The University of Minnesota

AGRICULTURAL EXPERIMENT STATION

REPORT OF NORTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION DULUTH

1918-1919

UNIVERSITY FARM, ST. PAUL

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REPORT OF NORTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION, 1918-19. 9

M. J. THOMPSON, Superintendent

THE SEASONS OF 1918-1919

Spring conditions in 1918 were almost ideal. The snow melted in February, Lake Superior ice fields were largely broken by April 1, soil was in excellent condition for planting, late frosts were light, and there was sufficient rainfall until about June 10. Following this period came the great drouth, culminating in the destructive forest fire of October 12. Up to the middle of October the rainfall for the season was the lowest on record at Duluth, the total being only 13.93 inches. Grain crops were good, root crops were fair, and hay was poor. In spite of the drouth, pastures remained good until early fall, owing to the surplus rainfall before June 10. The station equipment for weather observations was destroyed by the fire on October 12.

Following a winter of such unexampled mildness that all but one of the burned buildings were completely rebuilt by the first of April, spring opened early in 1919. Aside from a dry spell in July, the growing season of 1919 has probably never been excelled in the agricultural history of northern Minnesota. Rainfall and sunshine were ample and well distributed. The last severe frost of the spring occurred May 5, while the first corresponding minimum temperature of the fall (29 degrees, F.) was recorded September 27 and was barely sufficient to kill potato vines. The frost-free period of 145 days made possible the ripening of corn, tomatoes, and other tender crops. Hay, potatoes, barley, rutabagas, and all fodder crops were excellent. Altho oats were affected by the army worm and wheat was attacked by rust and scab, good crops were harvested.

The summery weather abruptly changed about October 20. New snow records were established for both October and November while December was abnormally cold. It was commonly observed that the temperature before Christmas 1919 was more severe and for a more extended period than during the entire winter previous.

FIELD CROPS

A few varieties of wheat, oats, and barley were under test in 1918. Plot threshing was unavoidably delayed. Owing to the fire and its aftermath of disorganization and confusion, incomplete data on yields were obtained. The time required to ripen oats varied from 101 days for 60-day (Minn. No. 261) to 113 days for White Russian. White hull-less, six-rowed, and two-rowed barleys required 96, 99, and 104 days respectively to ripen, with six-rowed barley leading in yield. Prelude wheat ripened in 104 days, Velvet Chaff and Mindum in 113 days, Marquis, Fife, and Bluestem in 116 days. Mindum showed great promise.

Fig. 1. Durum or Macaroni Wheat Plots
Mindum averaged more than 26 bushels per acre in 1919.

Field peas produced well. Alaska and common peas matured in 95 days and Arthur, a Canadian variety, in 101 days. These varieties yielded respectively 26.21, 27.1, and 16.33 bushels per acre. Buckwheat was cut down by frost while in blossom. Five millets were grown. Early frost prevented ripening of seed. Japanese, German, Siberian, Hungarian, and Proso millets yielded respectively 3.66, 3.84, 4.2, 4.32, and 4.72 tons of hay per acre. Soy beans failed to set seed. Hemp made good growth and set much seed. It gives promise as a source of poultry feed. Sunflowers yielded 13.56 tons of green material per acre which was converted into silage. Cattle and poultry relish it. A

series of duplicate grass and clover plots was begun. First crops were removed in 1919. The dry season cut the hay yields. They varied from 0.97 tons per acre on an old pasture tract that has never been plowed, to 2.16 tons per acre on a ten-acre tract sown in 1917 and top-dressed the following winter.

In 1919 five series of plots were set aside to be devoted exclusively to variety and plot test work, on a five-year rotation basis. For two years they will be planted to grain, two years to grass, and one year to cultivated crops. Table I covers details of the 1919 crop on variety test plots.

TABLE I

YIELDS PER ACRE OF SPRING GRAINS AND BEANS IN VARIETY TEST PLOTS

Crop	Minn. No.	Plot 1	Plot 2	Plot 3	Average
		Bu.	Bu.	Bu.	Bu.
Wheat—					
Prelude	....	17.10	15.73	16.19	16.34
Marquis	1239	16.50	20.17	19.71	18.79
Preston	924	15.96	15.04	10.46*	13.82
Mindum	470	20.62†	30.71	28.87	26.73
Kubanka	2102	17.92	22.53	20.67	20.37
Arnautka	2103	17.92	18.40	18.40	18.24
Oats—					
Lincoln	505	42.63	40.91	59.52	47.69
Victory	514	47.23	49.50	53.62	50.11
Silver Mine	506	48.64	42.63	45.77	45.68
Irish Victor	358	45.20	35.75	41.84	40.93
Minota	512	50.34	41.77	52.64	48.25
Swedish Select	502	49.50	44.34	52.64	48.83
Iowa (60-day)	103	50.36	52.08	50.50	54.31
Imp. Ligowa	281	44.34	48.12	46.06	46.18
Barley					
Imp. Manchuria	184	44.97	48.41	47.84	47.07
Lion Manchuria	438	50.13	45.54	54.14	49.94
Minsturdi	439	40.73	47.04	40.16	42.64
Svansota	440	57.57	53.57	50.13	53.76
French Chevalier	230	39.53	43.54	40.68	41.25
Spring rye	....	32.20	30.10	33.70	32.00
Beans—					
Brown Swedish	....	29.28	24.20	17.46	23.64
Snowflake	....	29.28	24.20	46.12	33.20
Boston Favorite	....	21.60	17.72	24.88	21.40

* An unfavorable location.
† Badly lodged.

The oats crop was materially reduced by attacks of the army worm. The probable extent of the damage done is seen by comparing these yields with those of the plots in the phosphate-manure experiment, where practically no harm was done. Wheat was injured by scab and rust but barley was free from disease and insect pests.

Barley and oats seed was treated with formalin and sown with untreated seed in adjacent duplicate plots, in a study of oat and barley smut. A careful examination of samples from all plots failed to dis-

close the presence of any disease whatever, and in all cases the yields were higher from untreated seed.

ROUGHAGE CROPS IN 1919

The yields in the grass plots are very disappointing in view of the grass in other fields. Both series were sown without nurse crop in 1918. Series I was thoroly limed but Series II was limed only in part. The especially low yields on Series I, a dry location, are probably the result of poor germination and thin stands in the dry season of 1918.

Fig. 2. Second Crop After Clearing

This land yielded a crop of 200 stumps per acre in 1917, 45 bushels of oats in 1918, and 3 tons of hay in 1919.

TABLE II

YIELDS PER ACRE OF HAY CROPS, 1919

Kind of forage	Series 1	Series 2	Series 3	Average
	Pounds	Pounds	Pounds	Pounds
Timothy	1,692	4,680	....	3,186
Bromus	1,880	5,760	....	3,820
Bluegrass	1,598	4,920	....	3,259
Redtop	4,042	4,920	....	4,481
Orchard grass	1,316	2,880	....	2,098
Medium red clover	3,236	2,880	....	3,058
Mammoth clover	3,666	2,420	....	3,043
Alsike clover	6,016	4,440	....	5,228
Grimm alfalfa	5,082	1,890	....	3,486
Sweet clover	3,347	2,790	....	3,069
Siberian millet	7,052	5,486	3,340	5,293
Common millet	5,520	4,330	4,124	4,658
Golden millet	9,900	6,348	8,084	8,111
Hungarian millet	6,145	5,362	4,950	5,486

The millets were combined in the making of silage. Feeding and analytical tests are being conducted on each of the group of four, together with clover silage and potato silage.

TABLE III

YIELDS PER ACRE OF SILAGE CROPS

Kind of crop	Plot 1	Plot 2	Plot 3	Average
	Pounds	Pounds	Pounds	Pounds
Siberian millet	11,054	9,480	11,920	10,818
Common millet	10,270	19,700	10,060	10,147
Golden millet	21,940	13,500	18,932	20,190
Hungarian millet	11,460	8,538	12,514	12,491
Peas and oats	8,414	28,460	11,632	9,528*
Sorghum	33,820	41,420	31,180	31,153
Sunflowers	32,900	....	35,680	36,666

* This crop was sown about the first of July in dry weather, following another crop.

POTATOES

PLACE EFFECT ON POTATOES

The study of the effect of place of growth and source of seed on type and yield of Early Ohio potatoes (see 1917 report) was continued in 1918 and 1919 in coöperation with the Division of Horticulture of the Central station. Seed stock from the 1916 crop grown at Faribault, Moorhead, Anoka, and Duluth was planted in quadruplicate at University Farm, Duluth, Grand Rapids, and Crookston in 1917. In 1918 seed stock was secured from each of these sixteen plots and planted at Duluth. The Anoka and Moorhead stocks were carried an additional season.

Two tendencies were noticeable; (1) The first season seed from native stocks produced larger yields of market potatoes than seed from further south. (2) The second year, the seed, removed by one season from southern Minnesota, showed a relative increase in yield and uniformity of type, thus apparently adjusting itself to the new conditions.

VARIETY TESTS OF POTATOES

In 1918, variety test plots of potatoes were in duplicate and in 1919 they were in triplicate. In 1919, the Rural New Yorker was planted about two weeks later than the other varieties and from new stock. This shortened the growing season and probably lessened the yield. The eight varieties tested are those recommended for Minnesota growers. Two years' results seem to indicate that the later varieties are better adapted to Northeast Minnesota conditions.

TABLE IV

YIELDS PER ACRE OF POTATOES ON VARIETY TEST PLOTS, 1918

Variety	1918		1919		Average 2 years	
	Mktble	Total	Mktble	Total	Mktble	Total
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
Bliss Triumph	122	143	186	219	154	181
Early Ohio	129	146	265	287	197	217
Irish Cobbler	157	173	243	282	200	227
Green Mountain	184	191	318	375	251	283
Rural New Yorker.....	167	179	187	229	177	204
Russet	185	200	261	325	223	262
King	192	190	262	309	227	254
Burbank	190	216	304	385	247	300

SEED TREATMENT

In 1919 a project was undertaken to study the effect of seed treatment on yield and to compare the efficiency of the various treatments. Three lots of seed were treated with corrosive sublimate, formalin, and copper sulphate, respectively, and a fourth lot was untreated. The seed was planted in triplicate plots. Results are recorded in Table V. Green Mountain potatoes were used.

TABLE V

YIELD PER ACRE OF POTATOES IN SEED TREATMENT PLOTS, 1919

Plot	Corrosive sublimate		Formalin		Copper sulphate		Untreated	
	Mktble	Total	Mktble	Total	Mktble	Total	Mktble	Total
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	319	347	...	...	...	...	...	...
2	...	...	299	240	...	...	...	...
3	...	...	...	...	215	239	...	...
4	...	...	...	...	...	...	366	377
5	310	347	...	...	...	...	...	...
6	...	...	310	343	...	...	...	...
7	...	...	...	...	240	263	...	...
8	...	...	...	...	...	...	316	350
9	294	321	...	...	...	...	...	...
10	...	...	291	310	...	...	...	...
11	...	...	...	...	225	242	...	...
12	...	...	...	...	...	...	347	373
Averages	307.6	338	300	331	226.6	248	333	368.6

The seed was clean Green Mountain stock. At digging time a little scab was found at one corner of the series, due probably to soil infection. Otherwise, the crop from the various treatments was uniformly free of disease. Yields seemed to be depressed somewhat by seed treatment, noticeably so in the case of copper sulphate.

LEVEL VERSUS RIDGED CULTIVATION

In the northeastern counties of Minnesota the practice of ridging potatoes is almost universally practiced, while further south, in the region of lighter soils and larger-scale production, level cultiva ion is the general custom. A study of the two methods was made in 1919. Green Mountain potaotes were used and plots were in triplica:e. Results are given in Table VI.

Fig. 3. Potato Field

The part of the field to the left, with heavy growth, was cultivated level. Tha: to the right, with smaller growth, was ridged.

TABLE VI

COMPARISON OF YIELD PER ACRE OF POTATOES GIVEN LEVEL AND RIDGED CULTIVATION

Plot	Level cultivation		Ridged cultivation	
	Marketable	Total	Marketable	Total
	Bu.	Bu.	Bu.	Bu.
1	385	434	...	...
2	...	...	313	361
3	266	333	...	...
4	...	...	284	326
5	300	330	...	...
6	...	...	302	320
Average	317	365.6	299.6	339

No material differences were noticed in 1919. The vine growth was much heavier, however, in the level cultivated plots. The argument

advanced by local growers in favor of ridged culture is that it better meets the conditions of a heavy soil and normally heavy rainfall.

SPRAY TESTS

In the variety tests of 1918 and 1919, the early Ohio place-effect project of 1918, and the seed treatment and cultivation tests of 1919, a study of the effect of spraying for blight and kindred diseases was included. In each case the rows were divided at the middle, thus dividing the series of rows into two units or half series. One half series was sprayed with bordeaux mixture (three applications) and the other half was unsprayed. In 1918 a gain of twelve bushels per acre was recorded on the sprayed half of the variety test plots.

In 1919 the sprayed halves of the rows of early potatoes remained green much longer, but there was no corresponding increase in yield. Indeed, yields were rather lower than otherwise. It would seem that with a very favorable season the crop ripened normally without being attacked by disease, and the spray was a negative factor, as affecting yield.

CROP ROTATIONS

In 1919 a tract of land was set apart for a study in crop rotations. The object is primarily to learn what system of cropping is best adapted to local farms, a question of farm management. Plowing is expensive here, but altho a five-year rotation means a small area to break each year it may mean too much land in hay. Again, there is a feeling that with a three-year rotation meadows do not reach their maximum output. It is granted that hay is a safe crop in this region and a cheap one to handle, but it is an extensive type of farming and there is a question whether or not it should be more limited in a country of small clearings and necessarily intensive farming methods.

This study is being made on thirty-six tenth-acre plots divided as follows: Three-year rotation of barley, hay, sunflowers, 9 plots in triplicate; four-year rotation of barley, hay, hay, sunflowers, 12 plots in triplicate; five-year rotation, barley, hay, hay, hay, sunflowers, 25 plots in triplicate. In starting the experiment, oats was the filler, replacing the grass crop. The 1919 yields are given in Table VII.

As the work was just begun, the yields apparently have no significance beyond indicating relative crop production for 1919. Altho barley produced fifty per cent more grain per acre than oats, the actual excess was less, for the oat crop was severely injured by the army worm. The same variety of oats was grown on the fertilizer plots, which were cut before injury, and averaged 55.4 bushels per acre on checks and 58.7 per acre on all plots.

TABLE VII

YIELDS PER ACRE OF CROPS ON ROTATION PLOTS, 1919

Plot	Barley	Oats	Sunflowers
Ser. V.	Bu.	Bu.	Tons
1	49.16*	†	....
2	....	....	....
3	....	....	10.29
4	56.6	....	....
5	....	55.77	....
6	....	....	10.38
7	52.08	....	....
8	....	50.00	....
9	....	....	9.79
10	53.54	....	....
11	....	54.[illegible]4	....
12	....	51.25	....
13	....	....	9.25
14	54.60	....	....
15	....	46.60	....
16	....	49.09	....
17	....	....	9.95
18	‡	....	....
Ser. VI			
1	....	45.[illegible]0	....
2	....	46.55	....
3	....	....	10.15
4	46.8	....	....
5	....	50.78	....
6	....	47.[illegible]7	....
7	....	52.17	....
8	....	....	9.[illegible]0
9	45.8	....	....
10	....	53.25	....
11	....	54.34	....
12	....	46.[illegible]0	....
13	....	....	11.86
14	54.8	....	....
15	....	49.03	....
16	....	48.50	....
17	....	46.21	....
18	....	....	10.05
Averages	51.67	49.24	10.12

* Some lodging.

† One drill row was sown to barley by mistake. Returns were: Oats, 39.9 bushels; and barley, 11.35 bushels. One hundred eighty-two pounds of mixed grain was threshed.

‡ It was possible this season to sow only an irregular part of this plot.

ORCHARD TRIALS

(In coöperation with the Division of Horticulture, University Farm)

The late summer and autumn of 1917 were relatively dry. Snow came early in December and remained until late in February. The spring opened gradually with no severe frosts, consequently the tree injury during the winter of 1917-18 was not great. The fire of October 12 passed over the orchard and killed portions of two rows of trees on the west side. Following this came the open winter of 1918-19 which

proved as injurious to tree growth as that of 1916-17. Altho the orchard suffered severely from these two causes, it made excellent growth in 1919. A cover crop of rye was plowed under for the third successive season. Rutabagas and rape were then planted.

SOIL FERTILITY INVESTIGATIONS

(In coöperation with the Division of soils, University Farm)

A. PHOSPHATE-MANURE EXPERIMENTS

The phosphate-manure fertilizer project was begun in 1916, potatoes and rutabagas being the first crops. The west half of each plot and series was limed in 1916 at the rate of three tons of ground limestone per acre. Oats were added in 1917, and with the harvesting of the hay crop of 1918, the first cycle of the rotation was completed. The system of fertilization is illustrated in Table VIII.

KEY TO TABLES VIII, IX, X, XI

Plots	
1, 7, 13	Check, no treatment
2, 8, 14	Rock phosphate, 1 ton per acre, applied in 1916
3, 9, 15	Rock phosphate, 1 ton per acre Manure, 10 tons per acre, applied on grain stubble
4, 10, 16	Manure, 10 tons per acre, applied on grain stubble
5, 11, 17	Manure, 10 tons per acre, applied on grain stubble Acid phosphate, 360 pounds per acre, applied on cultivated crop
6, 12, 18	Acid phosphate, 360 pounds per acre, applied on cultivated crop

TABLE VIII

YIELDS PER ACRE OF POTATOES IN PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1918 crop		1919 crop		4-yr. av.
		Mktble.	Total	Mktble.	Total	Mktble.
		Bu.	Bu.	Bu.	Bu.	Bu.
1	No treatment	184.5	194.5	229.8	271.3	
2	Rock phosphate	162.2	172.2	239.3	268.2	
3	Rock phosphate and manure	206.2	217.5	293.5	321.0	
4	Manure	175.0	188.0	279.3	309.8	
5	Manure and acid phosphate	168.0	181.5	290.5	316.0	
6	Acid phosphate	186.8	200.5	246.3	273.5	
7	No treatment	165.5	182.2	245.5	275.7	
8	Rock phosphate	157.8	178.8	203.7	232.5	
9	Rock phosphate and manure	202.3	215.7	245.7	279.7	
10	Manure	179.7	190.8	222.0	265.8	
11	Manure and acid phosphate	184.0	200.3	244.0	266.7	
12	Acid phosphate	153.0	167.7	232.5	257.8	
13	No treatment	120.3	130.7	189.5	206.2	
14	Rock phosphate	171.7	178.3	221.5	253.7	
15	Rock phosphate and manure	201.2	216.2	240.0	276.8	
16	Manure	178.3	190.5	204.7	239.2	
17	Manure and acid phosphate	210.0	224.2	207.0	265.3	
18	Acid phosphate	165.3	176.0	167.0	206.0	
Averages						
1- 7-13	No treatment	156.8	169.1	221.6	251.1	169.9
2- 8-14	Rock phosphate	163.9	176.4	221.5	251.5	172.2
3- 9-15	Rock phosphate and manure	203.2	216.5	259.7	292.5	196.9
4-10-16	Manure	177.7	189.8	235.3	271.6	178.9
5-11-17	Manure and acid phosphate	187.3	202.0	247.2	282.7	189.5
6-12-18	Acid phosphate	168.4	181.4	215.3	245.8	160.0

Manure seems to be most effective when in combination with either rock or acid phosphate, giving on the average about 20 bushels more. On the other hand, neither kind of phosphate seems of value unless combined with manure. The effect of manure would doubtless be much more pronounced were it applied following the grass crop instead of before. As now applied the grass or hay crop receives the primary benefit from the manure, while potatoes and rutabagas receive the secondary or residual effect only. In 1917 and 1919 the limed portion of the plots outyielded the unlimed by 9.5 and 12.4 bushels per acre, respectively, but in 1918 this condition was reversed. Plot 18, on peat soil, is usually affected by frosts earlier than the others, which partly accounts for the lower annual yields. An average of plots 6 and 12 would be a fairer comparison for acid phosphate.

TABLE IX

YIELDS PER ACRE OF RUTABAGAS IN PHOSPHATE-MANURE EXPERIMENTS

Plot	Treatment	1918 crop		1919 crop		Four-year av.	
		Roots	Tops	Roots	Tops		
		Tons	Tons	Tons	Tons	Tons	Tons
1	No treatment	1.73	1.41	12.92	4.08		
2	Rock phosphate	3.18	2.25	14.40	4.83		
3	Rock phosphate and manure	4.20	2.14	14.93	3.80		
4	Manure	6.54	2.40	12.92	3.55		
5	Manure and acid phosphate.	8.88	2.06	15.24	3.38		
6	Acid phosphate	13.41	3.21	16.54	3.60		
7	No treatment	8.72	3.12	14.00	3.00		
8	Rock phosphate	5.68	2.34	14.00	3.14		
9	Rock phosphate and manure	6.62	2.46	13.80	3.06		
10	Manure	6.98	2.64	16.00	3.31		
11	Manure and acid phosphate.	12.07	2.86	15.00	3.00		
12	Acid phosphate	10.66	2.78	14.40	3.46		
13	No treatment	6.00	4.43	16.40	3.94		
14	Rock phosphate	9.24	5.94	16.30	4.00		
15	Rock phosphate and manure	11.13	5.44	15.60	3.72		
16	Manure	14.30	5.00	15.20	3.60		
17	Manure and acid phosphate.	16.64	4.24	15.80	3.63		
18	Acid phosphate	13.70	3.34	15.70	5.14		
Averages							
1- 7-13	No treatment	5.48	2.99	14.44	3.67	11.85	3.42
2- 8-14	Rock phosphate	6.03	3.51	14.90	3.99	11.57	3.61
3- 9-15	Rock phosphate and manure	7.32	3.35	14.78	3.53	12.70	3.60
4-10-16	Manure	9.27	3.35	14.71	3.49	13.41	3.95
5-11-17	Manure and acid phosphate.	12.53	3.05	15.35	3.34	13.70	3.16
6-12-18	Acid phosphate	12.59	3.11	15.55	4.07	12.93	3.26

In 1917 and 1918 the rutabaga crop was almost a failure owing to insect pests and drouth. It was necessary to reseed, in some cases twice, and still the stand was irregular. The acid phosphate plots were outstanding every season. Under quite adverse conditions these plots grew continuously, while other plots, weakened by drouth or insects, were sown twice.

The grain crop is two seasons removed from the manure application and one from the acid phosphate application, but there is some evidence of results, tho slight, from both manure and phosphate. The manure plots produced about seven bushels more than the checks.

TABLE X

YIELDS PER ACRE OF OATS IN PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1918		1919		Three-year av. 1917-18-19	
		Grain	Straw	Grain	Straw	Grain	Straw
		Bu.	Tons	Bu.	Tons	Bu.	Tons
1	No treatment	36.3	0.694	56.2	1.175		
2	Rock phosphate	55.1	0.895	56.5	1.147		
3	Rock phosphate and manure	57.8	0.892	56.2	1.137		
4	Manure	60.0	0.888	58.4	1.295		
5	Manure and acid phosphate.	60.9	0.817	57.2	1.257		
6	Acid phosphate	53.4	0.772	41.2*	1.530		
7	No treatment	54.3	0.735	52.7	1.364		
8	Rock phosphate	56.6	0.530	61.6	1.534		
9	Rock phosphate and manure	57.3	0.740	63.6	1.677		
10	Manure	60.9	0.808	56.6	1.252		
11	Manure and acid phosphate	56.7	0.687	60.5	1.280		
12	Acid phosphate	54.5	0.610	60.1	1.264		
13	No treatment	57.0	0.694	57.6	1.153		
14	Rock phosphate	52.1	0.665	59.8	1.235		
15	Rock phosphate and manure	58.4	0.694	63.9	1.330		
16	Manure	56.2	0.683	56.7	1.245		
17	Manure and acid phosphate.	70.0	0.923	62.6	1.325		
18	Acid phosphate	83.2	1.050	57.5	1.155		
Averages							
1- 7-13	No treatment	49.4	0.707	55.5	1.231	51.5	0.988
2- 8-14	Rock phosphate	54.6	0.696	59.3	1.305	56.1	0.975
3- 9-15	Rock phosphate and manure	57.8	0.775	61.2	1.321	59.3	1.052
4-10-16	Manure	59.1	0.793	57.2	1.231	58.7	1.061
5-11-17	Manure and acid phosphate.	62.5	0.809	60.1	1.287	60.4	1.142
6-12-18	Acid phosphate	63.7	0.810	58.8†	1.316	61.7	1.141

* Very severely burned by the fire of October 12, 1918. Large area lodged and not filled.

† Two plots (12 and 18) for grain and all three plots averaged for straw. Plot six was so badly injured by the fire that a large portion produced straw only.

The first hay crop in this experiment was harvested in 1918. The extreme drouth of 1917 and 1918 caused irregular stands and reduced yields. The 1919 crop was very heavy. The limed half exceeded the unlimed half of the series by not quite 18 per cent in 1918 and by not quite 8 per cent in 1919. The manured plots outyielded the unmanured plots by 7.5 per cent in 1918 and by 14 per cent in 1919, when the normal rainfall made the manure available. The phosphates are without any distinct effect upon the hay.

TABLE XI

HAY YIELDS PER ACRE IN PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1918	1919
		Tons	Tons
1	No treatment	0.91	2.51
2	Rock phosphate	0.92	2.28
3	Rock phosphate and manure	1.14	2.56
4	Manure	1.02	2.58
5	Manure and acid phosphate	1.02	2.44
6	Acid phosphate	1.30	2.21
7	No treatment	0.99	2.17
8	Rock phosphate	0.60	2.08
9	Rock phosphate and manure	0.89	2.46
10	Manure	0.96	2.51
11	Manure and acid phosphate	0.87	2.51
12	Acid phosphate	0.84	1.98
13	No treatment	0.89	2.09
14	Rock phosphate	0.83	2.26
15	Rock phosphate and manure	1.00	2.59
16	Manure	0.97	2.61
17	Manure and acid phosphate	1.00	2.73
18	Acid phosphate	0.99	2.59
Averages			
1- 7-13	No treatment	0.93	2.26
2- 8-14	Rock phosphate	0.79	2.21
3- 9-15	Rock phosphate and manure	1.01	2.54
4-10-16	Manure	0.98	2.57
5-11-17	Manure and acid phosphate	0.97	2.56
6-12-18	Acid phosphate	1.04	2.26

B. CLOVER UTILIZATION EXPERIMENTS

Six plots are annually sown to clover with timothy. The following year two plots are pastured close, two are plowed under when the grass has reached its maximum growth, and two are cut for hay. The following year the group of six plots is cropped to potatoes and rutabagas and the third year to oats with which clover and timothy are sown for the next cycle of the rotation. This work was begun in 1917 and the first data were collected in 1918.

The striking superiority of the potato crop on the green manure plots in 1918 was not maintained in 1919. Altho the rutabaga crop of 1918 was practically worthless, owing to drouth and insect pests, there is a tendency for better yields where the crop was harvested and the sod plowed under both seasons. In July 1918, when plots 2 and 5 were plowed, the weather was dry. This resulted in poorer plowing, a poorer seedbed, and probably very considerable drying out, which conditions would lead to decreased yields of both potatoes and rutabagas in 1919.

TABLE XII

YIELDS PER ACRE OF POTATOES IN CLOVER UTILIZATION EXPERIMENT

Plot	Treatment	1918		1919	
		Marketable	Total	Marketable	Total
		Bu.	Bu.	Bu.	Bu.
1	Pastured	145.8	162.8	240.7	284.3
2	Clover plowed under	170.3	194.7	236.8	282.8
3	Clover harvested	97.8	124.2	227.5	278.5
4	Pastured	86.7	107.0	228.3	279.0
5	Clover plowed under	105.2	131.5	217.6	258.7
6	Clover harvested	65.3	88.2	209.8	261.5
Averages					
1-4	Pastured	116.2	134.7	234.5	281.6
2-5	Clover plowed under	137.7	163.1	227.2	270.7
3-6	Clover harvested	81.5	106.2	218.6	270.0

TABLE XIII

YIELDS PER ACRE OF RUTABAGAS IN CLOVER UTILIZATION EXPERIMENT

Plot	Treatment	1918		1919	
		Roots	Tops	Roots	Tops
		Tons	Tons	Tons	Tons
1	Clover pastured*	0.13	0.20	11.32	2.79
2	Clover plowed under	0.21	0.29	13.12	2.91
3	Clover harvested	0.35	0.31	11.40	2.74
4	Clover pastured	1.14	0.98	14.14	2.82
5	Clover plowed under	0.97	0.89	13.20	2.19
6	Clover harvested	1.98	1.54	16.04	3.50
Averages					
1-4	Clover pastured	0.63	0.59	12.73	2.80
2-5	Clover plowed under	0.59	0.59	13.16	2.55
3-6	Clover harvested	1.17	0.92	13.72	3.12

* The meadow is a clover and timothy mixture.

In 1919 the first grain crop was harvested from the clover utilization plots. These plots were cultivated in 1918, and were in grass in 1917 (see Table XIV).

TABLE XIV

YIELDS PER ACRE OF OATS IN CLOVER UTILIZATION EXPERIMENT, 1919

Plot	Treatment, 1917	Oats	Straw
		Bu.	Lbs.
1	Clover pastured*	59.1	2,325
2	Clover plowed under	52.8	2,620
3	Clover harvested	52.5	2,030
4	Clover pastured	51.7	1,865
5	Clover plowed under	49.4	1,785
6	Clover harvested	45.8	1,625
Averages			
1-4	Clover pastured	55.4	2,095
2-5	Clover plowed under	51.1	2,202
3-6	Clover harvested	49.1	1,827

* The meadow is a clover and timothy mixture.

Oats followed potatoes and rutabagas (1918). Plots 3 and 6 were low in potatoes in 1918 and were also low in grain, and especially straw, in 1919.

C. ROTATION WITHOUT CLOVER OR MANURE

In the rotation without clover or manure there is a succession of barley, oats, potatoes-rutabagas with no application of manure or sowing of clover or grass. The purpose of the project is to measure the productivity of virgin forest soil which has not been improved by the growth of clover and pasturage before first plowing, and which later receives no manure or fertilizer and on which no clover is grown. The data show just how beneficial the growing of clover is. The work was begun in 1917 on virgin soil as low in humus as most forest soils. Three years' results have now been obtained.

TABLE XV

CROP YIELDS PER ACRE IN ROTATION WITHOUT CLOVER OR MANURE

	Plot	1917	Plot	1918	Plot	1919	Three-year average
Barley, bu.	2	6.6	3	6.9	1	*	
Barley, bu.	5	7.7	3	6.0	4	8.1	
Average	2-5	7.1	3-6	6.4	1-4	8.1	7.2
Oats, bu.	3	16.9	1	42.5	2	48.4	
Oats, bu.	6	20.9	4	27.8	5	47.3	
Average	3-6	18.9	1-4	35.1	2-5	47.8	33.9
Potatoes, bu.	1	102.3† 113.0‡	2	109.0† 121.3‡	3	173.7† 225.0‡	
Potatoes, bu.	4	43.7† 55.3‡	5	86.5† 100.2‡	6	174.0† 208.7‡	
Average	1-4		2-5		3-6		113.8† 137.2‡
Rutabagas, tons	1	6.78	2	1.46	3	11.42	
Rutabagas, tons	4	4.40	5	0.28	6	7.48	
Average	1-4	5.59	2-5	0.87	3-6	9.45	5.3

* Not threshed because of weeds.
† Marketable.
‡ Total bushels.

It will be observed in the clover utilization experiment and in that without manure or clover that plots 1, 2, and 3, as a group, almost invariably outyielded the paired plots, 4, 5, and 6. This is probably because of some slight variation in the soil, but the plots are so grouped that average results are not impaired. After three years' work it would seem that on virgin soil without either clover or manure, barley is a very poor crop to grow; rutabagas, potatoes, and oats are 60, 65, and 76 per cent, respectively, of a normal crop when compared to crops grown on clover sod without manure (see checks in rate-of-manuring and phosphate fertilizer series of plots). The yields of hay on plots 3 and 6 indicate how much clover and timothy was plowed under as green manure and accordingly how much the green manuring cost through loss of feed.

TABLE XVI

YIELDS PER ACRE OF HAY IN CLOVER UTILIZATION EXPERIMENT

Plot	1917	1918	1919
	Tons	Tons	Tons
3	1.05	1.30	2.35
6	1.12	0.95	2.92
Average	1.08	1.12	2.63

D. RATE OF MANURING

The rate-of-manuring project was begun in 1917 with potatoes and rutabagas as the first crop in the experiment. Grain was added in 1918 and hay in 1919, completing the first cycle of the rotation. Duplicate plots are given applications of five, ten, and twenty tons of manure per acre, respectively, spread over the oat stubble at three-year intervals.

TABLE XVII

YIELDS PER ACRE OF POTATOES, RATE-OF-MANURING EXPERIMENT

Plot	Treatment	1918		1919		Three-year av.	
		Mktble.	Total	Mktble.	Total	Mktble.	Total
		Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
7	No treatment	54.7	85.3	322.6	357.6		
8	5 tons manure	93.0	117.3	342.5	371.5		
9	10 tons manure	122.2	140.2	329.2	362.7		
10	20 tons manure	142.2	158.0	300.7	355.0		
11	No treatment	101.7	120.0	233.8	292.2		
12	No treatment	75.7	93.8	240.7	287.0		
13	No treatment	70.0	93.3	232.1	283.5		
14	5 tons manure	134.5	149.2	255.3	296.3		
15	10 tons manure	135.3	149.8	234.5	273.2		
16	20 tons manure	105.7	119.7	276.6	328.8		
17	No treatment	64.7	77.3	242.0	301.3		
18	No treatment	118.3	135.7	251.0	306.7		
Averages							
7-11-12-13-17-18	No treatment	80.8	100.9	253.7	304.7	137.6	167.4
8-14	5 tons manure	113.7	133.2	298.9	333.9	162.5	185.1
9-15	10 tons manure	128.7	145.0	281.8	317.9	161.8	183.4
10-16	20 tons manure	123.9	138.8	288.7	341.9	166.0	193.4

As in the case of potatoes, very little effect is noticeable from manure applications for rutabagas, but in both crops, thus far, the return per ton has been greatest with the five-ton application. It is well to remember that a crop of hay is taken off between the application of manure and the potato-rutabaga crop and this hay crop absorbs most of the fertilizing elements. This land is raw and new, but as it ages and its physical condition is improved with clover and manure, there is a marked improvement in the potato crop. The root crop is a

TABLE XVIII

YIELD PER ACRE OF RUTABAGAS, RATE-OF-MANURING EXPERIMENT

Plot	Treatment	1918	1919	Three-year av.
		Tons	Tons	Tons
7	No treatment	0.95	15.88	
8	5 tons manure	0.60	20.34	
9	10 tons manure	1.42	14.34	
10	20 tons manure	2.25	17.24	
11	No treatment	2.63	14.04	
12	No treatment	0.78	14.10	
13	No treatment	1.75	14.94	
14	5 tons manure	2.35	13.90	
15	10 tons manure	0.95	16.44	
16	20 tons manure	1.81	16.30	
17	No treatment	0.42	15.10	
18	No treatment	0.41	14.33	
Averages				
7-11-12-13-17-18	No treatment	1.16	14.73	6.86
8-14	5 tons manure	1.47	17.12	7.44
9-15	10 tons manure	1.18	15.39	7.14
10-16	20 tons manure	2.03	16.77	8.04

The grain crop shows a distinct, tho small, reaction to the manure treatment, altho two crops have intervened since its application. The ten-ton plots show the largest increase in yield per ton of fertilizer compared with the fertilizer series.

TABLE XIX

YIELD PER ACRE OF OATS—RATE-OF-MANURING EXPERIMENT

Plot	Treatment	1918		1919	
		Grain	Straw	Grain	Straw
		Bu.	Lbs.	Bu.	Lbs.
7	No treatment	30.6	690	48.6	1,709
8	5 tons manure	34.4	840	52.4	2,059
9	10 tons manure	36.9	820	60.3	2,525
10	20 tons manure	44.1	1,160	61.6	2,565
11	No treatment	36.4	960	60.2	2,435
12	No treatment	36.4	960	54.7	1,815
13	No treatment	36.1	910	51.9	1,855
14	5 tons manure	27.0	640	55.3	2,210
15	10 tons manure	29.7	800	59.7	2,555
16	20 tons manure	28.8	910	62.4	2,759
17	No treatment	15.3	475	58.1	2,310
18	No treatment	10.5	405	59.2	2,365
Averages					
7-11-12-13-17-18	No treatment	27.6	733	55.4	2,081
8-14	5 tons manure	30.7	740	53.8	2,135
9-15	10 tons manure	33.3	810	60.0	2,540
10-16	20 tons manure	36.4	1,035	62.0	2,662

TABLE XX

YIELD PER ACRE OF HAY IN RATE-OF-MANURING EXPERIMENT

Plot	Treatment	Yield
		Tons
7	No treatment	1.35
8	5 tons manure	1.68
9	10 tons manure	2.05
10	20 tons manure	2.45
11	No treatment	1.92
12	No treatment	1.88
13	No treatment	1.94
14	5 tons manure	1.95
15	10 tons manure	2.36
16	20 tons manure	2.25
17	No treatment	1.86
18	No treatment	2.21
Averages		
7-11-12-13-17-18	No treatment	1.85
8-14	5 tons manure	1.81
9-15	10 tons manure	2.22
10-16	20 tons manure	2.35

Altho the hay crop follows immediately after the application of manure to grain stubble, the first crop yields are very small. The ten-ton application yielded an increase of 18.8 per cent over the no treatment plots of this series, and 14 per cent in the fertilizer series.

Potatoes show some gain, and grain and hay still greater gains where manure has been applied; but the most notable lesson from the entire group of soil-fertility projects is that under proper management, northern wooded soils grow more productive and that the popular notion that such virgin mineral soils are immediately or extremely fertile is not justified. Above all else, the woodland soils require careful, constructive management.

PASTURE TRIALS

A. PASTURE VALUES IN PRODUCING BUTTERFAT

The year 1918 was the fourth and last year of the pasture project on cut-over stump land, cut off in November, 1913, sown to clover and timothy (5 pounds per acre) in April, 1914, and pastured during the seasons of 1915-16-17-18. During the pasture season of 1918 the land was partially stumped and plowed.

Average weight of cows, June 1, pounds	775.0
Average weight of cows, Sept. 1, pounds	818.0
Average increase in weight per cow, pounds	43.0
Total days pasture, 3 cows, 3.9 mo	351.0
Total production of butterfat, pounds	336.4
Total value of butterfat at 45.5 cents per pound	$153.06

Total value of grain fed at 1.9 cents per pound	$ 26.60
Net value day and night pasture	$126.36
Net value day pasture only	$ 63.36
Net value per acre, day pasture	$ 12.67

The latter part of the season was very poor for pasture crops. Grass production was also cut by a June fire that overran one third of the area and by the stump-pulling operations which began in June and continued during the summer months. The returns per acre in 1916 were $13.83 and in 1917, $16.29. The average for the three seasons, all very dry summers, was $14.26 per acre for butterfat only. If skimmilk values were added, it would total above $15 per acre, annually. There is a considerable gain in flesh that should also be credited to the pasture.

B. PASTURE VALUES FOR YOUNG STOCK

In 1918 young stock was placed on pasture, June 1. Autumn weights were recorded October 7, altho some feeding was possible until December. The rains of May and June afforded good pasture until early August. For this reason better gains were made than in the season of 1917. Six heifers, averaging eighteen months each, made an average gain for the season of 129 days, of 175 pounds, or 1.35 pounds daily.

In 1919 a group of eight heifers was placed on pasture June 3 and withdrawn October 27. They were on pasture 146 days and made an average gain of 172 pounds for the season, almost identical with that of the previous year. The longer season and the younger age of the stock somewhat reduced the daily gain.

C. PASTURE VALUES FOR HORSES

Summer night pasture was continued for a third and fourth season. The following data were gathered.

	1918	1919
Number of horses fed	6	6
Average weight of horses, stall-feeding period, pounds	1,301	1,373
Average weight of horses, pasture-feeding period, pounds	1,326	1,373
Net gain in weight of horses, pounds	25	0

The active season for the entire lot of horses is from May 1 to November 1. In May and October the horses are stall fed entirely, but during the other four months they are pastured at night and on idle days. Horses are weighed twice monthly, when frost and snow do not prevent. The pasture practice seems advisable since the observations made over several years have indicated that only about half the

usual amount of hay is consumed altho on steady summer work. There is also a considerable saving in labor in a busy season in the care of horses and barn.

POULTRY

Poultry work has been continued. About 300 breeding hens and pullets are wintered and about 1,000 are hatched each year. The work is limited to demonstrations of flock improvement by culling, use of males from high-producing stock, distribution of breeding stock and eggs, proper feeding and care, and utilization of northern produced feeds. A new feature this season is the use of sunflower silage in connection with roots as a succulent feed. The stalks were cut by running them through a straw cutter and the silage was stored in barrels in the basement of the residence. One barrel will hold about 350 pounds of silage if properly packed. The feed keeps well and is relished by the stock. During the winter months frozen fish is fed as a substitute for meat scrap. The cost is about one fourth that of meat scrap and equally good results have been obtained. This work is of special interest in the Lake Superior district and indeed anywhere in the state where fishing is a commercial enterprise. In this way a large amount of material that would otherwise be disposed of as fertilizer is utilized for feed.

Fig. 4. Field of Sunflowers

They began blossoming July 20, 1919, and were cut for silage late in August. They averaged 12 tons per acre, field yield.

OBSERVATIONS ON MILKING MACHINE

Owing to labor conditions, it was found advisable to install a milking machine in June, 1918. It has been used ever since. In order to give some idea of the effect on milk production, the individual records for June are given in Table XXI. Three cows that freshened after the first of June are not included.

TABLE XXI

MILK PRODUCTION OF STATION HERD, JUNE, 1918

Name	Hand milking	Machine milking		
	June 1-7	June 8-14	June 15-21	June 22-28
	Lbs.	Lbs.	Lbs.	Lbs.
Nellie II	172.1	183.5	175.8	170.6
Daisy	151.3	140.8	143.3	147.5
Kate II	198.0	225.0	.....	.....
Jewell II	178.1	168.6	161.0	160.0
Tillie	91.2	105.7	100.7	102.0
Angeline	188.6	182.6	191.8	186.5
Genevieve	163.1	163.2	169.5	165.9
Starlight	105.1	115.3	110.7	112.9
Dolly	183.7	190.5	185.3	174.9
Antona	113.8	110.5	102.5	105.5
Mimosa	91.0	93.4	83.1	87.3
June	101.8	102.8	98.1	92.5
June II	95.6	121.2	122.8	117.2
Star	156.2	349.4	322.5	334.7
Total	1,989.6	2,252.6	1,967.1	1,958.5
Average	142.1	160.9	151.2	150.6

Operation of the machine began June 8. Part of the increase noted is doubtless due to the fact that several cows were very recently fresh and the milk flow would naturally be greater up to a certain time. On the other hand, two cows, Daisy and June II, were dehorned early in the month and a drop in production occurred as a result. After nearly twenty months continual operation of the mechanical milker we have concluded that:

1. A careful operator is the first essential.
2. Every cow should be stripped after milking with machine.
3. Under normal conditions production not only may be maintained but it can be increased as easily as with hand milking.
4. The labor requirements of milking are considerably reduced.
5. The men prefer mechanical to manual milking.
6. It is preferable to start with heifers or with cows at freshening time.

LAND CLEARING

In the fall of 1913 a tract of twenty acres of timber land was brushed and logged. The following summer, five acres were stumped with dynamite; a second five-acre tract was cleared by a combination

of dynamite and stump-puller, and a third in the same way except that the stumps were first pulled, then blasted, a reversal of operations. The data on the original work were published in Experiment Station bulletin 163. The fourth five-acre tract was sown to grass and clover in April, 1914, and was pastured until the fall of 1918. "Delayed" clearing was begun in 1918 and completed in 1919. A summary of the work follows:

1. Two thirds of the stumps were pulled by horsepower direct, without dynamite or machine.

2. The stumps not thus pulled averaged 13.17 inches in dameter.

3. The value of dynamite and accessories thus displaced averaged about $25 per acre.

4. The cost per acre of clearing ripe stumps, using dynamite, was $55.31, in 1918, as compared to $51.64, the cost of clearing an acre of green stumps in 1914, using dynamite; an increase of 7.1 per cent due to increased costs of labor and material.

5. On the same basis of cost of labor and material, 1914 prices, the cost of clearing ripe stumps in 1918 was $37.72, or 36.7 per cent less than the cost of green blasting in 1914.

6. The cost of clearing an acre of ripe stumps in 1918, using the stump puller, was $44.08, a saving of $14.96, or 33.9 per cent, on the cost of removing an acre of green stumps by machine power in 1914.

7. On the basis of costs of labor and material in 1914, the cost of clearing an acre of ripe stumps in 1918 with stump-puller was $31.81, a saving of 46 per cent on the cost of removing an acre of green stumps with the machine in 1914.

8. The stump-puller was loaned for this work, so no rental charge was made. Properly, a charge based on the cost of maintaining the machine and the acreage cleared should be added.

9. Stump-puller clearing cost more than dynamite in 1914 but in clearing ripe stumps in 1918 it was lower than all other costs for either year. This was due to the practical elimination of the high-priced factor, dynamite, and a reduction of labor costs by more than one third.

10. The average cost of removing and piling a stump was reduced about forty per cent for ripe stumps. It cost as much to blast, pull, and pile one large decayed stump as to pull and pile ten small ones by horsepower. It cost as much to pull one stump, machine power, and pile it as to pull and pile three stumps by horsepower.

11. More than fifteen dollars' worth of dairy products was realized annually from this stump pasture.

12. In 1915 clearing operations, receipts exceeded costs of clearing up to the stump stage with a surplus credit of pole and slab wood and sawdust. The sawdust was used for bedding.

13. In land-clearing work in 1917, 30 per cent dynamite proved more effective than 20 per cent.

14. The delayed system of clearing on Tract III was superior to green clearing in three respects:

A. There was a saving of one third or more in costs of clearing per acre.

B. An assured annual pasture crop was harvested by the cattle while the crops on tracts I and II were low in volume and high in cost of production.

C. The quality of the land was improved by the decaying vegetation and thickening sod, the land was more easily plowed, and a better and cheaper seedbed was produced.

THE GREAT FOREST FIRE

This report would be incomplete without an account of the great fire of October 12, 1918, that threatened to destroy the entire building and mechanical equipment of the plant and has given a new bearing to the development of the station and the nature of its work, for it probably is the first, and, to date, the only institution of its kind in the country or on this continent that has been devastated by a forest fire.

Saturday, October 12, 1918, was unseasonably warm with a considerable wind that grew into a gale by noon. By three o'clock the latent fires about the farm and thruout the district were rekindled, the sky was overcast and routine work was abandoned. The first wave of fire came from the west-northwest about half past three in the afternoon. This passed directly to the rear and about the poultry buildings, but with the entire crew fighting the fire and with a providential shift in the wind, these buildings were saved. The second wave struck about six o'clock. By seven o'clock the superintendent's residence and the auditorium were on fire and some time later the horse barn was in flames. The balsam grove directly behind the first two buildings was the immediate cause of their destruction. Escape to Duluth was cut off from six o'clock until midnight. Men, women, and children took refuge under blankets in open fields, under bridges, and in streams.

The physical loss to the station was severe, coming as it did in an era of high prices and scarcity of labor and material. The total loss in buildings, lumber, fuel, livestock, fences, and miscellaneous equipment was nearly $25,000 with $9,000 insurance. Pastures were ruined and the short supply of hay, due to a dry season, was one third or more destroyed. Fortunately, the fall work was about complete, records were saved, and all projects were intact.

A miscellaneous crew was gathered and reconstruction begun at once. The debris was cleared away, burned groves were cut down, fence posts were sawed and timber gotten out during the winter months. Reconstruction of buildings was begun in November and by April the superintendent's residence, the herdsman's cottage, and the horse barn were completed and occupied. Grass seed was sown over all the remaining timber land, stump land, and burned meadows in the early spring, the farm fences were rebuilt and essential equipment purchased. In October and November twenty acres of timber land was cut off, thus making the buildings reasonably safe from future fires. December 31, 1919, finds the farm not only back to normal but in better shape than before the fire. With abundant rain and summer warmth, nature was a silent but potent agent not only in restoring meadows and pastures in better shape than they were before, but in making the crops of 1919 the best in the agricultural history of the Northeast Experiment Station.