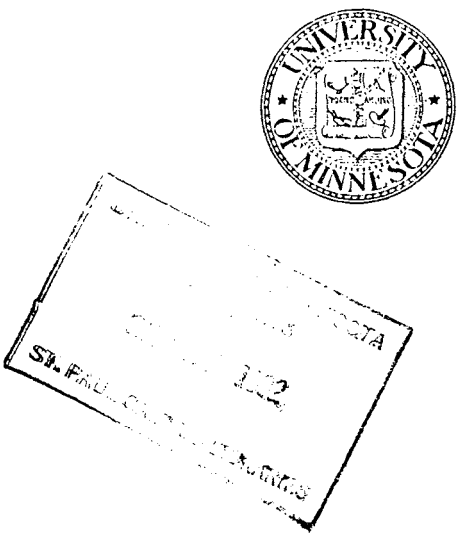
University of Minnesota

AGRICULTURAL EXPERIMENT STATION

REPORT OF
NORTHEAST EXPERIMENT STATION
DULUTH

1926 AND 1927

M. J. THOMPSON, Superintendent



UNIVERSITY FARM, ST. PAUL

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Introduction

This publication contains a summary of all enterprises of the Northeast Experiment Station for the years 1926 and 1927. It is devoted primarily to details of the experimental work in progress, some of which has been carried on for ten or more years.[1] The data presented are a direct continuation of those in the 1924-25 report. There has been included an 11-month study of horse management under northern conditions, covering a detailed report of feed consumption and labor output, for 1923. A report of the co-operative tests in grain production and the use of fertilizer on Iron Range farms, financed by the St. Louis County Club, is included; also results of the Lake County projects. This is the twelfth publication issued by the station since its organization in 1913.

The Weather

The winter of 1925-26 might be considered as rather open, deficient in snowfall and moderate in temperature after the holidays. That of 1926-27 closed with much snow. There have been four consecutive rough Decembers, 1924-27. The growing season of 1926 opened dry and closed wet. The year 1927 reversed this order. November, 1925, was mild; December was stormy and cold, with snow, but it was possible to saw stump wood until the 18th. Christmas Day was very cold. The post-holiday period was mild and open with one heavy snow in late March. Frost penetrated deep because of scant snow covering, and left the ground slowly, thus keeping the surface moist and compensating for the deficient rainfall of early spring and summer. Early seeding, dry seedbeds, fine hay weather, was the seasonal order for 1926, followed by wet weather after August. Grain sprouted in the shock, threshing was delayed until October on many farms, and in late September it was necessary to break the ice in field depressions when gathering silage bundles. It was the third consecutive disagreeable October. November was severe and December cold, with snow.

Steady winter temperatures continued to February 22, 1927, when the thaw began. March was mild and April not severe. The spring was very wet, with some seeding on poorly prepared fields delayed until June. With few breaks, the weather was good through the haying sea-

[1] The following persons assisted in carrying on the station projects: Herman Landre, farm foreman; Herman Meyer, plotman; James Morse and Alvin Stinson, herdsmen; James McIntyre, shepherd; Gladys Landre, poultry woman; Sigfrid Monson, consulting poultryman

son and until November 10. The ground froze early. Late November and most of December were very cold and marked by two hard storms and heavy snows. Temperatures of 20 degrees below zero occurred several times.

There is a strong relation between temperature, rainfall, and crop production. In Table I are presented the weather factors of the seven growing months of 1926 and 1927 and the seasonal influence upon staple crops.

TABLE I

METEOROLOGICAL DATA, SUMMERS OF 1926 AND 1927

Month	Temperature							Rainfall		
	Maximum		Minimum		Mean		Normal			
	1926	1927	1926	1927	1926	1927		1926	1927	Normal
	deg.	deg.	deg.	deg.	deg.	deg.	deg.	in.	in.	in.
April	74	74	8	21	37	39	37	0.48	3.07	2.14
May	84	74	21	33	49	44	47	1.49	3.26	3.47
June	92	89	39	35	57	56	57	3.93	4.04	4.53
July	90	83	43	44	63	62	63.9	1.84	5.00	3.65
August	90	80	49	42	63	60	62.6	3.60	2.59	3.53
September	74	82	25	32	50	57	55.1	5.51	3.36	3.55
October	70	74	18	26	40	46	44.1	2.81	0.91	2.74
Mean Av. temperature	..	..	..	..	51.6	52.2	52.5	...	...	...
Total precipitation	..	..	..	..	...	...	...	19.66	22.23	23.61

In 1926 the weather was extremely dry in the spring and very wet in the fall. In 1927 conditions were reversed—the spring months were extremely wet and the fall months were dry. The year 1927 was a trifle warmer than 1926 and both were deficient in moisture as well as in heat. The summer of 1926 was marked by frost in June and August, with killing temperatures and ice in late September.

A dry spring with superior seedbeds and early seeding usually means good yields of grain and potatoes, but light cuttings of hay. In 1926, the heaviest tonnage of potatoes in the history of the station was harvested. Acre yields were much like those of 1923. Early-seeded oats on productive land yielded well, but green plant lice severely reduced the yield of crops sown late or on poor soils. The late June rains, so providential in a dry season, as usual produced a normal hay tonnage; and a dry July insured a grain harvest of fair quality. The spring of 1927 was very wet. A wet spring usually means a good crop of hay, and inferior crops of grain and potatoes. This, again, largely held true. Yields of clover and timothy, especially clover, ranked with those of our best years—were comparable to the crop of 1922. But the favorable growing season and the late fall frost did not counteract the handicaps of poor seedbeds and late planting of potatoes, followed by late blight. Late oat plantings on muddy, sticky fields resulted in stands of low vitality, and rust took a heavy toll. Both were good barley years. The

season of 1926 was better for apples than that of 1927. Both years were poor for cultivated silage crops, 1927 decidedly so, but the warm September saved the sunflower crop, improved potatoes, and ripened grains. As in 1924, harvests were late, as compared to those of the early Twenties.

General View—Barn Group

AGRONOMY

In co-operation with the Division of Farm Management, Agronomy, and Plant Genetics

Grain Crops

Field crop variety testing, conducted on a given field and under a rotation plan, has now been carried on for nine years. Varieties that have been discontinued or that have been grown less than two years are not reported. Test plots are one-fortieth acre in size, and each variety is grown in triplicate. Findings at Duluth have been checked on the sandy loam near Biwabik and Eveleth, on the clay loam at Chisholm and Virginia, on the Mesaba Iron Range, and on hardwood soil in the Little Fork Valley, at Meadowbrook.

The falls of both 1925 and 1926 were very wet at the time for planting fall grains. In 1927 seeding was delayed until the middle of October. As a consequence the rye and winter wheat crops of both years were extremely light, wheat being practically a failure. Winter wheat must be sown by September 1 and winter rye by September 15 in this latitude to obtain normal yields. The wet fall of 1926 was disastrous for wheat. Tho heavy, much of it was so badly spoiled that it was not threshed. The wet spring of 1927 delayed seeding, and packed sticky seedbeds reduced the crop. The 3-year average yields indicate the relative behavior of varieties for a reasonable period. The production of Progress wheat is marked. It is being generally grown for poultry feed throughout northeastern Minnesota.

TABLE II
YIELDS PER ACRE IN VARIETY TRIALS OF CEREAL CROPS

Crop and variety	Minn. No.	1926	1927	Years in test	3-yr. av.	7-yr. av.
Wheat:		bu.	bu.		bu.	bu.
Marquis	1239	16.4	00	8	15.36	16.03
Mindum	470	18.8	00	8	14.83	16.47
Kota	2151	18.0	13.1	7	14.43	15.07
Marquillo	2202	17.5	19.7	4	16.33	....
Java	2206	16.7	19.4	5	15.86	....
Progress	2225	25.1	24.1	3	21.03	....
Ceres	2223	18.0	18.8	3	16.33	....
Oats:						
Gopher	674	61.7	36.3	4	48.33	....
Minota	512	57.9	47.7	9	53.1	....
Victory	514	54.2	34.2	9	45.6	....
Liberty Hull-less	676	63.0	34.7	3	50.7	....
Anthony	686	45.3	67.4	4	57.0	....
Minota × White Russian	687	55.6	64.2	3	61.32	....
" " "	689	57.9	67.4	3	61.34	....
" " "	690	60.7	64.5	3	61.13	....
" " "	692	67.9	45.4	2	....	....
" " "	693	60.7	55.5	2	....	....
" " "	694	62.7	66.6	2	....	....
Swenson	...	...	35.5	1	....	....
Rye:						
Swedish	2	20.0	17.7	8	17.46	19.94
Midsommerog	87	18.7	20.6	2	....	....
Colorless Selection	90	16.4	21.5	2	....	....
Barley:						
Imp. Manchuria	184	43.2	51.8	9	35.46	34.57
Svansota	440	40.5	41.9	9	37.68	35.36
Glabron	445	45.1	59.0	2	....	....
Velvet	447	45.6	60.2	6	44.0	....
Trebi	448	50.9	65.1	5	50.7	....
Manchuria × Smooth Awn	457	46.0	54.2	2	....	....
" " "	458	48.5	51.5	2	....	....
Comfort	451	50.4	...	3	42.76	....

The four high yielding and rust-resistant late oat crosses given out by the plant breeding nursery are Nos. 686, 687, 689, and 690. These selections are so new that only the first has been named. The hull-less oat under test is the first to ripen at the Duluth station. It is valued for poultry and hog feed. It heats readily when moist, so requires care after threshing.

Both seasons have been good for barley. Svansota, the two-rowed variety, still holds the long-time production record. Trebi is a consistently heavy producer, but it has a handicap in short straw. The four high-yielding barley varieties at Duluth over a 6-year period are Velvet, Minn. No. 184, Svansota, and Minsturdi, with Velvet leading. Some flax was grown in both seasons. The fall of 1926 was so unfavorable that some commercial fields were not harvested or threshed until March, 1927.

Five additional projects in the culture of standard cereals were carried through each year. Of first importance was the date-of-seeding test. Oats were sown at two-week intervals beginning May 1. The 1926 yields were 44 bushels for May 1 seeding, and only 13.25 bushels for May 15 seeding. Plant lice took this and later crops. The corresponding returns for 1927 were 36.19 and 32.57 bushels respectively. Later seedings of both years were so spotted that all yields were discarded. The plant lice in 1926 and the rust in 1927 taught the value of seeding as early as possible. Barley sown on May 1, 1926, averaged 35.83 bushels per acre; sown on May 15, it averaged 36.27 bushels. The early June seeding produced 27.5 bushels per acre. The 1927 yields for May 12, May 27, June 12, and June 27 were respectively: 29.14, 33.7, 13.96, and 9.4 bushels. Judging from the yields for these two years, June seeding is markedly less satisfactory than May seeding.

Rate-of-seeding tests were much better defined. The findings of the two seasons are presented in tabular form, all tests being in triplicate.

TABLE III

YIELDS PER ACRE OF OATS AND BARLEY IN RATE-OF-SEEDING TESTS

Crop	Seeding rate	1926	1927	Average
	bu.	bu.	bu.	bu.
Oats	2	59.23	34.51	46.87
"	2½	63.79	34.83	49.31
"	3	64.80	41.15	52.97
Barley	2	30.12	31.70	30.91
"	2½	31.75	32.84	32.3
"	3	31.16	36.66	33.91

In both seasons a study was made of depth of seeding of oats; the second year, of barley as well. In 1926, with the drill set at the third notch, 35.17 bushels per acre was harvested. When set one notch lower, production dropped to 30.46 bushels; at the fifth notch, about 1½ to 2 inches deeper seeding than when set at the third, there was a further drop to 30.04 bushels. The 1927 findings were very irregular. The work will be continued.

A test of bin-run vs. cleaned seed was run in 1926 and 1927. The yields the first season were each just above 56 bushels. The crop of the second season was badly spotted by standing water.

Oats, lightly top-dressed, averaged 50.8 bushels in 1926; when harrowed but not manured, the yield was 45.57 bushels. Corresponding yields for like treatments of barley were 21.97 and 27.49 bushels. The value of top-dressing and of cultivating the grain crop in dry springs has yet to be established.

In both years oats were treated for smut infection and sown beside untreated seed. The check plots averaged 45.35 bushels for both seasons and the treated plots, 49.42 bushels. Treating the seed with formalin not only checked smut development but seemingly was accompanied by an increase in yield of 4 bushels per acre, as well.

Forage Crops

Altho some good silage corn was grown in 1926, both seasons were too cool for general corn culture.

Meadow mixtures.—While the growing of alfalfa and sweet clover is gradually being extended on upland soils, the hay crop on lands so situated that they can produce nothing else requires study. In this particular test, four grasses and clovers—redtop, bromus, timothy, and alsike—were sown in various combinations on six plots, each one-half acre in size. Three harvest records are available.

TABLE IV

YIELDS PER ACRE OF MEADOW MIXTURES

Plot	Crop seeded	1926	1926	1927	Average
	lb.	tons	tons	tons	tons
1	10 Bromus 3 Alsike	00	1.28	1.75	1.51
2	6 Timothy 3 Alsike	1.72	1.59	2.31	1.87
3	6 Redtop 3 Alsike	1.32	1.60	2.17	1.70
4	5 Bromus 3 Timothy 3 Alsike	1.39	1.51	1.82	1.57
5	5 Bromus 3 Redtop 3 Alsike	1.46	1.61	2.06	1.71
6	3 Timothy 3 Redtop 3 Alsike	1.84	2.04	2.38	2.09

There was no bromus on Plot 1 in 1925. The period was too short for it to get established. Bromus is often difficult to start. Once under way it is very persistent. It has been our experence that if sown in a good seedbed with plenty of moisture it will outyield all other grasses. It will be noted, however, that the combinations including bromus are usually lighter in yield each year. The findings of the three years establish three tendencies: (1) A mixture of three or more kinds of seed is more profitable than one or two kinds only; (2) the combination

of timothy, redtop, and alsike is a superior mixture; (3) timothy, in combination with alsike, is usually more prolific than redtop and alsike, altho it may not be better in quality.

Renovation of Meadowland

There is much permanent meadow in the timbered district of northeastern Minnesota. A great deal of it is too wet or too stony to plow frequently, if ever. But it must be renovated occasionally to introduce new seed, to break the sod, and to stimulate the grass roots already there. To make this test, a field, already in hay for 2 or 3 years, was divided in the fall of 1925. The west half only was manured. At right angles to the manuring, alternate plots were thoroly harrowed with a roller harrow. This made a triplicate test of harrowed and check plots on manured and unmanured land. Figure 1 illustrates the treatment.

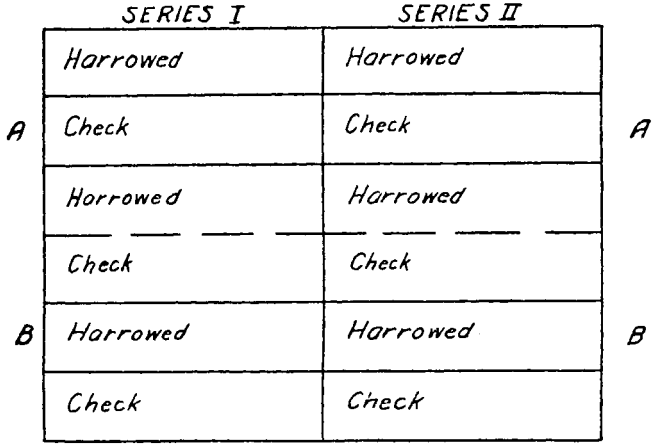


Fig. 1. Plots 1-2-3, Series I and II, constitute Block "A," in hay since and including 1923; Plots 4-5-6, Series I and II, constitute Block "B", in hay since and including 1924.

TABLE V

YIELDS PER ACRE OF HAY ON RENOVATED AND UNRENOVATED LAND

	West half (manured)			East half (not manured)			
	1926	1927	Average	1926	1927	Average	General average
	tons	tons	tons	tons	tons	tons	tons
Harrowed	1.60	2.56	2.08	1.60	2.22	1.91	...
Check	1.79	2.42	2.11	2.26	2.33	2.29	...
Harrowed	1.43	2.58	2.00	1.90	2.59	2.24	...
Check	2.23	2.52	2.37	1.83	2.18	2.00	...
Harrowed	1.50	2.44	1.97	1.20	2.06	1.63	...
Check	1.25	1.85	1.55	1.31	2.63	1.97	...
Averages:							
Harrowed	1.51	2.52	2.02	1.57	2.29	1.93	1.97
Check	1.76	2.27	2.01	1.79	2.38	2.09	2.05
All plots	1.63	2.39	2.01	1.68	2.33	2.01	2.01

The object of this experiment was to determine what effect, if any, breaking the sod with a roller harrow and top dressing with manure would have on a meadow half of which grew its first hay crop in rotation in 1923, the other half in 1924. Apparently, there has been no gain through the second year of the test. The spring of 1926 was very dry. As a probable consequence, where the sod was disturbed the grass roots died and there was a net loss of about one-fourth ton over the check. On the unfertilized series, the check was a trifle better in both years of the test. It may be assumed that if an old meadow is harrowed, the labor is wasted unless some fertilizer is added, and both harrowing and fertilizer may be ineffective in a dry spring. Probably the value of tillage and top dressing would be more manifest in the third or fourth year, measured less by increase in yield of stimulated plots than by decline in production on the unfertilized, sodbound series. It is very significant of the grass-producing power of these glacial clay loam soils that five-year-old meadows still produce more than 2 tons of hay per acre with or without manure.

Legume Crops

In 1926, a variety test of Grimm, Cossack, and Common alfalfa, in duplicate, was begun. A date-of-seeding test was undertaken at the same time. Duplicate seedings of Grimm alfalfa were made at two-week intervals from May 27 to August 27. In 1927 alsike produced a heavy crop. It seemingly choked out the alfalfa which, while it produced a second crop, was too irregular for experimental value. Sweet clover plants heaved fully two inches but re-established themselves and made a good crop. In order to determine the relative ability of sweet clover, Grimm alfalfa, and alsike clover to withstand winter exposure, triplicate plots of each were sown, side by side, in May, 1927.

Two distinct sweet clover projects were undertaken in 1927, and a third with alsike clover. In Series 1, nurse crops of spring rye, 2 pecks; wheat, 2 pecks; Gopher oats, 4 pecks; barley, 4 pecks, were sown with white sweet clover, in duplicate. The second project was rate-of-seeding. Using one bushel of Gopher oats as a nurse crop, sweet clover was sown in duplicate at the rate of 10, 15, and 20 pounds per acre. The date-of-seeding test was also begun in 1927. Duplicate plots of sweet clover and of alsike were sown every two weeks from May 18 to the middle of October. Yields of both these tests will be recorded in 1928. These results were observed in the fall of 1927: Plots sown up to and including June 15, produced hay crops; seedings made June 15 to July 15 developed a sod. The August 1 seeding produced a green ground covering. Later seedings were progressively less, with the black ground ever more in evidence. Clover was much more prominent than timothy. A

question is often raised as to how early or how late sweet clover may be sown. This work was undertaken to provide an answer.

Cereal Hay

There is much interest in the northeast counties in cereal hay production. This is usually grown as an annual crop to supplement shortage on the tame meadows. It is also an economical way of harvesting a small-grain crop when the acreage is small and binder and thresher are difficult and expensive to get. This project was planned with two aims: (1) To learn which grain, if any, made a superior forage crop in both yield and quality; (2) how late the crop can be sown as an emergency and still produce a yield. In 1926, a very dry year, the light hay crop was harvested, the land plowed, and spring rye was sown on July 14. Cut in late September, it produced over half a ton (0.55) per acre on a thin soil. In 1927, the work was expanded to include spring rye, oats, and beardless barley. Seedings were made in duplicate on May 12, June 15, and July 15. The yields are given in Table V.

TABLE V

YIELDS OF CEREAL HAY, 1927

Seeding date	Spring rye	Oats	Beardless barley
	tons	tons	tons
May 12	*	1.13	1.65
June 15	1.65	2.58	1.86
July 15	0.82	0.83	1.96
Average	1.23	1.51	1.82

*A heavy crop was lost because of excessive rain at cutting time.

A feeding test of each kind of hay was conducted. The findings are reported under Animal Husbandry. Beardless barley was a distinct surprise. In 1927, it promised even better than spring rye as a late emergency crop, one that can be planted after haying has begun. It is worthy of note that the yield increases progressively with later seedings. This work will be continued.

Succulent Feeds

Sunflowers.—The Duluth station has harvested its tenth consecutive sunflower crop for silage. In the zone of cool nights bordering Lake Superior, its value has been demonstrated. The Duluth work has been substantiated near Fort William, by the Provincial government, and at Chatham, in Upper Michigan, by the experiment station at that point. The relation of temperature and moisture to sunflower growth has been observed for four years. Findings for 1926 and 1927 are reported in Table VI.

In 1925, with an average daily temperature of 66.6 degrees and a total rainfall of 6.23 inches, from July 10 to August 31, the daily average growth was 1.33 inches. The effects of temperature and of rainfall upon daily growth are inseparable. But no definite relation between temperature alone and growth is apparent. In 1927, the largest average daily growth of the 3-year period was recorded and also the lowest daily mean temperature and the lowest rainfall. One might well conclude from three years' data that sunflowers really thrive best with moderate rainfall in late summer under prevailing temperatures. Perhaps the extra moisture tends to lower soil temperatures and thus check growth. August in 1927 was the coolest in years. This condition is reflected in volume of growth. With cool summer days, transpiration and evaporation are relatively slow and much rain is not needed. It is a possible hindrance. On the other hand, high temperatures and scant moisture also check growth. This occurred in 1925. Without attempting to establish a mean, from 3 years' data we may conclude that with the average midsummer temperature of over 60 degrees and the variable rainfall so common during this period, a range of daily growth of from 1.20 to 1.37 inches may be anticipated, with an average close to 1.33 inches. In a normal summer month, with daily mean temperatures ranging about 60 degrees, a total growth in sunflower plants of about 40 inches may be expected.

TABLE VI

RELATION OF TEMPERATURE AND RAINFALL TO SUNFLOWER GROWTH

Date	Mean temperature, 7-day periods	Total rainfall, 7-day periods	Gross increase, 7 days	Av. daily increase
1926	deg.	in.	in.	in.
July 20	66.12	0.32	8.44	1.21
" 27	65.62	0.42	11.25	1 61
Aug. 3	67.87	0.04	10.62	1.52
" 10	62.87	0.76	7.06	1.01
" 17	61.87	1.72	6.63	0.95
" 24	60.00	1.07	6 50	0.93
Average	64.06	4.33*	8.42	1.20
1927				
July 25	64.82	0.51	11.83	1.97
Aug. 2	61.7	0.12	14.92	2.13
" 9	61.7	0.40	11.25	1.61
" 16	57.14	0.51	5.66	0.81
" 23	59.43	0.15	2.50	0.36
Average	60.96	1.69*	9.63	1.38

*Total.

Sunflowers have been grown in fertilizer tests for two years. In 1926, neither sulfate of ammonia nor complete fertilizer showed much advantage over the check. In 1927, an application of 400 pounds per acre of complete fertilizer, 4-8-6 mixture, produced 0.8 tons per acre;

200 pounds sulfate of ammonia, 8.8 tons; the check plot, 9.2 tons. The 2-year average indicates a slight advantage for the complete fertilizer and none for sulfate of ammonia in the amount used.

For five years previous to 1926, tests were conducted on the proper spacing of rows of sunflowers for silage. Distances between rows have been 30, 36, and 42 inches. Findings of 1926 coincide with those of former years. A somewhat higher yield results with rows 30 inches apart. The stalk is finer and of better quality than when rows are farther apart. The 36-inch spacing is probably the most practical, but when the acreage is limited, 30-inch spacing is advised. In all cases the 42-inch spacing for heavy soil should be rejected.

TABLE VII

YIELDS PER ACRE IN SEEDING TEST I. SPACING OF ROWS OF SUNFLOWERS, USING CORN DRILL

Distance between rows	1926	6-year av.
in.	tons	tons
30	7.34	12.96
36	7.22	12.49
42	6.72	10.83

For four years a second method of seeding has been tested—a grain drill was used, with 6, 12, and 18 inches between rows. The object was to grow a slender stalk and to avoid tillage. In a dry season the stand is short, as the draft on available soil moisture is excessive. These plots are the first to wilt. In wet seasons, disease spreads more rapidly in narrow rows. The labor objection is most pronounced. A corn binder can not well be used, but at times a grain binder can serve the need. Yields and quality are satisfactory, but are obtained at greater labor cost. From a production viewpoint, there is little choice between the three spacings; from the management viewpoint, the 18-inch spacing is most desirable. Variable spacing is provided by plugging intervening flues of the grain drill. Much less space between rows and the use of a grain drill intsead of a corn drill are the differences between seeding tests I and II.

TABLE VIII

YIELDS PER ACRE IN SEEDING TEST II. SPACING OF ROWS OF SUNFLOWERS, USING GRAIN DRILL

Distance between rows	1927	4-year av.
in.	tons	tons
6	6.29	10.05
12	5.03	11.84
18	5.86	10.79

A rate-of-seeding test is conducted. Farmers often ask how many pounds of sunflower seed to sow per acre. It has been found that by setting a Van Brunt grain drill for 4 pecks of wheat, approximately 5 pounds per acre will be sown. The rows are 36 inches apart, the distance being established by plugging five flues in succession and leaving the sixth open. The 1926 crop was rejected.

TABLE IX

YIELDS PER ACRE IN SEEDING TEST III. SEEDING VARIOUS AMOUNTS OF SUNFLOWER SEED WITH A GRAIN DRILL

Set of drill	1927	4 year av.
	tons	tons
For 4 pecks wheat	5.57	9.75
" 8 " "	6.20	10.87
" 12 " "	6.34	11.02

With records from 12 plots for four seasons, the lowest rate of seeding seems hardly desirable, because of both low yield and coarser stalks. On the other hand, the heaviest seeding does not produce enough additional crop—about 300 pounds—to be significant. Setting the grain drill at 8 pecks provides a good yield of sunflowers of good quality.

The comparative test of sunflowers and corn, operated in 1924 and 1925, was continued through 1926 and 1927. Northwestern Dent corn was used, as it has proved slightly superior to Minn. No. 13 at various locations through several years of test.

TABLE X

YIELDS PER ACRE OF CORN AND SUNFLOWERS FOR SILAGE

Crop	Years of test	1926	1927	Av. for entire period
		tons	tons	tons
Corn	3	7.77	3.70	7.06
Sunflowers	4	11.21	7.77	10.78

With a yield of 50 per cent more green tonnage per acre and with a crop every year, the livestock farmer in the northeastern counties is playing safe by devoting some land to the sunflower crop. The seasons of 1915, 1917, 1924, and 1927 were poor for corn, yet a substantial crop of sunflowers was harvested each year. Altho corn is the major silage crop, a certain percentage of the land in the Superior Basin and northward should be allotted to sunflowers to insure succulent feed for the winter.

The results of a 2-year comparative test of rutabagas and sunflowers for succulent feed was reported in 1925. In 1926 the sunflower crop was injured by leaf-spot disease and weights were discarded.

TABLE XI

YIELDS PER ACRE OF SUNFLOWERS AND RUTABAGAS

Crop	Years of test	1926	1927	Av. for period
		tons	tons	tons
Sunflowers	3	0.00	8.25	9.07
Rutabagas	4	12.13	5.52	9.86

As in 1924 and 1925, the tonnage of rutabagas per acre is slightly higher than that of sunflowers. The cost of production is also somewhat higher. The recorded yields are very close to the yields on twenty-five farms in northern Pine County.

Stock Roots

Variety tests of stock roots were continued through 1926 and 1927. Where possible, 4-year averages are given in Table XII.

TABLE XII

YIELDS PER ACRE OF STOCK ROOTS IN VARIETY TESTS

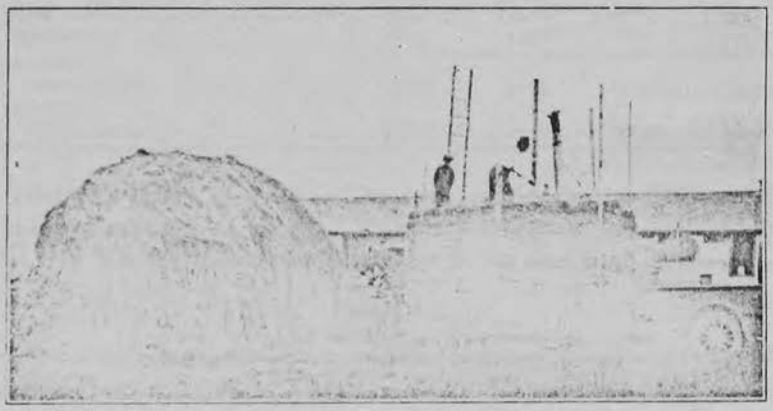
Variety	1926	1927	2-yr. av.	4-yr. av.	General average
	tons	tons	tons	tons	tons
Sutton's Acquisition rutabaga	11.24	15.32	13.28	19.9	....
American Purple Top rutabaga	16.08	11.32	13.70	....	....
All rutabagas	....	....	....	....	13.49
Green Globe turnip	20.35	18.60*	19.47	....	....
Magnum Bonum turnip	12.02	21.95*	19.47	....	....
Prizewinner Yellow Globe turnip	10.90	15.30*	13.10	....	....
All turnips	....	....	....	....	16.52
Sutton's Red Intermediate mangels	14.06	12.43	13.25	....	....
Sugar mangels	13.07	13.78	13.42	....	....
All mangels	....	....	....	....	13.33
White Belgian carrot	10.02	16.08	13.04	12.86	....
Red Intermediate carrot	8.50	8.01	8.86	....	....
All carrots	....	....	....	....	10.65

*Single plots.

Contrary to popular assumption, turnips have outyielded rutabagas the last two seasons and mangels have equalled them. A field of investigation as yet unexplored is the possible range in dates of planting the root crop. Stock roots must be planted very early; they will use all the available season. But the commercial crop for family consumption may be sown as late as early July. A date-of-seeding project has been started. This station is fully as much concerned with root culture for poultry as for cattle. As herds increase in size, silage necessarily replaces roots for succulent winter feed. But as a relatively small acreage will feed a large number of birds, and as roots are a very excellent supplementary feed, they should continue to hold a place in the northern rotation.

Silage

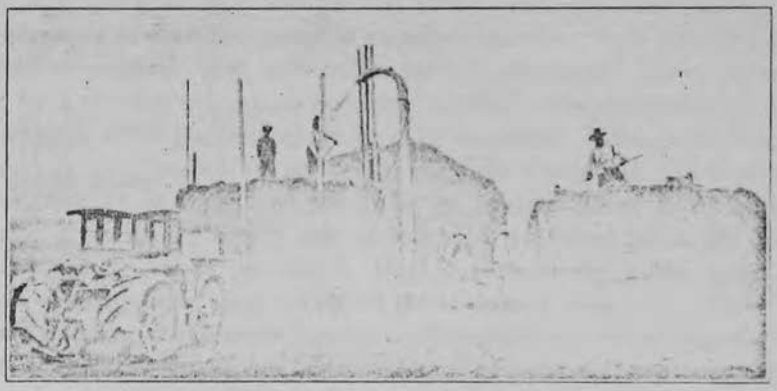
The northeast counties produced an extremely heavy clover crop in 1927. Until late in the season, however, the cultivated silage crop was very disappointing, hence a large part of the station clover crop was converted into silage. After the stave silo was two-thirds full, a temporary outdoor silo was constructed of woven wire and steel posts. The wire was 47 inches wide, and four sections were placed one above the other, making a structure nearly 16 feet high and 16 feet in diameter. The wire constituted the only wall, but by thoro tramping very little of the chopped feed worked down. During fermentation, the temperature ran slightly above 150 degrees inside the stack at points 18, 36, and 54 inches from the outside. The feed was hauled to the barn in early November and fed out before severe weather. There was naturally some loss at the outside. A ring 10 to 15 inches thick was decayed because of exposure and oxidation. The loss was greatest near the top.



Silage Production, Using Woven Wire Cage

The center core, however, was in fine shape to within a few inches of the top. It seems probable that if some cheap substance, such as heavy roofing material, could be placed just inside the wire to exclude air, the loss could be much reduced. If this can be done, this kind of silo may serve a temporary need for the northern farmer much as the trench silo does for the farmer in prairie districts. A sample of this feed has been submitted for analysis. The following findings were reported on the dry basis: Protein, 12.22 per cent; ether extract, 4.48 per cent; crude fiber, 34.89 per cent; nitrogen-free extract, 41.79 per cent. The green weight of the clover placed in this round wire feed cage was 39,205 pounds. As it was showery and the clover was hauled directly after cutting, it was full of surplus moisture. The net weight of good feed salvaged was 16,110 pounds. The difference in weight includes loss of

moisture and loss from oxidation and decay. (See the Animal Husbandry section for feeding test report.) In 1920 (see Duluth 1920 report) a sample of silage produced from second crop clover and timothy was analyzed with these findings on the dry basis: Protein, 15.40 per cent; ether extract (fat), 5.59 per cent; nitrogen-free extract (starches and sugars), 67.76 per cent. It will be noted that this legume silage is about twice as rich in nitrogen as corn or sunflowers and when fed the grain ration may be safely reduced.



Silage Cutter at Work, Filling Wire Cage

A stack was built of the green unchopped clover. This did not keep nearly so well because it was not built so carefully or packed so tight as the clover that passed through the silage cutter. The cattle did not eat it so readily but it made good sheep feed. The amount stacked green was 18,210 pounds.

A stack of uncut bundles of sunflowers was built in like manner when the crop was harvested. As it was impossible to exclude the air so completely, this plan was less successful with sunflowers than with clover.

Potatoes

The 1926 potato crop was heavy in consequence of a dry spring with good seedbeds and a cool summer with adequate moisture. The 1927 crop was subnormal in yield and was injured by late blight. The tubers were small.

Crop performance in 1926 and 1927 strikingly illustrates the extreme seasonal variation in potatoes. The productivity of varieties from year to year seems to be relatively uniform. In both seasons, Green Mountain and King headed the list, and Bliss Triumph, with Early Ohio as a close second, stood at the foot. Irish Cobbler, in 9 years' trial, is the outstanding yielder of early potatoes. Green Mountain for a few

years outyielded all other late varieties, but recently King has had a slight margin above it. Comparing the average yields over the 7- and the 9-year periods, respectively, only King and Green Mountain show a rising trend of production. Russet and Cobbler have held their own, Triumph shows a slight decline, and Rural New Yorker a somewhat greater loss. The lowering trend is more marked with Ohio and especially with Burbank.

TABLE XIII

YIELDS OF POTATOES PER ACRE IN VARIETY TESTS

Variety	1926	1927	7-year average	9-year average
	bu.	bu.	bu.	bu.
Bliss Triumph	189.04	87.02	140.7	147.10
Early Ohio	202.06	92.45	178.7	171.71
Irish Cobbler	299.60	120.20	216.8	216.38
Green Mountain	366.82	138.04	233.9	238.02
Rural New Yorker	217.69	118.55	186.5	182.65
Russet	296.7	125.88	211.1	211.14
King	385.9	133.16	236.5	241.6
Burbank	226.3	122.20	222.4	211.7
Average, early varieties	230.23	99.89	181.7	178.00
Average, late varieties	298.68	127.57	218.7	216.90

Distance apart of rows.—The year 1926 was the fifth and last of the spacing-of-rows project. Rows are spaced 30, 36, and 42 inches apart, but hills are about 16 inches apart in the row in all cases.

TABLE XIV

YIELDS OF POTATOES PER ACRE IN SPACING-OF-ROWS TEST

Spacing	1927	5-year average
in.	bu.	bu.
30	219.62	221.20
36	205.16	200.87
42	162.70	164.94

The margin of 21 bushels per acre makes the close planting well worth while when labor is scarce, available land is limited, and one-horse equipment is used. Thirty-six inches may be considered standard for most fields and farms. The 42-inch spacing is evidently a waste of ground and has no place on the heavy productive soils of the northeast counties.

Date of planting.—The date-of-planting test has also been carried for five years. In 1927, however, it was necessary to reject one whole block of plots and, owing to very wet weather, no May planting was made. The 1926 findings and the 4-year average are presented in Table XV.

TABLE XV

YIELDS OF POTATOES PER ACRE IN DATE-OF-PLANTING PROJECT

Date of planting	1926	4-year av.
	bu.	bu.
May 15-30	262 65	267.86
May 31-June 4	233.72	228.90
June 15	192.92	169.43
June 30-July 1	89.63	91.71

The spring of 1927 was the first in ten years that May planting was difficult or impossible, owing to extreme moisture. It is usually a practical proceeding, with reasonable surface drainage. There continues to be a decided advantage in early planting. The reduced yield from plantings after the first of June is pronounced. Taking the May 15 yield as 100 (bushels or per cent), the June 1 planting stands at 85.7; the June 15, at 63.3; and the June 30, at 34. About three times as many bushels of potatoes may be expected if planted about the middle of May, conditions permitting, than if planted six weeks later, and half as many more than if planted the middle of June.

Spraying for disease control.—Experiments involving the use of a pressure sprayer for disease control of potatoes have been carried out for five years. The work is simple. Two varieties, Irish Cobbler and Green Mountain, constitute the basis of the work. Plots sprayed with arsenate of lead, for protection from insects, are compared with plots sprayed with arsenate and bordeaux mixture, to control both insects and diseases. The value of the spray service, if any, is measured by increase in yield.

TABLE XVI

YIELDS OF POTATOES PER ACRE IN SPRAY TESTS

Variety	Management	1924	1925	1926	1927	4-yr. av.
		bu.	bu.	bu.	bu.	bu.
Green Mountain	Check	151.89	189.30	324.64	155.41	205 31
	Bordeaux spray	160.13	198.30	348.12	140.73	211.82
Cobbler	Check	134.98	192.30	221.59	110.00	164 72
	Bordeaux spray	156.76	181 80	276.62	91.64	177.45

The records of 1923 are not included, as the work was different at that time. After four years the net increase on sprayed plots of Green Mountain potatoes was only 6 bushels per acre and of Cobblers, 13 bushels. This seems to indicate that near Lake Superior the practice is not yet proved to be economical. Some distance inland these results might be reversed.

Storing seed potatoes.—The 1927 crop was the fifth and last in the test of the effect of warm and cold storage on the yielding power of seed potatoes. The practice has been to keep all seed in the cool root

house through the winter. Some seed is moved to a warmer location in early spring to stimulate sprouting; the so-called cold seed lot is taken directly from the root cellar, where sprouting seldom begins before late spring.

TABLE XVII

YIELDS PER ACRE IN TEST OF WARM VS. COLD STORAGE OF SEED POTATOES

Management	1922	1923	1925	1926	1927	5-yr. av.
	bu.	bu.	bu.	bu.	bu.	bu.
Warm storage	117.9	230.2	182.9	105	123.7	151.9
Cold storage	130.9	221.6	144.2	116.3	123.4	149.1

It has often been said that if potatoes are taken out of a cold root cellar and allowed to sprout before planting, a better stand and higher yield may be anticipated than if planted direct from the root cellar. In a short season, this might be true. But the evidence of five years does not support this, when the growing season is adequately long. Yields under both conditions are practically identical.

Cut vs. uncut seed.—In seasons of seed shortage, many devices are resorted to, to hold down cost. Some plant potato peelings, others dig out the eyes and use the tuber for the table. More generally, small tubers will be used, thus stretching the available seed supply over greater areas, perhaps the large stock will be sold and only the small stock planted. In this test, small uncut tubers were planted in comparison with large tubers cut into two-ounce pieces.

TABLE XVIII

YIELDS PER ACRE IN TEST OF SMALL UNCUT VS. LARGE CUT POTATOES FOR SEED

Kind of seed	1926	1927	4-yr. av.
	bu.	bu.	bu.
Small uncut seed seed end removed	109.6	150.32	146 57
Large, cut seed	110.6	118.55	151.24

The advantage in favor of large seed is so small that in periods of high prices, at least; it seems reasonable that the cautious grower would sell large potatoes and, after careful culling, plant the smaller stock. In such cases, however, potatoes should be chosen that are true to type. Whether the practice of cutting the seed end of potatoes of any size is worth while, is a matter of controversy. It is affirmed that by doing this, growth is concentrated at fewer places and is consequently more vigorous. Four years' work has been done on this problem at Duluth.

TABLE XIX

YIELDS PER ACRE IN TEST OF EFFECT ON YIELD OF CUTTING SEED END OF POTATOES

Treatment	1925	1926	1927	3-yr. av.
	bu.	bu.	bu.	bu.
Seed end cut	185.01	52.16	182	140.05
Seed end not cut	175.38	54.17	167	145.85

The records of 1923 and 1924 were discarded. At the end of the third year there is little appreciable difference between the two practices, with a very slight margin in favor of planting uncut potatoes. This work will be continued two more seasons.

In 1926, potatoes were grown for the first time in 3-, 4-, and 5-year rotations. In 1927, a project was begun to test the effect on yield of a series of cultivations ranging from none to five. This work is so new that no data are presented.

FARM MANAGEMENT

Under Farm Management two projects are included: (1) A study in 3-, 4-, and 5-year crop rotations, and (2) crop succession, or the effect of one crop upon the following one. Rotation work has been in progress for nine years. Three completed cycles of the 3-year rotation, and 2¼ cycles of the 4-year system have been recorded. Each rotation includes one grain crop (barley) and one cultivated crop (sunflowers), with a few rows of potatoes in the same plot. Mixed clover, timothy, and redtop hay constitutes the rest of the rotation, one, two, and three years of hay entering into the 3-, 4-, and 5-year rotations respectively. These rotations are each manured once in the course of the rotation. The manure is applied on the grain stubble at the rate of two tons per acre per year; that is, six tons are allotted to the 3-year, 8 tons to the 4-year, and 10 tons to the 5-year rotation.

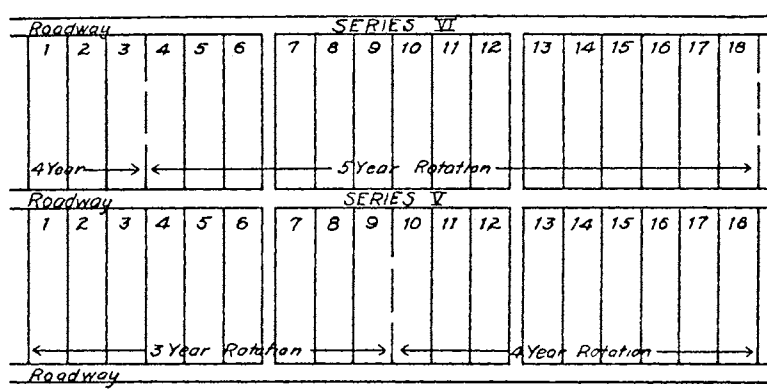


Fig. 2. Diagram of Rotation Plots

Plots are 2 rods wide and 8 rods long, each constituting 1/10 acre. Plots 1-9, Series V are 3-year rotation; Plots 10-18 inclusive, Series V, and Plots 1-3, Series VI, 4-year rotation Plots 4-18 inclusive, Series VI, constitute 5-year rotation. Series are separated by roadway Series extend north and south, Series VI lying west of Series V. Rotations are separate by broken lines.

TABLE XX

YIELDS OF HAY PER ACRE, CROP ROTATION PROJECT

Rotation	1926	1927	8-year average
	tons	tons	tons
3-year	1.83	2.72	2.09
4-year	1.59	2.52	1.84
5-year	1.64	2.79	1.95

It does not seem reasonable that hay in the 5-year rotation, in which it is grown consecutively for 3 years on the same land, should outyield that in the 4-year rotation, in which the land is plowed after the second hay crop. A part of the 4-year rotation is on higher ground that seems less productive than the lower land. The 3-year rotation, when practiced, however, seems to insure a continuous yield of more than 2 tons per acre. A comparison of the first, second, and third crops is presented in Table XXI.

TABLE XXI

YIELDS OF HAY PER ACRE, FIRST, SECOND, AND THIRD YEAR CROPS

Crop, all rotations	1926	1927	Average
	tons	tons	tons
First year hay	1.81	2.73	2.27
Second " "	1.65	2.79	2.22
Third " "	1.21	2.38	1.80

The dry spring in 1926 subjected the hay crop to a more rigid test than it had in 1927, which was so favorable that extremely old meadows responded generously. When handicapped by an unfavorable first season, the second crop may be greater than the first.

TABLE XXII

YIELDS OF BARLEY PER ACRE IN CROP ROTATION PROJECT

Rotation	No. of crops	1926	1927	Av. yield
		bu.	bu.	bu.
3-year	9	27.36	18.47	29.45
4- "	7	34.18	14.00	29.49
5- "	9	26.73	21.72	27.25

The same variety (Svansota) has been grown through the years. The shorter rotations still have some advantage, tho so slight as to be of little, if any, significance. As potatoes have been grown in the rotations only two years, they will not be included in this discussion.

TABLE XXIII

YIELDS OF SUNFLOWERS PER ACRE, CROP ROTATION STUDIES

Rotation	1926	1927	7-year av.
	tons	tons	tons
3-year	6.31	4.55	9.07
4- "	5.01	4.95	7.61
5- "	5.24	3.78	7.90

The low temperatures and surplus rainfall of certain growing months in the last two years are reflected in returns of cultivated crops. To visualize what returns may be expected in growing crops under a definite rotation system, the average yields for all crops in all rotations for the 9-year period are presented.

Hay	1.96 tons per acre
Barley	28.73 bu. " "
Sunflowers	8.22 tons " "

As the work grows in years, the margin in favor of the short rotation seems to lessen, but it still carries the handicap of greater labor requirements in operation.

Crop succession.—It has frequently been observed that the rutabaga crop is hard on the soil; that oats are better following rutabagas or sunflowers than directly after potatoes. A crop seems to have a certain influence upon the one immediately succeeding it. In 1926, five strips of land, each 2 x 7 rods, were measured off. The following crops were grown: Hay, oats, barley, sunflowers, potatoes. In 1927, cropping was at right angles to the lay of the 1926 plots. The following crops were grown in strips 10 x 1 rod: Spring rye, oats, barley, potatoes, corn fodder, sunflowers, rutabagas. See Figure 3.

TABLE XXIV

ACRE YIELDS IN CROP SUCCESSION EXPERIMENT

1927 Crops	Yields per acre, 1927 crops following				
	Meadow (1926)	Oats (1926)	Barley (1926)	Sunflowers (1926)	Potatoes (1926)
	bu.	bu.	bu.	bu.	bu.
Spring rye	14.07	18.63	22.22	25.00	25.69
Oats	24.30	35.24	37.07	36.46	36.46
Barley	8.10	18.63	16.20	25.92	21.07
Potatoes	176.30	172.41	191.85	169.81	136.11
	tons	tons	tons	tons	tons
Fodder corn	2.95	1.40	2.22	2.72	1.59
Sunflowers	4.09	5.56	5.44	5.76	5.76
Roots	4.39	2.09	9.01	7.51	6.37
Total crop units*	220.80	254.80	285.20	273.10	233.04

* By "crop unit" is meant either tons or bushels or both. As the same crops were grown in the same succession, it was thought that giving the total product, bushels and tons, of all crops following a given crop, the comparative influence of the 1926 crops on 1927 production could be more clearly indicated.

A study of this table reveals several facts. The three grain crops were poor on sod and best following the cultivated crops. The same holds true generally of roots. Potatoes and sunflowers have done nearly as well on sod as following other crops, and corn has yielded a trifle better than elsewhere. Both rye and oats did a trifle better following barley than following oats, but the yield of barley was two bushels less

when planted twice on the same soil and was highest when following sunflowers. Oats yielded better on sod than either barley or rye, altho rye is usually looked upon as the best grain on soil of low available fertility. It seems poor practice to follow potatoes with potatoes or grow

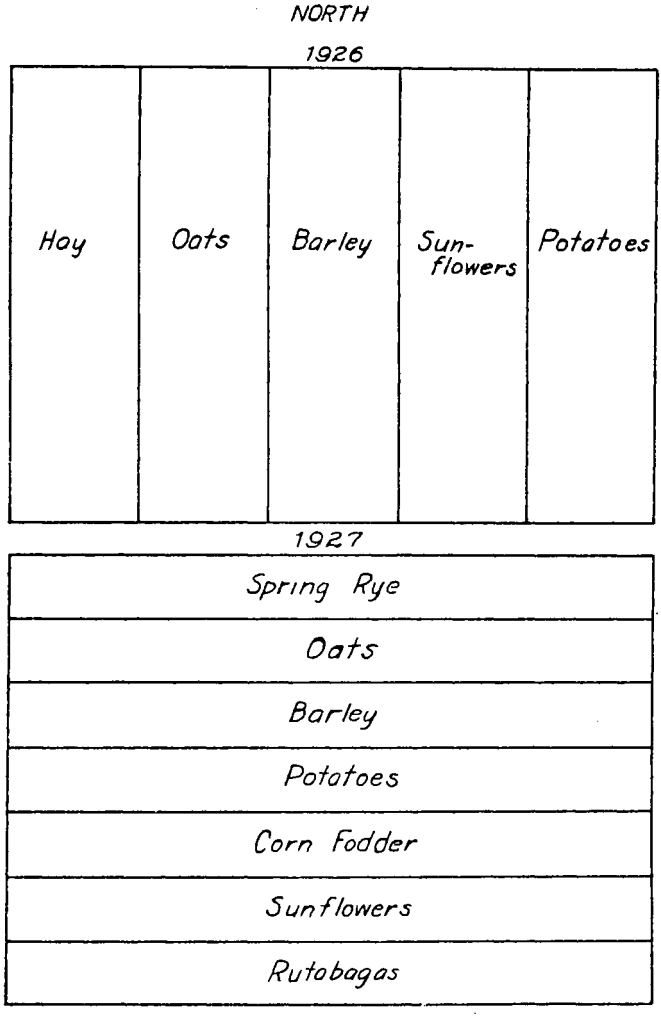


Fig. 3. Diagrams of Crop Succession Experiment, 1926 and 1927

1926 crops: Series 1 to 5, running north and south; Series 1, hay; Series 2, oats; Series 3, barley; Series 4, sunflowers; Series 5, potatoes.

1927 crops: Series A-G, running east and west; Series A, spring rye; Series B, oats; Series C, barley; Series D, potatoes; Series E, fodder corn; Series F, sunflowers; Series G, rutabagas.

corn or roots following oats. Sunflowers seem to flourish equally well whatever the preceding crop. Root crops seem to thrive best when a cultivated crop has preceded. Measuring the effect of one crop upon

the entire group following it in crop units harvested of the succeeding crop, the 1926 crops stood in this order: Sod, 229 units; potatoes, 233; oats, 254; sunflowers, 273; barley, 285. Interpreted in this way, considering only crops with prepared seedbeds in 1926, potatoes seemed to take most out of the soil and barley least. The lightest crops, generally, of 1927, followed potatoes in 1926 and three of the seven crops grown yielded best following barley.

HORTICULTURE

In co-operation with Division of Horticulture, University Farm

Garden Crops

Garden work includes (1) variety testing, and (2) fertilizer work. The former will be presented here; the latter is covered in the section on Soil Fertility.

TABLE XXV

GARDEN CROP VARIETIES IN ORDER OF PRODUCTION

Crop	1926	1927
Peas:	Peter Pan, Blue Bantam	Alaska, Peter Pan, Laxtonian
Beets:	Crimson Globe, Early Wonder	Early Blood, Early Wonder
Beans:	Refugee, Longfellow	Refugee, Longfellow
Cabbage:	Late Flat Dutch, Golden Acre	Late Flat Dutch, Danish Ballhead
Celery:	Newark Market, Golden Plume	Newark Market, Giant Pascal
Carrots:	Rubicon, Chantenay, Coreless	Danvers Half Long, Yellow Champion, Chantenay
Kohl Rabi:	White Vienna	White Vienna
Cauliflower:	Danish Giant, Catskill	
Turnip:	Purple-Top White Globe, Greystone, Early Purple-Top Milan	
Rutabaga:	American Purple-Top, Danish Bangholm, Yellow Perfection	Danish Bangholm, Yellow Perfection, Yellow Swedish
Onion:	Yellow Globe Danvers, Southport Yellow Globe	
Radish:	Early Scarlet, Cincinnati Market	Early Scarlet, Cincinnati Market
Spinach:	New Zealand, King of Denmark, Bloomsdale	Bloomsdale, Victoria, Early Summer
Parsnip:	Guernsey, Hollow Crown	Guernsey, Hollow Crown
Cucumber:	White Spine	
Pumpkin:	Fort Berthold	

The 1927 garden was the poorest in fifteen years. Heat-loving plants were almost total failures. There is much variation in variety performance in these two years. The following varieties show some consistency in yield: Peter Pan peas, Early Wonder beets, Refugee and Longfellow beans, Late Flat Dutch cabbage, Newark Market celery, Chantenay carrot, White Vienna kohl rabi, Danish Bangholm rutabaga, Early Scarlet and Cincinnati Market radish, Bloomsdale spinach, Guernsey parsnip.

Fruit Culture

Tree fruits.—The season of 1926 was the best apple year to date at the Duluth station. The spring was early, frost-free, and dry. The spring of 1927 was late, frost-free, but very wet and stormy at blossom time. The crop was much lighter. The preceding heavy crop may explain the decline. The most important development in apple culture at Duluth is the influence of sulfate of ammonia in stimulating tree growth and increasing the amount and quality of fruit. In lesser measure, heavy mulching with strawy manure has produced a like effect. The orchard is maintained in sod, with rather thoro working close to the tree once in two years or twice in three years.

Young Florence Crab Tree in Full Production

TABLE XXVI

APPLE PRODUCTION BY VARIETIES, 1924-27, INCLUSIVE

Variety	Trees	Number of trees bearing in			
		1924	1925	1926	1927
Hibernal	112	64	26	72	49
Wealthy	104	45	26	52	29
Anisim	47	11	2		24
Patten	23	15	9	13	14
Jewell Winter	4	0	0	3	0
Minnesota Crab	4	0	1	0	0
Iowa Beauty	4	2	0	1	0
Yellow Transparent	10	7	0	6	0
Whitney	5	2	0	3	0
Okabena	17	8	2	9	0
Longfield	4	1	0	1	1
Duchess	15	11	9	9	2
Sweet Russet	4	3	0	3	1
Florence Crab	14	7	2	5	0
Lyman Prolific	0	5	0	4	3
Transcendent	5	1	0	1	0
Red Siberian	5	3	1	3	1
Hyslop	4	3	0	2	1
Virginia	8	0	0	6	0
Totals	395	188	80	208	126

As all trees are not the same age, summaries of annual production can not be made. Hibernal has been a persistent producer of good sized apples. The quality of Wealthy has been inferior, the size small. Anisim reached maximum production in 1927. Patten is very promising in its dependability to produce regularly. Florence Crab, the pride of other years, failed completely in 1927. Undernourishment of heavy crops is a probable cause. Okabena and Duchess produced fruit of fine quality and in good amount in 1926. Yellow Transparent is the only apple that properly ripens in the Duluth orchard. The crabs, as a whole, have not done well. Some of the Fruit Farm varieties have come into production the last few years, notably Nos. 321, 308, and Minnehaha. Apples do better than plums at Duluth. The original DeSota and Compass Cherry plum trees have declined rapidly in the last few years. In the new orchard, however, on a southern slope with sandy soil, the plums grow well, especially when fertilized. Small trees are allowed 1 pound per tree of sulfate of ammonia. Foliage shows a deep coloring the same season. The apple crop of 1926 was probably the direct result of the 4 pounds of sulfate of ammonia per tree distributed in May, 1924.

Small fruits.—The small-fruit records include two years' data on currants and gooseberries and one year's on strawberries. The bush fruits have had no fertilization or care beyond one hoeing annually.

The yields tell the story of the productive power of the varieties under test. But quality of berry and vigor of foliage are also factors of importance. Pomona has smaller and fewer leaves than London

Market, with less uniformity in size of bush. London Market bushes were the largest, with good sized berries well distributed. Diploma ranks above the two preceding in size of berry, but the bushes are rather smaller. Holland is outstanding in size of bush and size and amount of leafage. The fruit is not numerous, but is large and of good quality. Both bush and fruit of Perfection are small. Wilder bushes are relatively small, with berries of fair quality. The maximum yield per bush, 77 ounces, was from a Pomona.

TABLE XXVII

YIELDS OF CURRANTS IN VARIETY TESTS

Variety	No. of bushes bearing	Season	Av. yield per bush	Variety av. 2 years
			oz.	oz.
Pomona	8	1926	24.9	
	10	1927	33.56	29.23
London Market	12	1926	22.33	
	12	1927	26.50	24.42
Diploma	10	1926	9.1	
	10	1927	13.73	11.42
Holland	5	1926	4.6	
	10	1927	16.18	10.39
Perfection	6	1926	4.16	
	6	1927	8.67	6.42
Wilder	10	1926	2.7	
	10	1927	8.6	5.65

Gooseberries produced a good crop both years, in spite of limited tillage and no fertilization. Five varieties are under test. Like the currants, the plants were set out originally in 1923, with production both spotted and limited until 1926.

TABLE XXVIII

YIELDS OF GOOSEBERRIES IN VARIETY TESTS

Variety	No. of bushes bearing	Season	Av. yield per bush	2-year av.
			oz.	oz.
Houghton	7	1926	38.20	
	7	1927	34.30	36.20
Carrie	10	1926	40.70	
	10	1927	7.90	24.30
Como	3	1926	30.00	
	4	1927	11.90	21.00
Champion	4	1926	12.75	
	5	1927	22.00	17.38
Downing	7	1926	6.86	
	7	1927	...	3.43

The variety Pearl, perhaps from local causes, has failed to produce appreciably either year. The Houghton stock has light foliage; the fruit, tho rather small, is well exposed. Carrie is a small bush with light foliage, but produces a fine, large, clear berry. Como fruit is fair

in size. The bush of Champion is extremely small, but, like Carrie, produces very choice fruit, tho a somewhat smaller berry. This variety led in 1927 in yielding surface. The fruit of Downing was extra large, but scant. The heaviest individual bush production was 91 ounces, variety Carrie, 1926. A bush of Houghton was second with 61 ounces. In 1927, one Houghton bush grew 54 ounces; one Champion, 40 ounces.

In 1927, a strawberry crop was harvested from eight varieties set out and carefully tended in 1926. The season was late. Harvesting began July 15. The last picking was done on August 17. Yields were in this order: Minnehaha, Easypicker, Chaska, Dr. Burrill, Bliss and Premier practically a tie, Dunlap, Nokomis. Too much stress should not be put on one year's findings, as many such factors as difference in vigor of plants or exposure might cause variation. Certain varieties were especially satisfactory. Minnehaha berries were uniformly large. Bliss and Chaska probably ranked next in quality, followed by Easypicker. The Dr. Burrill berries were very irregular in size; Bliss ranked about with Chaska. The raspberries under test yielded a scattered crop in 1927.

SOIL FERTILITY INVESTIGATIONS

In co-operation with Division of Soils, University Farm

The work in soil fertility is a continuation of the projects listed in former years: (1) Clover utilization; (2) rotation without clover or manure; (3) rate of manuring; (4) commercial fertilizers for potatoes in a 3-year rotation to which is added a statement on residual effects on clover and oats; (5) garden fertilization.

Much new work is under way. In 1927, a 3-year rotation, with various rates of liming, was begun. A 4-acre field has been taken over by the Soils division for a study of the causes of spotted productive power of well drained upland timber soils, a very common condition in the conifer country. Fertilization of apple trees with sulfate of ammonia is already under way.

Clover Utilization

This experiment was laid out in 1917. Eleven crops of potatoes, ten of oats, and nine of hay and pasture have been harvested. This is a study of the most effective use of clover on the stony clay loam glacial soils of northeastern Minnesota. It might also be called a test of green manuring. Three series of plots are included—one each of grain, grass, and potatoes-sunflowers. Plots 1 and 4, grass series, are pastured. Two dry cows are kept on each plot for 10 or 12 days when the grass is full grown. Plots 2 and 5 are plowed about July 1, turning the uncut grass crop down. The hay from plots 3 and 6 is harvested. The cultivated crop follows the grass in the second year, and oats are sown the

third year. The effect of the three ways of handling clover—pasturing, plowing under, or harvesting—is measured by crop yields in the two following years.

TABLE XXIX

YIELDS OF POTATOES PER ACRE IN CLOVER UTILIZATION SERIES

Plot	Management	1926	1927	6-yr. av.	8-yr. av.
		bu.	bu.	bu.	bu.
1	Crop pastured	184.8	93.18		
2	" plowed under	189.9	77.29		
3	" harvested	166.5	59.26		
4	" pastured	232.5	75.15		
5	" plowed under	251.5	75.15		
6	" harvested	181.1	62.93		
Averages					
1-4	" pastured			170.93	169.79
2-5	" plowed under			159.79	156.95
3-6	" harvested			152.94	144.06

Compared with the average after six years, potato yields are holding even on the pasture plots; they have dropped 3 bushels per acre on the green manure plots and 12 bushels where the grass crop was harvested.

TABLE XXX

YIELDS OF SUNFLOWERS PER ACRE IN CLOVER UTILIZATION SERIES

Plot	Management	1926	1927	6-yr. av.	8-yr. av.
		tons	tons	tons	tons
1	Crop pastured	5.32	4.95		
2	" plowed under	3.39	5.17		
3	" harvested	2.66	3.83		
4	" pastured	4.31	4.07		
5	" plowed under	4.67	3.52		
6	" harvested	5.04	1.98		
Averages					
1-4	" pastured			8.55	7.58
2-5	" plowed under			8.13	7.14
3-6	" harvested			7.87	6.35

Compared to the 6-year average yield, the 8-year average of sunflowers shows a decline of one ton per acre on the pasture and green manure plots and 1½ tons on the grass harvested plots. At the close of the third cycle of the rotation, findings indicate that clover will maintain potato yields when either pastured or plowed under, but a supplemental fertilizer must be supplied if harvested for hay, or yields decline. But sunflowers, irrespective of treatment or management, are declining from 1 to 1½ tons per acre. Clover seems to be insufficient to maintain yields. A supplemental fertilizer is called for. With liming, the heavier clover sod and aftermath may in part suffice.

TABLE XXXI

YIELDS OF HAY PER ACRE IN CLOVER UTILIZATION SERIES

Plot	Management	1926	1927	5-yr. av.	7-yr. av.
		tons	tons	tons	tons
3	Grass harvested	0.59	2.00		
6	" "	0.23	2.45	1.54	1.48

The difference between hay yields of 1926 and 1927 is extreme. This is not due to seasonal influence alone; the yields elsewhere in 1926 were good. But this land was very sour. It was limed in 1925-26 and the 1927 crop was the first to benefit. The stimulated clover crop should favorably influence succeeding cultivated and grain crops.

TABLE XXXII

YIELDS OF OATS PER ACRE IN CLOVER UTILIZATION SERIES

Plot	Management	1927	7-yr. av.
		bu.	bu.
1	Grass pastured	21.89	
2	" plowed under	17.12	
3	" harvested	16.44	
4	" pastured	17.46	
5	" plowed under	13.92	
6	" harvested	18.28	
Averages			
1-4	" pastured	19.67	41.89
2-5	" plowed under	15.52	40.29
3-6	" harvested	17.36	42.75

Owing to attacks of plant lice, it was necessary to discard the 1926 crop of oats. Late seeding followed by a heavy rust attack severely injured the 1927 crop. Thus far, the disposition of the clover two years in advance does not seem to affect the oats crop.

Rotation Without Clover or Manure

The rotation is: Sunflowers-potatoes, barley, oats. No hay crop is grown and no grass seed is sown. For eleven years the land has received no fertilizer of any kind beyond the grain and sunflower stubble and potato tops produced on it. In this experiment we trace the gradual decline in production to the absence of soil fertilization.

The averages include nine crops of oats, seven of sunflowers, and eleven of potatoes. Of all crops under test, barley appears most sensitive to a shortage of available plant food. The sunflower crop ranks second in its need for abundant soil fertility, dropping almost a ton in two years. Oats and potatoes seem most stubborn in their vigor of production under adverse conditions, yet each discloses a measurable decline in the biennial period. In physical condition, this land, with no

additions of either mineral plant food or organic matter for eleven years, has become a compact puddled soil, covered with a vigorous growth of thistles and quack grass.

TABLE XXXIII

YIELDS PER ACRE IN ROTATION WITHOUT CLOVER OR MANURE

Plot	Crop	1926	1927	Average 1917-25	Average 1917-27
A	Barley, bu.	*	*		
B	Oats, bu.	†	20		
C	Potatoes, bu.	133	11.61		
C	Sunflowers, tons	2.47	0.77		
D	Barley	*	*		
E	Oats, bu.	†	15.67		
F	Potatoes, bu.	95.33	74.73		
F	Sunflowers, tons	0.92	1.12		
Averages					
A-D	Barley	*	*	31.25	29.91
B-E	Oats	†	17.84	31.25	29.91
C-F	Potatoes, bu.	114.17	43.17	105.90	100.95
C-F	Sunflowers, tons	1.69	1.05	5.24	4.27

* Barley has produced no crop since 1923; the 7-year average then was 8.73 bushels per acre.

† The oat crop on this series was ruined by plant lice in 1926.

Rate-of-Manuring Plots, July, 1925

Rate of Manuring

This project, also, was begun in 1917. The fourth cycle of the 3-year rotation—oats, grass, sunflowers-potatoes—is well under way. The manure is spread in late fall before snowfall, in order to protect the tender clover. In the fall of 1927, the project was expanded into a 4-year rotation, with two years in hay. The averages given in the 1924-25 report are presented to show the upward or downward tendencies of production.

TABLE XXXIV

YIELDS OF POTATOES PER ACRE IN RATE-OF-MANURING PROJECT

Plot	Management	1926	1927	Average 1917-25	Average 1917-27
		bu.	bu.	bu.	bu.
7	No fertilizer	121.00	58.55		
8	5 tons manure after oats	161.34	57.07		
9	10 " " " "	198.73	90.40		
10	20 " " " "	207.00	80.34		
11	10 " " " hay	213.20	75.04		
12	5 " " " "	239.80	81.26		
13	No fertilizer	173.80	76.37		
14	5 tons manure after oats	244.56	124.22		
15	10 " " " "	262.53	85.27		
16	20 " " " "	283.80	75.13		
17	10 " " " hay	240.53	45.83		
18	5 " " " "	215.60	56.54		
Averages					
7-13	No fertilizer	147.46	67.46	124.69	121.24
8-14	5 tons manure after oats	202.95	90.64	148.56	148.21
9-15	10 " " " "	230.63	87.83	159.33	159.31
10-16	20 " " " "	290.40	77.73	173.49	175 60
11-17	10 " " " hay	226.86	60.43	147.58	146.79
12-18	5 " " " "	227.70	68.90	162.45	159.62

TABLE XXXV

YIELDS OF SUNFLOWERS PER ACRE IN RATE-OF-MANURING PROJECT

Plot	Management	1926	1927	Average 1920-25	Average 1920-27
		tons	tons	tons	tons
7	No fertilizer	1.56	2.07		
8	5 tons manure after oats	3.04	3.47		
9	10 " " " "	4.4	3.81		
10	20 " " " "	8.34	4.84		
11	10 " " " hay	8.80	4.07		
12	5 " " " "	7.88	4.40		
13	No fertilizer	5.22	3.85		
14	5 tons manure after oats	5.31	4.62		
15	10 " " " "	5.55	7.85		
16	20 " " " "	9.07	5.32		
17	10 " " " hay	4.31	5.06		
18	5 " " " "	7.88	5.50		
Averages					
7-13	No fertilizer	3.39	2.96	6.62	5.76
8-14	5 tons manure after oats	4.63	4.04	7.96	7.05
9-15	10 " " " "	4.97	5.83	10.18	8.99
10-16	20 " " " "	8.71	5.08	10.19	9.37
11-17	10 " " " hay	6.55	4.57	10.23	9.06
12-18	5 " " " "	7.88	4.95	9.07	8.41

TABLE XXXVI

YIELDS OF OATS PER ACRE IN RATE-OF-MANURING PROJECT

Plot	Treatment	1927	Average 1918-25	Average 1918-27
		bu.	bu.	bu.
7	Check—No fertilizer	20.84		
8	5 tons manure after oats	25.69		
9	10 " " " "	26.98		
10	20 " " " "	31.54		
11	10 " " " hay	21.71		
12	5 " " " "	27.81		
13	Check—No fertilizer	29.54		
14	5 tons manure after oats	32.17		
15	10 " " " "	38.60		
16	20 " " " "	42.38		
17	10 " " " hay	34.75		
18	5 " " " "	36.08		
Averages				
7-13	check	25.19	39.20	37.45
8-14	5 tons manure after oats	28.93	40.54	39.09
9-15	10 " " " "	32.79	46.50	44.78
10-16	20 " " " "	36.96	54.44	52.25
11-17	10 " " " hay	28.23	50.72	47.91
12-18	5 " " " "	31.94	46.07	33.30

TABLE XXXVII

YIELDS PER ACRE OF HAY IN RATE-OF-MANURING PROJECT

Plot	Treatment	1926	1927	7-yr. av. 1919-25	9 yr. av. 1919-27
		tons	tons	tons	tons
7	No fertilizer	0.53	1.54		
8	5 tons manure after oats	0.92	1.69		
9	10 " " " "	1.59	2.79		
10	20 " " " "	2.22	3.29		
11	10 " " " hay	1.48	2.55		
12	5 " " " "	0.65	2.49		
13	No fertilizer	0.55	2.14		
14	5 tons manure after oats	0.74	2.54		
15	10 " " " "	1.86	3.09		
16	20 " " " "	2.62	3.14		
17	10 " " " hay	1.22	2.64		
18	5 " " " "	1.34	2.14		
Averages					
7-13	Check—No fertilizer	0.54	1.84	1.22	1.21
8-14	5 tons manure after oats	0.83	2.11	1.55	1.53
9-15	10 " " " "	1.72	3.39	1.96	2.09
10-16	20 " " " "	2.04	3.21	2.11	2.22
11-17	10 " " " hay	1.37	2.59	1.65	1.72
12-18	5 " " " "	1.00	2.31	1.59	1.60

The 1926 and 1927 potato crops again exemplify the tremendous fluctuation in yield from year to year so common with this crop. This project is ten years old. The different systems of management are beginning to show effects. Compared with the 8-year average, the unmanured plots show a slight decline at the 10-year average. Where manure has been put on the grain stubble, it seems to be as effective in holding production at a given level, altho a crop year removed from the potato crop, as when it is spread on the grass stubble the autumn preceding the potato crop.

The last two seasons have been unfavorable for sunflower culture. Yields were below normal in both seasons. Unlike the potato crop, the 8-year average yield is decidedly lower than the 6-year, in all cases. The 6-year average, likewise, is lower than the 4-year. This progressive decline in yield indicates that (1) sunflowers are heavy feeders and (2) 10 tons of manure per acre once in 3 years is not adequate.

The 1926 oat crop was a failure. Plant lice attacked the crop in the early summer. Extreme wet weather delayed threshing until October, when the straw was rotted and the grain sprouted. The vitality of the plants was so lowered by the insects that little could be expected. The 1927 crop was seeded late in a wet seedbed that packed hard on drying. The resulting late crop suffered severely from rust. Yields were extremely low, hence in all cases the 8-year average is perceptibly lower than the 7-year.

The hay crop has held its own, for 1926 was a fair hay year and 1927 was excellent. In 1926, the yield on the unfertilized and both 5-ton plots was much reduced, while in 1927 the same plots averaged more than 2 tons per acre. The early wet season helped, but the 1922 crop, in a wet season and on rather new land, averaged only 1.85 tons per acre; and after a wet spring in 1924 the yield was only 0.66 ton. The hay crop is the only one in the rate-of-manuring series that shows a sustained increase after 10 years as compared with the 8-year average. Lime is the probable explanation. This was applied two years ago. The 1927 crop was the first to receive complete benefit from it. Irrespective of winter cover or spring rain, hay yields have been declining until the soil was reinforced with lime.

It is fitting that the hay crop should respond most to fertilizer and oats least, as hay follows immediately after the stubble top-dressing and oats is the furthest removed. Potatoes benefit from manure application only about 60 per cent as much as sunflowers, perhaps because they grow more slowly. In 1927, the sunflower crop grew in a very short time, requiring much available fertility. The return per ton is still largest with the smaller application.

TABLE XXXVIII

INCREASES IN YIELD PER ACRE OVER CHECKS, RATE-OF-MANURING PROJECT, 1917-27

Management	Potatoes	Sunflowers	Oats	Hay
	per cent	per cent	per cent	per cent
No fertilizer				
5 tons manure after oats.....	22.24	22.45	4.38	26.44
10 " " " "	31.40	56.00	19.57	72.89
20 " " " "	44.83	62.58	31.51	83.80
10 " " " hay.....	21.07	57.33	27.93	42.23
5 " " " "	31.65	45.92	18.29	32.36
Averages	30.24	48.86	20.34	51.54

Commercial Fertilizers

This work covers both field and garden crops. The 1927 crop was the seventh grown in the test. Late planting, extreme wetness, and later baking of the soil necessitated discarding one-third of the plots. The 1926 crop was excellent in stand and yield. The residual effect of the fertilizers on the grass and grain crops that follow in the rotation are given below.

TABLE XXXIX

YIELD PER ACRE OF POTATOES IN COMMERCIAL FERTILIZER PROJECT

Plot	Treatment	1926	1927	7-yr. av.	Gain over check	
					5-yr. period	7-yr. period
		bu.	bu.	bu.	bu.	bu.
1	Check	202.29	66.80	164.16		
2	Muriate of potash.....	261.58	132.66	202.01	37.05	37.95
3	Potash and phosphate.....	297.02	185.18	213.45	34.58	49.29
4	Treble superphosphate	235.29	152.10	182.13	8.04	17.97
5	Sulfate of ammonia.....	251.80	151.56	178.30*		
6	Nitrate of soda	251.19	150.38	192.27	17.81	28.11
7	Nitrate and potash.....	301.30	143.70	219.70	43.00	55.54
8	Potash, nitrate and phosphate...	363.03	231.08	270.38	87.00	106.22
9	Phosphate and nitrate.....	207.63	.....	242.00†	61.54	77.84
10	Nitrate of soda	235.35	115.14			
11	Check	202.90	81.78			
12	Muriate of potash.....	205.35				
13	Potash and phosphate.....	229.78				
14	Treble superphosphate	184.57				
15	Sulfate of ammonia.....	158.29				
16	Nitrate of soda.....	226.13				
17	Nitrate and potash.....	311.69	109.40			
18	Potash, nitrate, and phosphate.	350.20				
19	Phosphate and nitrate.....	245.68				
20	Nitrate of soda	215.13				

* 2-year average; † 6-year average.

The 1927 crop was very unsatisfactory and spotted on account of the unfavorable planting season, altho on high ground. For the first time, the complete fertilizer showed an average increase of more than 100 bushels per acre over the check. In studying the 5- and 7-year averages, when an increase is noted in the latter case, 10 bushels should

be allowed for the decline in the check from 174 to 164 bushels per acre. The gain to this extent is negative. Nitrate of soda alone, of the single fertilizers, shows a positive gain. Those in combination have all shown some net gain, the most pronounced being the complete fertilizer. As the phosphate-nitrate combination includes nothing in 1927, the showing is relatively too favorable, for the 1926 crop was very heavy throughout. From the results of the 7 years of work it is evident that nitrate, phosphate, and potash fertilizers cause much greater increases in yield when used in combination than when used singly. The relative results of the several treatments conform to the findings of previous years.

Oats follows potatoes in this rotation. In Table XL are given yields for 1926 and 1927.

TABLE XL

YIELDS OF OATS PER ACRE IN COMPLETE FERTILIZER PROJECT

Treatment	1926	1927	2-yr av.	Increase over check
	bu.	bu.	bu.	bu.
Check	51.24	20.50	35.87	
Nitrate of soda	64.17	29.50	46.83	10.96
Sulfate of ammonia	0.	21.30	0.	
Phosphate and potash	67.62	20.70	44.16	8.29
Potash and nitrate	77.02	29.04	53.03	17.16
Phosphate	63.63	29.04	46.33	10.46
Phosphate and nitrate	67.83	25.04	46.43	10.56
Nitrate, phosphate, and potash	74.78	33.30	54.04	18.17
Potash	72.99	28.37	50.68	14.81

TABLE XLI

HAY YIELDS PER ACRE—COMPLETE FERTILIZER PROJECT

Treatment	1926	1927	2-yr. av.	Increase over check
	tons	tons	tons	tons
Check	1.10	2.78	1.94	....
Muriate of potash	1.00	3.30	2.15	0.21
Treble superphosphate	1.46	3.69	2.57	.63
Nitrate of soda	1.56	3.16	2.36	.42
Potash and phosphate	1.36	3.72	2.54	.60
Potash and nitrate	1.70	3.63	2.67	.72
Phosphate and nitrate	1.62	3.24	2.43	.49
Potash, phosphate, and nitrate	1.72	3.30	2.51	0.57

The influence of the fertilizer applications in the first, second, and third years can best be studied by bringing together the increases over the check for the 2-year period of all three crops—potatoes, oats, and hay.

TABLE XLII

INCREASES OF HAY, OATS, POTATOES FROM USE OF FERTILIZER

Treatment	Potatoes 1st-yr. crop	Oats 2nd-yr. crop	Hay 3rd-yr. crop
	bu.	bu.	tons
Check	0.	0.	0.
Muriate of potash	44.67	14.81	0.21
Treble superhosphate	42.63	10.46	.63
Nitrate of soda	44.36	10.96	.42
Potash and phosphate	85.90	8.29	.60
Potash and nitrate	86.86	17.16	.72
Phosphate and nitrate	*	10.56	.49
Potash, nitrate, and phosphate	158.66	18.17	0.57

* No crop in 1927; one year data only.

This table shows the residual effects of fertilizer on the stony clay loam soil prevailing at Duluth, through the course of a 3-year rotation. There is some evidence of what might be termed a balanced influence upon production. The mixtures that produced the heaviest yields of potatoes weakened the second or the third year, and applications that were secondary in building a potato crop had a stronger residual effect on oats or potatoes. Complete fertilizer was first in yielding power for two years, but dropped to fourth place with the hay crop, the third growing season after spreading. (See Table XXXIX.) For the 7-year period, the mixture of phosphate and nitrate has stood second in potato production, but slumped badly with the other two crops. The potash-nitrate mixture has been most consistent of all. For the 7-year period it has stood third, and for the 2-year period second in potato production; for the same two years it stands second with oats and first with hay. Potash-phosphate, so valuable on lowland soils, considering both 7- and 2-year periods, seems secondary in value on upland soils, and is slightly inferior to the other three mixtures measured by first-year and residual yields. Nitrate of soda is most sustained in producing power of the three single-unit fertilizers. Potash seems to spend its energies the second year and phosphate seems to have a striking effect on hay yields.

Diminishing supplies of barnyard manure and increasing demands for soil amendments in the expanding truck gardening and potato country at the Head of the Lakes, prompted the garden fertilizer study begun in 1922. This was arranged in a 3-year rotation. The land not in garden was occupied by sweet clover, peas, and a non-leguminous crop during the 2-year intervals between garden crops. During the 6-year period two cycles of the rotation have been completed and each of the three blocks has produced two garden crops. There have been two good seasons—1923 and 1926; two intermediate growing years—1922 and 1925; two very poor ones—1924 and 1927. The last was the poorest of all. It will be noted that the pairs of good, medium,

and bad seasons came exactly three years apart. Table XLIV is a summary of the 6 years of work. The project is closed.

TABLE XLIV

YIELDS PER ACRE OF GARDEN CROPS IN FERTILIZER TEST, 1922-27

Treatment	Carrots	Beets	Rutabagas	Parsnips	Onions
	tons	tons	tons	tons	tons
Check	10.79	7.87	13.89	4.84	5.70
30 tons manure per acre	14.74	10.83	17.48	9.21	8.06
15 " " " "	13.18	11.86	15.53	7.04	8.74
15 " " " " + ½ " " " " com'l fertilizer	16.65	14.07	17.86	8.98	10.05
1 " " " "	17.42	14.74	22.50	9.69	7.60

In the table, six crops each of carrots and beets, five of rutabagas, four of onions, and two of parsnips are represented. In 1924 and 1927 the onion crop failed, owing to excessive rainfall. Parsnips are slow germinators, difficult to start. Those listed constitute our main commercial root crops. Yields of leaf crops—cabbage, cauliflower, and lettuce—were published in the 1924-25 report. Since then, yields have been recorded on basis of weight per head only. These data are given in Table XLV.

TABLE XLV

INCREASES IN YIELDS PER ACRE OVER CHECK OF GARDEN CROPS FROM FERTILIZERS, 1922-27

Treatment	Carrots	Beets	Rutabagas	Parsnips	Onions	Cabbage	Average all crops
Check	0.	0.	0.	0.	0.	0.	0.
30 tons manure	3.95	2.96	3.59	4.37	2.36	1.62	3.14
15 " "	2.39	3.99	1.64	2.20	3.04	2.21	2.58
15 " " + ½ " com'l fertilizer	6.06	6.20	3.97	4.14	4.35	2.39	4.52
1 " " "	6.63	6.87	8.61	4.85	1.90	3.21	5.35

Measuring the efficiency of each treatment in terms of 30 tons of manure as 100, the following relative measures of efficiency are indicated: 15 tons manure, 82 per cent; manure and fertilizer, 139 per cent; commercial fertilizer, one ton, 170 per cent. Fifteen tons manure has proved fully as good as 30 tons for beets, onions, and cabbage, but only half as good for rutabagas and parsnips. For general gardening, extremely heavy additions of barnyard manure seem to be wasteful. It is better to use less and apply it oftener. The mixture of manure and fertilizer has been extremely satisfactory, especially with carrots, beets, parsnips, and onions. For general farm practice, economy considered, this mixture may be preferred to all others. It is 85 per cent as efficient as complete fertilizer, and additional credit must be given for the addition of humus and the physical improvement of the soil. Combined with half a ton of 2-4-8 commercial fertilizer, manure has been much more productive than either 15 or 30 tons. The single heavy application of commercial fertilizer made the best showing

of the group with rutabagas and cabbage, the poorest with onions. The sensational response of rutabagas to commercial fertilizer has been noted before. Considering the 15-ton application of manure as the most efficient and the average of all garden crops under test, 1½ tons of manure has given the same return as 100 pounds of commercial fertilizer. This would cost about $2.50. Expressed reversely, 65 pounds of commercial fertilizer, costing $1.63, produced about the same yield as one ton of manure. This, however, is exclusive of soil improvement values through the addition of organic matter. At Duluth a return of $4.00 more per ton of manure has been realized from farm crops, than from garden crops (see report for 1924-25). The conclusion seems well founded that barnyard manure can be most profitably employed on the general farm crops, and commercial fertilizer on intensive garden crops.

AGRICULTURAL ENGINEERING

Land reclamation in timbered regions involves four steps: (1) Removing brush and overburden; (2) stumping; (3) breaking; (4) stoning. The first three were finished at Duluth some years ago, the last is now in process of completion. In this department, several projects are under way: (1) In the spring of 1926, Field V was virgin soil. It was broken and cropped to oats. A complete history of all stone operations on this field is being attempted, including the amount of stone removed annually and the cost of labor and explosive units. It is a farm management enterprise. (2) On the 3-, 4-, and 5-year rotation plots, the cultivated crop land is stoned in the fall following harvest. There are nine plots; the shorter rotations will have more frequent plowing and picking. The object is to learn what relation, if any, exists between frequency of plowing and the amount of stone removed and the labor cost of picking stones. (3) On another field the relative economy of picking closely before breaking or of taking out only the extremely large boulders is under investigation. (4) Careful determinations are being made of rocks at various depths to learn what action, if any, the frost may have in heaving them to the surface. A companion project is a series of observations on rock exposure in old fields, due in part to erosion.

Wind Power for Pumping Water

For fifteen years a windmill has been used to supply the water needs of the institution. In periods of calm, this has been supplemented by a gas engine and later by electric power. Through eleven months of 1926 a daily record was kept as to which source of power was used. It was found that the windmill was effective 81 per cent of the time, barring an occasional accident. This was economical service in the fourteenth year of steady work.

ANIMAL HUSBANDRY

Sheep

The station owns a flock of 18 Hampshire ewes and lambs. The 1927 lamb crop was exactly 100 per cent, all reared, the first crop of the flock of young breeding ewes. Fleeces averaged nearly nine pounds each, the heaviest in eight years. The stock has been used for sweet clover pasture tests, silage-feeding tests, and weed control. In 1927 they were effectively used on a field of quack grass. Clover was sown at the same time. Pasturage tests will be repeated in 1928. It is expected that clover sod will be so firmly established and quack grass so weakened by two seasons of pasture that the quack grass will die out. In feeding on it, the ewes cleaned up as they went along. Some of the grass got very woody and past the blossom stage before they reached it. One ram, 12 ewes, and 12 lambs fed off this field of about 1½ acres for nearly six weeks. Very little was left to be cut when they were taken off the field. Later, when the field became green once more, they fed on it again for a few days. Conclusions must await a second season of trial, but they did an efficient job in 1927.

Hogs

Eight Duroc Jersey sows constitute the station breeding herd. Sows are bred for two litters annually, both of which are sold as young pigs. The demand for spring pigs is far beyond the available supply. Fall pigs are sold to the lumber camps, and as roasters for the holiday markets. With potassium iodide fed regularly to pregnant sows, neither goiter nor hairless pigs have appeared in years. Feed consists almost entirely of cooked refuse, vegetables, ground screenings, and inferior grain from the seedhouse. This is cheap and satisfactory feed.

Dairy Cattle

The producing herd consists of 24 individuals. There are 42 females of all ages, 20 of which are purebred, the rest high grade. The herd sire, Beda's Follower, will have 15 daughters milking by April 1. The grade herd consists almost entirely of the offspring of three cows—Climax, Nellie, and Genevieve. The last is nearly 15 years of age. She has two daughters, two grand-daughters, and one each in the fourth and fifth generations. There are four generations in the Nellie family, and three in the Climax line. Since the first cows were purchased, nearly 14 years ago, only three females have been brought into the herd. As a consequence, it has been on the accredited herd list, free from tuberculosis, for about ten years without a break. No hay has been purchased by the station since 1913, when farming operations began, except a few acres of stumpage in 1915. The herd has been developed

only as the roughage supply was insured. Pasture is limited, so summer feeding of grain, light rations, is continuous, supplemented by a soiling crop shortly after July 10. This crop is usually spring rye or sweet clover. The cream is sold to a local distributor. It has been the policy to sell purebred male calves only, keeping the females for the producing herd. The herd is managed as a commercial enterprise to convert the roughage produced into a readily marketable product, to provide fertilizer, and for a few simple feeding tests, as reported later. Records of cows completing not less than one year's production are given in Table XLVI.

TABLE XLVI

DAIRY HERD PRODUCTION RECORDS FOR 12 MONTHS

Name	Kind	Butterfat
		pounds
Nellie 1-1	Grade Guernsey	394.06
Climax 1-1	" "	385.95
Climax 1-1-1	" "	408.70
Genevieve 1	" "	403.59
Genevieve 1-2	" "	455.06
Jewell 2-1	" "	459.98
Jewell 2-1-1	" "	428.23
Star 1-1-1-1	" "	395.72
May 1	" "	564.66
Climax 1-1-3-1	" "	344.92
Genevieve 1-1-2-1	" "	254.67
Nellie 1-1-1-2	" "	277.83*
Nellie 1-1-3	" "	272.42
Antonette	Purebred "	316.14
Merry Maid	" "	370.35
Alexia	" "	473.27
Minota	" "	403.26
Dairy Maid	" "	403.37
Alberta	" "	319.83
Dora of Amity	" "	256.91*
Average		374.94

* Heifers, producing two calves within the year.

Some feeding work has been conducted during the winter and late fall months: (1) Cereal hay test—spring rye, oats, and beardless barley were each sown in May, June, and July, in triplicate plots, for cereal hay. Yields are reported under Field Crops. The cows left 5 pounds of a 65-pound sample of spring rye, or about 7.7 per cent. There was nothing left of the oats, a 50-pound lot. Five pounds, or 5 per cent, of beardless barley was left. It seems that cereal hay can be fed to good advantage and with little waste. (2) Clover silage was put into the stave silo, and also into a wire silo separate from the buildings. Several tests were made of the feeding value of that in the wire enclosure, which was described under Forage Crops. In the early tests, 75 per cent was consumed. Later, consumption was practically 100 per cent. (3) Win-

ter maintenance of heifers on hay and silage only. Six heifers were weighed in early December and are being fed all the silage and hay they will consume. The gross weight was 348 to 580 pounds each. Weights will be taken in early spring to determine the gains made in the winter months.

Dairy Herd, July, 1925

Poultry

The station maintains no special poultryman and the production recorded was made by a farm flock under conditions of management that obtain on any well ordered farm. A consulting poultryman visits the flock from time to time and helps to plan the work; the farm foreman supervises it, and the routine duties are performed by a helper. The station service to the local poultry industry is limited to three fields: (1) Investigations in and recommendations on the proper types and varieties of grains and succulent feeds that can be successfully grown locally for poultry feeds; (2) studies in the relative desirability of various types of building construction; (3) a 2-year test of artificial light vs. no artificial light, from November to April, inclusive. Work is conducted in two houses: One built in October, 1923, 32 x 18, shed-roof type, with shutter ventilation and sawdust insulation in roof and walls. Double studding are used, alternating on outer and inner wall, thus providing a sawdust insulation fully 7 inches thick (see Fig. 4). The large house was remodeled and moved from the original location to a well drained site adjoining the main group of buildings. Each pen is 24 x 16 feet. Pen 1 is completely equipped with a ventilating system, and equipment. This pen, in its interior construction, was designed to fit the particular equipment installed to insure a proper base for comparison. Pens 2 and 3 are both modifications of the Acme plan: The first was designed by the Division of Agricultural Engineering, University Farm; the second was offered to the public by a farm news-

paper. The former ventilates through shutters; the third pen has two open spaces filled in with burlap doors, swinging at the middle. These two pens differ only in details of frontal ventilation and interior type and arrangement of nests and feeding equipment, both of minor importance. All three pens are built with shavings in ceiling and three walls and all are equally protected from immediate exposure to east or west wind by the feed room on the east and the sheep shed on the west.

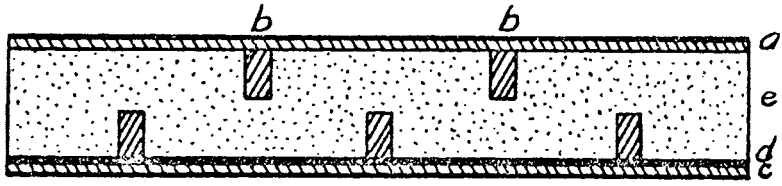


Fig. 4. Details of Poultryhouse Wall Construction
a, outside drop siding; b, studding; c, inside sheathing; d, insulite; e, shavings or sawdust

Conditions have been made as uniform as possible for a proper comparison of the three types of houses as exemplified by these three pens in a single house, for behavior under the severe exposures of Duluth. Both buildings are stocked with Tancred Bred White Leghorn fowls. The work reported here covers the winters of 1925-26 and 1926-27.

TABLE XLVII
LIGHT VS. NO LIGHT EGG PRODUCTION TEST, 1925-26

Month	Pen 1 (dark)			Pen 2 (light)		
	No. of birds	No. of eggs	Eggs per bird	No. of birds	No. of eggs	Eggs per bird
November 1925	77	515	6.70	86	648	7.54
December 1925	77	574	7.47	86	735	8.55
January 1926	77	535	6.95	80	711	8.88
February 1926	70	546	7.80	80	932	11.65
March 1926	63	647	10.27	80	1063	13.28
April 1926	61	1011	16.68	77	961	12.35
Totals	68*	3828	55.87	80*	5050	62.24

* Average number of birds through the winter.

TABLE XLVIII
LIGHT VS. NO LIGHT EGG PRODUCTION TEST, 1926-27

Month	Pen 1 (light)			Pen 2 (dark)		
	No. of birds	No. of eggs	Eggs per bird	No. of birds	No. of eggs	Eggs per bird
November 1926	45	420	9.34	45	382	8.49
December 1926	45	715	15.90	44	706	16.00
January 1927	44	705	16.00	44	493	11.20
February 1927	42	549	13.00	44	347	7.89
March 1927	42	603	14.35	44	596	13.54
April 1927	42	600	14.28	41	604	14.73
Totals	43.3*	3592	82.67	43.6*	3128	71.85

* Average number of birds in pen through the six months.

There is considerable similarity in the production records of the two winters. More eggs were laid the second year, owing, in part, to improved feeding, older stock, and better housing; and the margin in favor of light is nearly eleven eggs as against not quite seven the first winter. As they laid more eggs, the second year flock reached its maximum production in January, the first year flock in March. But in both years the greatest margin in favor of lighting was in February. This is usually a critical time in the winter history of the northern flock when the strain of confinement and perhaps the severity of winter weather is beginning to tell on the health and vitality of the birds. Perhaps the artificial light helps to balance or neutralize this condition. On the other hand, in April of both years the unlighted pen stood first, lending color to the argument that while artificial light undoubtedly speeds up winter production, birds living under natural lighting only will catch up in summer. The argument in favor of lighting, then, becomes economic—the heavy production comes at the time of highest prices.

The entire 12-month production record of the 1926-27 pullet flock is presented in Table XLIX.

TABLE XLIX

12-MONTHS' PRODUCTION OF PULLET FLOCK, SEASON OF 1926-27

Month		No. of birds	Total production	Eggs per bird
November	1926	89	772	8.67
December	1926	89	1419	15.94
January	1927	89	1198	13.46
February	1927	86	896	10.42
March	1927	86	1199	13.94
April	1927	83	1204	14.50
May	1927	81	1385	17.10
June	1927	69	1223	17.72
July	1927	66	724	10.97
August	1927	65	687	10.57
September	1927	65	330	5.08
October	1927	53	95	1.36
Totals		76.7*	11132	139.83

* Average.

This table gives the history of the flock during its pullet year, showing the distribution of egg production, the decline in number of birds through the season, and the sudden break in egg production at the end of nine months of sustained effort. The total production per bird, 139.83 eggs, is just a little short of 12 dozen. The number of pullets declined from 89 to 81 up to May 1. Twelve were culled at that time. Four more were lost before the next culling period. This means that 85 per cent of the flock came through in good health. This evidence of good health, coupled with a production of practically a dozen eggs per month, indicates that the shed-roof type of house, shutter ventilated, as previously described, is satisfactory for Duluth conditions.

Temperature records.—The flock must be comfortable to do its best work. If the temperature is above freezing, ventilation is usually much more active. Generally, as the margin between indoor and outdoor temperatures increases, conditions are improved for a more rapid movement of air and its corollary, moisture in suspension. The first need, therefore, is to build a tight-walled, draftless house. The large house of three pens, as well as the small one, is uniform in this respect. It has shaving insulation over the ceiling and along the entire north wall and all side walls except the south. Pen 1, large house, has a commercial installation; pen 2 has the shutter or louver type, identical with that of the small house; pen 3 has swinging burlap doors in the window openings. During January and February, 1926, daily morning and afternoon readings of outside and inside temperatures were taken at the small house.

TABLE L

TEMPERATURE READINGS, SHED-ROOF HOUSE, JANUARY AND FEBRUARY, 1926

Month	Indoors		Outdoors	
	Morning	Afternoon	Morning	Afternoon
	deg.	deg.	deg.	deg.
January 1926	36.5	42.6	8.6	15.5
February 1926	38.4	43.3	13.1	21.2

Morning readings were taken about 7:30, afternoon readings, usually shortly after one o'clock. On six days in January and three in February the thermometer dropped below freezing, but rarely to 20 degrees above zero. A south wind is usually more severe than a north wind. Wind is the limiting factor. On January 12 it was only zero outside, but it was the coldest day of the winter inside, 14 above. The daily range, inside and out, was about the same, 5 to 8 degrees. The mean temperature is well above freezing. The birds were comfortable. See Table XLIX for record of egg production, ranging from nearly 8 eggs per bird in the dark pen to nearly 12 in the lighted one. Measured by temperature and production, this house has been successful.

In Table LI temperature records made at the large house during the winter of 1926-27 are presented. A comparative study was made of outdoor temperature and that of the three pens each morning. In January, the work was limited to pens 1 and 2, since pen 2 was the same general type as pen 3. Refer to the text above for differences in ventilating system.

The outdoor temperature was below freezing continuously through the last half of December, with subzero weather on four days. Yet pen 1 was above freezing all this time. Pen 2 was a trifle cooler and more airy than pen 3, perhaps because the shutters were kept open more

and were spaced wider. But both were a trifle under freezing in the early morning, during very severe weather. In January the work was confined to pens 1 and 2, as pen 3 was vacated January 12, and as pens 2 and 3 are much alike in type and ventilation system. January was extremely cold, with a daily average temperature a fraction of a degree below zero. Yet pen 1 was comfortable at all times, altho sub-zero temperatures prevailed for 11 days. Pen 2 was perceptibly cooler but not frosty. The records of the two months indicate that pen 1, with a specialized, patented ventilation system was not quite 5 degrees warmer than pen 2.

TABLE LI

TEMPERATURE READINGS, LARGE POULTRY HOUSE, 1926-27

Period	Average Daily Temperature			
	Outdoors	Pen 1 Vent and intakes	Pen 2 Shutters or louvers	Pen 3 Burlap window
	deg.	deg.	deg.	deg.
December 16-31	16.67	33.46	28.73	30
January 5-30	0.64	30.72	26.33	

In Table LII production records for these two pens are given, as already presented for the small house, winter of 1925-26.

TABLE LII

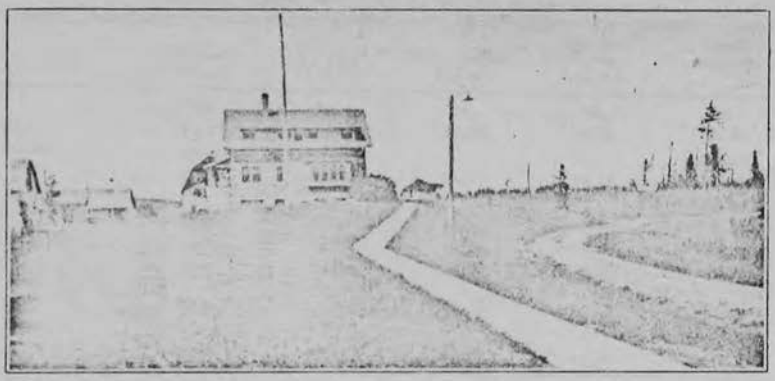
EGG PRODUCTION PER BIRD, WINTER OF 1926-27

Month	Pen 1	Pen 2
November 1926	5.65	3.26
December 1926	13.30	12.19
January 1927	14.11	11.58
February 1927	11.74	11.64
March 1927	15.20	14.14
April 1927	17.77	15.30
Total	77.77	67.90

Both pens were lighted. Both were filled with birds of the same age and breeding. After December 1, birds of both pens were fed alike. Yet those in pen 1 led in production by nearly 10 eggs per bird. Therefore, the largest production occurred in the pen that was the most comfortable in severe weather. Both pens were healthy, no frost was visible in either, so it may be assumed that ventilation was quite satisfactory in both. On the basis of production and comfort, other factors being equal, pen 1, with ceiling and out-take vent, and intakes under the eaves, made decidedly the better showing.

INSTITUTIONAL DEVELOPMENT

Much has been accomplished during the calendar years of 1926 and 1927 in spite of the extremely wet autumn in the first year and a wet spring in the second year, and two closed, snowy winters. Breaking of the large swamp on the north 80 was completed in 1926, and the entire area was in grass or grain in 1927. In addition, about 2 miles of drain tile was installed on this 80-acre tract in October, 1926. All but a small portion of the remaining virgin mineral soil was broken and stoned in 1926. The job, delayed by the wet autumn, was completed in the summer of 1927. In December, 1926, five weeks of pole and stump sawing culminated. This job may be considered done at the Duluth station, aside from small detached lots of pickup material. In the same summer and autumn, the basement of Institute Hall was reconstructed into a

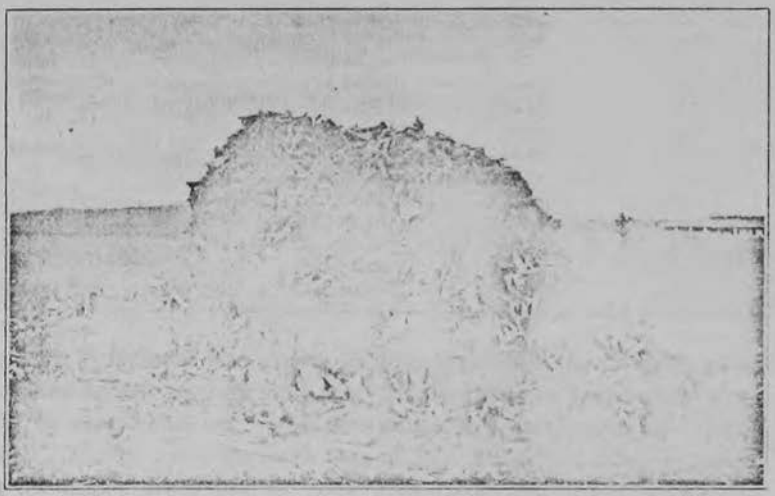


Administration Building from Institute Hall

garage. New windbreaks were set up on the campus to separate the building and residence groups from the barns and to provide much needed winter protection. In the late summer of 1927, the greenhouse purchased the previous year was erected near the root cellar. The herdsman's residence was enlarged in the late fall, water mains were extended to the site of the new greenhouse in June, 1926, and to the herdsman's house in November, 1927. The age of steel and concrete has reached the Duluth station. Steel fence posts have replaced wooden ones. New concrete yards surround the hog barns. Wood is still used for fuel, but another year will see the end.

The Northeast Experiment Station is concentrating its personal contact and teaching service on the annual spring Institute, which was organized in 1924 and is usually held the first week in April. The attendance at day and evening sessions totals about 1800. The Duluth Chamber of Commerce, the St. Louis County Club, the several breed and crop associations, all co-operate in the day programs. The evenings

are given over to recreational and dramatic contests. In planning and managing this annual event, an advisory committee has been called into being, which meets annually in February. The initiative for the various programs is now coming from the people of the territory themselves, but the work cannot expand until additional housing facilities are provided. A modest addition to the present Institute Hall would provide an adequate home for what has come to be the Farmers' Week of Northeast Minnesota. The Duluth station will celebrate its fifteenth birthday in April, 1928.



Stump Fuel—Converting a Liability into an Asset

Sub-experimental Fields

For four years the Northeast Experiment Station has operated outlying sub-experimental fields. The first year the work was done only at Biwabik on sandy loam soil, and at Two Harbors on red clay soil. In 1925, Virginia was added to the list. The 1926 projects were carried on at Chisholm, Virginia, Two Harbors, and Biwabik. Chisholm, like Virginia, lies on the typical Iron Range stony clay loam glacial drift. In 1927, the larger projects were concentrated at two places: at Meadowbrook, 20 miles west of Cook, and 50 miles northwest of Virginia, in the fertile hardwood country of the Little Fork Valley; and south of Eveleth, on sandy loam soil very much like that at Biwabik, both growing originally a jack pine crop. Potato work only was conducted at Biwabik, and both potato and grain work at the other two places. The object of this work is (1) To determine what crops and practices were best adapted to these several soils and localities. (2) To acquaint the people with the range in choice of crops, new plant creations, and

the effects of fertilizers. (3) To demonstrate to its more distant constituents the work of the experiment station. The work in St. Louis County through recent years has been financed by the St. Louis County Club.

The writer wishes to acknowledge the fine co-operation he has received from this organization and from the institutions and individuals listed below that have co-operated through the four years in conducting the tests: Lake County Farm, Supt. J. J. Harney, County Agents B. H. Gustafson and Fred Peterson, all of Two Harbors; Wm. Hanke, Gilbert, Minn.; Albert Engel, Eveleth; George Perham, Eveleth; M. Thornberg, Meadowbrook; County Agent August Neubauer, Tony Glowaski, Chisholm; Fred Wallin, Virginia; Virginia School Farm, Chisholm School Farm.

TABLE LIII

YIELDS OF GRAIN PER ACRE ON HEAVY SOILS

Crop	Chisholm (1926)	Virginia (1926)	Two Harbors (1926)	Meadowbrook (1927)	4-field average
	bu.	bu.	bu.	bu.	bu.
Spring rye	32.58	29.87	25.95	14.85	25.81
Java wheat	33.97	24.44	....	....	29.20 *
Progress "	31.70	27.63	22.51	12.50	29.66 †
					23.60 ‡
Marquis "	30.30	28.52	19.54	4.00	19.54
Mindum "	24.71	24.86	18.70	11.45	19.93
Hull-less barley	35.21	25.83	28.94	25.50	28.87
6-rowed " (No. 184)	36.10	25.25	38.76	22.75	30.71
2-rowed " (No. 440)	52.10	27.78	45.30	17.70	35.57

* 2-field average; † Chisholm-Virginia average; ‡ 4-field average.

Spring rye, wheat, and barley have yielded well on heavy soils. The crop at Meadowbrook, in 1927, however, was cut about 60 per cent by rust. Marquis wheat was an absolute failure. For proper comparison, the two Progress fields should be compared to the two Java fields grown the same year at the same places, as there was no test of Java at either Meadowbrook or Two Harbors. These results indicate that Progress wheat still leads Java by a small margin, and is much better than either Marquis or the macaroni wheat, Mindum. The 2-rowed barley bears out nearly ten years' findings at Duluth, in that it exceeds all others, with 6-rowed second, and Hull-less third. One test of Velvet barley, made in 1927 at Meadowbrook, yielded 28.25 bushels per acre. The oat crop of 1927 was so badly cut by rust that it was rejected. The early or 60-day oats averaged 56.84 bushels at Chisholm in 1926. This was an average of Iowar and Gopher. The former crop produced 29.2 bushels on new land at Two Harbors, with late seeding on wet ground. The variety Victory averaged 55.47

bushels at two places—Chisholm and Virginia. White Russian grew an average of 50.95 bushels per acre in 1926 at 3 places—Chisholm, Virginia, Two Harbors; 57.58 bushels at Chisholm and Virginia only. This crop yielded 23.17 bushels at Meadowbroow, 1927, the best of the group.

TABLE LIV

YIELDS PER ACRE OF GRAINS ON LIGHT SOILS

Crop	Biwabik	Eveleth	2-field average
	1926	1927	
	bu.	bu.	bu.
Spring rye	24.17	13.98	19.08
Java wheat	20.94		
Progress "	20.27	14.06	17.17
Marquis "	23.73	10.58	17.16
Mindum "	18.01	10.55	14.28
Hull-less barley	18.38	16.65	17.27
6-rowed "	29.66	26.22	27.94
2- " "	32.96	25.45	29.22
Iowar oats	20.26		
Gopher "	20.21	28.37	24.29
Victory "	22.37	30.87	26.62
White Russian "	24.57	27.20	25.88

The crop at Eveleth was grown on first breaking; the Biwabik plots were on land almost as new and raw. Both crops in both years were badly hit by rust, hence oat yields are about half and wheat two-thirds of normal. Barley came through best of all. It should interest dairymen in the upper townships to know that barley flourishes so well in their locality. It is usually assumed that virgin soil is most productive; but in the old pine country, the reverse seems to be true. The Chisholm tract is old soil; it produced far more than the newer soils, which must be gradually built up. Reviewing both tables, a fair crop of spring rye is indicated on both heavy and light soils of Lake County and the Range country. Progress wheat and 2-rowed barley are slightly better than the others; early, midseason, and late oats are much the same except in straw, which is lightest with early oats. Barley was a good crop both years on both soils.

Potato Fertilizer Work

Two years' information is available for complete fertilizers on sandy soils; one year with sulfate of ammonia. The results can best be presented in two tables showing yields of early and late potatoes, respectively. The averages represent two plots each.

TABLE LV

YIELDS OF EARLY POTATOES (IRISH COBBLER) IN FERTILIZER TESTS

Treatment	Biwabik	Eveleth	Average
	bu.	bu.	bu.
Check	80.66	90.33	85.5
Sulfate of ammonia, 200 pounds per acre	.....	196.38	....
Complete fertilizer, 4-8-6; 400 pounds per acre	102.65	162.37	132.51
" " 4-8-6; 600 " " "	104.50	202.65	153.57
" " 4-8-6; 800 " " "	108.16	209.52	158.84

TABLE LVI

YIELDS OF LATE POTATOES (CARMEN) IN FERTILIZER TESTS

Treatment	Biwabik		Eveleth	Meadowbrook	Av.
	1926	1927	1927	1927	
	bu.	bu.	bu.	bu.	bu.
Check	121.9	157.45	124.66	160.00	141.00
Sulfate of ammonia, 200 pounds per acre	.....	219.05	205.79	186.70	203.85
Complete fertilizer, 4-8-6; 400 lbs. per acre	130.1	216.71	188.67	207.87	185.84
" " 4-8-6; 600 " " "	146.7	240.37	193.23	221.50	200.50
" " 4-8-6; 800 " " "	180.0	253.93	209.80	241.79	221.38

For early potatoes, 600 pounds of complete fertilizer seems an effective application; at $2.50 per hundred, it is more profitable than either 400 pounds or 800 pounds. Sulfate of ammonia, from present limited tests, seems about equal to 600 pounds of the 4-8-6 combination in producing power. For late potatoes there is little choice between 400, 600, and 800 pounds; in each case 100 pounds of fertilizer seems good for an additional 10 bushels of potatoes. At the 16-year average price of about 65 cents per bushel, an investment in fertilizer ranging from $2.50 to $3.00 will return about $6.50 exclusive of residual influence on succeeding crops. With both early and late potatoes, however, 200 pounds of sulfate of ammonia seems as good as 600 pounds of 4-8-6. If this continues to hold true it will mean a saving of $9.00 per acre, at present fertilizer prices, in growing costs. It is planned to continue the crops work at Eveleth and Meadowbrook in 1928, and perhaps open a new field at Forbes.

SUMMARY

1. The season of 1926 was marked by an extremely dry spring followed by a very wet fall. Conditions were reversed in 1927.

2. A heavy potato crop, like that of 1923, was produced in 1926; a heavy hay crop, like that of 1922, characterized 1927.

3. Progress wheat, Minota-White Russian oat crosses, and Trebi barley were variety leaders of cereals in 1926 and 1927.

4. Plant lice in 1926 and rust in 1927 taught the value of early seeding of grain crops.

5. Largest yields followed the use of 3 bushels of seed per acre for oats and barley.

6. Timothy, redtop, and alsike gave the largest return of six different combinations of seed. Timothy-alsike outyielded redtop-alsike.

7. No positive value was discernible from tillage and manuring, without reseeding, in attempted renovation of old meadow.

8. Clover sown up to the middle of June produced a hay crop; sown up to the middle of July, it formed a sod. Later seedings softened the blackness of the ground with a green tinge.

9. Beardless barley gave greater promise than either oats or spring rye, sown in the middle of May, June, and July.

10. Under a 3-year average of temperature and rainfall, sunflowers averaged a daily growth of about 1⅓ inches through midsummer.

11. Rows 36 inches apart and setting the grain drill for 8 pecks of wheat seem effective for sunflower planting.

12. In a 3-year test, sunflowers produced a tonnage about 50 per cent greater than corn and about equal to rutabagas, a little over 9 tons.

13. Stock roots average: Turnips, 16.5 tons; rutabagas, 13.5 tons; mangels, 13.34 tons; carrots, 10.64 tons.

14. King and Green Mountain still lead in production of late potatoes. Cobbler is first among early ones.

15. The largest potato crop followed the 30-inch spacing.

16. Let 100 represent the crop of potatoes planted the middle of May. Then June 1 planting yields 85; June 15, 63; June 30, 34, or about a third of the first.

17. After 4 years, spraying with bordeaux mixture has given an increase of only 13 bushels of Cobbler and 6 of Green Mountain.

18. Warming seed potatoes in advance of planting has not influenced yield in a 5-year period.

19. In 4 years, large potatoes, cut, have produced a small excess over small uncut seed, with seed end removed.

20. Cutting the seed end has slightly decreased production, using medium sized seed.

21. One-year-old meadows average 2.268 tons per acre; 2-year-old meadows, 2.217 tons; 3-year-old, 1.796 tons.

22. Barley has produced about the same in 3- and 4-year rotations and 2 bushels less on a 5-year cycle.

23. In the 4- and 5-year rotations, sunflowers produce about a ton less than in the 3-year cycle.

24. In studying the influence of one crop upon the next, the lowest yields followed sod, with this ascending order: Potatoes, oats, sunflowers, barley. Three of the seven crops of 1927 produced largest yields after barley in 1926.

25. These garden varieties led for two successive seasons: Peter Pan peas, Early Wonder beets, Refugee and Longfellow beans, Late Flat Dutch cabbage, Newark Market celery, White Vienna kohl rabi, Danish Bangholm rutabaga, Early Scarlet and Cincinnati Market radish, Bloomsdale Spinach, Guernsey parsnip.

26. Yellow Transparent is the earliest apple to ripen in the Duluth orchard. Hibernal is the heaviest bearer.

27. Four pounds sulfate of ammonia per tree, scattered in May, 1924, produced a large apple crop in 1926.

28. Currants produce in this order: Pomona, London Market, Diploma, Holland, Perfection, Wilder.

29. Gooseberries produced in this order: Houghton, Carrie, Como, Champion, Downing.

30. Strawberries produced in this order: Minnehaha, Easy Picker, Chaska, Dr. Burrill, Bliss and Premier, Dunlap, Nokomis.

31. With clover pastured or plowed under, potato yields are better sustained than those of sunflowers, which declined 1 to 1½ tons per acre comparing 7- and 9-year averages.

32. Owing to lime influence, the 9-year hay average is above that of 7 years.

33. Oats have declined 1⅓ bushels, potatoes 5 bushels, sunflowers nearly 1 ton, comparing the 8- and 10-year average of crop in rotation without clover or manure.

34. Manure spread on the grain stubble seems fully as effective in holding potato production at a given level as that spread on grass stubble the fall just preceding the crop.

35. Sunflower yields are progressively declining on plots in rate-of-manuring series, comparing 4-, 6-, and 8-year averages. This indicates that 10 tons of manure once in three years is inadequate to maintain yields.

36. Two poor oat years have depressed the average under that of seven years.

37. The hay crop is the only one in rate-of-manuring series that shows a sustained increase after 10 years as compared to 8 years.

38. Compared with checks, manure has increased oat yields, 20.3 per cent; potatoes, 30 per cent; sunflowers, 48.8 per cent; hay, 51.54 per cent.

39. In complete fertilizer tests, the 4-8-6 mixture has increased potato yields 106 bushels per acre, 7-year average; and phosphate-nitrate mixture, 77.8 bushels.

40. In residual effect on the crop following, oats, the 4-8-6 mixture has increased the yield 18.17 bushels. The potash-nitrate combination is second with 17.16 bushels.

41. In residual effect on the second crop hay, potash-nitrate is first with an increase over check of 0.723 tons; treble superphosphate follows with 0.631 tons; 4-8-6 is fourth.

42. Garden fertilizers: Using the yields with 30 tons manure as a standard, or 100, 15 tons manure stands at 82; 15 tons manure and ½ ton fertilizer, at 139; 1 ton fertilizer at 170.

43. The manure and fertilizer mixture noted above is 85 per cent as efficient as complete fertilizer alone, in ton lots.

44. Sixty-seven pounds complete fertilizer has been as efficient as 1 ton manure in garden fertilization. It costs about $1.63.

45. One ton of manure will produce $4.00 worth of farm crops (see Duluth report 1924-25). We suggest using manure for farm crops and commercial fertilizer for intensive garden crops.

46. The Duluth station is making extensive studies in stoning land.

47. A windmill used for pumping has functioned 81 per cent of the time during eleven months.

48. Sheep have worked successfully in quack grass control. A field of 1½ acres maintained 12 ewes, 1 ram, and 12 lambs for over a month.

49. The Duluth station Guernsey herd has one family of five generations and one of four. It has been on the accredited herd list for 10 years. The herd sire has 15 daughters in milk or of breeding age. Neither loose nor baled hay has been bought since 1913, when farming operations began.

50. In feeding tests, cereal hay and clover silage were practically all consumed.

51. During 6 months, November to April, inclusive, for two winters, pullets in lighted pens produced 7 eggs more than those in dark pens the first winter and 11 eggs the second winter. In April of both years, the birds in dark pens led those in lighted ones.

52. With morning temperatures in January and February, 1926, at 8.1 and 13.1 degrees, inside temperatures of the small shed-roof house, shutter ventilated, were 36.5 and 38.5 degrees. Egg production was 8 eggs in the dark pen and 12 in the light pen.

53. With patented ventilator system, inside temperatures were 33.5 in December, 1926, when it was 16.67 outdoors; 30.7 when it was —0.64 degree outside. The pen with the patented ventilator was always 5 degrees warmer than that with shutter ventilation and winter production was 10 eggs higher.

54. In 1926, sub-experimental fields were operated at Two Harbors, Biwabik, Virginia, and Chisholm; in 1927, at Biwabik, Eveleth, and Meadowbrook (Little Fork Valley).

55. Progress wheat, 2-rowed barley, medium and late oats showed greatest promise in grain work on these fields, of both heavy and light soils.

56. Sulfate of ammonia, 200 pounds per acre, seemed fully as effective as 600 pounds of 4-8-6 complete fertilizer, with both early and late potatoes on both heavy and light soils. This could be used at a saving of $9.00 per acre at present prices.

APPENDIX

STUDIES IN HORSE FEEDING AND MAINTENANCE

Following is a record of feed consumption, monthly weights, and labor output of the six horses at the Northeast Experiment Station, Duluth, for the eleven months beginning February 1, 1923. This information is presented rather as an experience than as an experiment. Certain feeds were fed in given volumes; the hours of work done were recorded, and such gains and losses in weight as ensued from the combined effects of food intake and labor. No effort was made to establish model rations or to determine fundamental maintenance or production requirements, as neither equipment nor staff was available, nor was there need of such studies in this location. But it was believed that a complete narrative of horse management covering nearly a year would be of both interest and value to the farmers and timbermen of this northern territory. Our country is one of abundant roughage and little grain. It is a region where there is both winter and summer employment for horse labor. How far our cheap and usually abundant local forage may supplant the largely imported grain and in turn be replaced by the cheaper pasture during the summer months, without disturbing the weight or working capacity of our horses, is a pertinent question. Many of our farmers are concerned with the feed cost of maintaining a work horse through the year—what feeds to buy and to what minimum they can restrict these purchases.

The procedure was simple. For years previous to 1923 our horses had been weighed monthly on the platform scales. This practice was discontinued during extreme winter weather and occasionally a weighing period would be passed over during the pressure of summer work. Oats and corn in about equal amounts were fed, with an occasional bran mash, once or twice a week. Grain was purchased on the basis of monthly needs, so there was no carry-over. The common ration of 2 to 3 pounds of hay and grain per hundredweight was adopted as a base. The horses were allowed what hay they would clean up and this was supplemented by something less than a one per cent grain ration. The grain ration was split on Sundays and idle days and reduced materially through the winter months. Labor records were kept daily for

each horse. Records of grain fed are available for January, 1923, but labor records did not begin until February 1. Three factors, feeds, weights, and labor, will be discussed in turn.

TABLE I

DAILY AND MONTHLY FEED CONSUMPTION PER HORSE, FEBRUARY TO DECEMBER, 1923

Month	Hay consumption per horse, lb.		Grain consumption per horse, lb.		Grain cost per horse	
	Monthly	Daily	Monthly	Daily	Monthly	Daily
January	...	....	271.6	8.74	$4.07	$0.13
February	991	35.4	304.6	10.90	4.57	.16
March	1116	36	286.1	9.23	4.04	.13
April	1080	36	280.1	9.53	4.38	.15
May	1116	36	332.3	10.72	5.96	.19
June	540	18	320.0	10.66	5.55	.19
July	558	18	335.4	10.82	5.63	.18
August	558	18	335.4	10.82	5.04	.18
September	558	18	360.0	12.00	5.76	.19
October	1116	36	335.4	10.82	5.64	.18
November	1080	36	293.0	9.76	5.47	.18
December	1116	36	172.0	5.55	2.84	.09
Averages	893	29.3	302.6	9.96	$4.96	$0.16

The reader will be disposed to consider the hay ration entirely too heavy. Perhaps it was. We are neither recommending nor defending it, merely recording what actually happened.

TABLE II

MONTHLY VARIATION IN WEIGHTS OF HORSES, FEBRUARY TO DECEMBER, 1923

Date	Nancy	Bess	Pat	Colonel	Fannie	Queen	Average
April 1	1540	1500	1450	1310	1370	1340	1434
" 15	1600	1640	1540	1390	1450	1430	1508
May 1	1540	1560	1470	1330	1360	1360	1437
" 15	1510	1530	1500	1340	....	....	1470
June 15	1550	1580	1510	1400	1400	1450	1482
August 1	1580	1630	1520	1440	1490	1497	1530
September 1	1640	1680	1470	1530	1540	1560	1570
November 4	1640	1590	1430	1400	1470	1490	1503
December 2	1610	1622	1500	1400	1430	1540	1517
Average	....	....	....	....	....	....	1468.4

Starting with the assumption that each horse should be fed what it would nicely clean up between meals, and after giving a number of test feeds to determine the amount, the feeds were weighed at irregular times monthly, unknown to the barnmen. Whatever hay was left, if any, was collected, weighed, and the amount deducted from the total. Slight losses occurred because some hay naturally fell into the bedding. Undoubtedly the hay ration would be much less if more grain were fed, but the policy was to hold the grain ration at a minimum and maintain body weight on roughage as far as possible. The value of pasture can not be overestimated in northern farm economy. On the newer farms, even hay is not over-plentiful, but stump land pasture may be both

abundant and luxuriant. Repeated tests over three years indicated that pasturing nights, Sundays, and idle days, the horses could maintain weight even tho on steady labor, and much hay could be saved for winter feeding. The average daily grain feed of about ten pounds is ⅔ of a one-per-cent ration for a 1500-pound horse, the approximate average weight of the six horses under test. The cost of purchased grain, roughly $5.00 a month, was based upon 1923 costs. Perhaps a price of $15 would not be inaccurate for the hay consumed. The expensive item in horse maintenance in the northern timbered counties, however, is the grain.

Tables I and II should be studied together. If the hay ration was too heavy, it quite evidently produced no gain in weight, for the horses show the lightest weight in the early spring, following the longest period of heavy hay feeding of the year. This table indicates an interesting trend in weights which increase regularly from month to month during the summer season of heaviest work, April to September. The decline from September to November is probably due to the nature of the work. Most of the plowing is done in the fall. At this season the soil is usually very dry and the work steady in order to finish before freezing weather. Coming as it does just after the peak of the harvest rush, the horses are bound to lose flesh, altho the grain ration is the highest of the year. Note, further, that the horses gain in weight while on night pasture and a reduction of one half in the hay allowance. There is a difference of only two pounds of grain per day between the summer and the winter ration, yet it is significant that the horses put on flesh with this slight increase altho doing the heaviest work of the year. Was feeding too heavy? The weight on April 15 is excessively high. Two possible explanations are offered. The spring was very late and the horses could do little work during the first half of the month, tho they were on somewhat heavier feed. As this energy could not be expended in muscular activity, it was stored in body weight. However and more probably, the frost was coming out of the ground irregularly, and this might disturb the accuracy of the scales at that time. We are disposed to accept the second explanation and reject the April 15 weights.

The labor hours for January would probably range between those of December and February. A mean of the two would not be far wrong. March is the vacation period for our horses; there is little work to do. May is the busiest month, altho almost equaled by October. The winter of 1922-23 was a severe one, with considerable snow and much wind. Drifting became more pronounced toward the close of the season, as one drift piled upon another. As the spring breakup is sometimes delayed until early April, it follows that March may be a month of relative inactivity for horses. This particular March was one of the

coldest in years, with the night temperature ranging around 20 degrees below zero continuously during the last week. Drifts were piled so high along the roadsides that a man could walk on the drifts with his head above the telephone wires on April 1. May is a month of feverish activity in preparing the soil and planting the crop. In October, all horse power is employed in either plowing or clearing land, breaking and stoning new tracts. More new land is cleared during this month than during any other month of the year. July and September, marking the peak of the hay, the grain harvest, and the threshing and silage cutting seasons, are next heaviest in their demands upon horse labor. June is less exacting, coming between the labor peaks of planting and cultivating. In August there is frequently a period of relaxation between hay and grain harvest.

TABLE III

HORSE LABOR HOURS, FEBRUARY TO DECEMBER, 1923

Month	Nancy	Bess	Pat	Colonel	Fannie	Queen	Monthly av.	Daily av.
February	133	141	113	113	59.5	60	103.2	4.30
March	76	76	95	99	17	21	64.0	2.37
April	197	197	154	154	130	130	160.3	6.16
May	236	241	244	238	194	243	234.3	8.68
June	190	190	167	175	19	142	152.1	5.85
July	134	134	222	213	207	227	189.5	6.11
August	173	173	207	207	113	113	164.3	6.09
September	201	201	147	147	220	220	189.3	7.28
October	203	203	239	239	239	239	227.0	8.40
November	189	189	76	186	110	0	150.0	5.77
December	192	192	96	182	100	4	127.6	4.72

TABLE IV

SYNOPSIS OF FEED, LABOR, AND WEIGHT TABLES

Month	Weights	Averages per horse of: Labor per month	Labor per day	Hay fed daily	Grain fed daily	Total feed per cwt.
		hr.	hr.	lb.	lb.	lb.
February	....	103.2	4.30	35.4	10.9	....
March	....	64.0	2.37	36	9.23	....
April	1434	160.3	6.16	36	9.53	3.17
May	1453	234.3	8.68	36	10.72	3.21
June	1482	152.1	5.85	18	10.06	1.93
July		189.5	6.11	18	10.82	1.91
August	1530	164.3	6.09	18	10.82	1.88
September	1570	189.3	7.28	18	12.00	1.91
October		227.0	8.40	36	10.82	3.05
November	1503	150.0	5.77	36	9.76	3.04
December	1517	127.6	4.72	36	5.55	2.74
Averages	1498.4	160.1	5.975	29.3	10.05	2.54

As indicated at Halstad (Red River Valley) and Cokato (south central Minnesota) the average farm horse works not quite 3⅓ hours per day. This figure doubtless holds for the northern developed farm

as well as the prairie farm. The horses at Duluth averaged six hours a day. Land clearing is the explanation of the greater service. It seems from these findings that during the period of farm reclamation from timber, stumps, and stone, horse power can be used very economically and made highly serviceable, as it is easy to provide employment—cropping in summer, clearing in spring and fall, and timber work in winter. It costs more to maintain a horse through the year in northern than in other latitudes, but by increasing the labor output the cost per hour can probably be held down to a reasonable figure.

Summary

1. The station horses showed a maximum gain of 135 pounds and a mean gain of 64 pounds on an average ration of 2½ per cent, and working six hours per day.

2. Two thirds of this ration was roughage, and one third grain.

3. The horses were fed a mixture of cracked corn and crushed oats, with two bran mashes per week.

4. The monthly cost of grain per horse was about $5.00, at 1923 prices.

5. The horses reached the peak of weight at the close of the night pasture period, which permitted a saving of half the hay.

6. The horses not only attained greatest weight but also did their heaviest work on a ration under 2 per cent, while on night pasture.

7. The minimum weight was recorded in early spring before heavy work began, and following a long period of heavy hay feeding.

8. In northeast Minnesota, during the period of farm development, horses can be made to produce up to six hours of labor per day. In this way the cost per hour of labor need not exceed the normal for older sections of the state, in spite of higher gross cost.

9. In this experiment, the average daily consumption was about 29 pounds of hay and 10 pounds of grain.

10. The horses averaged only 2.37 hours of labor daily in March and 8.68 in May, the two extremes of the year.

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* Resigned March 5, 1927.
† Appointed April 15, 1927.
‡ Resigned October 1, 1926.
§ On leave, February 19 to June 30, 1927.
‖ Sabbatical leave, 1926-27.