackensack, Osage or Miller's Cream, Jenny Lind.

Onion.—Red: Large Red Globe, Early Red Flat, Minnesota Red Globe; Yellow: Danvers Globe, Danvers Flat, Ohio Yellow Globe; White: Minnesota White Globe, White Silver Skin, Southport White Globe.

Parsnip.—Guernsey, Hollow Crown, Sweet Marrow.

Pea.—Surprise, Little Marvel, American Wonder, Alaska, Teddy Roosevelt.

Pepper.—Golden Dawn, Large Bell or Bull Nose, Ruby King, Long Red Cayenne.

Pop Corn.—White Rice.

Pumpkin.—Connecticut Field, Mammoth Prize, Large Cheese.

Radish.—Summer: Deep Scarlet, White Olive, Yellow Ball, White Icicle, Long Scarlet; Winter: Round Black Spanish, Large Black Spanish.

Rutabaga.—American Purple Top, Sweet Russian, Sweet German, Prize Winner.

Squash.—Improved Hubbard, White Bush Scallop, Mammoth Chili.

Sugar Beet.—Vilmorin Elite, Royal Giant, Klein Wanzlebener.

Tomato.—Chalks Early Jewel, Earliana, John Baer, Early Minnesota, Truckers' Favorite; Small: Red Cherry, Red Pear, Yellow Plum, Peach.

Turnip.—Purple Top White Globe, Early Model, Purple Top Strap Leaved, White Globe.

Watermelon.—Klondike, Kentucky Wonder, Harris Earliest, Fordhook Early, Kleckley Sweet.

FRUIT INVESTIGATIONS

The work with small fruits includes variety testing of strawberries, currants, gooseberries, raspberries, dewberries, blackberries, highbush cranberries, and grapes. All of these have given promising results except blackberries, dewberries, and grapes. All the grape vines of every variety have been winter-killed. Blackberries also show severe winter injury and the berry production from them as well as from the dewberries, has been discouraging.

STRAWBERRIES

Results indicate that strawberries can be grown successfully in this district and that where conditions are favorable the returns are both certain and abundant.

TABLE 50

SUCCESSFUL VARIETIES OF STRAWBERRIES

Variety	Flowering	Season	Fruit	Remarks
Warfield	Imperfect	Medium	Dark red	Very satisfactory
Lovett	Perfect	Medium	Firm, medium to large	
Senator Dunlap	Perfect	Medium	Medium size, good quality, good keepers	
Chesapeake	Perfect	Late	Dark red	
Wolverton	Perfect	Late	Large deep red, flattened berries	
Haverland	Perfect	Early	Light red, large	
Wm. Belt	Perfect	Late	Conical, glossy red	
Clyde	Perfect	Medium early	Firm, large	Upright vines
Brandywine	Perfect	Late	Fine quality, large	
Enhance	Perfect	Medium	Large, uniform	Strong vigorous vines

Raspberries, gooseberries, and currants have all done well considering location and adverse conditions of drought and severe winters the two years just after they were set out, when the bushes were not yet fully established. Table 51 gives data as to the hardiness of each variety. They are named in order of amount of fruit produced.

TABLE 51

HARDINESS OF SMALL FRUITS

Gooseberries

Variety	Number plants May, 1916	Number living in fall of		Percent living, 1919
		1917	1919	
Champion	10	9	8	80
Red Jacket	10	6	6	60
Houghton	10	9	9	90
Josselyn	11	10	7	61
Downing	11	8	5	41
Keepsake	10	7	2	20
Portage	10	3	2	20

TABLE 51—*Continued*

Currants

Variety	Number plants May, 1916	Number living in fall of		Percent living, 1919
		1917	1919	
Victoria	6	6	5	83
Black Champion	14	13	12	86
North Star	6	6	6	100
Lee Prolific	7	7	7	100
White Grape	7	7	7	100
Long Bunch Holland	6	6	6	100
Wilder	6	6	6	100
Red Dutch	6	5	4	66
Raspberries				
Shaffer	26	8	4	15
Shippers' Pride	11	10	10	91
Sunbeam	13	5	8	61
St. Regis	19	10	10	52
King	38	15	4	11
Herbert	25	6	6	24
Worthy	31	29	22	71
Minnesota No. 30	3	3	3	100
Minnetonka Ironclad	13	10	4	30
Minnesota No. 31	4	3	3	75
Columbian	26	13	8	30
Miller	24	5	2	8
Cuthbert	25	7	1	4
Golden Queen	29	8	0	0
Marlborne	12	9	0	0
Gregg	20	5	0	0

TREE FRUITS

A diagram of the tree fruit orchard is shown in Figure 14. Plums, including Compass Cherry, were planted alternately with apples and crabs in order to utilize the ground more fully while the apple trees are small. In the event of crowding, the plum trees will be removed. Table 52 indicates losses by winter-killing. These losses are very great among the apples. Charlamoff, Hibernal, Jewell Winter, and several University seedlings are relatively hardy, tho almost every tree shows winter injury. The three varieties of crabs under test are apparently about equally hardy. The average loss with crabs is less than with apples. The hardiest varieties of the plums are Surprise, Kahinta, Egana, Topa, Terry, Toka, Wyant, and Yutteca. The Compass Cherry seems to be as hardy as the plums. It should be stated, however, that conditions at this station are not so favorable as on many farms in the neighborhood. Farmers having heavier soil and located near the larger lakes, as Pokegama Lake, four miles south of the station, are having very encouraging results, not only with plums and crabs, but with apples and grapes as well.

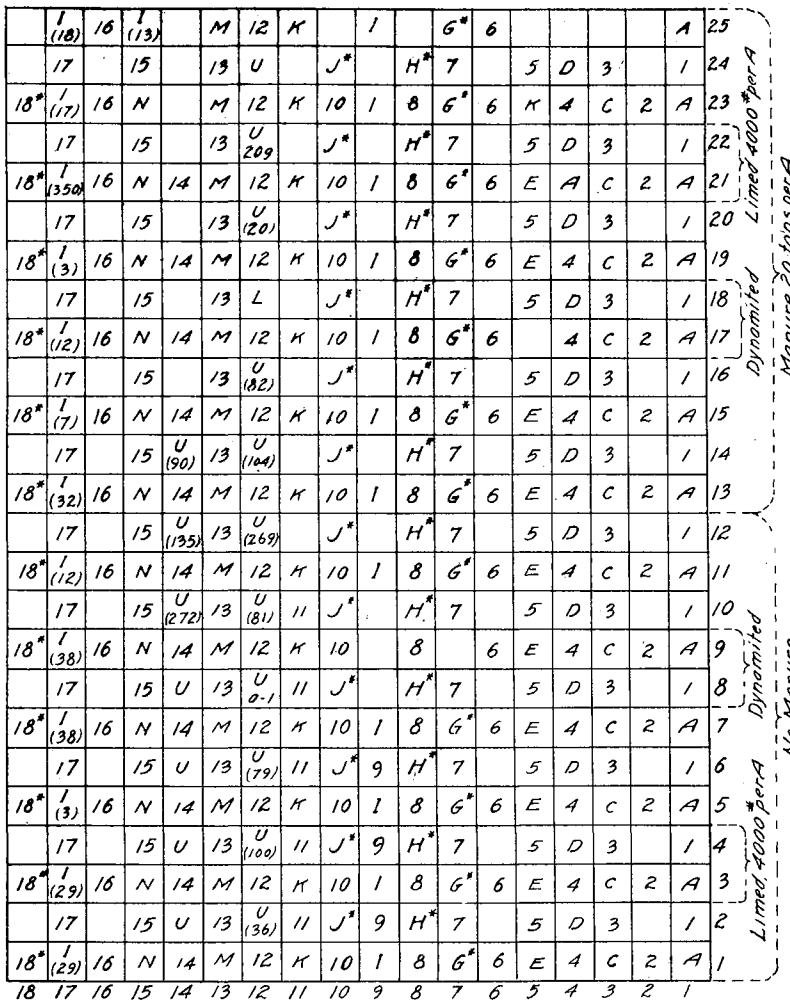

Fig. 14. Plan of Tree Fruit Orchard

Plums and Cherries

1. Cheresota
2. Opata
3. Hanska
4. Sapa
5. San Sota
6. Egama
7. Toka
8. Kahinta
9. Wachampa
10. Etopa
11. Surprise
12. Zekanta
13. Yuttecca
14. Wyant
15. Terry
16. Topa
17. Wastessa
18. Compass Cherry

Apples and Crabs

A. Wealthy
B. (Vacant)
C. Duchess
D. Jewell Winter
E. Hibernal
F. (Vacant)
G. Whitney Crab*
H. Early Strawberry Crab*
I. Malinda
J. Sweet Russet Crab*
K. Charlamoff
L. Gilbert Winesap
M. Delicious
N. King David
O. (Vacant)
U. University Seedling

TABLE 52

ORCHARD DATA

Variety	Number of trees	In poor condition when planted May, 1916	Dead at beginning of winter		Number dead	Number alive	Percent living
			1916–17	1918–19			
Plums							
Cheresota	12	0	0	4	4	8	67
Opata	12	5	2	4	6	6	50
Hanska	12	1	5	3	8	4	33
Sapa	12	2	1	5	6	6	50
San Sota	12	0	0	6	6	6	50
Egama	12	0	0	2	2	10	83
Toka	12	0	0	4	4	8	67
Kahinta	12	0	1	8	9	3	85
Wachampa	3	0	0	2	2	1	33
Etopa	12	4	1	7	8	4	33
Surprise	5	1	0	0	0	5	100
Zekanta	13	1	2	4	6	7	54
Yuttecca	12	0	1	6	7	6	61
Wyant	11	1	1	3	4	7	61
Terry	12	0	0	4	4	8	67
Topa	13	5	2	2	4	9	69
Wastessa	12	4	2	5	7	5	42
Compass Cherry	12	0	0	3	3	9	75
Apples							
Wealthy	13	0	10	3	13	0	0
Duchess	12	4	2	10	12	0	0
Jewell Winter	12	0	3	6	9	3	25
Hibernal	10	0	0	6	6	4	40
Malinda	12	6	4	7	11	1	9
Charlamoff	14	4	0	5	5	9	65
Delicious	13	5	3	9	12	1	8
King David	12	6	6	6	12	0	0
Minnesota Numbers:							
36	1	0	0	1	1	0	0
100	1	0	0	0	0	1	100
79	1	0	0	1	1	0	0
A-1	1	0	0	1	1	0	0
81	1	0	0	0	0	1	100
269	1	0	0	1	1	0	0
104	1	0	0	0	0	1	100
82	1	0	0	1	1	0	0
20	1	0	0	1	1	0	0
20-G	1	0	0	1	1	0	0
132	1	0	1	0	1	0	0
272	1	0	0	0	0	1	100
135	1	0	0	1	1	0	0
University seedling	4	0	1	2	3	1	25
Malinda Number:							
29	2	1	0	1	1	1	50
3	2	0	1	0	1	1	50
38	2	0	0	0	0	2	100
12	1	0	0	0	0	1	100
32	1	0	0	0	0	1	100
7	1	0	0	0	0	1	100
12	1	0	1	0	1	0	0
35	1	1	1	0	1	0	0
17	1	0	0	0	0	1	100
18	1	0	0	1	1	0	0
13	1	0	0	0	0	1	100
Gilbert Winesap	1	0	0	1	1	0	0

TABLE 52—*Continued*

Crab Apples

Variety	Number of trees	In poor condition when planted May, 1916	Dead at beginning of winter		Number dead	Number alive	Percent living
			1916–17	1918–19			
Whitney	12	0	2	5	7	5	42
Early Strawberry	12	4	3	4	7	5	42
Sweet Russet	12	1	0	5	5	7	58
Summary							
Plums	213	24	18	72	90	123	60
Apples	130	27	33	65	98	32	25
Crab Apples	36	5	5	14	19	17	47

FORESTRY INVESTIGATIONS

Forestry work dates back to 1897, when seedlings were purchased and planted in nursery rows by Warren Pendergast, then superintendent at this station. These seedlings included White, Norway, Scotch, and Jack pine. The Norway and jack pine seedlings were wild stock. In 1899, thirty-two acres on a rough and stony cut-over area were platted into one-acre tracts of 10 by 16 rods. Most of these plots were planted in 1900 and 1901 to Norway, White, Scotch, and Jack pine at varying distances as follows: 4 by 4, 6 by 6, 8 by 8, and 10 by 10 feet. In some of these plots only one kind was planted, in others the rows were alternated between the different kinds of pines. This planting was done under the supervision of Herman H. Chapman, who was then superintendent.

A fire swept over the entire tract in the spring of 1905. The south plots, containing most of the White and some of the Norway pine were severely injured. The portion of the plantation not greatly injured by fire made good growth, as shown in Table 53. Measurements were taken in 1916 and will be taken again in 1921.

White pine has suffered somewhat from tip-worm, and Scotch pine has been considerably injured by branch-knot. Norway and Jack pines are in perfect condition.

In 1916 the regents of the University approved setting aside fifty acres for forest plantation and wood lot. This includes the present plantation, which will be increased from time to time by transplanting seedlings of different kinds of pine that have already been planted in nursery rows for that purpose.

In 1916, 3,000 pines of the various kinds were set out north of the station grounds for a windbreak. Part of this windbreak is being cultivated. The rest were planted on cut-over land among stumps, the object being to compare the growth of pine windbreak plantations with and without tillage. This plantation is now three years old and the beneficial effects from inter-tillage as shown by the growth and thriftiness of the trees are very marked. The maximum height of the trees receiving no tillage is now 16 inches, while that of the trees receiving tillage is 30 inches. Further plantings are being made. Seven thousand trees were set out in 1919, mostly White spruce. These were planted for a windbreak west of the station grounds.

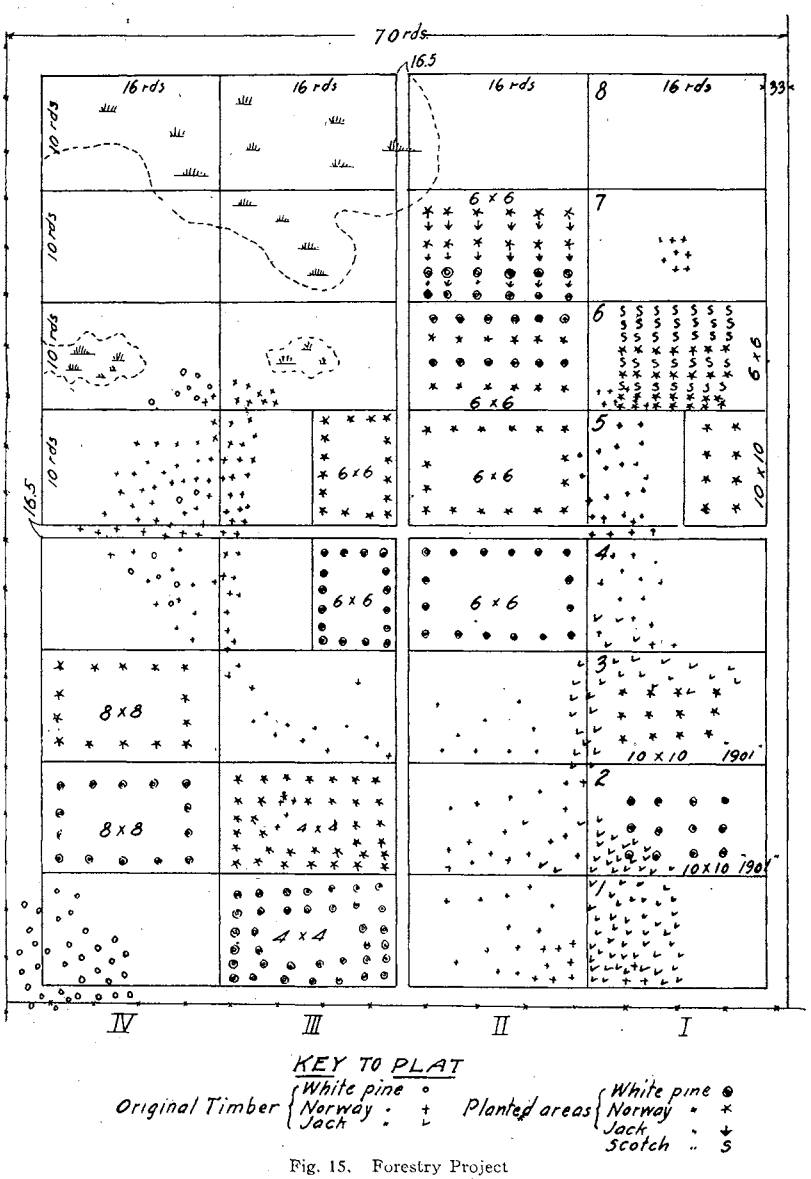

Fig. 15. Forestry Project

Series numbered in Roman numerals, from east to west; in Arabic numerals, from south to north.

TABLE 53

GROWTH OF PINES PLANTED AT VARYING DISTANCES, ALONE, AND IN COMBINATION

Species	Spacing	Diameter			Height
		Maximum	Minimum	Average	
	Feet	Inches	Inches	Inches	Feet
White pine	4 x 4	4.0	3.0	3.5	16 – 22
White pine	6 x 6	4.3	3.8	4.0	16 – 20
Norway pine	4 x 4	7.0	3.5	5.0	15 – 20
Norway pine	6 x 6	6.0	5.0	5.3	19 – 22
Norway pine	8 x 8	6.0	5.5	6.0	18 – 20
Norway pine	10 x 10	7.0	5.5	6.4	22 – 26
	Norway pine	alternating	with White		
White	6 x 6	5.0	3.0	4.1	16 – 20
Norway	6 x 6	5.5	2.5	4.7	16 – 24
	Norway pine	alternating	with Jack		
Jack	6 x 6	7.0	5.5	5.8	20 – 28
Norway	6 x 6	6.0	4.5	4.6	18 – 24
	White pine	alternating	with Jack		
Jack	6 x 6	7.5	4.0	5.8	20 – 28
White	6 x 6	5.0	3.5	4.2	18 – 22
	Scotch pine	alternating	with Norway		
Scotch	6 x 6	6.0	4.5	5.5	20 – 26
Norway	6 x 6	6.0	4.0	5.1	20 – 26
Scotch	6 x 6	6.0	3.0	5.1	18 – 24

Fig. 16. Forestry Plantation
Norway pines 6 feet apart each way, fifteen years after planting.

LAND CLEARING

The most important problem before the farmers in northeastern Minnesota, and one that is universal, is that of land clearing. It is not only the biggest task, but the most pressing for immediate action and calls for the largest immediate investment of money and labor of any general farm operation. The question of how to clear these lands and prepare them for field crops is a farm management problem of first importance.

The following report sets forth information derived from a land clearing project carried on in cooperation with the Division of Agronomy and Farm Management, Department of Agriculture, University of Minnesota. This report is by A. H. Benton, field man in immediate charge of recording and compiling the data relating to all factors and operations involved.

The costs of the operations set forth in the report were based on those for 1917. Wages for horse and man labor have increased considerably since then, probably 100 per cent for such work as land clearing, while the cost of dynamite has increased but little. Nevertheless, even with these adjustments to present prices, it is clearly evident that the stump-puller can be used to advantage in clearing lands similar to the land cleared in this project.

It is possible that farmers use too much dynamite in their land clearing operations, that they would save money by putting in more time with the stump-puller. It is also apparent that dynamite is necessary in any land-clearing operation.

Conditions vary so greatly that it is impossible to lay down a fixed rule as to what part of the work should be done with the stump-puller and what part with dynamite; however, one should keep in mind the condition that the land is left in, after the clearing has been done, as the work of preparing the land for crops is by no means finished when the stumps are dislodged, piled, and burned. The number of roots still remaining in the soil and the size and character of the holes left by the removal of the stumps are entirely dependent upon the methods used in clearing.

The seeding down and pasturing of stump land for several years previous to the removal of the stumps can be recommended wherever permissible. Such delayed clearing will be found economical on at least a portion of every farm.

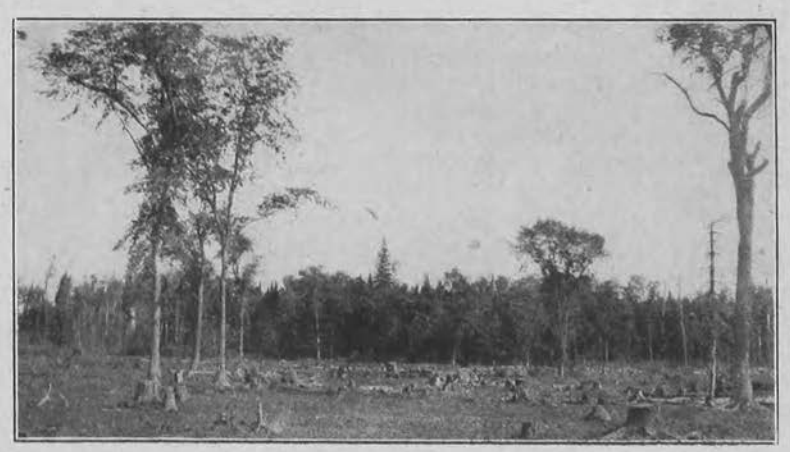

Fig. 17. Delayed Clearing Tract
Delayed clearing will be found economical on at least a part of every farm.

Fig. 18. Land-Clearing Investigation
The land selected had about an equal number of hard and soft wood stumps.

LAND CLEARING AT GRAND RAPIDS

PURPOSE AND PLAN

The project outlined for the land-clearing investigation called for the clearing of nine acres in three 3-acre plots. The purpose of the investigation was to try to determine the relative merits and cost (1) of clearing land of stumps with a horse-power stump-puller, breaking up the larger stumps after pulling when necessary; (2) of shattering the larger stumps before pulling with a horse-power stump-puller; and (3) of blasting out the stumps with dynamite. The tract of land selected had about an equal mixture of hard- and soft-wood stumps. The trees had been cut from three to ten years in case of hardwoods and from twenty to thirty years in case of pine and larger spruce. The land is typical of the better land found along the rivers in this region. The soil on the east half of the tract is a silty loam to a depth of about 12 inches, which holds a large amount of organic matter. Below this is a very sticky bluish gray clay. The soil on the west half graded from a sandy loam to almost a pure sand in some places.

All stumps 5 inches in diameter and larger on the 9-acre tract were numbered, the size and kind noted.

Plot I was selected as the one on which all stumps would first be pulled by a stump-puller; Plot II, the one on which stumps would first be shattered with a small charge of dynamite, and then these and the remainder pulled with the stump-puller. On Plot III all stumps were to be blasted out by the use of dynamite.

On Plot III the plan was carried out as described and all stumps more than 5 inches in diameter were blown out with dynamite. The E. I. Du Pont de Nemours & Company of Wilmington, Delaware, furnished the dynamiting material and one of their experts, O. O. Strayer, took charge of the blasting operations.

The original plan was to have the demonstration experts of one of the stump-puller companies take charge of the stump pulling. Arrangements of this kind could not be made, and L. C. Lathrop of Hill City, Minnesota, was hired to pull and pile the stumps at $25 a day for himself and two other men, a team and a two-horse stump-puller.

Mr. Lathrop cleared 200 acres of land in the spring and summer of 1917 with unusual success. His charge was $37.50 for clearing, piling, and burning, where there were about 100 white pine stumps per acre. The stumps were practically all white pine averaging 20 inches in diameter. His plan of operation was to use a stump plow on all of the larger stumps and tear them to pieces rather than pull them as a whole. This method left a much smaller hole and also made the stumps much easier to pile. He used a No. 3 Faultless stump-puller and changed the stump plow from a two-pronged point to a single point, as he found the double points could not be used in getting the plow under the stumps. The stump-puller, used with 150 feet of cable, cost $200.

It was found impossible to tear the solid oak and elm stumps apart as had been the practice with pine. Either small roots would break off or the whole stump would be pulled.

Fig. 19. A Stump-Puller in Action, Pulling an Acre a Day

TABLE I
SKETCH OF TRACT CLEARED

Plot I 477 stumps pulled	Plot II 638 stumps pulled and dynamited	Plot III 639 stumps dynamited*
Stumps	Stumps	Stumps
92	111	125
99	121	125
115	118	95
29	79	103
32	80	63
31	38	30
42	49	26
37	42	72
10 rods	10 rods	10 rods

* Of the 639 stumps on Plot III, 82 were found too rotten to warrant dynamiting. This left 557 stumps actually blasted.

TABLE II

KIND, SIZE AND NUMBER OF STUMPS

	Plot I			Plot II			Plot III		
	No. of stumps	Per cent	Diameter	No. of stumps	Per cent	Diameter	No. of stumps	Per cent	Diameter
			Inches			Inches			Inches
Ash	124	26.0	8.5	86	13.4	10.3	132	20.6	10.0
Birch	10	2.0	10.7	6	0.9	14.3	11	1.7	20.0
Elm	101	21.2	10.0	129	20.2	13.1	109	17.2	12.9
Basswood	6	1.2	6.5	3	0.5	10.0	21	3.4	11.1
Oak	78	16.3	13.0	110	17.3	16.6	55	8.5	14.3
Balsam	62	13.0	8.4	181	28.3	9.8	139	21.8	9.5
Poplar	43	9.0	12.9	87	13.7	17.3	84	13.1	19.4
Spruce	45	9.4	13.9	22	3.5	17.8	64	10.0	13.9
Tamarack	0	0.0	0.0	6	0.9	17.5	10	1.5	12.4
White pine	8	1.9	12.1	8	1.3	14.4	14	2.2	15.2
Average or total	477	100.0	10.5*	638	100.0	13.2*	639	100.0	12.7*

* Weighted averages.

Under the project outlined, no dynamite was to be used on Plot I, but this was found impractical. While a very large stump can be pulled, frequently there are no anchor stumps available of sufficient strength to hold the stump-puller. This necessitated shattering in the ground four stumps on Plot I. The stumps were pulled on Plots I and II at the rate of about an acre a day, and were piled at the rate of 1½ acres a day. The larger stumps were skidded to the piles by the team and the small material was carried by hand. Mr. Lathrop says that large piles of hardwood need not be made as it burns very easily. However, with pine, large piles must be made or the stumps will char and then cease to burn.

Fig. 20. Using a Single-Point Stump Plow

USE OF STUMP-PULLER

It will be noted in Table III that the cost of pulling and piling the three acres in Plot I was $43.61, or $14.54 per acre, and the cost for three acres in Plot II was $78.62, or $26.21 per acre. On Plot II thirty stumps of 18 inches or more in diameter were shattered with a small charge of dynamite before pulling. The average diameter of the stumps on Plot I was 2.7 inches less than of those on Plot II (Table II).

TABLE III

TIME REQUIRED AND COST OF PULLING STUMPS ON PLOTS I AND II

Plot I

Man labor in pulling stumps, 78 hours at 25 cents	$19.50
Horse labor in pulling stumps, 52 hours at 15 cents	7.80
Man labor in piling stumps, 36½ hours at 25 cents	9.13
Horse labor in piling stumps, 32 hours at 15 cents	4.80
Dynamite, fuses, and caps used in shattering stumps before pulling—4 stumps at 27 cents	1.08
Dynamite, fuses, and caps used in shattering large stumps after pulling—5 charges at 27 cents	1.35
Total cost of 477 stumps (3 acres)	43.66
Cost per acre	14.55
Cost per stump	0.09

Plot II

Man labor in pulling stumps, 108 hours at 25 cents	$27.00
Horse labor in pulling stumps, 72 hours at 15 cents	10.80
Man labor in piling stumps, 57 hours at 25 cents	14.25
Horse labor in piling stumps, 38 hours at 15 cents	5.70
Dynamite, caps, and fuses used in shattering stumps before pulling—30 stumps, 33 charges at 27 cents	8.91
Time used in shattering stumps after pulling, 23 hours at 25 cents	5.75
Dynamite, caps, and fuses used in breaking up large stumps—27 charges at 27 cents	7.29
Total cost—638 stumps (3 acres)	79.70
Cost per acre	26.53
Cost per stump	0.12

USE OF DYNAMITE

The high cost of labor shown in Tables IV, V, and VI is no doubt partly due to the fact that the spring and summer of 1917 were unusually dry and the ground was packed very hard, which made it difficult to get charges under the stumps. The tools used in blasting the stumps were a pointed tool-steel drill 3½ feet long and sledges for driving it, a chain for pulling the drill from the hole, a tamping stick and blasting machine with 150 feet of copper wire. It is well to note that without the use of a blasting machine it is impractical to blow the solid hardwood stumps, as the charges must be distributed around the stump and fired simultaneously for the best results.

For Plot III, where all stumps were dynamited, Table IV shows the amount and cost of materials used. The average cost per acre of the materials was $70.76 or 38.1 cents per stump. The amount of dynamite used per stump was 1.44 pounds and the number of caps 1.82. Table V gives the amount and cost of labor required in blasting and piling the stumps. The labor cost per acre was $33.37, or 18 cents per stump. Table VI is a summary of the costs in clearing Plot III. The total cost was $104.13 per acre, or 56.1 cents per stump.

TABLE IV

AMOUNT AND COST OF MATERIAL USED IN CLEARING PLOT III—3 ACRES

Dynamite (20 per cent strength), 654 lbs. at 19 cents	$ 124.26
Dynamite (40 per cent strength), 150 lbs. at 23 cents	34.50
Electric caps (4 ft. wires), 932 at $5.49 per 100	51.17
Blasting caps (for fuses), 81 at $1.70 per 100	1.38
Fuse, 126 feet at 77 cents per 100 feet	0.97
Total cost of material	$ 212.28
Cost per acre	70.76
Cost per stump—557 stumps	0.38
Amount of dynamite used per stump, pounds	1.44
Number of caps used per stump	1.82

TABLE V

TIME REQUIRED AND LABOR COST ON PLOT III

Hours of man labor required in blasting 557 stumps	308
Minutes of man labor per stump in blasting	33.2
Cost at 25 cents per hour	$ 77.00
Labor cost per acre	25.66
Labor cost per stump in blasting	0.14
Cost of man labor in pulling—15 hours at 25 cents	3.75
Cost of horse labor in pulling—10 hours at 15 cents	1.50
Total cost in pulling stumps	5.25
Cost of man labor in piling stumps—51 hours at 25 cents	12.75
Cost of horse labor in piling stumps—34 hours at 15 cents	5.10
Total labor cost in piling stumps	17.85
Total labor cost in removing and piling stumps	100.10
Average labor cost per acre	33.37
Total labor cost per stump	0.18

TABLE VI

SUMMARY OF COST ON PLOT III

Cost of material in blasting 557 stumps	$ 212.28
Man labor in blasting 557 stumps	77.00
Man labor cost in pulling stumps after blasting	3.75
Horse labor cost in pulling stumps after blasting	1.50
Man labor cost in piling stumps after blasting	12.75
Horse labor cost in piling stumps after blasting	5.10
Total cost on three acres	312.38
Average cost per acre	104.13
Average cost per stump	0.56

Fig. 21. Hardwood stump
It was impossible to tear the solid oak and elm stumps apart as was the practice with pine.

On Plot III, where dynamite alone was used, an attempt was made to find the relative value of 20 per cent and 40 per cent strength (Table VIII). There does not seem to be much difference in the amount used. However, inspection showed that the 40 per cent strength blasted out the stumps more effectively than the 20 per cent. The argument advanced by the powder company for 20 per cent dynamite is that it is slower in action and has more heaving force than the 40 per cent. As indicated in one of the tables, the 40 per cent strength costs 4 cents more per pound than the 20 per cent, and on the basis of the amount used there would have been an additional cost of $16 per acre.

TABLE VII

COMPARISON OF THE USE OF 20 PER CENT AND 40 PER CENT DYNAMITE*

Kind of stump	Stumps on which 20 per cent dynamite was used			Stumps on which 40 per cent dynamite was used		
	Number	Diameter	Dynamite	Number	Diameter	Dynamite
		Inches	Lbs.		Inches	Lbs.
Ash	91	10.0	1.4	34	9.9	1.2
Birch	9	20.9	1.7	0	0	0
Elm	65	13.6	1.9	21	13.8	2.0
Basswood	21	11.1	1.4	0	0	0
Oak	35	14.2	3.2	17	16.0	3.1
Balsam	100	9.5	0.8	22	9.9	0.9
Poplar	76	19.4	1.0	2	23.0	1.3
Spruce	44	14.7	0.9	1	16.0	1.75
Tamarack	10	12.4	1.5	0	0	0
White pine	6	14.0	1.3	3	22.0	1.5
Average or total	457	13.1	1.4	100	12.4	1.5

* Additional cost due to the higher cost of 40 per cent dynamite, $16 per acre, on the basis of the same amount of 20 per cent dynamite.

The amount of dynamite used on stumps of different kinds is shown in Table VIII. Oak and elm required the most. They were usually of good size and in sound condition. In Table IX the amounts of dynamite used on the different kinds of stumps of various sizes is shown.

TABLE VIII

AMOUNT OF DYNAMITE USED FOR STUMPS OF DIFFERENT KINDS, PLOT III

Kind of stump	Number of stumps	Average diameter	Amount per stump
		Inches	Pounds
Ash	125	10.0	1.4
Birch	9	20.9	1.7
Elm	86	13.6	1.9
Basswood	21	11.1	1.4
Oak	52	14.2	3.1
Balsam	122	9.5	0.8
Poplar	78	19.4	1.0
Spruce	45	14.7	0.9
Tamarack	10	12.4	1.5
White pine	9	14.0	1.4
Rotten stumps,	82		
Average or total	557	13.1	1.4

TABLE IX

DYNAMITE USED FOR STUMPS OF DIFFERENT SIZES

Kind of stump	5 to 9 inches		10 to 12 inches		13 to 15 inches		16 to 18 inches		19 to 21 inches		22 to 24 inches		More than 24 inches	
	No. of stumps	Lbs. Dyn.	No. of stumps	Lbs. Dyn.	No. of stumps	Lbs. Dyn.	No. of stumps	Lbs. Dyn.	No. of stumps	Lbs. Dyn.	No. of stumps	Lbs. Dyn.	No. of stumps	Lbs. Dyn.
Ash	63	1.0	39	1.3	12	2.2	12	2.5					1	1
Birch			1	1.0	1	1.0	1	1.0	3	1.4	2	1.6	1	2
Balsam	71	0.8	38	0.9	8	0.9	5	1.0						
Elm	23	1.1	26	1.2	7	2.3	19	2.2	4	4.6	3	1.5	3	7.7
Basswood	7	1.1	10	1.4	4	2.1								
Oak	7	1.4	6	1.6	10	2.2	9	3.5	8	4.6	2	2.6	10	6.3
Poplar	2	1.0	6	0.8	9	0.9	19	0.8	17	0.9	16	1.0	8	1.6
Spruce	7	0.8	13	0.9	10	1.4	8	1.0	1	1.5	2	0.9	4	3.1
Tamarack	4	0.8	1	0.3	3	1.8	2	1.5						
White pine	5	0.8					1	1.0	1	0.2	1	0.4	1	0.2

A further analysis of the cost of removing stumps on the basis of the cross-sectional area removed for each cent of cost is shown in Table X. This again indicates very conclusively the advantage of pulling over dynamiting. At a cost of one cent, 9.52 square inches of stump was removed on Plot I and 11.12 square inches on Plot II, but on Plot III only 2.26 square inches. There is also an indication that shattering before pulling has a little advantage over pulling without shattering. A dry sandy soil is usually considered less satisfactory for getting best results with dynamite. As already stated, the west part of plot III was rather sandy but the stumps were smaller, the trees had been cut longer, and were largely soft wood, mostly spruce, tamarack, and pine. The result was that the dynamite worked more successfully and left smaller cavities than in the silt loam on the east half of the plot.

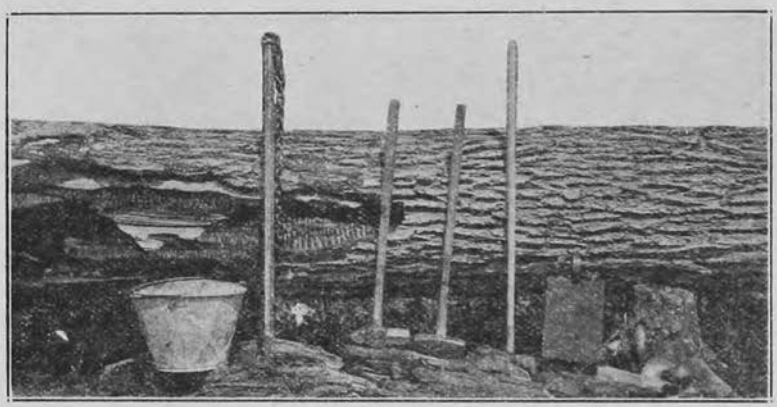

Fig. 22. Tools Used in Blowing Out Stumps With Dynamite

TABLE X

SQUARE INCHES OF STUMP AREA REMOVED FOR EACH CENT OF COST

	Manner of removal	Average cross-sectional area per stump	Average cost of clearing per stump	Cross-sectional stump area removed each cent of cost
		Sq. In.	Cents	Sq. In.
Plot I....	Pulled.....	86.58	9.1	9.52
Plot II....	Shattered and pulled.....	136.85	12.3	11.12
Plot III...	Dynamited.....	126.68	56.1	2.26

CONDITION OF CLEARED LAND

The condition of the ground after clearing is of nearly as great importance as the actual cost. One advantage of shattering stumps before pulling is that much less dirt is turned up with the roots and the parts of the stump are much more easily handled. The cavities left after blasting stumps were much larger than those where stumps were

pulled as indicated in Table XI. The average depth of cavities left after pulling 50 representative stumps was 13.1 inches and the average width 44.3 inches. It should be noted that the cavities left from blasting were nearly twice as deep as those left from pulling stumps.

Fig. 23. Blowing Out a Stump
Danger! Look up!

While pulled stumps frequently turn up a large amount of earth, this earth is left near or in the cavity when the stump is removed to a pile. On the other hand, the earth thrown up by a blast of dynamite is scattered over a considerable area. It was observed that many more roots were removed when stumps were pulled than when dynamite was used. The dynamite tended to blow out the body of the stump but to leave nearly all the roots.

Fig. 24. The Cavity

TABLE XI

DEPTH AND WIDTH OF CAVITIES LEFT AFTER REMOVING STUMPS

Pulled stumps			Dynamited stumps		
Stump No.	Depth of cavity	Width of cavity	Stump No.	Depth of cavity	Width of cavity
	Inches	Inches		Inches	Inches
1	15	60	1	24	42
2	15	40	2	20	30
3	10	30	3	36	54
4	25	70	4	27	48
5	6	40	5	36	42
6	22	60	6	24	36
7	8	30	7	30	42
8	6	40	8	24	36
9	15	60	9	24	42
10	10	25	10	30	48
11	5	15	11	24	36
12	11	30	12	36	56
13	13	70	13	42	42
14	20	30	14	30	36
15	15	70	15	30	72
16	20	70	16	18	30
17	35	85	17	36	42
18	17	45	18	36	80
19	14	30	19	34	36
20	14	50	20	18	30
21	17	30	21	18	30
22	6	20	22	30	56
23	30	65	23	30	54
24	9	30	24	36	80
25	15	30	25	14	42
26	6	40	26	24	36
27	5	30	27	24	48
28	15	50	28	18	30
29	6	30	29	42	60
30	6	50	30	24	42
31	5	30	31	40	74
32	10	40	32	24	54
33	9	50	33	24	43
34	10	60	34	24	36
35	8	80	35	26	44
36	20	50	36	24	55
37	20	70	37	22	34
38	8	30	38	19	62
39	10	35	39	20	48
40	16	40	40	18	40
41	20	45	41	16	36
42	17	40	42	27	80
43	16	35	43	15	32
44	8	30	44	20	38
45	15	40	45	18	38
46	17	35	46	26	55
47	8	50	47	15	30
48	6	40	48	24	60
49	10	30	49	20	36
50	14	60	50	24	40
Average	13.1	44.3	Average	25.5	45.8

Another advantage in pulling was that a large number of small stumps were removed that still remained when dynamiting was completed. A count of the stumps less than 5 inches in diameter showed 135 on Plot I; 90 on Plot II; and 134 on Plot III. In the itemized account of expenses for Plot III there is a charge for pulling stumps. This is a result of not being able completely to blow out some large solid stumps. If the first charge is not successful it seems a waste of time and material to make another attempt, as the ground is so loosened and the stump so shattered that the gas escapes without any heaving effect.

Fig. 25. Horse and Sheep Barn

LIVESTOCK

POULTRY

Four breeds of poultry are raised at this station. They are Single Comb White Leghorn, Rose Comb Rhode Island Red, Barred Plymouth Rock, and White Orpington. Approximately four hundred laying hens are kept. Only the very best hens are kept for more than two years. Those having completed their second year are disposed of in the fall and replaced by pullets. We find that the pullets average between 40 and 43 per cent more eggs per year than the hens.

The poultry house is similar throughout except that the west part has a gable roof with a straw loft over an open ceiling, and the east end a shed roof and no loft. Altho the temperature in the part having the straw loft is considerably lower during the coldest weather, it is considerably dryer because of the straw loft, and the birds seem to thrive much better in those pens than in the pens having no straw loft. The lowest temperature recorded in the pens having a straw loft is 14 degrees below zero, as compared with 7 degrees below zero in the pens with a shed roof. Considerable frost collects on the ceiling of the latter pens and on mild days it drops on the floor, making it wet and disagreeable. The plumage of the birds in these pens is usually discolored while that of the birds in the pens under the straw loft is clean and bright. Roll curtains of muslin are provided for the roosts. These are raised in the morning and dropped in the evening to protect the birds from the cold during the night.

TABLE 54

COMPARATIVE FEED AND EGG RECORD, 1917 TO 1919

Breeds	Eggs per hen			Three-year average	Feed per hen			Three-year average	Eggs per pound of feed			Three-year average
	1917	1918	1919		1917	1918	1919		1917	1918	1919	
					Pounds	Pounds	Pounds					
White Leghorns	118.64	132.3	114.8	121.90	87.72	49.0	38.5	58.5	1.35	2.70	2.98	2.35
Rhode Island Red	121.45	108.7	84.3	104.82	96.34	117.7	79.9	97.98	1.26	0.92	1.05	1.08
Plymouth Rock	87.09	85.5	86.3	86.30	95.09	79.0	86.1	86.73	0.91	1.08	1.01	1.00
White Orpington	79.23	90.9	75.2	81.78	124.29	110.2	111.2	115.23	0.64	0.81	0.67	0.71
Average	101.59	104.4	90.2	98.71	100.86	88.9	78.9	89.59	1.04	1.38	1.42	1.28

All the breeds are kept for profit under the same system of management and feeding. Table 54 shows the annual egg production by breeds for 1917, 1918, and 1919. It also gives the amount of feed consumed per hen per year and the average number of eggs produced per pound of feed, by breeds. Economy in production is of more importance to the farmer and general poultryman than is high production alone, and a report of an egg-laying test is not complete unless the feeding data are also given.

COMPARISON OF POULTRY BREEDS

The egg and feed records in Table 55 are a summary of daily records covering a period of three years with the four breeds kept under the same conditions of housing, feed, and management. The flocks had free access to the mash-feed hoppers at all times. Scratch feed was supplied according to their demands. Skimmilk and buttermilk are included in the "feed consumed" at one-sixth by weight. Green feeds such as potatoes, roots, and cabbage are not included.

From the data obtained it seems that Leghorns can be recommended for poultrymen who keep flocks mainly for egg production. Leghorns are pre-eminently the breed for townspeople and for the man who is going into the poultry business for egg production in an extensive way. The Leghorns not only produced more eggs but larger eggs than either of the other breeds under test, and on much less feed, which recommends this breed to the man who must keep the flock penned in and for which the feed must be purchased. Leghorns seldom become broody. At this station the chickens are hatched the latter part of April, or the first of May, which in this region is the earliest practical date for having chickens hatch without undue losses from inclement weather. Leghorns hatched at this time usually begin laying in November before the severe winter weather sets in, and with proper feed and management will continue laying all winter. It is much more difficult to get the pullets from the larger breeds to lay during the early winter. Hatched at the same time, they do not mature sufficiently to lay before winter sets in, and it is difficult to get them to begin laying until the days become longer and the coops are brightened by more sunshine.

TABLE 55

THREE-YEAR SUMMARY OF POULTRY RECORDS BY BREEDS

	Single Comb White Leghorn	Rhode Island Red	Barred Plymouth Rock	White Orpington
Average number of eggs per year per hen by breeds	121.91	104.82	86.30	81.78
Feed consumed per hen, pounds	58.50	97.98	86.73	115.23
Number of eggs produced per pound of feed	2.35	1.08	1.00	0.71
Average weight of eggs, by breeds, ounces	2.15	2.12	2.02	2.02
Pounds of eggs laid per year	16.38	13.89	10.89	10.32
Average weight of hen, pounds	3.90	5.80	6.70	7.10
Egg production of hen times her own weight	4.20	2.40	1.63	1.45
Value of eggs per year at 48 cents per dozen	$4.88	$4.19	$3.45	$3.27
Value of feed consumed at $60 per ton	$1.76	$2.94	$2.60	$3.46
Profit per hen above cost of feed	$3.12	$1.25	$0.85	.....
Loss per hen above value of eggs	.....	.....	.....	$0.19

SWINE

The improved large White Yorkshire is the only breed of swine kept. On account of poor quarters no feeding investigations have been attempted except those relating to pasture crops. From ten to twenty brood sows are kept and each sow is bred to produce two litters yearly. The demand for small pigs has been so great that they have all been sold as soon as weaned. This station is in urgent need of a swine barn. For several years the sows have been wintered in A tents covered with snow.

Fig. 26. Improved White Yorkshire

During the summer a combination of pastures is used for the brood sows. One of these is of winter rye; one of bluegrass, and one of clover. These pastures have brought the mature brood sows through the summer in perfect condition for farrowing in the fall without any supplementary feed.

Fig. 27. "A" Cot With Curtain Doors in Which the Brood Sows Have Been Wintered

SHEEP

A flock of 18 sheep was purchased in the fall of 1919. These sheep were selected by Vice Director Andrew Boss from the flock at University Farm, St. Paul. Eight of the ewes and the ram are registered Shropshires. One is a registered Hampshire ewe; one a registered Oxford ewe, and the rest are Shropshire crosses with other breeds as follows: Rambouillet, Southdown, Hampshire, and Oxford. Quarters for these sheep were provided in the barn built in 1917. The floor below the west haymow is used for sheep and the floor below the east haymow, for horses.

Fig. 28. The Station Flock

CATTLE

The project of breeding up a herd of grade Guernseys from common native cows is being continued. This project was started in 1905 by A. J. McGuire, then superintendent of the station. The average yearly production of the cows in the herd at that time was 196 pounds of butterfat and less than 5,000 pounds of milk. Since then the herd has been headed by good Guernsey bulls and daily production and feed records have been kept and the milk tested semi-monthly in winter and monthly in summer. These records have been used as a basis for selection through which the production of the herd has been increased to a maximum yearly average of 7,184.1 pounds of milk with 358.1 pounds of butterfat. The average yearly production for the last three years was 6,946.0 pounds of milk with 334.7 pounds of butterfat. Until 1914 no cow in the herd had made a record of 400 pounds butterfat; since that year, however, 15 cows have made records above 400 pounds, four have made records of 450 pounds, and one cow has made a record of over 500 pounds. This cow is Brindle 2, a seven-eighths Guernsey, who has just completed a yearly record of 10,381 pounds of milk containing 543.5 pounds of butterfat. This record was made under general herd conditions. The cow was milked twice daily. She freshened April 5, 1919, and again March 16, 1920, thus giving birth to two calves during the year while making the above record, which places her in the double letter class.

The herd is now headed by two registered Guernsey bulls. The senior sire is Duenota 3rd's Son, 40983. He has many noted Guernseys in his ancestry, among whom are Selma of Pinehurst, Lord Mar, Lucretia's Maid of Honor, and Count Lonan. This bull has several near females now running in the advanced registry. A sister, Clover of Hope Farm, recently produced in 30 days

1,638.5 pounds of milk with 75.36 pounds of butterfat. Duenota 2nd, a full sister of his dam, has just completed a yearly record of 12,781.2 pounds of milk with 708.06 pounds of butterfat. He is an animal of show-ring class unusually large for his breed, weighing when three years and three months old, 1,804 pounds. He is shown in Figure 30.

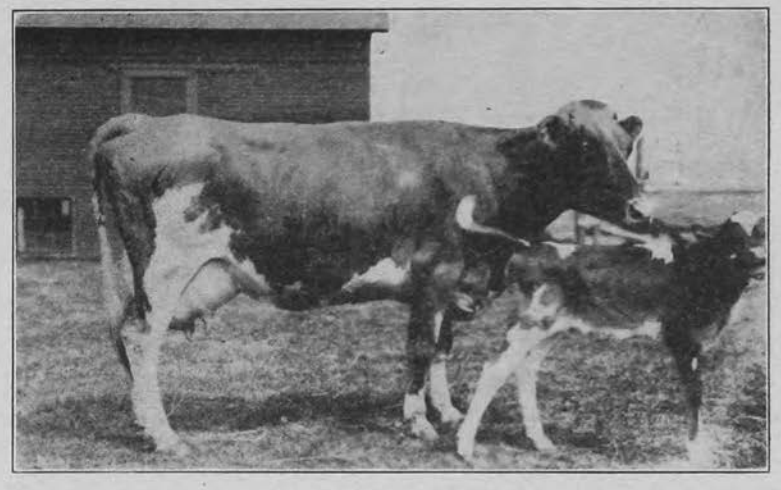

Fig. 29. Brindle 2d and Brindle 2-5

The junior herd sire is Maid's May King 56873 out of Julians Island Maid with a record of 11723.5 pounds of milk and 438.39 of butterfat in class G. His sire is Beda's May King one of the best sons of the noted bull Imp. May Rose King 8336.

Fig. 30. Duenota 3d's Son, No. 40983
Weight 1,804 Pounds at 3 years, 3 months.

TABLE 56

DAIRY HERD RECORD

	1911	1912	1913	1914	1915	1916	1917	1918	1919
Average number of cows milking	30	44	47	34	41	41	27	27	23
Average number years per cow milking	3.2	3.1	3.5	3.0	3.9	4.4	4.7	4.4	4.0
Average number of weeks milking per cow	43	45	48	47	45	49	48	49	48
Average pounds of milk per cow	5300.9	5370.6	5312.5	5518.7	5721.2	6281.0	7184.1	6502.0	7152.0
Average pounds of butterfat per cow	226.6	235.8	236.6	259.0	279.8	300.7	358.1	313.1	333.0
Average percentage of butterfat	4.27	4.39	4.4	4.7	4.9	4.79	4.99	4.81	4.66
Average value of butterfat per cow*	$135.96	$141.48	$141.96	$155.40	$167.88	$180.42	$214.86	$187.86	$199.80
Average pounds of grain per cow	1189	1183	1674	1416	1949	2298	3094	2520	3085
Average cost of grain per cow†	$29.73	$29.58	$41.85	$35.40	$48.73	$57.45	$77.35	$63.00	$77.13
Average pounds of roughage per cow	1962	2192	2217	2094	2978	4406	2555	1845	2236
Average cost of roughage per cow†	$24.53	$27.40	$27.71	$26.18	$37.23	$55.08	$31.84	$23.06	$27.95
Average pounds succulence per cow	6596	5549	5741	4827	4861	1385	3022	71	4151
Average cost of succulence per cow†	$16.49	$13.86	$14.35	$12.07	$12.15	$3.46	$7.56	$0.18	$10.38
Average pounds of straw per cow	.....	.....	.....	.....	.....	.....	118	251	34
Average cost of straw per cow†	.....	.....	.....	.....	.....	.....	$0.54	$1.26	$0.17
Average pounds of fodder corn per cow	.....	.....	686	.....	.....	292	.....	.....	.....
Average cost of fodder corn per cow†	.....	.....	$3.43	.....	.....	$1.46	.....	.....	.....
Average pounds of roots per cow	.....	.....	.....	.....	.....	188	1135	224	298
Average cost of roots per cow†	.....	.....	.....	.....	.....	$0.38	$2.27	$0.49	$0.60
Average total cost of feed per cow†	$70.75	$70.84	$87.34	$73.65	$98.11	$117.83	$119.56	$87.99	$116.23
Average value of butterfat above cost of feed	$65.21	$70.64	$54.12	$81.75	$69.77	$62.59	$95.30	$99.87	$83.57
Date put into pasture	May 6	April 28	May 18	May 17	May 16	May 20	May 22	May 9	May 31
Date taken from pasture	Nov. 5	Nov. 4	Oct. 12	Nov. 9	Oct. 4	Oct. 9	Oct. 9	Oct. 20	Oct. 19
Days stall-fed	182	176	218	189	224	224	225	182	210
Days part stall-fed and part pastured	15	34	14	21	16	7	6	19	14
Days pastured	168	156	133	155	125	135	134	164	141

* Butterfat valued at 60 cents per pound.

† Cost of feeds per ton: Grain, $50; Hay, $25; Straw, $10; Corn Fodder, $10; Roots, $4; Ensilage, $5.

TABLE 57

SUMMARY OF PRODUCTION AND FEED RECORDS FOR STATION HERD, 1911 TO 1919

Year	Number of cows	Average yield of milk per cow	Average yield of butterfat per cow	Percentage butterfat	Amount of feed per cow			Days stall feeding	Days partly stall fed	Days pastured
					Grain	Roughage	Succulence			
		Pounds	Pounds		Pounds	Pounds	Pounds			
1911	30	5,300.00	226.6	4.27	1,189	1,962	6,596	182	15	168
1912	44	5,370.00	235.8	4.39	1,183	2,192	5,549	176	34	156
1913	47	5,312.50	236.6	4.40	1,674	2,903	5,741	218	14	133
1914	34	5,518.70	259.0	4.70	1,416	2,094	4,827	189	21	155
1915	41	5,721.20	279.8	4.90	1,949	2,978	4,861	224	16	125
1916	41	6,281.00	300.7	4.79	2,298	4,698	1,573	224	7	135
1917	27	7,184.10	358.1	4.99	3,090	2,673	4,157	225	6	134
1918	27	6,502.00	313.1	4.81	2,520	2,096	295	182	19	164
1919	23	7,152.00	333.0	4.66	3,085	2,236	4,449	210	14	141
9-year average	34.9	6,037.94	282.53	4.65	2.045.3	2,648	4,227.6	204	16	145
Average for one cow per day	.....	16.55	0.77	.....	7.02	13	20.7*			

* For 204 days and pasture plus 3.8 lbs. feed for 161 days.

The first registered Guernsey female owned by this station was purchased this winter. She is First Maid of Woodend 30071, and will be used as a foundation cow for a registered herd to supplement the present grade herd, if her production justifies. She is of fair type and good size.

Table 56 gives the yearly records of the production and feed for the herd for the nine years, 1911 to 1919, inclusive. The prices used for the different feeds and the butterfat are arbitrary. However, they approximate the values for 1919. The average number of days on pasture per year for the nine years was 161, including the days that the cows were partly stall fed. The average number of days partly stall fed while on pasture was 16.2 days. It should be stated, however, that some concentrates were fed throughout the pasture season. Some of the heavy milkers while fresh received as high as 10 pounds of feed a day while on pasture. The average number of pounds of concentrate feeds fed per cow during the pasture season was 3.8 pounds per day.

Table 57 is a summary of the production and feed records compiled to show the average daily production per cow and the average daily ration fed. The average production per cow for the nine-year period was 16.55 pounds of milk per day and the average daily ration fed during the stall-feeding season (204 days per year) was: 7.02 pounds of grain; 13.0 pounds of roughage; and 20.7 pounds of succulence. The summer ration while on pasture was: pasture plus 3.8 pounds of grain daily. Assuming that the average production while on pasture was the same as the daily production during stall feeding, then one day's pasture per cow was equal to 20.7 pounds of ensilage, 13 pounds of hay, and 3.22 pounds of grain. Calculating the factors necessary to maintain a daily production of 100 pounds of milk, based on the actual production and feed records, we get the following formula:

A daily ration of { 124.2 lbs. silage* / 78.0 lbs hay† / 43.12 lbs. grain‡ } Fed to six cows = 100 lbs. of 4.6 per cent milk

* Mainly from corn.

† Mainly clover and timothy.

‡ Grain; ½ wheat bran; ¼ flour middlings, and the rest ground oats, barley, and corn with a small amount of oilmeal.

In connection with the above formula, which is based on actual feed records, it may be interesting to note how it compares with the calculated requirements based on the Haecker feeding standard. Taking the average weight of the cows in the herd, which is approximately 1,050 pounds, we find that six cows together producing 100 pounds of 4.6 per cent milk per day will require the following nutrients:

TABLE 58

NUTRIENTS REQUIRED

	Protein	Carbohydrates	Fat
	Lbs.	Lbs.	Lbs.
Daily maintenance for six cows weighing 1,050 pounds each	4.31	44.10	0.66
Nutrients required for the production of 100 lbs. of 4.6 per cent milk	5.79	26.8	2.30
Total nutrients required	10.10	70.9	2.96

TABLE 59

NUTRIENTS CONTAINED IN THE RATION FED

	Protein Lbs.	Carbohydrates Lbs.	Fat Lbs.
124.2 lbs. corn silage	1.5525	17.598	0.8694
78.0 lbs. hay: Timothy and clover, two to one	3.3020	32.400	1.0960
43.12 lbs. grain: Bran, 2 parts; middlings, one part; corn, one part	5.2498	22.099	1.4445
Total nutrients provided in ration	10.1043	71.097	3.4099

The table giving the calculated nutrients required shows a surprisingly close agreement with the table showing the nutrients provided in the ration actually fed to the station herd over a period of nine years. This agreement gives strong support to the formula given above, which gives the feed necessary to produce 100 pounds of 4.6 per cent milk. This formula we believe can safely be used as a basis for feed costs in calculating the cost of producing milk.

PEAT FOR BARN LITTER

Peat from the muskeg has been used for litter in the dairy barn and poultry pens for several years with very satisfactory results. It is prepared as follows: A bog previously drained and plowed is disked and cultivated during a dry period in the summer. When the pulverized surface is dry enough, the litter is hauled into a shed built on the principle of a corncrib. The open walls allow further drying until the peat is to be used. Some of the advantages from the use of peat as barn litter are: (1) It helps to keep the stock clean, serving both as an absorbent and a deodorizer. (2) It conserves the urine, which contains approximately 50 per cent of the nitrogen and 85 per cent of the potash in the total excreta from cattle. (3) The peat litter is itself a fertilizer, adding nitrogen and organic matter to mineral soils. (4) When used liberally it may double the manure output from the barns. (5) It takes the place of straw, leaving it to be fed. This has been a substantial gain the last two years when the market price of straw in this district has ranged from $12 to $15 per ton.

TABLE 60

INDIVIDUAL DAIRY HERD RECORD, 1919

Name of cow	Breed	Years milking	Weeks milking Jan. 1, 1919	Weeks lactation Jan. 1, 1920	Milk	Butterfat	Value of butterfat*	Feed consumed					Total cost of feed†	Value of butterfat above cost of feed
								Grain	Hay	Straw	Ensilage	Roots		
					Lbs.	Lbs.		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	
Brindle 2....	7/8 Guernsey	6	39	38	9,395.8	492.5	$315.20	2,842	2,376	.....	3,736	105	$104.36	$210.84
Brindle.....	3/4 Guernsey	8	52	62	9,933.2	446.7	285.89	3,637	2,376	.....	5,651	105	129.02	156.87
Garden 2....	3/4 Guernsey	5	50	33	8,668.3	421.2	269.57	3,394	2,398	.....	4,602	205	120.75	148.82
Four 2.....	Pure bred....	7	51	42	8,665.3	394.0	252.16	3,310	2,349	.....	4,503	105	117.71	134.45
Belle 6.....	1/2 Guernsey	2	45	31	7,535.9	370.0	236.80	3,002	2,243	98	3,723	705	108.69	128.11
Spot.....	15/16 Guernsey	8	41	41	9,323.1	350.8	224.51	2,812	2,195	.....	2,821	225	99.75	124.76
Sawyer 2....	3/4 Guernsey	6	51	20	8,795.6	399.6	255.74	3,659	2,267	.....	4,770	205	126.48	129.26
Three 2-2...	Pure bred....	3	43	43	7,645.4	326.3	208.83	2,532	1,560	.....	3,040	205	86.91	121.92
Brindle 2-3..	15/16 Guernsey	2	45	5	6,504.9	338.1	217.38	2,582	2,279	.....	4,620	188	99.27	118.11
Four 3.....	Pure bred....	6	50	47	7,693.0	358.9	229.70	3,164	2,262	.....	4,498	205	113.38	116.32
Spot 3.....	31/32 Guernsey	3	52	57	8,033.5	367.5	235.20	3,484	2,289	.....	4,753	205	122.28	112.92
Two 2.....	Pure bred....	5	52	44	7,896.2	333.2	213.25	3,274	2,300	.....	4,336	205	116.10	97.15
Roxy 4.....	1/2 Guernsey	9	40	40	6,619.5	301.5	192.96	2,860	2,234	98	2,962	255	102.25	90.71
Exelda 5....	7/8 Guernsey	1	52	56	7,304.7	306.8	196.35	3,200	2,279	.....	4,580	205	114.65	81.70
Garden 2-3..	7/8 Guernsey	1	52	64	6,194.2	296.7	189.89	3,223	2,236	.....	4,546	205	114.71	75.18
Garden 2-2..	3/8 Guernsey	2	49	8	5,645.8	270.8	173.31	2,586	2,251	.....	4,546	205	98.94	74.37
Exelda.....	3/4 Guernsey	9	52	84	6,083.5	311.1	199.10	3,613	2,241	98	4,321	852	125.73	73.37
Grace 4-3...	3/4 Guernsey	2	46	6	4,905.4	274.5	175.68	2,790	2,196	98	4,076	789	103.97	71.71
Sawyer 2-3..	7/8 Guernsey	1	52	24	6,202.6	274.8	175.87	3,136	2,207	98	4,720	252	113.26	62.61
Ida 2-3-2-4..	7/8 Guernsey	1	52	25	5,429.3	270.6	173.18	3,233	2,196	98	3,068	797	112.54	60.64
Ida 2-2-4-3..	3/4 Guernsey	2	52	54	6,056.1	274.1	175.43	3,240	2,241	98	5,004	227	116.86	58.57
Grace 7-4...	3/4 Guernsey	1	52	41	5,386.3	256.0	163.84	3,042	2,225	.....	2,758	205	105.60	58.24
Stuffy 5-2...	3/4 Guernsey	2	44	47	4,578.6	223.5	143.05	2,353	2,217	98	3,840	210	91.50	51.55

† Cost of feeds per ton: Grain, $50; Hay, $20; Straw, $10; Roots, $4; Ensilage, $5; Fodder Corn, $10. (Pasturage not included.)

* Butterfat valued at 64 cents per pound as per Itasca Cooperative Creamery Association, average for year 1919.