The University of Minnesota

AGRICULTURAL EXPERIMENT STATION

REPORT OF NORTHEAST DEMONSTRATION FARM AND EXPERIMENT STATION DULUTH

1921

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† Appointed July 1, 1921.
‡ On leave, 1921-22.

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1921

M. J. THOMPSON, Superintendent

SEASON OF 1920

The winter of 1920-21 was the first in the history of the institution when it was possible continuously to operate trucks and automobiles between the farm and the city of Duluth. January, February, and March, except for occasional variations, were abnormally warm. In even greater degree than the two preceding summers, the summer of 1921 was abnormally hot and dry. The frost-free period extended from May 16 to October 10. As a consequence, corn, tomatoes, cucumbers, melons, pumpkins, and a variety of tender crops matured under almost all conditions. Fortunately, the drouth did not begin until the latter half of the growing season and occasional late rains made possible the harvest of a partial potato crop. Altho the heat reduced yields of potatoes and grain, the damage was less extensive than elsewhere in the state. One result of the high temperatures was to advance the season from ten to twenty days. Seeding began April 20. All planting of regular crops was completed by May 25. Haying was finished July 23, corn was silking by the middle of July, and the grain harvest was complete by August 1. There was an abundance of moisture until the middle of June, which saved the hay crop. The drouth of midsummer and early fall was almost an exact parallel of the historic season of 1918. November was colder than usual and the last half of December was the coldest period of the year. Minimum temperatures of 30 degrees below zero, Fahrenheit, were recorded December 20 and 21.

FIELD CROPS

Variety testing constitutes the most extensive experimental work with field crops at the Duluth station. The work is conducted under a five-year rotation plan with two years each in grain and grass and one in cultivated crops. Varieties are grown for three years unless extreme inferiority justifies excluding them after the second year. Three-year averages are now available in most instances.

Some very definite tendencies are in evidence with the varieties under test for three years. This station can not yet recommend the growing of spring wheat in the northeast counties. It does not fit in well with the system of agriculture, and rust and scab frequently exact a heavy toll. The heaving of the heavy clay soil prevailing in this district has made the culture of winter wheat somewhat uncertain.

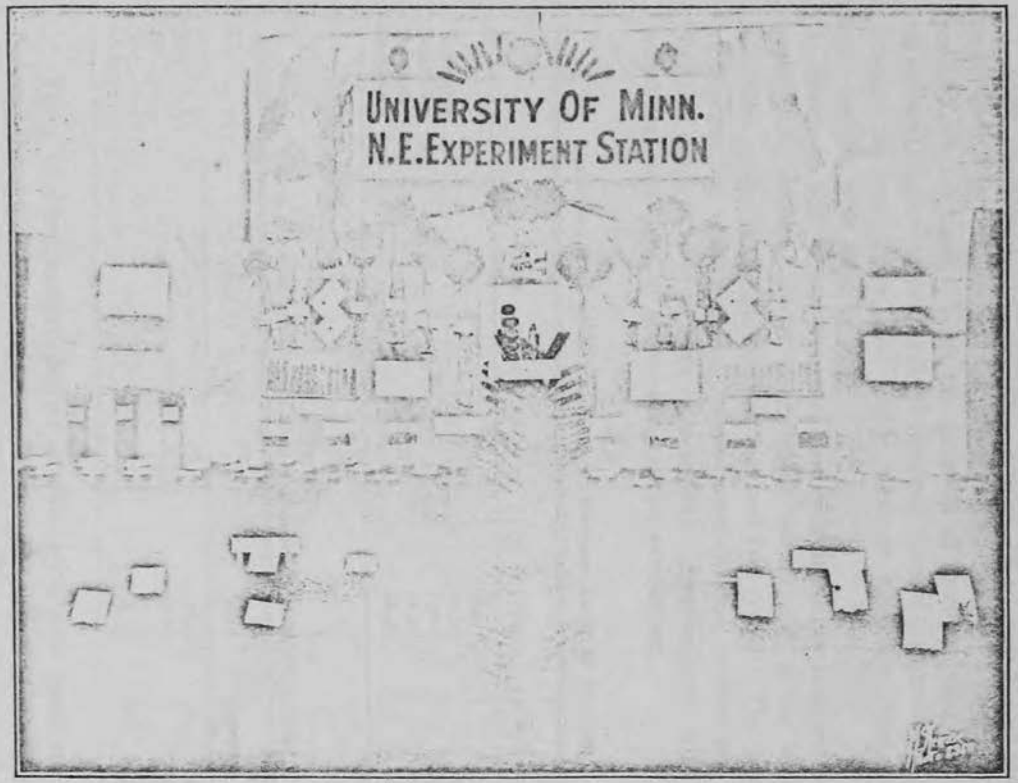

Fig. 1. Exhibit of Northeast Experiment Station at International Potato Show, Duluth, October 26-28 1921.

TABLE I

YIELD PER ACRE IN VARIETY TEST PLOTS

Crop	No.	Yield 1919	Yield 1920	Yield 1921	3-yr. av. yield
	Bu.	Bu.	Bu.	Bu.	Bu.
Wheat—					
Marquis	1239	18.79	15.16	16.65	16.86
Preston	924	13.82	17.12	15.24	15.39
Mindum	470	26.73	8.46	20.40	18.53
Kubanka	2194	20.37	10.96	16.62	15.98
Arnautka	2103	18.24	12.91	22.41	17.85
Acme	1967	....	10.95	17.77	14.36*
Emmer	1165	....	18.78	15.48	17.13*
Oats—					
Sixty Day	1-17-72	...	57.01	49.70	53.35*
Iowa	103	54.31	50.96	41.59	48.95
Iowar	670	....	58.88	56.15	57.56*
Garton	784	....	66.25	38.39	52.32*
Minota	512	48.25	70.50	46.98	55.24
Lincoln	505	47.69	73.45	44.41	55.17
Victory	514	50.11	75.29	56.80	60.73
Silver Mine	506	45.68	68.12	45.84	53.21
Irish Victor	358	40.93	76.08	41.83	52.95
Imp. Ligowa	281	46.18	77.73	41.26	55.06
Swedish Select	513	48.83	....	38.11	43.47*
Rye—					
Spring	61	32.00	21.98	12.93	22.30
Rosen	82	....	10.47	23.21	16.83*
Wis. Pedigree	84	....	13.90	21.73	17.36*
Swedish	2	....	14.72	22.69	18.70*
Barley—					
Imp. Manchuria	184	47.07	45.08	25.47	39.21
Lion X Manchuria	438	49.94	37.72	30.44	39.36
Minsturdi	439	42.64	40.08	29.04	37.25
Svansota	440	53.76	50.08	33.51	45.78
Fr. Chevalier	230	41.29	33.48	24.05	32.92
Manchuria	1-15-2	....	42.30	28.89	35.59*
Manchuria	1-16-66	....	39.29	32.21	35.75*
Beans—					
Brown Swedish	74	23.64	16.80	10.48	16.97
Snowflake	75	33.20	17.11	29.29	26.53
M. A. C. Robust	76	....	20.47	32.58	26.53*
Boston Favorite	77	21.40	14.66	14.11	16.72

* Two-year average.

Altho an early variety, Iowar, exceeds it slightly in yield, Improved Ligowa, or Minnesota No. 281, oats maintains its position as leader among the main crop varieties. It is perhaps more widely known than any other improved strain in the northeast counties.

Minnesota No. 184 barley, a six-rowed type, is becoming well established on several farms in the wooded region. Three years' results justify its growing popularity. The two-rowed Svansota, with a margin of nearly 6.5 bushels per acre over any competitor for a period of three years, is an extremely promising variety for the heavy clay soils of the cut-over country.

Two years' results do not indicate that Rosen rye is quite the equal of the old Minnesota No. 2 Swedish rye under northern conditions.

With a two-year average yield of 4 bushels per acre above Snowflake, M. A. C. Robust is the most promising navy bean grown to date, at Duluth.

After repeated discouragements, a small lot of squaw flint corn was matured in 1920. This was increased in 1921 so that a large supply of seed is now on hand. With the question of maturity now pretty well established, future efforts will be directed toward improvement in uniformity of type, color, and yield. Minsoy soybeans were matured here for the first time in 1921.

When to sow winter rye and just how much to sow per acre on heavy clay soil and under unfavorable winter and spring conditions has been under investigation for the last two years. The project is incomplete but results to date show some definite tendencies. No. 2 Swedish rye was used in both experiments. Similar work with winter wheat was destroyed by severe early spring conditions.

TABLE II

YIELDS PER ACRE OF WINTER RYE AT DIFFERENT DATES OF SEEDING

Date	1921	2-year average 1920-21)
	Bu.	Bu.
September 1	29.33	28.32
September 10	19.86	23.98
September 20	28.90	26.80
September 30	28.46	21.92

* Winter killed.

TABLE III

YIELDS PER ACRE OF WINTER RYE AT DIFFERENT RATES OF SEEDING

Rate	1921	2-year average (1920-21)
Lbs.	Bu.	Bu
70	26.23	19.60
84	27.22	20.98
98	26.40	22.20

There is a progressive decline in yield with later dates of seeding. Sowing dates should range from August 20 to September 20 in order to insure a vigorous fall stand in all years. The slight increase in yield secured with maximum seeding will hardly justify the practice.

ROUGHAGE CROPS

Alfalfa was very severely injured during the open winter of 1920-21, owing to the heaving action of the frost on the heavy clay soil. The hay crop was not above normal owing to the drouth of late June. Work was begun on the annual (Hubam) and the biennial white and

yellow sweet clovers. Crops were grown both broadcast and in cultivated rows. Grimm and Cossack alfalfa were sown in adjacent rows. Altho not sown until May 25, Hubam set a small amount of seed. This plant grows so rapidly in this latitude that the proportion of woody stem and branches is very high. Its superiority over the white and yellow biennial clovers is still to be proved. Hubam produced heavily in cultivated rows, reaching a height of six feet, but the other clovers developed a creeping habit and are easiest handled broadcast. Hubam produced a small quantity of silage, a use for which it offers great promise.

Fig. 2. Plant Sunflowers Early

The tall crop to the left of the boy was planted June 1; the crop to the right, June 15. Photo. July 31.

Three years' work has indicated that millets may be successfully grown in Northeast Minnesota if given proper soil conditions. But the crop should be limited in acreage and be used primarily as an emergency or annual forage crop. Proso, a grain millet, has exceeded all other types in production, with a yield of 4.17 tons per acre. Japanese, a variety of barnyard millet, with an average yield of 3.66 tons per acre, has produced equally as well as the commonly grown foxtail types. Siberian, Common, Golden, Hungarian, and German are standard varieties of foxtail millet, all of which have been grown at Duluth. Siberian, Hungarian, and German have produced equally well, with an average yield of 3.63 tons per acre. The average annual production of all millets was: 1918, 4.14 tons; 1919, 2.92 tons; 1921, 3.85 tons.

SILAGE CROPS IN 1921

Although small quantities of corn, rutabaga top, and sweet clover silage were produced in 1921, the main effort was concentrated on the sunflower plant. Four lines of work were under way. Considerable effort was spent upon a continuation of the improvement and development of a local early maturing strain. The first seeds were selected in 1919 and the first crop from home-grown seeds was grown in 1920. Both earliness and type were considered in 1921 selections. Fertilization was complete on the earliest heads and the blossoms were drying off the first of August.

Many farmers have a limited acreage of plow land, yet they should produce a silage crop for succulent feed for their increasing dairy herds. From necessity they must grow a maximum tonnage on a limited acreage. A project along this line was begun in 1921. Duplicate plots of sunflowers, with rows 30, 36, and 41 inches apart were grown.

Fig. 3. A Twenty-Ton Crop

Allow the sunflowers to ripen somewhat before cutting, and avoid hauling water to the silo.

TABLE IV

YIELD PER ACRE OF SUNFLOWERS PLANTED IN ROWS 30, 36 AND 42 INCHES APART

Series	30-inch rows	36-inch rows	42-inch rows
	Tons	Tons	Tons
1	15.625	14.877	13.99
2	12.90	12.92	12.885
Average	14.264	13.90	13.44

One year's work is admittedly inconclusive, but there is some indication of a slight improvement in yield under close planting. There is a decided advantage, however, in the quality of the silage for it lacks the coarse, woody, fibrous character of the more scattered plants.

The third project was concerned with date of seeding. This also is in its first year. The short season required for growing and the hardiness of the plant afford a wider range for planting than is possible with corn. Altho sunflower seed can probably be planted as late as July, it will be at the expense of the net yield of dry matter.

Fig. 4. Sunflowers in Full Bloom, Grown from Home Selected Seed. Photo August 1, 1921

Fig. 5. Flint Corn Well Eared and Silk Dry, July 31, 1921

TABLE V

YIELD PER ACRE OF SUNFLOWERS PLANTED MAY 18, JUNE 1, AND JUNE 15

Series	May 18	June 1	June 15
	Tons	Tons	Tons
1	16.20	15.48	12.29
2	19.58	17.07	19.58
3	22.27	17.82	16.06
Average	19.35	16.79	15.97

The margin in favor of seeding in the middle of May is very marked, but there is apparently little choice between June 1 and June 15. All seedings were sufficiently mature for silage but this probably would not hold true for much later seedings.

The fourth project begun in 1921 was a comparison of yields secured in growing the crop on spring-plowed and fall-plowed land. The fall-plowed land was top dressed during the winter and disked early in the spring. Manure was spread over the unplowed land and plowed under in the spring.

TABLE VI

YIELDS PER ACRE OF SUNFLOWERS ON FALL AND SPRING PLOWING

	Plot 1	Plot 2	Average
	Tons	Tons	Tons
Fall plowed.....	18.48	18.88	18.68
Spring plowed.....	18.48	15.00	16.74

Since the season was very dry the spring plowing, being less well compacted, dried out more readily with a resulting injury to production.

POTATOES

Altho the wet weather of May produced a broken stand and some decay, and some replanting was necessary, the total injury was much less than in 1920. Nevertheless the hot summer, which was abnormal for this latitude, materially reduced yields. This injury was increased by a lack of rain during the late summer. The following special potato projects were under way in 1921: Variety testing; seed treatment; level versus ridged cultivation; checked versus drilled culture; distance between rows. Fertilization work will be covered under "Soils."

TABLE VII

YIELDS OF POTATOES IN VARIETY TESTS, 1918, 1919, 1921

Variety	1918	1919	1921	3-year average
	Bu.	Bu.	Bu.	Bu.
Triumph	122	186	86.28	131.42
Early Ohio	129	265	215.10	203.00
Irish Cobbler	157	243	267.00	213.00
Green Mountain	184	318	227.70	243.20
Rural New Yorker.....	167	187	212.00	188.68
Russet	185	261	215.30	220.44
King	192	262	265.40	239.30
Burbank	190	304	218.50	237.50

The Green Mountain variety retains its supremacy in production. Late varieties apparently generally outyield early ones.

Of the early varieties, Irish Cobbler has a slight advantage over Early Ohio.

A seed-treatment project has been under way for several years. Untreated seed has been planted side by side with seed treated with corrosive sublimate, formalin, and copper sulfate. The crops harvested were all equally free from disease, but some unexpected differences in yield have been secured annually.

TABLE VIII

YIELDS PER ACRE OF MARKET POTATOES IN SEED TREATMENT PLOT, 1921

Plot	Corrosive sublimate	Formalin	Copper sulfate	Untreated
1	165.91			
2		208.0		
3			209.0	
4				227.3
5	244.7			
6		223.6		
7			222.7	
8				292.4
9	200.7			
10		251.1		
11			249.3	
12				268.8
Average 1921	203.8	227.6	227.0	262.8
3-yr. average	262.3	269.5	229.4	282.4

The yield from untreated seed exceeds that from the treated by a wide margin in each of the three years, and the copper sulfate plots were depressed two years out of three. Local conditions depressed the yield on one corrosive sublimate plot and this group may be considered as on a par with the formalin.

In regard to the yield secured from untreated seed, it must be remembered that in every case this seed was produced from treated seed of the year before, planted on clean land, and to this freedom from disease much of its high yield must be attributed.

A comparison of the value of ridging potatoes as contrasted with cultivating them level was begun in 1919 and continued through 1920 and 1921. Table IX covers three years' work.

TABLE IX

YIELDS PER ACRE OF MARKETABLE POTATOES GIVEN LEVEL AND RIDGED CULTIVATION

Plot	Level culture	Ridged culture
1	206.1	
2		229.3
3	242.2	
4		220.8
5	222.6	
6		198.5
Average, 1921	223.6	216.2
3-year average	251.6	250.4

This subject is frequently debated with some vigor. Evidently, under Duluth conditions, where moisture is usually abundant, but not excessive during the summer months, there is no material difference over a period of years, altho in two years out of three there has been a slight advantage in favor of level cultivation.

A new project, begun in 1921, involves a comparison of planting potatoes in drills and check rows. On very weedy land, sometimes on new land, or land newly plowed but not well subdued, it is advisable to plant in check rows in order to secure proper cultivation. This practice reduces the number of hills, but the larger production per hill will more or less balance this loss.

TABLE X

YIELDS PER ACRE OF POTATOES IN DRILLS VERSUS IN CHECKED ROWS

Plot	Drilled rows	Checked rows
	Bu.	Bu.
1		228.5
2	209.2	
3		260.5
4	222.6	
5		250.1
6	198.2	
Average	210.0	246.4

It is the usual practice at this station to plant potatoes in rows 3 feet apart, 16 inches apart in the row. The checked plot has just half as many hills as the drilled plot. Both lots produced extremely heavy foliage. This project will continue for at least two more years.

Another project of somewhat similar character was also begun in 1921. On the small clearings of the cut-over country farms it is very necessary to get maximum yields. This is especially true of potatoes, the cash crop. In view of this fact a project was carried through in which potatoes were grown in rows 30, 36, and 42 inches apart. The findings of 1921 are reported in Table XI.

TABLE XI

YIELDS PER ACRE OF POTATOES WITH ROWS AT VARYING DISTANCES

Plot	30 inches	36 inches	42 inches
	Bu.	Bu.	Bu.
1	261.3		
2		268.7	
3			223.0
4	309.4		
5		245.2	
6			190.8
Average	285.3	256.9	206.9

The margin in favor of close planting is very marked, but no conclusions can be drawn as yet. Rows could be run no closer without eliminating horse labor in tillage, thus increasing cost. Some work was done on growing potatoes on both spring and fall plowing. It will be reported when additional data are available.

CROP ROTATIONS

Crop rotation work, as a farm management study, has passed through its third year. It is primarily a study in cropping systems and farm practice, involving three-, four-, and five-year rotations in order to determine (1) which is best adapted to the labor situation of the northern farm; (2) which will best fit the livestock requirements; (3) which will produce the greatest amount of safe forage crops, and (4) which is the most economical in operation. The crops grown are barley, sunflowers, and clover-timothy hay. The only difference in the rotations is the number of years in hay—one, two, and three years, respectively, in the three-, four-, and five-year rotations. The three-year rotation has completed its first cycle. Manure is applied to the barley stubble at the rate of two tons per acre per year, that is, six, eight, and ten tons respectively to the three-, four-, and five-year rotations. The three-year rotation includes the first nine plots; the four-year rotation the following sixteen plots, and the five-year rotation the last twenty-five plots.

TABLE XII
YIELD PER ACRE OF BARLEY IN VARIOUS CROP ROTATIONS

Rotation	1919	1920	1921	3-yr. av.
	Bu.	Bu.	Bu.	Bu.
3-year	52.61	26.00	20.50	33.04
4-year	54.07	22.00	17.08	31.05
5-year	49.13	20.79	16.85	28.92

TABLE XIII
YIELDS PER ACRE OF HAY IN VARIOUS CROP ROTATIONS

Rotation	1920	1921	2-yr. av.
	Tons	Tons	Tons
3-year	2.65	1.75	2.20
4-year	2.67	1.45	2.06
5-year	3.14	1.36	2.25

Sunflowers have been grown experimentally in this work for one year only. The average production per acre on the three-, four-, and five-year rotations, respectively, was 15.65 tons, 11.72 tons, 13.69 tons. A progressive decline is noticeable in the yield of both barley and hay, in both cases due to unfavorable seasonal conditions, while 1919 was abnormally good. A wet spring followed by hot weather

injured the grain crop, and the deficient rainfall of middle and late June reduced the yield of hay. Three years' results with barley indicate a general plot average of 30.9 bushels per acre, and the two-year general average of hay was 2.17 tons per acre.

Different cultural methods are beginning to show some effect on yield. Both barley and hay show a progressive decline from the shorter to the longer rotation. The increased yields produced on the shorter rotation plots probably do not as yet compensate for the additional labor involved in plowing. Since fertilization was in uniform amounts, whatever increases are noted must be explained as due to more frequent tillage.

Fig. 6. Orchard in Full Bloom, June 1, 1921.

THE STATION ORCHARD

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

The small coöperative orchard set out in 1915, shared in the common attack from field mice during the season of 1920-21. The damage done was almost as severe as that of the previous winter, but the loss from winter-killing was very slight. Apples bloomed more abundantly than in any previous year, but the fruit was almost entirely destroyed by the last spring frost. Plums were not materially injured. Compass Cherry exceeded De Soto in production, but not in quality. All trees made excellent growth in 1921. Additional land was cleared to be thoroly tilled in 1922 and set to orchard trees in 1923.

SOIL FERTILITY INVESTIGATIONS

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

1. PHOSPHATE MANURE EXPERIMENTS

This project was begun in 1916. It has passed through two complete cycles of the rotation. Six crops of potatoes and rutabagas, five of oats, and four of hay have been harvested. One ton of rock phosphate per acre was applied to the indicated plots in 1916. The west half of all plots was treated with raw crushed limestone at the rate of three tons per acre at the same time. One hundred and sixty pounds of superphosphate per acre and 10 tons of manure are annually allotted to six and nine plots respectively as indicated. Manure is always spread over the grain stubble and the acid phosphate is put on just before or at the time of planting the cultivated crop.

TABLE XIV

YIELDS PER ACRE OF POTATOES IN PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1921		6-yr. average
		Marketable	Total	Marketable
		Bu.	Bu.	Bu.
1	Check	134.4	144.4	
2	Rock phosphate	172.7	181.8	
3	Rock phosphate and manure	175.7	181.2	
4	Manure	240.7	258.8	
5	Manure and acid phosphate	173.6	180.2	
6	Acid phosphate	193.2	201.6	
7	Check	161.9	172.5	
8	Rock phosphate	165.1	173.3	
9	Rock phosphate and manure	215.3	224.8	
10	Manure	178.2	188.1	
11	Manure and acid phosphate	167.2	179.0	
12	Acid phosphate	157.8	170.2	
13	Check	127.2	135.8	
14	Rock phosphate	153.3	164.2	
15	Rock phosphate and manure	182.0	189.3	
16	Manure	191.9	201.8	
17	Manure and acid phosphate	156.3	172.2	
18	Acid phosphate	138.8	157.5	
Averages				
1- 7-13	Checks	141.1	150.9	175.9
2- 8-14	Rock phosphate	163.7	173.0	185.5
3- 9-15	Rock phosphate and manure	191.0	198.4	203.0
4-10-16	Manure	203.6	216.2	195.8
5-11-17	Manure and acid phosphate	165.7	177.2	205.7
6-12-18	Acid phosphate	163.3	176.4	179.5

TABLE XV

YIELDS PER ACRE OF RUTABAGAS IN PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1921		6-year average	
		Roots	Tops	Roots	Tops
		Tons	Tons	Tons	Tons
1	Check	4.47	1.50		
2	Rock phosphate	5.88	1.33		
3	Rock phosphate and manure	6.41	1.66		
4	Manure	5.71	1.08		
5	Manure and acid phosphate	7.75	1.81		
6	Acid phosphate	7.93	2.63		
7	Check	9.98	3.29		
8	Rock phosphate	7.69	2.19		
9	Rock phosphate and manure	9.04	2.42		
10	Manure	6.53	1.83		
11	Manure and acid phosphate	8.00	2.16		
12	Acid phosphate	6.68	1.29		
13	Check	5.80	1.92		
14	Rock phosphate	7.81	1.70		
15	Rock phosphate and manure	8.45	2.85		
16	Manure	7.79	2.30		
17	Manure and acid phosphate	7.76	2.50		
18	Acid phosphate	3.72	1.49		
Averages					
1- 7-13	Checks	6.75	2.24	9.80	2.04
2- 8-14	Rock phosphate	7.12	1.74	10.76	3.12
3- 9-15	Rock phosphate and manure	7.97	2.31	11.73	3.21
4-10-16	Manure	6.66	1.74	12.40	3.35
5-11-17	Manure and acid phosphate	7.84	2.15	12.03	2.73
6-12-18	Acid phosphate	6.11	1.80	11.19	2.66

The potato plots that were manured produced 14.4 per cent more than the check plots. The rock phosphate and the acid phosphate plots each produced 11 per cent more than the check, over the six-year period. Altho these yields seem to indicate that manure and either rock or acid phosphate are both more effective when used together than when either is used alone, the manure is probably the more active agent of the two. There seems to be no material difference between the rock and acid phosphate after six years of trial. Altho some increase in production can be attributed to these fertilizers, it is very questionable if their cost will justify their use on potatoes.

Altho rutabagas have been grown for six years on this area, abundant yields were secured in 1916 and 1919 only, with a fair yield in 1920. Hot weather and plant lice cut the yield in two in 1921 as in 1917 and 1918.

Over a six-year period the rock phosphate, acid phosphate, and manure plots produced 14.8, 18.4, and 23 per cent, respectively, above the check plots. Potatoes maintain production more consistently on clover sod alone than do rutabagas. On the other hand, both manures and fertilizers show a greater influence on rutabaga production.

As the country is cleared, surplus water drains away, better air drainage occurs, the soil becomes warmer and drier, and crop production is affected. Livestock increases in numbers with this development, and for cheap and abundant production of the succulent feeds required, root crops must give way to silage.

TABLE XVI
YIELDS PER ACRE OF OATS IN PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1921		5-year average	
		Grain	Straw	Grain	Straw
		Bu.	Tons	Bu.	Tons
1	Check	37.0	0.66		
2	Rock phosphate	42.5	0.75		
3	Rock phosphate and manure	41.2	0.93		
4	Manure	43.7	0.82		
5	Manure and acid phosphate	42.8	0.77		
6	Acid phosphate	40.6	0.47		
7	Check	36.6	0.55		
8	Rock phosphate	42.0	0.55		
9	Rock phosphate and manure	42.7	0.67		
10	Manure	46.7	0.75		
11	Manure and acid phosphate	45.6	0.71		
12	Acid phosphate	38.7	0.61		
13	Check	41.2	0.67		
14	Rock phosphate	40.6	0.57		
15	Rock phosphate and manure	44.1	0.62		
16	Manure	40.9	0.76		
17	Manure and acid phosphate	40.9	0.95		
18	Acid phosphate	50.0	0.80		
Averages					
1- 7-13	Checks	38.3	0.63	48.9	0.92
2- 8-14	Rock phosphate	41.7	0.62	53.9	0.89
3- 9-15	Rock phosphate and manure	42.6	0.74	56.2	1.03
4-10-16	Manure	43.8	0.78	56.1	1.02
5-11-17	Manure and acid phosphate	43.1	0.81	58.2	1.07
6-12-18	Acid phosphate	43.1	0.63	57.1	1.05

Over a five-year period, manured plots produced 16.1 per cent; rock phosphate plots, 12.6 per cent; and acid phosphate plots 17.7 per cent in excess of the check plots. Altho the crop has been grown not less than two years after application, fertilization has produced an increase of from five to eight bushels per acre. Acid phosphate has no material advantage over manure. If a farmer has manure he is not justified in buying either of the phosphates, but, in its absence, should he buy either, five-year crop yields would indicate that acid phosphate would be the better investment.

This project is also valuable as a variety test. Improved Ligowa, Minnesota No. 281 oats, has been grown in this series throughout the five years. It also indicates what field production may be expected under the varying conditions of the five-year period. The average of all plots for five years is 55 bushels per acre.

The four-year general average yields may be taken as a fair indication of what may be expected in yields of hay over a period of time. The common assumption that two-ton production may be expected annually is unfounded, as occasional drouths are experienced. Manure is spread over the grain stubble the fall preceding the hay crop. On the average, the manured hay plots produced 17 per cent more hay than the unmanured, while those treated with phosphate exceeded the check by 14 per cent. It will be noted that there is little difference between rock and acid phosphate and neither has as yet justified the cost.

TABLE XVII
YIELD PER ACRE OF HAY, PHOSPHATE-MANURE EXPERIMENT

Plot	Treatment	1921	4-yr. average
		Tons	Tons
1	Check	1.45	
2	Rock phosphate	1.70	
3	Rock phosphate and manure	2.30	
4	Manure	2.20	
5	Manure and acid phosphate	1.80	
6	Acid phosphate	1.85	
7	Check	1.30	
8	Rock phosphate	1.05	
9	Rock phosphate and manure	1.43	
10	Manure	1.65	
11	Manure and acid phosphate	1.50	
12	Acid phosphate	1.30	
13	Check	1.00	
14	Rock phosphate	1.25	
15	Rock phosphate and manure	1.62	
16	Manure	1.50	
17	Manure and acid phosphate	1.55	
18	Acid phosphate	1.30	
Averages			
1- 7-13	Checks	1.25	1.63
2- 8-14	Rock phosphate	1.34	1.68
3- 9-15	Rock phosphate and manure	1.79	2.09
4-10-16	Manure	1.78	1.91
5-11-17	Manure and acid phosphate	1.62	1.93
6-12-18	Acid phosphate	1.48	1.76

CLOVER UTILIZATION EXPERIMENTS

The clover utilization project was begun in 1918. There are three ways of using the clover-timothy crop; (1) pasture it; (2) harvest the crop and feed the hay; (3) plow it under at time of maximum growth. In the present instance we are interested in the effect of each method on soil fertility and crop production. Six plots are sown to clover-timothy annually, using oats as a nurse crop. The following season two plots are pastured close; two are plowed under about July 1, and two are harvested. The following year a crop of potatoes and of sunflowers is grown, followed the second year by oats with grass seeding, thus beginning a new cycle of the rotation. Four years' work with potatoes, three with oats, and two with sunflowers have been completed.

TABLE XVIII

YIELDS PER ACRE OF POTATOES IN CLOVER UTILIZATION EXPERIMENT, 1921

Plot	Treatment	Market stock	Total stock	4-yr. av. Market stock
		Bu.	Bu.	Bu.
1	Pastured	144.3	151.6	
2	Plowed under	172.3	181.0	
3	Harvested	111.6	124.1	
4	Pastured	106.7	116.5	
5	Plowed under	115.7	127.7	
6	Harvested	76.9	91.3	
Averages				
1-4	Pastured	125.5	134.0	193.3
2-5	Plowed under	144.0	154.4	185.1
3-6	Harvested	94.2	107.7	165.2

TABLE XIX

YIELDS PER ACRE OF OATS IN CLOVER UTILIZATION EXPERIMENT, 1921

Plot	Treatment	Grain	Straw	3-year average	
				Grain	Straw
		Bu.	Tons		
1	Pastured	46.78	0.70		
2	Plowed under	49.44	0.72		
3	Harvested	49.91	0.78		
4	Pastured	52.41	0.81		
5	Plowed under	48.97	0.84		
6	Harvested	48.81	0.86		
Averages					
1-4	Pastured	49.49	0.75	54.3	0.98
2-5	Plowed under	49.20	0.78	52.6	0.99
3-6	Harvested	49.36	0.82	53.8	0.95

TABLE XX

YIELDS PER ACRE OF HAY IN CLOVER UTILIZATION EXPERIMENT, 1920-1921

Plot	Treatment	Yield	5-yr. average
		Tons	Tons
3	Harvested	0.86	
6	Harvested	1.05	
Average		0.95	1.49

TABLE XXI

YIELDS OF SUNFLOWERS IN CLOVER UTILIZATION EXPERIMENT, 1920-21

Plot	Treatment	1920	1921	2-yr. average
		Tons	Tons	Tons
1	Pastured	9.8	11.2	
2	Plowed under	11.8	12.5	
3	Harvested	11.9	10.0	
4	Pastured	11.4	10.9	
5	Plowed under	12.4	9.3	
6	Harvested	10.1	9.1	
Averages		10.6	11.0	
		12.1		
1-4	Pastured	10.6	11.0	10.8
2-5	Plowed under	12.1	10.9	11.5
3-6	Harvested	11.0	9.6	10.3

After four years' work it is becoming evident that removing the hay crop and returning nothing but the accumulated sod is expensive practice when it means declining yields. The hay crop of 1.5 tons harvested must not only equalize the loss of 8 bushels of oats, nearly 30 bushels of potatoes, and more than half a ton of silage when compared with the pasture plots, but the value of the pasture feed as well.

This pasture has a seasonal value of from $10 to $15 per acre.[1] The crop plowed under represents an immediate loss followed by several years of lower production. But the accumulated vegetable matter is beginning to influence the potato crop at least, altho the third oat crop does not as yet show an appreciable gain from this source.

ROTATION WITHOUT CLOVER OR MANURE

TABLE XXII
CROP YIELDS PER ACRE IN ROTATION WITHOUT CLOVER OR MANURE

Crop	Plot	1921	5-year average
		Bu.	Bu.
Barley	3	9.80	
	6	7.00	
	Average	8.40	8.0
Oats	1	31.09	
	4	24.22	
	Average	27.65	35.9
Potatoes, marketable stock	2	152.00	
	5	85.15	
	Average	118.57	125.9
Sunflowers	2	8.39	
	5	8.97	
	Average	8.68	7.9*

* Two-year average.

Some very interesting deductions may be drawn from this table. It shows what abuse will do to land and what happens when vegetable or animal matter is not added to build up the native fertility. Barley is practically a failure on new clay land in the absence of clover or manure somewhere in the rotation. Oats maintain a better yield than any other crop. Potatoes show a greater decline in quality than in quantity and sunflowers as a succulent feed produce more heavily than rutabagas over a period of several years.

Properly to measure the loss in crops and soil injury, a comparison should be drawn between the results of cropping without clover and manure as contrasted with production with one or both. This comparison is made in Table XXIII.

1 See Agr. Exp. Sta. Bul. 189, "Forced versus delayed systems of clearing land," pp 14-15.

TABLE XXIII
CROP YIELDS PER ACRE WITH AND WITHOUT CLOVER OR MANURE

Treatment	Potatoes	Rutabagas	Sunflowers	Oats	Barley
	Bu.	Tons	Tons	Bu.	Bu.
5-year average production on soil, new in 1915, in rotation since without clover or manure.....	125.9	5.30*	7.92†	35.9	8.0
6-year average production on soil, new in 1915, cropped and reinforced since with clover sod...	174.5	9.80	11.50†	48.9	‡
6-year average production on soil, virgin in 1915, reinforced since by both clover and manure.....	199.6	12.05	13.35†	56.8	30.9

* Three-year average.
† Two-year average.
‡ Barley not in this rotation.

When land is broken immediately after stumping and brushing a crop of potatoes 50 bushels smaller may be expected than if sod is plowed under. Top dressing this sod would add 25 bushels more. The loss of rutabagas would be from 4 to 7 tons, and of sunflowers from 4 to 6 tons. The loss in oats would range from 14 to 22 bushels and nearly 300 per cent less of barley would be harvested than if the new breaking was enriched by the top dressing of manure and a clover sod between the stumps in advance of stumping.

RATE OF MANURING

Limited quantities of manure are available on the average cut-over farm. To realize maximum returns the farmer must determine in what measure this shall be distributed and at what time in the rotation. This subject has been under investigation since 1917 at the Duluth station. The soil used was still a virgin clay, lying rather level. Twelve plots were laid off, numbered from 7 to 18. Plots 7 and 13 are checks; 8 and 14, 9 and 15, 10 and 16 are fertilized respectively with 5, 10, and 20 tons per acre applied to the oats stubble in a three-year rotation. Plots 11 and 17, 12 and 18 are fertilized respectively with 10 and 5 tons of manure per acre applied to the grass stubble on the rotation or just preceding the cultivated crop. Oats, clover-timothy, potatoes-sunflowers, constitute the rotation.

The two tables should be studied together. The increase in amount of manure applied has had little influence on potato yields. Twenty tons of manure per acre has produced practically the same number of bushels of potatoes over a four-year period as 10 tons. Altho 10 tons

of manure have been followed by a slightly greater gross production than 5 tons, the returns per acre per ton have been much greater with the smaller application. The manuring of the grass stubble directly in advance of the cultivated crop has been in progress but two years, hence potato plots 11, 12, 17, and 18, really check plots until 1920, can not yet be compared to the plots fertilized for four seasons.

TABLE XXIV

YIELDS PER ACRE OF POTATOES, RATE OF MANURING EXPERIMENT

Plot	Treatment	1921 Market stock	Total	4-yr. average Market stock
		Bu.	Bu.	Bu.
7	Check	91.0	101.1	
8	5 Tons per acre after oats	118.8	129.3	
9	10 Tons per acre after oats	146.9	163.9	
10	20 Tons per acre after oats	137.0	149.3	
11	10 Tons per acre after hay	154.8	160.2	
12	5 Tons per acre after hay	108.9	122.3	
13	Check	110.3	127.3	
14	5 Tons per acre after oats	152.1	164.5	
15	10 Tons per acre after oats	203.3	213.3	
16	20 Tons per acre after oats	185.8	195.1	
17	10 Tons per acre after hay	137.6	141.1	
18	5 Tons per acre after hay	163.1	176.9	
Averages				
7-13	Checks	100.7	114.2	132.2
8-14	5 Tons per acre after oats	135.5	146.9	155.7
9-15	10 Tons per acre after oats	175.1	188.6	165.2
10-16	20 Tons per acre after oats	161.4	172.2	164.8
11-17	10 Tons per acre after hay	146.2	150.6	
12-18	5 Tons per acre after hay	136.0	149.6	

TABLE XXV

YIELDS PER ACRE OF SUNFLOWERS, RATE OF MANURING EXPERIMENT

Plot	Treatment	1921	2-yr. average
		Tons	Tons
7	Check	9.57	
8	5 Tons per acre after oats	12.29	
9	10 tons per acre after oats	15.34	
10	20 Tons per acre after oats	14.85	
11	10 Tons per acre after hay	15.84	
12	5 Tons per acre after hay	12.37	
13	Check	9.98	
14	5 Tons per acre after oats	11.96	
15	10 Tons per acre after oats	12.62	
16	20 Tons per acre after oats	14.35	
17	10 Tons per acre after oats	12.34	
18	5 Tons per acre after oats	12.04	
Averages			
7-13	Checks	9.77	8.44
8-14	5 Tons per acre after oats	12.12	9.36
9-15	10 Tons per acre after oats	13.98	11.40
10-16	20 Tons per acre after oats	14.55	11.12
11-17	10 Tons per acre after hay	14.09	
12-18	5 Tons per acre after hay	12.20	

Sunflowers react quite readily to manure as a fertilizer. In the 1921 crop, which was normal, a gradual increase is to be noticed of from none to 20 tons per acre. The two-year average is less regular, as the 1920 crop lacked uniformity because of surplus rainfall. As with potatoes, the increased production with 20 tons per acre is much less than

TABLE XXVI
YIELDS PER ACRE OF OATS, RATE OF MANURING EXPERIMENT

Plot		1921		4-year average	
		Grain	Straw	Grain	Straw
		Bu.	Tons	Bu.	Tons
7	Check	27.2	0.41		
8	5 Tons per acre after oats	30.0	0.48		
9	10 Tons per acre after oats	32.3	0.48		
10	20 Tons per acre after oats	41.6	0.72		
11	10 Tons per acre after hay	38.6	0.66		
12	5 Tons per acre after hay	32.8	0.64		
13	Check	24.1	0.75		
14	5 Tons per acre after oats	35.1	0.55		
15	10 Tons per acre after oats	35.4	0.53		
16	20 Tons per acre after oats	43.0	0.71		
17	10 Tons per acre after hay	45.5	0.39		
18	5 Tons per acre after hay	37.1	0.62		
Average					
7-13	Checks	25.6	0.58	42.8	0.87
8-14	5 Tons per acre after oats	32.5	0.52	43.4	0.88
9-15	10 Tons per acre after oats	33.8	0.51	45.9	1.00
10-16	20 Tons per acre after oats	42.3	0.71	52.8	1.05
11-17	10 Tons per acre after hay	42.0	0.52	48.0	....
12-18	5 Tons per acre after hay	34.9	0.63	44.0	....

TABLE XXVII
YIELDS PER ACRE OF HAY, RATE OF MANURING EXPERIMENT

Plot	Treatment	1921	3-yr. average
		Tons	Tons
7	Check	1.35	
8	5 Tons per acre after oats	1.35	
9	10 Tons per acre after oats	1.25	
10	20 Tons per acre after oats	1.55	
11	10 Tons per acre after hay	1.25	
12	5 Tons per acre after hay	1.28	
13	Check	1.10	
14	5 Tons per acre after oats	1.07	
15	10 Tons per acre after oats	1.41	
16	20 Tons per acre after oats	1.40	
17	10 Tons per acre after hay	1.25	
18	5 Tons per acre after hay	1.40	
Averages			
7-13	Checks	1.22	1.53
8-14	5 Tons per acre after oats	1.21	1.70
9-15	10 Tons per acre after oats	1.33	2.06
10-16	20 Tons per acre after oats	1.47	2.13
11-17	10 Tons per acre after hay	1.25	1.73
12-18	5 Tons per acre after hay	1.34	1.74

the increase from 5 to 10 tons, and the 5 tons produced the greatest sunflower tonnage per ton of manure applied. So far the manure applied to the grain stubble has produced as large a return as that distributed on the grass stubble just before the cultivated crop.

The oats and hay crops are closely associated in this work and will be discussed together. Five tons of manure produced an increase of less than 2 per cent, 10 tons an increase of 7.2 per cent, and 20 tons an increase of 23.5 per cent over the unfertilized check plot of oats.

Unlike potatoes and sunflowers, the 20-ton applications of manure make the most striking showing not only in 1921 but in the four-year period as well. This may partly be due to the fact that since two years intervene between the spread of the manure and the oat crop, the heavy applications still stimulate production while the lighter ones have lost their productive power. On the last two plots of each series, only one year has intervened between fertilization and crop. The 10- and 5-ton lots are about equally as effective, respectively, in terms of bushels of oats produced as the 20- and 10-ton lots distributed two years in advance. The hay crop shows a gradual and progressive increase with larger allowances of manure from none to 20 tons per acre. Five tons show an excess of 9 per cent; 10 tons, 31.6 per cent; and 20 tons, 34.8 per cent over and above the yield of the check plots. The hay crop received the first stimulus from the manure on the first four plots of each series, but where the manure just precedes the cultivated crop, two years intervene and the grass crop is the last to be benefited. The results are not yet conclusive, as this practice did not begin until 1920.

FERTILITY OF BURNED VIRGIN MINERAL SOIL

In 1920 a tract containing 6 tenth-acre plots was selected on virgin mineral soil that had been severely burned in the forest fire of 1918, with the object of determining what effect, if any, this fire had on the productive power of the soil. A second tract was established in 1921, and the first was maintained through a second year. The year 1920 was very favorable for grains, but as 1921 was very hot, the farm yields of oats and barley ranged from 50 to 75 per cent of normal, not only on this group of plots but over the entire farm. Potatoes, with a production of not quite 100 bushels per acre yielded true to form on new land with hot, dry summer conditions. Silage production was up to the farm average, and the clover-timothy hay crop closely approached it.

Careful observations over a two-year period would seem to indicate that the first year's crop on severely burned mineral soil is subnormal except in the case of sunflowers, but the second year's crop is about

normal with the possible exception of potatoes. The additional tillage may account for these results. Sunflowers produced remarkably well. On the well drained upland where the "burn" was heaviest, grass made the best "catch."

DELAYED CLEARING PLOTS

By "delayed clearing" is meant removing brush and timber, the forest growth, from a tract of land, seeding between the stumps, pasturing for a series of years, and then stumping. It is organized, systematized, seasonal, land clearing. The impression is growing that land that is broken and cropped after such handling will produce better than virgin land that has been brushed, stumped, and broken all in one season and put into crop at once, without any interval for pasturing and accumulation of a grass sod. This project, a comparative study, was begun in 1920 in order to measure results under both practises.

TABLE XXVIII
CROP PRODUCTION ON DELAYED CLEARING PLOTS

Plot	1921		2-year average	
	Oats	Sunflowers	Oats	Sunflowers
	Bu.	Tons	Bu.	Tons
1	38.3	....		
4	34.9	....		
3	....	9.98		
6	....	9.06		
Averages	36.6	9.52	48.7	9.15

But one crop of barley has been grown. It was reported in 1920. Hay and potatoes were both grown in 1921.

A comparison has already been drawn between crop production without clover or manure, with clover only, and with both clover and manure.

The next table involves a discussion of the handling of new or virgin land under three heads: (1) Unburned, cleared, cropped at once; (2) Severely burned land, cleared and cropped at once; (3) Unburned land, pastured for a period in advance of stumping and cropping and reinforced by a clover sod.

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

Treatment	Oats	Sunflowers
	Bu.	Tons
Upland soil, burned severely October 12, 1918, 2-year average..	25.5	8.92
Unburned land, broken in 1915, cropped since without clover or manure, 6-year average.....	35.9	7.91
Delayed clearing land, unburned land reinforced by clover-grass sod, 2-year average.....	48.7	9.10

The second year oat crop on the burned land was so severely injured by cattle that broke through the fence that it was of necessity discarded. It looked equal to any oat field on the farm. But for the loss of this crop the oat crop on burned land would doubtless exceed that on the land without clover or manure. Sunflower production was good. A two-year comparison of hay and potatoes under the three conditions will be available in 1922.

At the close of the second year the delayed clearing plots are distinctly more productive than any group of new-land plots handled otherwise. The burned upland soil is almost normal in production and already exceeds in yielding power the unburned land whose vitality has been lowered by continued cropping without clover or manure.

In summarizing soil fertility data for 1921, it is evident that neither rock phosphate nor acid phosphate has as yet afforded sufficient increase to justify its purchase. Pasturing off the clover crop is still the most efficient disposal of it from the soil fertility viewpoint. Smaller applications of manure are more efficient than larger ones and produce almost as large a gross tonnage.

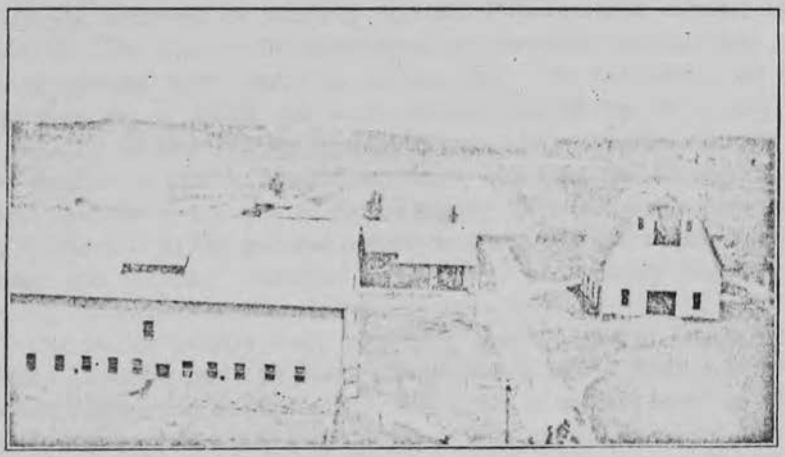

Fig. 7. Barn Group from Top of Windmill, with Plots and Poultry Plant to North

GRAZING

For six years records have been kept on the summer feeding of young stock on continuous pasture in order to learn what returns may be expected from exclusive grass feeding. An open shed is provided for shelter from the flies and the cold rains of spring and fall. The stock does not leave the pasture through the entire season. Ten head were on pasture part time and eight full time in 1921. The pasture feeding period began May 25 and closed November 2, a total of 161

TABLE XXX
GAINS AND MAINTENANCE OF HEIFERS ON GRASS, SIX-YEAR PERIOD

Year	Continuous pasture began	Continuous pasture ended	Total days	No. of cattle	Average age of cattle	Average total gain	Average daily gain
					Mo.	Lbs.	Lbs.
1916	June 12	October 17	103.6	10	17.2	161.6	1.56
1917	June 1	October 17	138.0	..	....	74.0	0.53
1918	June 1	October 18	128.0	6	19.0	175.0	1.36
1919	June 3	October 27	146.0	8	10.5	172.0	1.18
1920	May 25	October 27	155.0	9	15.5	168.0	1.08
1921	May 25	November 2	161.0	8	15.0	162.0	0.98
Average	June 1	October 21	138.6	8	15.4	152.0	1.10

days, the longest continuous day and night pasture period in six years. Day pasture only was continued from November 2 until December 1.

The day-night pasture season lacks only ten days of a full five months. During this time yearlings have made a gross gain of 150 pounds, or 1.1 pounds per day. To this must be added the later fall

Fig. 8. Sheep Are Prolific in the Cut over Country

gains made on day pasture only. This period extends from October 21 into late November and sometimes to the middle of December.

LIVESTOCK AND POULTRY

Twelve grade Hampshire ewes, purchased in the fall of 1919, increased to a flock of 36 by the spring of 1921. The increase in 1921 was 125 per cent. The practise of moving the stock from one brush pasture to a second, and a third, inaugurated in 1920, was continued. As a consequence, the second growth is practically cleaned up after the second year and the grass seeding has started well. It is a serious mistake to allow sheep free range over a large area if brush is to be killed. By stretching a couple of cross fences or making hurdle fences out of cheap lumber or even from slabs, one pasture may be divided into several rotation pastures, the sheep will have fresher feeding, they will keep in better condition and the brush will be disposed of to better advantage. The ram lambs, sold on the holiday market, averaged more than 80 pounds and brought $7.55 each. They received no hay, tame grass, or grain.

The dairy herd of grade and purebred Guernseys is being continuously improved by breeding and the elimination of inferior individuals. The aim is a high standard of production secured under as nearly normal farm conditions as possible. The herdsman and one half-time helper during the winter months handle the dairy and the hogs. Six of the milking herd of twenty are purebreds. A part of the produce is sold to retail distributors who take the product at the farm, and the rest is sold to the creamery. A considerable percentage of the herd is in the 300-400 pound class and two individuals average about 400 pounds. Purebred male calves are readily disposed of among the settlers in the adjacent counties.

The station poultry flock, consisting roughly of 250 Single Comb White Leghorns and 150 Single Comb Rhode Island Reds, was never in better condition, owing to rigid culling, use of mature breeding stock, and purchase of males from high producing strains. The surplus breeding stock and hatching eggs find a ready market in the northeast counties. Large quantities of buttermilk are fed during the milder portions of the year as a cheap source of protein and to sustain and prolong the egg-laying period. No experimental work is under way at this time.

LAND CLEARING OPERATIONS IN 1921

Three land clearing projects were in effect during the winter of 1920-21 and the following summer:

(1) Effect of brush removal at different seasons of the year.

(2) Effect of the forest fire upon cost of clearing

(a) Standing brush and timber
(b) Stumpage.

In this discussion summaries only will be given, since a special bulletin will be issued, dealing with the entire subject of fire in relation to land clearing. Brush should be cut at that season of the year when the likelihood of a second growth is most remote. In this instance four tracts were measured off and one each cut in August, September, October, and November. Careful observations made the following spring and summer disclosed no material difference in the amount of second growth. The old notion that August is the best and only month for cutting brush was not borne out.

Fig. 9. Well-Decked Pile

The information relating to the effect of the forest fire on cost of clearing can best be offered in tabular form. In so far as brushing and logging are concerned, the comparison is a direct one between clearing the green forest growth before the fire and removing it after being killed by fire. The first tracts were brushed and logged in 1914 and 1915 and the second tracts after the fire in 1919 and 1920.

TABLE XXXI

EFFECT OF FIRE ON LAND CLEARING COSTS IN TERMS OF LABOR AND MATERIAL UNITS OF COST

Item	Before fire	After fire
Brushing, logging, brush burning, man hours.....	153.63	119.40
Stump removal, man hours.....	90.33	54.88
Horse hours.....	114.60	48.50
Pounds dynamite.....	128.75	37.91

Different prices existed for both labor and material in 1914, 1918, and 1921. The only way to compare costs of the several operations for both before and after the fire is to establish a uniform or average price which will be an average of the prices paid during these different years. This gives an average of 23 cents per hour for man labor; 11.5 cents per hour for horse labor; 16 cents per pound for dynamite. Applying these unit prices we have an average cost of clearing of $61.70 per acre before the fire, and $26.55 after the fire. The reduction or saving amounted to 57 per cent, which may be directly credited to the fire.

Four sets of conditions existed. The "before fire" figures are an average for green and ripe or dead stumps. The "after fire" data are an average for ripe stumps burned over, and for stumpage green until killed by the fire. The saving in brushing costs is 22 per cent, owing to the removal of much small debris by the fire. The saving in man labor is 38 per cent; in horse labor, 57 per cent; in amount of dynamite used, 70 per cent.

GENERAL DEVELOPMENT OF THE STATION PLANT

The long season, reduced labor costs, and lower prices for material together with the help of an experienced staff, all combined to make 1921 an outstanding year in the development of the physical plant. The last heavy brush and timber growth was harvested in the late fall and all remaining dead timber of any kind will follow before April 1, 1922. About thirty-two acres were stumped during the June and October land-clearing periods, and all this land will be ready for breaking in the early spring. Stump land seeding was continued. Nearly a carload of tile was placed in October, thus completing the underdrainage of the main experimental area. Institute Hall was rebuilt and will be dedicated on Washington's birthday, 1922. A greatly needed icehouse and two wings to the seedhouse to be used as garages were built in November. The main farm buildings were badly scorched by the fire and all were repainted in October. Windbreak work was extended and ground is being prepared for a new orchard in a protected location to be set in the spring of 1923. The ninth birthday of the institution will be celebrated April 1, 1922.

SUMMARY

1. The winter of 1920-21 and the summer of 1921 were the warmest on record at the Northeast Experiment Station.

2. Minnesota No. 281, Improved Ligowa oats, Minnesota No. 2 Swedish rye, Minnesota No. 184 Manchuria (six-rowed) barley, M. A. C. Robust navy bean are standard field crop varieties for the heavy soil in northeast Minnesota.

3. Svansota, a two-rowed barley, exceeds all other varieties in yield, by 6.5 bushels per acre over a three-year period.

4. Corn, soybeans, and sunflowers have been acclimated and now mature seed at this station.

5. In sowing winter rye on heavy woodland soils, sow not less than 1.5 bushels per acre not later than September 15.

6. Sweet clover makes good silage.

7. Millets have been grown for three years. During this time they have averaged 3.65 tons per acre.

8. A native strain of sunflowers has been developed. Close planting of rows improved both quality and yield. The middle of May proved the best time to plant. Fall plowing produced greater tonnage than spring plowing.

9. Green Mountain potatoes lead the eight standard varieties over a three-year period.

10. Untreated potato seed produced heaviest, and seed treated with copper sulfate produced least in a three-year test.

11. Potatoes given level and ridged culture produced equally well over a three-year period.

12. Highest yields of potatoes were secured with rows 30 inches apart.

13. Crop yields are heaviest in three-year rotations, growing lighter in the four-year, and still more so in the five-year rotations.

14. Manured plots produced 14.4 per cent and phosphate 11 per cent more potatoes than the untreated check plots over a six-year period.

15. Manured plots produced 23 per cent, acid phosphate plots 18.4 per cent, and rock phosphate plots 13.7 per cent more rutabagas than the check plots for six years.

16. Manured plots produced 16.1 per cent, acid phosphate plots 17.7 per cent, and rock phosphate plots 12.6 per cent more oats than the check plots for the six-year period.

17. Manured plots produced 17 per cent, and phosphate plots 14 per cent more hay than the check plots over a four-year period.

18. To maintain soil fertiliity it is better practice to pasture the clover crop than to plow it under or harvest it.

19. The farmer that crops continually without clover or manure

loses annually on the average 61 bushels of potatoes per year; 5.6 tons of sunflowers; 18 bushels of oats; 23 bushels of barley per acre.

20. From five to ten tons of manure per acre has proved the most economical application for potatoes and sunflowers.

21. Twenty tons of manure increased the oat crop 23.5 per cent; ten tons, 7.2 per cent; and five tons, 2 per cent, altho put on the ground two years in advance of the crop of oats.

22. Ten tons of manure produced an increase of 31.6 per cent in hay yields, and 20 tons 34.5 per cent. Manure was applied the fall before the crop was grown. Ten tons was most efficient.

23. Crops on delayed clearing plots surpassed production of all competitive new or virgin soil plots.

24. The second year's crop on burned upland soil is approaching normal for new land, with sunflowers fully normal.

25. For a six-year period young stock have averaged a seasonal gain of 152 pounds, a daily gain of 1.1 pounds, and a day-night pasture period of nearly 140 days (161 in 1921).

26. The increase in lambs in 1921 was 125 per cent. Spring lambs, brush fed, brought $7.55 each on the holiday market.

27. Brushing seemed to be equally effective as regards killing second growth whether done in August, September, October, or November.

28. Burned land was brushed at a saving of 22 per cent; stumped at an average saving of 57 per cent, less than like charges on unburned land.