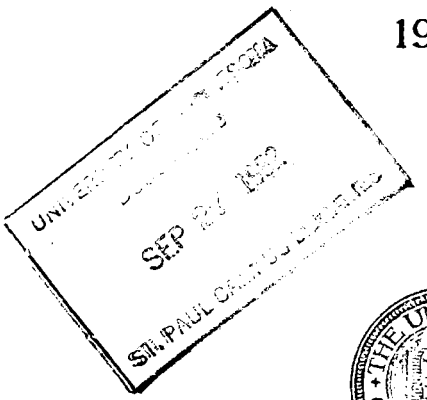
The University of Minnesota

AGRICULTURAL EXPERIMENT STATION

REPORT OF NORTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION DULUTH

1920



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M. J. THOMPSON, Superintendent

SEASON OF 1920

In many respects, the growing season of 1920 was very similar to that of 1919, but this was not true of the beginning and the end of the year. January and the latter part of February were extremely cold, with an abundance of snow. The lowest temperature of the winter, 31 degrees below zero, was recorded January 25. March was decidedly milder. Snow began to disappear rapidly about the middle of the month, and before the first of April the roads were dry and automobiles were in use. April 2 was marked by one of the worst blizzards of the season, and it was followed by zero weather on the 4th and 5th which did great injury to winter grains. The last killing frost of the spring (28 degrees F.) occurred May 15-16 and the first severe frost of the fall (26 degrees F.) came the night of September 30-October 1. This frost-free growing period of 138 days allowed such tender crops as corn, tomatoes, and cucumbers to mature. The early part of the growing season was marked by high temperatures and extreme rainfall. The heavy rains of May and June caused the washout or decay of seed potatoes in many places and the grain crop in low places was also injured. The ground was packed and left in poor physical condition with the result that crops were spotted and yields generally reduced. July was wetter than usual, but it was followed by excellent weather for hay making. The hay crop, while good, was somewhat below 1919 standards. The fall months were in marked contrast to 1919. There were not more than five days of sub-zero weather up to December 3 and very little snow fell. Fall crops were gathered with little difficulty, and conditions were unexcelled for brushing and clearing land.

FIELD CROPS

In 1919 the variety testing work was incorporated into a five-year rotation, two years in grass, two in grain, and one in cultivated crops. By 1922 the rotation will be completely established. Table 1 covers the details of varity plot tests.

TABLE I

YIELDS PER ACRE OF SPRING GRAINS AND BEANS IN VARIETY TEST PLOTS, 1920

Crops	No.	Plot 1	Plot 2	Plot 3	Average	2-yr. Av.
		Bu.	Bu.	Bu.	Bu.	Bu.
Wheat—						
Prelude	1970	8.25	5.31	4.17	5.89	11.12
Marquis	1239	14.98	15.81	15.16	15.32	17.06
Preston	924	16.50	20.00	14.85	17.12	15.47
Mindum	470	6.87	*	10.05	8.46	17.60
Kubanka	2102	*	14.13	7.79	10.96	15.67
Arnautka	2103	24.87	7.31	6.55	12.91	15.58
Acme	1967	7.05	12.98	12.83	10.95	†
Emmer	1165	17.19	20.30	*	18.74	†
Oats—						
Sixty Day	1-17-72	48.99	63.60	58.45	57.01	†
Iowa No. 103	531	52.43	54.04	46.41	50.96	52.64
Iowar	670	51.57	73.06	52.03	58.88	†
Garton No. 784	1-15-53	67.04	69.59	62.11	66.25	†
Minota	512	70.70	74.78	66.04	70.50	59.58
Lincoln	505	71.37	77.35	71.62	73.45	60.57
Victory	514	73.75	81.65	70.48	75.29	62.70
Silver Mine	506	51.38	75.63	77.35	68.12	56.90
Irish Victor	358	75.21	75.63	77.35	76.08	58.50
Imp. Ligowa	281	70.97	74.77	87.45	77.73	61.96
Barley—						
French Chevalier	230	34.59	21.25	44.62	33.48	37.37
Svansota	440	39.05	*	61.12	50.08	51.90
Manchuria	1-15-2	37.60	36.52	52.88	42.30	†
Manchuria	1-16-66	37.16	41.66	39.05	39.29	†
Minsturdi	439	38.75	40.10	41.41	40.08	41.36
Lion × Manchuria	418	31.40	37.16	45.00	37.72	43.83
Lion × Manchuria	184	42.04	40.00	53.22	45.08	46.08
Rye—						
Spring	61	20.62	26.64	18.68	21.98	22.81
Beans—						
Brown Swedish	74	12.83	19.25	18.33	16.80	20.22
Snowflake	75	12.83	21.08	17.42	17.11	25.15
M. A. C. Robust	76	23.83	18.33	19.25	20.47	†
Boston Favorite	77	16.50	11.92	15.58	14.66	19.03

* Discarded.

† Only one year's results available.

The season was very poor for wheat. Winter wheat was so badly injured by the April freeze that crop results were of no experimental value. Spring wheat was badly rusted and Prelude was also severely attacked by the joint worm. The extreme wet weather of early summer reduced barely yields below those of 1919. Winter rye, like winter wheat, was badly hit by the April cold. Spring rye maintains a uniform production. In both seasons the Snowflake bean has maintained a slight lead over two other varieties.

A project was begun in the fall of 1919 to determine the proper dates and rates of seeding for winter rye and winter wheat on the heavy clay soils of the cut-over district. The dates of seeding in both cases were September 3, 10, 20, 30 and October 10 for the date-of-seeding test. In the rate-of-seeding test the rates were 1, 1½, and 1¾ bushels per acre. Following the seedings of September 10 there was a progressive decrease for each later date in the case of both wheat and rye. Heavier yields of both wheat and rye were secured with the heavier seedings.

ROUGHAGE CROPS

The tables deal only with the grass garden crops as distinct from the hay crops in the various fertilizer and rotation studies.

TABLE II

(A)

YIELDS PER ACRE OF HAY IN 1920 (OLD PLOTS)

Kind of forage	Series 1	Series 2	Average	2-yr. Av.
	Pounds	Pounds	Pounds	Pounds
Timothy	1,457	5,370	3,413	3,300
Bromus	2,679	4,890	3,784	3,802
Bluegrass	1,598	3,030	2,314	2,786
Redtop	2,538	5,310	3 924	4,202
Orchard grass	1,598	2,280	1,939	2,018
Medium red clover	3,290	4,080	3,685	3,371
Mammoth clover	4,794	3,420	4,107	3,575
Alsike clover	5,264	3,360	4,312	4,770
Grimm alfalfa	8,574	6,833	7,703	5,594

(B)

YIELDS PER ACRE OF HAY IN 1920 (NEW PLOTS)

	Series 1		Series 2		
	1st crop	2d crop	1st crop	2d crop	Average
	Pounds	Pounds	Pounds	Pounds	Pounds
Northern grown common alfalfa.	3,544	2,868	3,828	2,681	6,461
Southern grown common alfalfa.	4,923	3,259	4,549	2,717	7,724
Grimm alfalfa—					
June 9 seeding	4,300	3,243	3,777	2,533	6,627
June 17 seeding	4,260	3,536	3,414	3,014	7,112
June 30 seeding	3,736	3,375	3,670	3,415	7,098

Two years' results seem to indicate that bromus and redtop are as good as timothy in this locality, if not better, and that orchard grass is even poorer than bluegrass for hay. On the older plots, alsike is not far behind alfalfa in gross yields.

The new alfalfa plots were first harvested in 1920. In all cases the seed was inoculated and, in addition, dirt from sweet clover plots

was liberally distributed over the ground. A thoro dressing of ground limestone was also applied late in the fall of 1919 and ten tons of manure in the fall of 1920.

Sweet clover was included in all meadow seedings in 1920 and it was also grown in plots, both with and without a nurse crop. While a better stand was secured in the latter case, yields were poor. Millets were grown for hay and for silage, but yields were discarded because the crop was so badly injured by water.

Fig. 1. Where stumps are scattered, excellent crops of tame hay can be gathered between them.

SILAGE CROPS

As during the previous season, several substitute silage crops were grown. These included clover-timothy of the second cutting, small potatoes, rutabaga tops, millet, corn, and sunflowers. The last-named plant is the major silage crop of this station. Feeding tests have been in operation through the winter and results will be published in the 1921 report. Clover-timothy silage, tho dark in color, has always been eaten ravenously. Millet proved rather an inferior feed both seasons, probably on account of over-ripeness and dryness. Corn was no better than sunflowers. Rutabaga tops were not only very palatable but probably stimulated milk production above all other feeds. Potato silage to which a very small amount (2 per cent) of cornmeal has been added to stimulate fermentation is an exceptionally good feed for milking cattle. Its concentrated feeding value makes possible the feeding of smaller rations. It was always eaten with relish and no coaxing was needed to start the feeding of it. Sunflower silage is being fed during the winter of 1920-21. With the exception of two cows the herd was on full feed the second day. A part of the 1919 crop was analyzed by the Division of Agricultural Biochemistry.

TABLE III

ANALYSIS OF SAMPLES OF SILAGE (DRY BASIS)

Kind	Ash	Protein	Ether Ext.	Crude fiber	Nitrogen-free extract
	Per cent	Per cent	Per cent	Per cent	Per Cent
Sunflower	8.36	6.51	6.51	2.44	76.18
Potato	3.11	4.66	0.69	0.30	91.24
Pea-oat	7.27	9.57	0.39	2.98	79.79
Clover-timothy	7.57	15.40	5.59	3.68	67.76
Millet	7.04	8.54	2.65	3.29	78.48
Sorghum	3.96	4.22	2.49	4.21	85.12

POTATOES

The extremely wet weather of May and June seriously injured the potato crop on the heavier soils. Owing to decay and washing of seed, stands were both spotted and uneven and yields were generally reduced. It was necessary to discard the variety test plots, and spray treatment was suspended for the season as the stands were too irregular for experimental value. Where drainage was good yields were good to excellent.

SEED TREATMENT

This project has gone through its second year. As in the previous year, starting with clean seed on clean ground, all treatments were neutral so far as effect on disease was concerned. The crop was clean in all cases but a distinct decrease in yield was noticed in both 1919 and 1920 from seed treated with copper sulfate. Duplicate tests only are available for 1920.

TABLE IV

YIELDS PER ACRE OF POTATOES IN SEED-TREATMENT PLOT, 1920

Plot	Corrosive sublimate		Formalin		Copper sulfate		Untreated	
	Mktble stock*	Total	Mktble stock*	Total	Mktble stock*	Total	Mktble stock*	Total
	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	242	264	...	...	...	...	...	...
2	...	...	248	284	...	...	...	...
3	...	...	...	...	230	254	...	...
4	...	...	...	...	...	...	197	226
5	309	340	...	...	...	...	...	...
6	...	...	314	340	...	...	...	...
7	...	...	...	...	239	258	...	...
8	...	...	...	...	...	...	306	348
Average	275.5	302	281	312	234.5	256	251.5	287

* The two-year average yield from seed treated with corrosive sublimate was 291.5 bushels; with formalin, 290.5 bushels; with copper sulfate, 230.5 bushels; and from untreated seed, 292.5 bushels.

LEVEL VERSUS RIDGED CULTIVATION

This is a continuation of a project begun in 1919. Green Mountain potatoes were used. Plots were arranged in triplicate.

TABLE V

COMPARISON OF YIELDS PER ACRE OF POTATOES, GIVEN LEVEL AND RIDGED CULTIVATION

Plot	Level cultivation		Ridged cultivation	
	Marketable stock*	Total	Marktable stock*	Total
	Bu.	Bu.	Bu.	Bu.
1	....	....	284.3	305.6
2	205.3	224.6	....	....
3	....	....	228.3	247.6
4	206.2	227.3	....	....
5	....	....	193.7	216.7
6	231.3	252.0	....	....
Average ...	214.2	234.6	235.4	256.6

* The average for two years was 265.5 bushels for level cultivation; and 267.5 bushels for ridged cultivation.

The season of 1919 was relatively dry and this condition favored level cultivation. A reverse condition obtained in 1920 with opposite results. Two years' results are not conclusive, but at this stage of the development of the project, results are relatively the same in both cases.

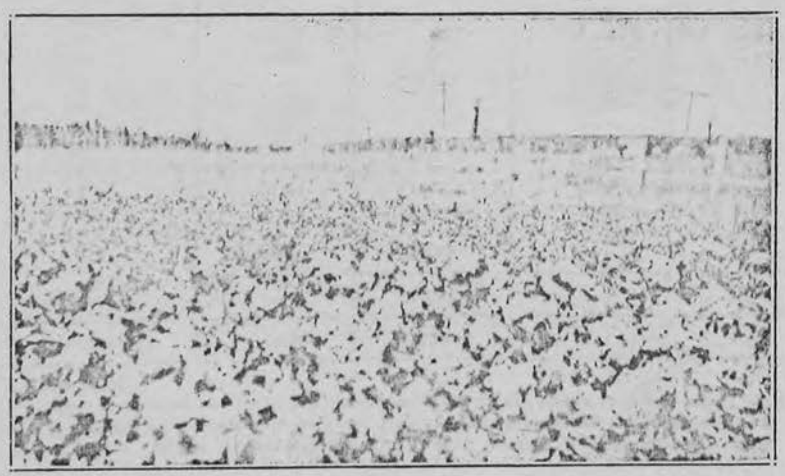

Fig. 2. Potatoes still in blossom, September 1, with heavy rutabaga crop in the foreground.

CROP ROTATIONS

(In coöperation with Division of Agronomy and Farm Management, Central station.)

Crop rotations were begun in 1919 and a detailed explanation of the scope and purpose appeared in the 1918-19 report. Briefly, it is a farm management study of three-, four-, and five-year rotations for the purpose of determining which is better adapted to the regional conditions of soil, farm industry, and labor supply. The crops involved are barley for grain; sunflowers; clover-timothy hay. The three-year rotation includes these three crops only; the four-year rotation includes two hay crops, and the five-year rotation three hay crops. Manure is applied on the grain stubble at the rate of two tons per acre per year. For example, on the three-year rotation the manure is applied once in three years in the amount of six tons per acre The report for 1920 covers two years of grain and one year of hay, since all the hay plots have been fertilized with manure in various quantities. The first experimental results with sunflowers will come in 1921.

Fig. 3. Corn for silage and fodder is a common crop at the Head of the Lakes and some flint varieties are matured.

The wet season hit the barley crop very hard, and as a result the yield was less than half that of the previous year, 51.67 bushels per acre. The effect of manure on the hay crop is scarcely evident. Applied at the rate of two tons per acre per year, six, eight, and ten tons, respectively, were applied to the three-, four-, and five-year rotation plots. The five-year rotation plots were the only ones that showed any appreciable response.

TABLE VI

YIELDS PER ACRE OF GRAIN AND HAY PLOTS, ROTATION SERIES, 1920

Series	Barley	Average by rotation	Hay	Average by rotation
Three-year rotation				
Series V	Bu.	Bu.	Tons	Tons
Plot				
1	....	....	2.70	....
2	....	....	....	....
3	22.08	....	....	....
4	....	....	2.65	....
5	....	....	....	....
6	29.17	....	....	....
7	....	....	2.60	2.65
8	....	....	....	....
9	26.73	26.00	....	....
Four-year rotation				
Plot				
10	....	....	3.04	....
11	....	....	2.27	....
12	....	....	....	....
13	23.75	....	....	....
14	....	....	2.69	....
15	....	....	2.63	....
16	....	....	....	....
17	27.06	....	....	....
18	....	....	*	....
Series VI				
Plot				
1	....	....	2.75	2.67
2	....	....	....	....
3	15.17	22.00	....	....
Five-year rotation				
Plot				
4	....	....	2.52	....
5	....	....	2.45	....
6	....	....	2.93	....
7	....	....	....	....
8	16.66	....	....	....
9	....	....	4.37†	....
10	....	....	3.37†	....
12	....	....	....	....
13	‡	....	....	....
14	....	....	3.14	....
15	....	....	2.85	....
16	....	....	3.00	3.14
17	....	....	....	....
18	24.92	20.79	....	....
Average	....	22.93	....	2.82
Two-year average	....	37.30	....	....

* Discarded.

† These plots were cut under the same conditions as the others, but this group of three seemed to contain more clover and were not quite so dry, altho given the same treatment and repeatedly tedded. Hence the average for the five-year rotation is taken from the other two blocks.

‡ Rejected.

In 1920 a comparison was made between the relative value of plowing and disking for grain a field that had produced a cultivated crop the year before. The land in question had produced a crop of beans, sunflowers, and potatoes in 1919. Alternate plots, one-twentieth acre in size, were fall plowed and the remaining plots were disked in the spring without plowing. Oats was the crop grown. Tests were made in duplicate.

TABLE VII

DISKING VERSUS PLOWING OF CULTIVATED CROP LAND FOR GRAIN

Plot	1919 crop	Treatment	1920 crop	Bu. per acre
1	Cultivated	Fall plowed	Oats	98.40
2	Cultivated	Disked	Oats	72.50
3	Cultivated	Fall plowed	Oats	81.25
4	Cultivated	Disked	Oats	107.19
Average fall-plowed plots.....		.....	.....	89.82
Average disked plots.....		.....	.....	89.84

This project will run two years more. There was no difference in yield the first year under these treatments, but the crop produced on the disked land required less labor. The yield of 107.19 bushels on Plot 4 is the largest yield of oats recorded to date at this station.

ORCHARD PROJECT

The winter of 1920-21 was the first severe one following the big fire which destroyed the natural protection afforded by the forest to the station orchard and the resulting injury showed what might be expected from northwest winds in this latitude. A narrow zone of trees extending from northwest to southeast was either killed out or severely injured, while on both sides the injury was slight owing to protection from brush or high land to the northwest.

A change in orchard management was made in 1902. The entire acreage between the trees was seeded to clover and grass and top-dressed with manure. Several new varieties were used to replace those that were killed by frost and fire. The following were planted: Malinda, Longfield, Yellow Transparent, Iowa Beauty, Lowland Raspberry, Jewell's Winter, Charlamoff, Wolf River.

The first apples were gathered in 1920, from year-old stock set in 1915. Sixteen Hibernal, 8 Wealthy, 3 Anisim, 1 Duchess, and 1 Patten Greening, produced one or more apples per tree. On the basis of the number of trees of each variety, Hibernal made the best showing and Anisim the poorest. Okabena did not produce a single apple. Compass Cherry produced its first fruit in abundance, and indicated its ability to withstand considerable severity of winter

temperature. After freezing back repeatedly, these trees have established a low heading character and apparently will continue to thrive and bear fruit.

SOIL FERTILITY INVESTIGATIONS

(In coöperation with the Division of Soils of the Central station.)

PHOSPHATE-MANURE EXPERIMENT

The soil fertility investigation was begun in 1916 and has been in continuous operation ever since. The west halves of the plots were limed in 1916 at the rate of three tons of ground limestone per acre. Rock phosphate was applied the same year at the rate of one ton per acre on plots 2, 8, 14; 3, 9,15; ten tons of manure are annually applied to the grain stubble on plots 3, 9, 15; 4, 10, 16; 5, 11, 17. Acid phosphate, 360 pounds per acre, is applied annually to the cultivated crop on plots 5, 11, 17; 6, 12, 18.

TABLE VIII

YIELDS PER ACRE OF POTATOES, PHOSPHATE-MANURE EXPERIMENT, 1920

Plot	Treatment	1920 average		5-yr. average
		Marketable	Total	Marketable
		Bu.	Bu.	Bu.
1	No fertilizer	246.1	271.1	
2	Rock phosphate	263.2	297.6	
3	Rock phosphate and manure	325.4	347.9	
4	Manure	258.0	267.6	
5	Manure and acid phosphate	410.8	433.8	
6	Acid phosphate	328.6	348.9	
7	No fertilizer	255.3	265.7	
8	Rock phosphate	275.9	289.5	
9	Rock phosphate and manure	173.2	192.1	
10	Manure	271.4	288.8	
11	Manure and acid phosphate	306.9	331.1	
12	Acid phosphate	268.0	290.8	
13	No fertilizer	173.2	188.9	
14	Rock phosphate	197.2	209.7	
15	Rock phosphate and manure	201.5	217.1	
16	Manure	193.9	211.9	
17	Manure and acid phosphate	173.2	192.4	
18	Acid phosphate	183.3*	199.9	
Averages				
1- 7 13	No fertilizer	224.8	241.9	182.8
2- 8-14	Rock phosphate	245.4	265.6	189.8
3- 9-15	Rock phosphate and manure	233.3	252.3	205.4
4-10-16	Manure	241.1	256.1	194.2
5-11-17	Manure and acid phosphate	297.1	319.1	213.7
6-12-18	Acid phosphate	259.9	279.9	182.8

* This yield is computed from the west half of the plot. The east half was rejected because of poor stand.

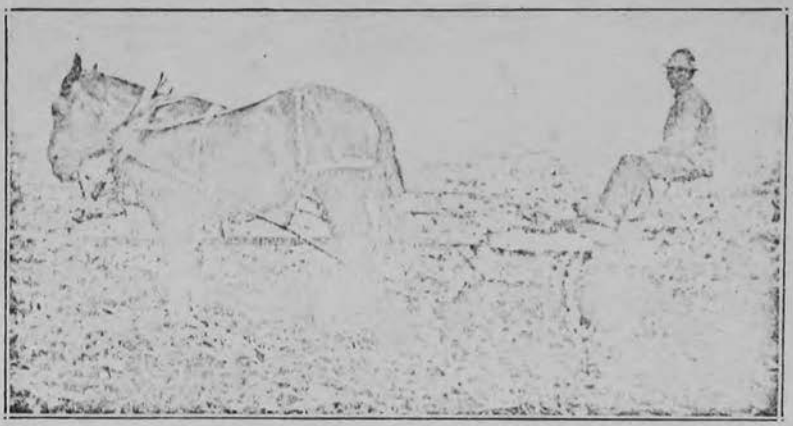

Fig. 4. The extra heavy tool steel cutaway harrow sometimes called a "Bush and Bog" plow is an invaluable implement on new timber land.

TABLE IX

YIELD PER ACRE OF RUTABAGAS IN PHOSPHATE-MANURE EXPERIMENTS, 1920

Plot	Treatment	Roots	Tops	5-year average	
				Roots	Tops
		Tons	Tons	Tons	Tons
1	No fertilizer	9.88	2.21		
2	Rock phosphate	13.59	3.66		
3	Rock phosphate and manure	13.65	3.10		
4	Manure	13.43	3.04		
5	Manure and acid phosphate	10.04	1.99		
6	Acid phosphate	10.08	1.57		
7	No fertilizer	9.22	1.92		
8	Rock phosphate	10.67	2.03		
9	Rock phosphate and manure	9.38	2.54		
10	Manure	8.82	1.97		
11	Manure and acid phosphate	9.50	1.78		
12	Acid phosphate	7.35	1.23		
13	No fertilizer	7.50	1.85		
14	Rock phosphate	9.20	1.10		
15	Rock phosphate and manure	11.90	2.66		
16	Manure	10.90	2.64		
17	Manure and acid phosphate	8.59	1.85		
18	Acid phosphate	9.13	1.67		
Averages					
1- 7-13	No fertilizer	8.87	1.99	10.15	2.75
2- 8-14	Rock phosphate	11.15	2.26	11.49	3.40
3- 9-15	Rock phosphate and manure	11.64	2.57	12.49	3.39
4-10-16	Manure	11.05	2.55	13.55	3.67
5-11-17	Manure and acid phosphate	9.38	1.87	12.80	2.90
6-12-18	Acid phosphate	8.85	1.49	12.21	2.83

The combination of manure and either rock or acid phosphate, is giving best results, thus repeating the experience of former years. But the 1920 results secured through the use of manure and acid phosphate are the most marked in the five-year history of the project. In spite

of a generally unfavorable season, there has been no break in the progressive increase in yield from year to year. The yield of check plots is especially noticeable, as it has increased annually, in the absence of anything added other than the plowing under of the clover and timothy sod.

No marked effect from the use of fertilizer on rutabagas has been seen in five years. With no fertilizer, yields are somewhat lowered, but manure and acid phosphate, either alone or in combination, have influenced yield to the extent of only one or two tons per acre. Manure is the most active agent in stimulating production. These yields also indicate that, considering the labor involved, a farmer had better grow a silage crop for succulent feed, if he has a herd of any size. Our experience does not support the popular notion that rutabagas are a very dependable crop. Between drouth and insect pests, we have had heavy crops in only two years, 1916 and 1919, out of five.

TABLE X

YIELDS PER ACRE OF OATS IN PHOSPHATE-MANURE EXPERIMENT, 1920

Plot	Treatment	Grain	Straw	4-year average	
				Grain	Straw
		Bu.	Tons	Bu.	Tons
1	No fertilizer	45.8	1.12		
2	Rock phosphate	69.5	0.90		
3	Rock phosphate and manure	72.6	1.59		
4	Manure	73.4	1.52		
5	Manure and acid phosphate	69.8	1.42		
6	Acid phosphate	62.0	1.73		
7	No fertilizer	52.2	1.23		
8	Rock phosphate	55.5	0.86		
9	Rock phosphate and manure	60.9	1.07		
10	Manure	65.9	1.16		
11	Manure and acid phosphate	58.1	0.97		
12	Acid phosphate	63.6	0.99		
13	No fertilizer	56.1	0.85		
14	Rock phosphate	52.8	0.87		
15	Rock phosphate and manure	58.9	1.07		
16	Manure	61.1	1.03		
17	Manure and acid phosphate	59.7	1.04		
18	Acid phosphate	46.1	0.84		
Averages					
1- 7-13	No fertilizer	51.4	1.07	51.5	0.99
2- 8-14	Rock phosphate	59.3	0.88	56.9	0.95
3- 9-15	Rock phosphate and manure	64.1	1.25	60.5	1.13
4-10-16	Manure	66.8	1.24	60.7	1.11
5-11-17	Manure and acid phosphate	62.5	1.14	60.9	1.21
6-12-18	Acid phosphate	57.2	1.18	60.6	1.15

Four years' work is complete. Following a definite rotation and with no addition of manure or phosphate, we have on the check plots an average annual yield of 51.5 bushels of oats per acre for the four-year period. When either phosphate or manure is added there is an increase of nearly ten bushels per acre.

TABLE XI

YIELDS PER ACRE OF HAY IN PHOSPHATE-MANURE EXPERIMENT, 1920

Plot	Treatment	Limed	Unlimed	Entire plot	3-year average
		Tons	Tons	Tons	Tons
1	No fertilizer	2.36	2.21	2.28	
2	Rock phosphate	2.61	2.10	2.35	
3	Rock phosphate and manure	2.84	2.63	2.73	
4	Manure	2.58	1.85	2.21	
5	Manure and acid phosphate	2.81	2.14	2.47	
6	Acid phosphate	3.14	2.18	2.66	
7	No fertilizer	2.43	1.83	2.13	
8	Rock phosphate	2.44	2.32	2.88	
9	Rock phosphate and manure	3.58	3.17	3.37	
10	Manure	2.40	2.56	2.48	
11	Manure and acid phosphate	2.42	3.18	2.80	
12	Manure	2.29	2.51	2.40	
13	No fertilizer	1.66	1.94	1.80	
14	Rock phosphate	1.89	1.96	1.92	
15	Rock phosphate and manure	3.36	2.48	2.92	
16	Manure	2.07	2.38	2.22	
17	Manure and acid phosphate	2.41	2.44	2.42	
18	Acid phosphate	1.72	1.85	1.78	
Averages					
1- 7-13	No fertilizer	2.15	1.99	2.07	1.75
2- 8-14	Rock phosphate	2.65	2.13	2.38	1.79
3- 9-11	Rock phosphate and manure	3.26	2.76	3.01	2.19
4-10-16	Manure	2.35	2.26	2.30	1.95
5-11-17	Manure and acid phosphate	2.55	2.59	2.56	2.03
6-12-18	Acid phosphate	2.38	2.18	2.28	1.86

The three-year average is lower than normal owing to the short crop harvested in the dry season of 1918. The manure plots showed an increase over the unmanured of a little more than 11 per cent both in 1920 and for the entire period of four years. The manure is spread over the grain stubble in the fall just preceding the hay harvest. The lime has failed to show any marked effect on the clover altho there has been a slight increase.

CLOVER UTILIZATION EXPERIMENTS

Six plots are annually sown to clover and timothy, using oats as a nurse crop. The following season two are pastured close, two are plowed under when the grass has reached its maximum growth, and the hay crop is harvested off the remaining two plots. The group is cropped to potatoes and sunflowers the following season and the third year to oats, with clover and timothy seeding, beginning a new cycle of the rotation. The first crop of potatoes (and rutabagas, since discontinued for sunflowers) was grown in 1918. Only one year's results are available with sunflowers, and all rutabaga data have been printed. So yields of potatoes, oats, and hay only, are reported here.

TABLE XII

YIELD PER ACRE OF POTATOES IN CLOVER UTILIZATION EXPERIMENT, 1920

Plot	Treatment	Marketable stock	Total yields	Marketable stock 3-year average yield
		Bu.	Bu.	Bu.
1	Pastured	317.1	337.2	
2	Plowed under	228.6	250.3	
3	Harvested	289.5	315.8	
4	Pastured	277.2	293.5	
5	Plowed under	234.8	241.1	
6	Harvested	243.8	253.6	
Averages				
1-4		297.1	315.3	216.0
2-5		231.7	245.7	199.0
3.6		266.6	284.7	189.0

TABLE XIII

YIELD PER ACRE OF OATS IN CLOVER UTILIZATION EXPERIMENT, 1920

Plot	Treatment	Grain	Straw	2-year average	
				Grain	Straw
		Bu.	Tons	Bu.	Tons
1	Pastured	58.0	1.26		
2	Plowed under	50.6	1.05		
3	Harvested	59.5	1.07		
4	Pastured	59.2	1.06		
5	Plowed under	64.5	1.12		
6	Harvested	66.7	1.20		
Averages					
1-4	Pastured	58.6	1.16	57.0	1.10
2-5	Plowed under	57.5	1.09	54.3	1.09
3-6	Harvested	63.1	1.13	56.1	1.02

TABLE XIV

YIELD PER ACRE OF HAY IN CLOVER UTILIZATION EXPERIMENT, 1920

Plot	Treatment	Yield	4-year average
		Tons	Tons
3	Harvested	2.07	
6	Harvested	1.30	
Averages			
3-6	Harvested	1.68	1.66

These tables can be best studied together. It is quite obvious that plowing under the crop of grass has not materially stimulated yields and, in some cases, it has been followed by depressed production. This was probably caused by plowing in July when the ground and the weather were dry. Capillarity was broken and not readily re-established, the furrow slice of matted sod not only dried out still further but decayed very slowly, and as a result the crop was affected adversely the following year. In the case of potatoes a clear gain is

indicated from pasturing the clover and timothy as compared with plowing it under or cutting it for hay. But altho there is a less favorable showing of oats and potatoes on plots 3 and 6, where the hay crop was removed, the value of this hay crop will probably compensate, partly or wholly, for the difference. The evidence to date would indicate that it is better to feed the grass crop than to plow it under.

ROTATION WITHOUT CLOVER OR MANURE

TABLE XV

CROP YIELDS PER ACRE IN ROTATION WITHOUT CLOVER OR MANURE, 1920

Crop	Plot	1920 yield	4-year average yield
		Bu.	Bu.
Barley	2	*	*
Barley	5	10.1	7.9
Barley	5	10.1	
Oats	3	52.2	
Oats	6	48.4	
Oats	Average	50.3	38.0
Potatoes	1	188.8†—212.2‡	
Potatoes	4	143.9†—160.5‡	
Potatoes	Average	166.3†—186.3‡	127.7†—149.5‡

* Failure.
† Marketable stock.
‡ Total yield.

Rutabaga culture was discontinued in 1920 and all the data up to that time have been published. Sunflowers replaced the root crop. Two years' results will be published next season. This experiment, now four years old, is designed to show what happens in the absence of constructive management of timber land soils. The rotation of barley, oats, potatoes-sunflowers (formerly potatoes-rutabagas) is not reinforced by commercial fertilizer, manure, or even a grass or clover sod. The observations of previous years are sustained. Barley is worthless as a pioneer crop on cut-over timber soils or until the land has been improved. Oats maintain a good and potatoes a fair yield.

These results become more intelligible when compared with the behavior of the same crops in the presence of a soil amendment such as clover or clover reinforced by manure.

Excluding the first group of figures, the data for potatoes represent a general average of all series of plots where potatoes are grown on clover sod with no other soil amendment from three to five years. Four crops of rutabagas, four of oats, and two of barley have been averaged. About ten tons of manure per acre, applied once in three years, is the extent of fertilization with manure. The influence of the clover-timothy sod is much more pronounced than that of the manure.

TABLE XVI

YIELD PER ACRE ON VIRGIN SOIL WITH AND WITHOUT CLOVER AND MANURE, 1920

Treatment	Potatoes (marketable stock)	Rutabagas	Oats	Barley
	Bu.	Tons	Bu.	Bu.
Four-year average production on virgin soil in rotation without clover or manure	127.7	5.3*	38.02	7.93
Two- to five-year average production on virgin soil reinforced by clover sod.	173.0	11.85	51.00	†
Two- to five-year average production on virgin soil reinforced by both clover sod and manure	183.0	13.27	61.00	37.60

* Data available for three-year average.
† Data available for one year only.

RATE OF MANURING

In this project, potatoes-sunflowers (potatoes-rutabagas until 1920), oats and clover-timothy are grown in a three-year rotation. Plots 7 and 13 are checks; plots 8 and 14, 9 and 15, 10 and 16 are fertilized respectively by 5, 10, and 20 tons of manure per acre applied to the grain stubble every third year. Plots 11 and 17, and 12 and 18 are fertilized respectively by an application of 10 and 5 tons of manure per acre on a grass sod the fall preceding the cultivated crop. There is involved, then, a comparison not only of the value of different quantities of fertilizer, but also of the most effective time of application as measured by crop production. Owing to the excessive water injury to the potato plots, these are valueless for experimental purposes. Drainage rather than fertilization was the determining factor in 1920. The grain crop was not materially affected. Results are given in Table XVII.

Note that plots 11, 12, 17, and 18 are check plots. Manuring the grass sod began in the autumn of 1919, so in 1920 the only crops involved were potatoes and sunflowers. The results in 1920 and the average for three years seem to indicate that the manure application made two years before and affecting first the hay crop and then the cultivated crop does not influence the grain crop as much as might be expected. As compared with the no-manure, no-clover experiment, we have a surplus of 12 bushels per acre in favor of fertilization by clover or manure or both for 1920 and for the three-year period as well.

TABLE XVII

YIELDS PER ACRE OF OATS IN RATE OF MANURING EXPERIMENT, 1920

Plot	Treatment	1920 yields		3-year average yield	
		Grain	Straw	Grain	Straw
		Bu.	Tons	Bu.	Tons
7	No manure	61.9	1.84		
8	5 tons manure per acre	57.2	1.93		
9	10 tons manure per acre	67.5	1.91		
10	20 tons manure per acre	78.6	1.97		
11	No manure	66.1	1.27		
12	No manure	59.2	1.23		
13	No manure	63.6	1.37		
14	5 tons manure per acre	55.8	1.24		
15	10 tons manure per acre	45.6	1.72		
16	20 tons manure per acre	62.8	1.30		
17	No manure	63.7	1.23		
18	No manure	62.5	1.48		
Averages					
7-11-12					
13-17-18	No manure	62.8	1.40	4.86	0.94
8-14	5 tons manure per acre	56.5	1.58	47.0	1.00
9-15	10 tons manure per acre	56.5	1.81	49.9	1.16
10-16	20 tons manure per acre	70.7	1.64	56.4	1.16

TABLE XVIII

YIELD PER ACRE OF HAY IN RATE-OF-MANURING EXPERIMENT, 1920

Plot	Treatment	1920 yield	2-yr. average
		Tons	Tons
7	No manure	1.64	
8	5 tons manure per acre	2.17	
9	10 tons manure per acre	2.32	
10	20 tons manure per acre	2.29	
11	No manure	2.06	
12	No manure	1.37	
13	No manure	1.79	
14	5 tons manure per acre	2.01	
15	10 tons manure per acre	2.93	
16	20 tons manure per acre	2.83	
17	No manure	2.07	
18	No manure	2.29	
Averages			
7-13-11-17			
12-18	No manure	1.87	1.86
8-14	5 tons manure per acre	2.09	1.95
9-15	10 tons manure per acre	2.62	2.41
10-16	20 tons manure per acre	2.56	2.45

In 1919 the 10-ton application of manure yielded an increase of 18.9 per cent above the unfertilized plots in the manure series, and 14 per cent in the fertilizer series. In 1920 the same application yielded an increase of 40 per cent in the manure series and 11 per cent in the fertilizer series. The manure is distributed over the grain stubble and the grass crop secured the first benefit from it.

FERTILITY OF BURNED VIRGIN MINERAL SOIL

All the remaining timber land of the station was severely burned over on October 12, 1918. In most cases the fire penetrated to the clay, leaving spotted deposits of vegetable matter where formerly there was a complete layer. Grass seed sown in 1919 made a splendid growth where the fire burned the cleanest. In other places where a small amount of vegetable matter intervened between the seed and the cool moist clay below, the ground dried off on top and the clover failed to catch. It was concluded that the more severe the fire, the better was the grass seeding secured.

For these reasons it was decided to run a series of experiments on upland soil to see what was the effect of the fire on the production of other than grass crops. The land was stumped in the fall of 1919 and plowed in the spring of 1920. A three-year rotation consisting of barley, oats, and sunflowers was established the first season. Land clearing cos's were recorded.

TABLE XIX

CROP PRODUCTION PER ACRE ON BURNED VIRGIN MINERAL SOIL, 1920

Plot	Crop	Yield
1	Oats	11.2 bu.
2	Barley	2.1 bu.
3	Sunflower	4.31 tons
4	Oats	34.7 bu.
5	Barley	14.6 bu.
6	Sunflowers	9.0 tons

The first three plots may well be discarded, since the crop was ruined by water. The land lay high but rather flat, and, with practically no humus left in the soil, it became thoroly waterlogged and later it baked during the dry weather of July.

The second block made a fair growth. Barley acted about as usual on a new soil and oats produced about the same as the first year in the rotation without clover or manure. Sunflowers did very well. On the whole, the first year's results would seem to indicate that the burned land soils were not severely injured by the fire, but no interpretations can be made for some years.

On a second tract of land the soil was disked only, instead of being plowed, and the same crops were grown. The disked plots, however, were a distinct surprise. They produced nothing whatever. This is directly contrary to the experience recorded at this station on the cropping of virgin soil, unburned, in 1913. The disked plots were plowed in the fall of 1920 and will be used as a check on the work outlined above in 1921.

DELAYED CLEARING PLOTS

Six plots were laid out on land that had been brushed and logged in 1913, seeded in the spring of 1914, pastured from 1915 to 1919, and stumped in 1919. In 1919 a 3-year rotation was established and the first crops grown were oats, barley, and sunflowers. The following yields were secured.

TABLE XX

CROP YIELDS ON DELAYED CLEARING PLOTS, 1920

Plot	Oats	Barley	Sunflowers
	Bu.	Bu.	Tons
1	51.9		
2		20.8	
3			9.54
4	69.7		
5		23.5	
6			8.03
Average	60.8	22.2	8.78

These yields are most interesting when compared to yields on virgin soil that has never produced a grass sod between the stumps. The contrast is drawn below for oats, barley, and sunflowers.

TABLE XXI

CROP PRODUCTION ON BURNED VIRGIN SOIL, ON UNBURNED LAND WITHOUT CLOVER OR MANURE, AND ON DELAYED CLEARING LAND

Treatment	Oats	Barley	Sunflowers
	Bu.	Bu.	Tons
Upland virgin soil, burned October, 1919	23.0	8.3	6.65
Unburned upland soil, virgin in 1915, cropped since without clover or manure	38.0	7.9	7.16
Crops on delayed clearing tract first season	60.8	22.2	8.78

One year's results prove nothing, but the comparasion is instructive, for the 60-bushel yield has been repeatedly checked in the case of other plots. The yield of 23.0 bushels of oats is lower than usual, perhaps owing to the season or to fire injury, but the 38-bushel yield is about normal, as the usual yield of oats grown on virgin soil directly after brush is removed, is 40 bushels per acre. Barley is always very poor as a pioneer crop and the presence of a sod has had a material effect. Since one year's results only are available in the case of sunflowers, comment must be deferred. Potatoes were not included in this test, but the average yield on virgin soil reinforced by grass sod has been 173 bushels per acre (see Table XVI) as compared to 117 bushels per acre without sod.

In summarizing the soil fertility data for 1920, we find that the acid phosphate is apparently showing results on potatoes for the first time. Lime only slightly influences the hay crop, altho applied in

1916. Grass and clover sod continue to affect yield more than manure, except in the case of hay. Sowing clover between the stumps and pasturing it not only lessens the cost of clearing and provides profitable pasture but it has a striking effect on the first farm crop following stumping. Altho splendid grass seedings followed where the forest fire was most intense, the first year's results with tilled crops point to contrary conclusions.

GRAZING

The season of 1920 was the fifth during which records have been kept for young stock on pasture. Nine heifers were included in the 1920 lot. They went on pasture May 25, and were withdrawn from continuous day and night pasture October 27, a total of 155 days of feeding. This is the longest continuous period of day and night pasture recorded during the five-year period. They averaged a gross seasonal gain of 168 pounds, or 1.08 pounds per day. The fall months were very fine and the young stock had free range during the day until the middle of September. The data for five years are summarized in Table XXII.

TABLE XXII

GAINS AND MAINTENANCE OF HEIFERS ON STUMP LAND PASTURE, 5-YEAR PERIOD

Year	Continuous pasture begun	Continuous pasture ended	Number of cattle	Average age of cattle	Average total gain	Average daily gain
				Months	Lbs.	Lbs.
1916	June 12	Oct. 17	10	17.2	103.6	1.59
1917	June 1	Oct. 17	..	..	74.0	.53
1918	June 1	Oct. 18	6	19.0	175.0	1.35
1919	June 3	Oct. 27	8	10.5	172.0	1.18
1920	May 25	Oct. 27	9	15.5	168.0	1.08
Average	June 2	Oct. 19	8.25	15.5	138.5	1.145

Briefly summarizing five years' results, there are 140 days of day and night pasture in the average season, conservatively estimated. This could easily be extended to a full five months, starting May 20, if there is ample range. Day pasture begins in late May and extends to early November and about every third year it will extend into December. During the day-night pasture season, the young stock averaged a total gain of not quite 140 pounds or 1 1-7 pounds per day.

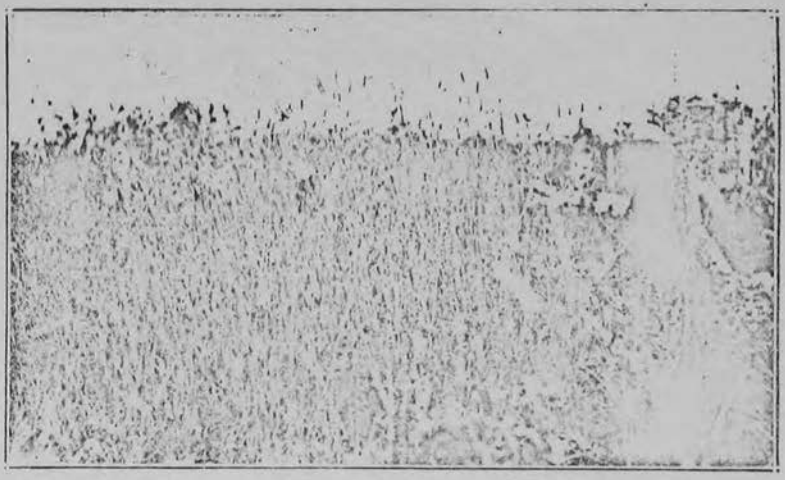

Fig. 5. Grass seed properly sown between stumps in April will frequently set seed in August of the same year, and clover will come into blossom.

LIVESTOCK AND POULTRY

This station maintains a flock of grade Hampshire sheep, with a purebred ram heading the flock. Lambs came in late April and early May. The flock was put on brush pasture in the middle of May. There are two of these pastures on the farm, consisting of land overrun by the forest fire and brushed during the winter of 1919-20. The sheep were transferred back and forth between these two pastures monthly. This served the double purpose of keeping down the brush and maintaining the sheep in good condition. The ram lambs were sold in November. They averaged a little over 88 pounds and brought 9½ cents per pound or $8.40 each. Our experience indicates that sheep will do good work brushing if they are allowed to graze on two or three tracts in alternate periods.

One-third of the producing dairy herd of 22 cows now consists of registered Guernsey cattle. For five years this station has produced all its hay, expanding the cleared acreage with its growing herd. The average production of the herd is approaching 300 pounds of butterfat. Through the use of a mechanical milker and a power separator one man handles the cattle and hogs, except cleaning the barns and feeding bulk forage. During the winter hay, sunflower silage, and a grain ration of one pound of grain for each 2½ to 3 pounds of milk is fed. The pastures are so divided and arranged that the cattle have two shift pastures for day feeding and three for night feeding.

The station has disposed of its Yorkshire hogs and now breeds Duroc Jerseys exclusively.

Skimmilk is fed to the producing flock of chickens instead of meat scrap or other high-protein feeds during the summer months. This reduces the cost and greatly stimulates production. Sheep and poultry are in charge of one man, who also cares for the orchard, which is just beginning to bear. Experimental work under way includes a comparison of the straw and ceiled loft; the feeding of fish versus milk versus meat scrap; the feeding of silage versus roots; the use of cement versus wood floor.

GENERAL DEVELOPMENT

At the close of 1920 the remaining timber resources of this station consisted of not more than three acres of brush and timber land and about twenty-five acres of open timber pasture that was sodded over and had been repeatedly culled. Twenty thousand feet of lumber was sawed in the spring of 1920 and about sixteen acres were cut off in the late fall, the brush was piled and burned, the poles and fence posts were piled and the logs skidded together, in readiness for the portable sawmill. With the completion of this job this particular piece of equipment will have completed its service, and one phase in the development of the farm will be closed. About six acres were stumped and broken in 1920 and a part of this was sown to winter grain. About sixteen acres were sown to clover and timothy and the farmstead was entirely cleared of stumps and the remnant of the old evergreen windbreak destroyed by fire. A new windbreak about the buildings was begun and the evergreen plantation along the river was replanted. This station now has a full hundred acres of plow land available for crop production.

DEVELOPMENT PLANS FOR 1921

Since the direction of the investigational and instructional end of the land-clearing service of the University has been centered at Duluth, the land-clearing and land-utilization projects now in operation at this station will be extended and duplicated at several points in northern Minnesota. New local projects peculiar to the fire zone will be started. The cost of clearing burned-over land will be featured, the general clearings extended, and the seeding of grass following the 1920 brushing will follow in the early spring. The physical plant will be improved and the building unit once more made complete by the re-erection of Institute Hall. The livestock and field-crop improvement service of this station to the people in the northeast counties will be continued through the distribution of purebred livestock and pedigreed seed. The continued policy of the Duluth station in the ninth year of its history will be systematized, progressive development.