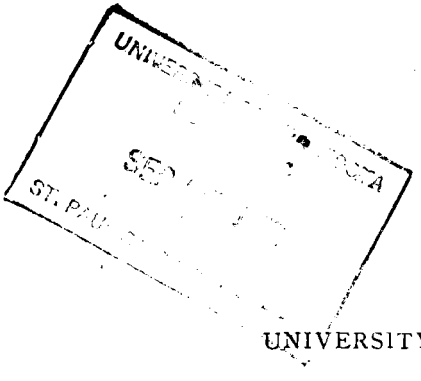
University of Minnesota

AGRICULTURAL EXPERIMENT STATION

REPORT OF
THE NORTHEAST EXPERIMENT STATION
DULUTH

1924 AND 1925



UNIVERSITY FARM, ST. PAUL

REPORT OF THE NORTHEAST EXPERIMENT STATION, DULUTH

1924 AND 1925

M. J. THOMPSON, Superintendent

INTRODUCTION

This report is a summary of the experimental work in progress at the Northeast Experiment Station, located near Duluth, for 1924 and 1925, together with a progress report on the development and expansion of the institution during the same period. It is the eleventh publication in the series prepared since the establishment of the station in 1912. The first nine are enumerated in the 1922-23 report, and most of them are still available. The tenth in the series, University of Minnesota Bulletin No. 220, "Effects of Forest Fires on Land Clearing and Crop Production," was released in May, 1925. Numerous press articles only, were released in 1924, as the institution is now committed to the policy of biennial reports. In 1925 the Board of Regents of the University gave official sanction to the shortened name, "Northeast Experiment Station," which has been used in general practice for a decade.

Fig. 1. Animated Lawn Mowers at Work on the Duluth Campus

WEATHER OBSERVATIONS

Following two severe and blustery winters, those of 1923-24 and 1924-25 were comparatively mild and open. The last two months of 1923 were mild and dry with no snow until December 27. Plowing, blasting, and stone picking were in progress until late November. Clearing and burning continued through December and even later, in

places. Following New Year's day, the coldest of the year, cold snaps were of short duration and outdoor work continued with few interruptions. The summer of 1924 was exceptionally cold, wet, and frosty, and was followed by a late, open fall. The winter of 1924-25 was even milder than the preceding one, following one of the coldest Decembers on record. Stoning and liming land and burning stumps are unusual practices in January and February. The summer was one of contrasts, altho on the whole warmer than usual. The earliest spring seeding on record (April 4) was followed by a frosty May with heavy frost in low ground on June 27. A warm, dry summer, a good corn season, was followed suddenly by the coldest, snowiest October on record, with a heavy loss of potatoes on many farms.

Weather and moisture data are of greatest value when correlated with crop production data. In Table I, data for summer months only are given.

TABLE I

METEOROLOGICAL DATA, SUMMERS OF 1924 AND 1925

Month	Temperature							Precipitation		
	Maximum		Minimum		Mean					
	1924	1925	1924	1925	Normal	1924	1925	Normal	1924	1925
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	In.	In.	In.
April	61	72	13	24	37.0	36.6	42.0	2.14	2.96	1.03
May	75	89	28	25	47.3	45.7	48.2	3.47	2.91	1.79
June	82	88	36	37	57.2	55.9	58.7	4.53	3.92	3.20
July	85	90	42	42	63.9	62.3	65.5	3.65	5.79	3.10
August	89	91	42	46	62.6	61.9	67.5	3.53	4.40	3.04
September	76	89	28	33	55.1	52.6	56.4	3.55	3.94	3.73
October	71	60	30	8	44.1	51.0	34.2	2.74	1.63	1.59
Mean Av. temperature, growing season	..	..	..	..	52.5	52.3	54.5	....	....	....
Total precipitation, growing season	..	..	..	..	....	....	....	23.61	25.55	17.57

October, which was abnormally warm in 1924, is normally a harvest and not a growing month. The accumulated deficiency of temperature between January 1 and October 1, 1924, was 231 degrees, but for the same period of 1925 there was an excess of 706 degrees. For seven months in 1924 there was a surplus of moisture of 1.94 inches, and for 1925 a deficiency of 6.04 inches. From this range of 937 degrees of temperature between the first eight months of 1924 and 1925, or nearly 4 degrees a day; and from this difference of 8 inches of moisture, or one inch a month, we can trace the variation in crop quality, yield, and behavior of these two years. The cool summer temperature and abundant rainfall, which usually spell heavy crops of hay, grain, and potatoes, were too extreme at Duluth in 1924. The cold, wet seedbeds forced late seeding and frequent reseeding, with the latest harvest in years, cutting running into late September. Yields were good, quality poor. Continuous summer rains projected the hay harvest over a six-

weeks period, into the last week of August. The yield was good but quality was much impaired by excessive rainfall, which reduced both yield and quality of potatoes. The season was very late throughout. The apple crop was the best yet harvested at the station, partly because of the moist, backward spring.

The dry seedbeds and excellent April weather in 1925 made possible the earliest grain seeding on record at this station—the first week of April. This advantage, supplemented by normal summer weather, was realized in fair to good harvests ripe in early August, about one week late. Yields were somewhat subnormal, owing to the drouth of April and May and inadequate rains of June and July. June rains grow hay at Duluth. Altho not abundant, rainfall was so distributed as to produce a fair to good hay crop, about ten days late. This hay was mostly timothy, owing to the effects of the open winter on legumes. Early potatoes hardly recovered from the drouth of midsummer, but the late August rains produced excellent yields of late varieties. The cold, wet October made root and tuber harvest difficult and caused the loss of many acres. The warm summer was reflected in the ripening of corn, tomatoes, edible squash, and pumpkins. The open winter, followed by May frosts, was injurious to fruit.

AGRONOMY

Grain Crops

In Co-operation with the Division of Agronomy and Farm Management, University Farm

Since 1919, variety tests of grains have been conducted on a given field, operated on a five-year rotation plan—two years of hay, two of grain, one of cultivated crops. Discontinued varieties previously reported and those grown for the first time in 1925, have been omitted from the table. These plots are one-fortieth acre in size and the yield recorded is the average of three plots of the given variety.

Minturki wheat, which averaged 24.49 bushels per acre in 1924, was a failure in 1925 following the open winter. Swedish rye, Minn. No. 2, still leads other varieties with a six-year average of 19.58 bushels per acre, and a two-year average for 1924 and 1925 of 15.72 bushels. Promising new varieties of rye are Colorless and Dark Green, both nursery creations. Extended clearings and lack of snow protection are proving decided handicaps to rye production.

Java, a spring wheat of high gluten content, after three years' trial at Duluth and shorter tests at Two Harbors, Biwabik, and Virginia is suggested for a chicken feed crop. An improved selection, Progress,

was introduced in 1925. The popular Gopher oats have not yet outdistanced Iowar. Minota, a leafy variety, makes splendid hay and produces good yields of seed when grown for that purpose. Minota and Victory are the best midseason varieties. The late "side" oats are not recommended for this latitude for ripe grain. There is about one week difference in maturity of early and mid-season oats. Improved Manchuria, Minn. No. 184, six-rowed barley, and Svansota, a two-rowed barley, have led in yields for years. The new smooth-awned variety, Velvet, has yielded as high as Improved Manchuria over a period of two years. Svansota is about a week later in ripening, but threshes more nearly free from awns than the other variety.

TABLE II

YIELDS PER ACRE OF GRAIN VARIETIES

Variety	Minn. No.	Yield 1924	Yield 1925	Days to ripen	2-yr. Av. 1924-25	5-yr. Av. 1921-25	7-yr. Av. 1919-25
Spring wheat		Bu.	Bu.		Bu.	Bu.	Bu.
Marquis	1239	20.9	8.8	128	14.9	16.3	16.5
Mindum	470	16.7	9.0	135	12.9	19.6	17.6
Kota	2151	17.0	12.2	127	14.6	14.9	....
Marquillo	2202	20.3	11.8	127	16.0	....	....
Java	2206	27.7	11.5	127	19.6	....	....
Oats							
Gopher	674	72.6	46.8	115	59.7	....	....
Minota	512	63.7	53.7	120	58.7	54.4	55.8
Victory	514	68.9	48.4	121	58.7	55.0	57.6
Imp. Ligowa	281	47.6	42.1	120	44.8	48.6	52.5
White Tartar	339	75.8	54.9	124	65.4	54.2	....
					3-yr. Av.	4-yr. Av.	
Barley					1923-25	1922-25	
Imp. Manchuria	184	34.8	11.4	101	30.1	30.4	34.2
Svansota	440	37.9	30.7	100	35.3	32.9	38.4
Minsturdi	439	26.6	30.5	94	27.6	26.0	30.8
Velvet	447	37.4	26.3	97	32.9	35.4	....
Smooth Awned × Manchuria	445	30.5	26.2	97	32.6	33.5	....
Trebi	448	28.9	46.4	98	38.0	....	....

Field peas were a failure in 1924, owing to water damage, the average yield being but 7.15 bushels per acre. In 1925, seven varieties averaged 43.17 bushels per acre. Chang was the only variety that ripened properly in 1924, and produced twice as much grain as the next highest. It was likewise earliest in 1925. This variety required 128 days to mature in 1924, and 122 days in 1925. Alberta White and Chancellor rank second in earliness.

A number of miscellaneous field crop tests were carried through both seasons. (1) In the depth-of-seeding test for oats, the disks were set at 3, 4, and 5 notches with respective yields of 43.1, 42.3, and 39 bushels per acre. This finding would argue against deep seeding on the prevailing heavy soils. (2) A comparative test was made of bin-run and cleaned seed. Corresponding yields of 34.6 and 41.9 bushels

per acre were recorded, a gain of 7 bushels per acre for cleaning. (3) In the copper carbonate test for smut, yields were not affected. (4) For two years, tests in rate of seeding of barley and of oats have been under observation, using rates of 2, 2.5, and 3 bushels per acre. The resulting yields of barley have averaged 24.04, 28.61, and 30.03 bushels per acre. In the oats test, the averages were respectively 33.87, 36.82, 47.51 bushels. Both tests indicated that the heavier seeding is to be preferred in this locality. (5) Of like importance has been the date-of-seeding work of 1924 and 1925. Barley seeded May 15 and June 1 produced identical yields, but the yield dropped 4 bushels when the crop was sown on June 15. The oat crop, sown May 1, 15, and 31, respectively, produced yields of 56.5, 47.8, and 49.9 bushels per acre. These data indicate that barley should be sown not later than June 1; and oats, May 1.

Fig. 2. Victory Oats Following Sunflowers at Duluth. Find the Man

No corn ripened at this station in 1924. In 1925, considerable quantities of Howes Alberta Flint ripened in August. Soo Squaw was about as early but of poorer quality. A few ears of yellow Assiniboine and New Brunswick Yellow were gathered.

Forage Crops

Dry feeds.—Under this heading are included hay and corn fodder. The alfalfa work at Duluth comes under four heads: Date of planting; nurse crops; effect of lime; variety tests.

The date-of-seeding project was begun in 1923, with triplicate plots sown as indicated in Table III. Yields are given for 1924 and 1925. All plots were limed at not less than two tons per acre in May, 1923.

TABLE III

ALFALFA YIELDS, DATE-OF-SEEDING PLOTS

Plots	Treatment	Date sown	—Yield per acre— 1924	1925
			Tons	Tons
1-11-21	Barley-nurse crop	5/11	2.45	Trace
2-12-22	No nurse crop.....	5/11	2.49	"
3-13-23	" " "	5/21	2.08	"
4-14-24	" " "	5/31	2.42	2.00*
5-15-25	" " "	6/15	2.12	2.04†
6-16-26	" " "	6/30	2.80	2.3†
7-17-27	" " "	7/15	Trace	2.31*
8-18-28	" " "	7/30	"	Trace
9-19-29	" " "	8/15	"	"
10-20-30	" " "	8/31	"	"

*One plot only. † Two plots only.

The results given in Table III teach two lessons. (1) While the nurse crop helped to keep down weeds, and in a dry spring apparently retarded the alfalfa by absorbing most of the available moisture, conditions seemed to be equalized by the time of the first cutting of the following year and yields were almost identical. As a general proposition, there can be no objection to a light nurse crop. On the other hand, it has some advantage in holding back weed growth and if a good stubble is left, catching more snow for winter protection.

(2) About July 1 should be the time limit for seeding alfalfa, owing to the dry period that usually follows that date. It will be noted that all seedings made later than July 1 failed to make a crop the first year; while all but one of the plots that came through the disastrous winter of 1924-25 and made a crop the second year were July 1 or earlier seedings. Only six plots survived the winter of 1924-25 and these lived through only because of a somewhat favored location. It sometimes happens that a rather thin but vigorous stand the first crop year will thicken up the following year, rather a reverse operation. This will happen under favorable conditions of growth and can be noted in the single July 15 seeding that survived the first crop year.

Lime seems indispensable for alfalfa culture on the red drift soil of the experimental farm. The west half of Series 2 was limed, three tons per acre, in the fall of 1916. Eight years later, a mixed seeding of alfalfa and alsike clover produced 36.8 per cent more feed on the limed than on the unlimed half, altho eight years intervened since the application of the lime. In 1925 the increase was but 12 per cent, as other grasses had taken the place of the alfalfa injured during the preceding winter. The use of inoculating material is absolutely indispensable.

Alfalfa Varieties

Variety test work can best be illustrated in tabular form. The several varieties were sown in May, 1923, on limed soil in consecutive order and without a nurse crop. Sweet clover was used for inoculation. All varieties were grown in triplicate plots. Cossack and Baltic were of South Dakota production. As its name implies, Ontario seed came from Canada. Hardigan came from Michigan. Grimm seed was produced in Minnesota, and Northern Grown common was grown in the Northern Great Plains alfalfa seed district.

Fig. 3. Sweet Clover Pasture a Success at Duluth for All Classes of Livestock

Cossack seemed to have a slight advantage over Grimm in yield, but later developments have not borne this out. The two-crop average on the oldest stand on the farm in 1924 showed an increase in yield of 15.9 per cent of Grimm over Cossack. Finally, following the open winter of 1924-25, Grimm was the only variety of the group that survived, producing 2.15 tons per acre.

TABLE IV

PLOT YIELDS, VARIETY TESTS OF ALFALFA, 1924

Variety	First crop	Second crop	Total
	Tons	Tons	Tons
Grimm	1.27	1.05	2.32
Cossack	1.38	1.10	2.48
Ontario Variegated	1.12	1.19	2:30
Hardigan	1.19	1.23	2.42
Baltic	1.27	1.35	2.61
Northern Grown common	1.03	1.14	2.17
Kansas	1.00	0.88	1.88

Sweet Clover Tests

Work with sweet clover in 1924 was confined to the completion of hay and soiling crop projects described in the 1922-23 report. The first, or hay, crop of 1924 (1923 seeding), white sweet clover, averaged

1962 pounds per acre, and yellow sweet clover, 1448 pounds of air-dried hay per acre, a difference of fully one third. The second crop, used for green feeding in the dairy barn during late summer, produced an average of 8169 pounds (4.84 tons) of white sweet clover and 6600 pounds (3.3 tons) of yellow sweet clover, a difference of 24 per cent. In 1925 a pasture project was begun. This maintained from two to five head of cattle on two acres throughout the season. It will be repeated in 1926. White sweet clover is to be preferred to yellow, owing to the heavier growth.

Meadow Mixtures

In spite of the expansion of the alfalfa acreage, the greater portion of our hay crop must continue to be grown on lands as yet unfitted for alfalfa culture. The job must be to replace the present low-grade grasses with those of higher yielding power and greater protein content. To this end a field has been blocked out into six areas with various combinations of alsike, redtop, timothy, and bromus. Reports will be issued when additional crops of these grasses and clovers have been harvested.

Extensive comparative tests of dent, flint, and sweet varieties of corn for fodder were conducted at this station and outlying experimental fields during the crop seasons of 1924 and 1925.

TABLE V

YIELDS PER ACRE IN VARIETY TESTS OF CORN FOR FODDER

Variety	No. of lots grown 1924-25	Yields		
		1924	1925	2-yr. Av.
		Tons	Tons	Tons
Gehu, flint	6	1.74	1.84	1.79
North Dakota White, flint	5	2.47	2.03	2.25
Manitoba	4	1.76	2.77	2.26
Minn. No. 23	4	1.91	2.54	2.23
Minn. No. 13	5	1.78	3.38	2.58
Northwest Dent	8	1.95	3.24	2.59

The cold, wet season of 1924 was very unfavorable for corn, but 1925 was much better, as was reflected in yields. Minn. No. 13 and Northwest Dent must be preferred above all other varieties for fodder production. The flints have a place likewise, but the tall-growing varieties matured poorly. As corn for fodder produced nearly twice as many tons per acre, and as each ton is equally rich in carbohydrates but contains one third more protein than timothy hay, the northeast counties should grow more fodder corn to enrich the dairy ration, at least until silage feeding becomes more general.

Succulent Feeds

Under this heading will be discussed soiling crops, silage crops, and root crops.

Oats constitute a dependable and early soiling crop that has maintained a minimum production of 6 tons per acre, frequently reaching 8 tons of green feed. Earlier and better still is a combination of rye and vetch, 5 pecks of rye and 15 pounds of vetch per acre, the vetch usually spring sown. This produced 4.8 tons of green feed in 1925, somewhat more than white sweet clover. It was ready for feeding on July 22. Sunflowers follow when these crops are fed and should yield not less than 8 tons per acre of early green feed. For this purpose we recommend "Zenith Special" developed at this station and blossoming about the middle of July, two to four weeks in advance of Mammoth Russian. Hubam, as a soiling crop, is not ready in this latitude before late August or early September.

The first sunflowers for silage were grown at the Duluth station in 1918. Their culture has continued ever since, and despite cold years, a silage crop has been harvested annually. The Duluth station does not recommend sunflowers to replace corn where corn is reasonably certain to make a crop every year, but suggests the culture of sunflowers as an insurance crop to be grown where corn is uncertain. It should be grown in separate fields, tho it can be put in the silo at the same time as corn to good advantage. The wisdom of growing a supplemental silage crop was demonstrated in 1915, 1917, and 1924 when empty silos on many farms gave mute evidence of the need of a silage crop that can be depended on each year.

In the following paragraphs is discussed the experimental work relating to cultural practices with sunflowers. Fertilization and rotations are discussed later. Tables VI, VII, and VIII show the rate of seeding: (1) Spacing of rows—30, 36, and 42 inches apart; (2) sowing with grain drill with certain spouts closed; (3) setting the grain drill for 4, 8, and 12 pecks of grain per acre. This series of experiments is of first importance as it deals with the use of a single machine for several operations, thus reducing the machinery needs and investments on farms of limited acreage.

TABLE VI

YIELDS PER ACRE OF SUNFLOWERS WITH DEFINITE SPACING IN ROWS

Spacing of rows	1924	1925	5-yr. Av.
In.	Tons	Tons	Tons
30	7.59	8.41	14.08
36	8.16	8.20	13.54
42	6.67	7.59	11.64

The 36-inch spacing is most practical. The half ton additional silage secured by closer seeding is not worth the additional labor entailed in cultivation. Close planting produces a plant with finer stems, which is desirable. Wide spacing, on the other hand, is a waste of labor on the prevailing heavy soils of the northeast counties.

TABLE VII

YIELDS PER ACRE OF SUNFLOWERS, WITH CERTAIN SPOUTS OF GRAIN DRILL CLOSED

Drill row spacing	1924	1925	4-yr. Av.
In.	Tons	Tons	Tons
6	8.97	10.29	10.99
12	8.25	8.20	13.54
18	6.85	14.34	12.02

This is an extremely awkward crop to handle at harvest time when planted in this way. It is almost impossible to cut these plots with a binder. The only advantage of this way of growing is that slender stalks are insured, thus reducing the woody fibrous material. The thick stand on the ground makes a heavy draft on available moisture and fertility, and as a consequence the plants do not grow tall. Altho these plots usually show the first effects of drouth, they recover quickly and the drouth injury seems not to be permanent. The yields are slightly better on the wider spacing, altho on the whole yields are quite satisfactory.

TABLE VIII

YIELDS PER ACRE OF SUNFLOWERS, WITH DIFFERENT QUANTITIES OF SEED

Set of drill	1924	1925	3-yr. Av.
	Tons	Tons	Tons
4 pecks wheat	6.13	10.65	11.14
8 " "	7.59	11.69	12.43
12 " "	7.51	12.06	12.58

Setting the grain drill in use at this station for 4 pecks of wheat will require roughly 5 pounds of sunflower seed per acre. This is sufficient for a good yield, as indicated, but a farmer can well afford to sow an additional 5 pounds, with an additional cost of perhaps 50 to 60 cents, in order to harvest an additional ton and a quarter of silage per acre. Setting the drill at 8 pecks, by providing a thicker stand insures a finer quality of growth, but setting at 12 pecks is really a waste of seed. It will be noticed that good yields are secured in all cases where a grain drill is used. The small farmer can well plant his silage and fodder crops with the same equipment he uses for drilling his grain and thus avoid investing in farm machinery that is in use but a few days each year.

TABLE IX

YIELDS PER ACRE OF SUNFLOWERS, DATE-OF-SEEDING PROJECT

Date of seeding	1924	1925	5-yr. Av.
	Tons	Tons	Tons
May 15	8.25	10.03	14.04
June 1	7.82	11.76	11.86
June 15	6.77	10.38	9.92
July 1	2.54	7.78	6.08

Five years' experience justifies the practice of sowing sunflower seed as early after May 10 as weather and soil conditions permit. The nine crops grown have never yet suffered from spring frost. The greatest danger is from the soil packing because of excessive moisture. In this district of short seasons and limited clearing, very early seeding is almost indispensable in insuring sufficient winter silage of good quality.

Fig. 4. Date of Planting Tests with Sunflowers

The July 1 planting, at the boy's left, yielded 6 tons per acre; the June 15 planting, at his right, yielded 9.9 tons; the June 1 planting, beyond, 11.8 tons; and the May 11 planting, 14 tons. Photograph taken July 31, 1925.

It has been suggested by some growers and students of this crop that check-rowing should be practiced in order to save the foliage from wilt and disease through better aeration and sunlight control under this system. This advantage, if any, is probably more than balanced by the smaller yield and more woody quality of the plants standing thinner.

During July and August of 1924 and 1925 an interesting study was conducted on the rate of growth of the sunflower plant with respect to rainfall and temperature recorded during these months. Observations were taken at various places in the field and readings recorded twice a week. Data for 1925 are presented in Table X.

TABLE X

RELATION OF SUNFLOWER GROWTH TO RAINFALL AND TEMPERATURE

Date	Mean temperature, 10-day period	Rainfall, 10-day period	Average gross increase, 10 days	Average daily growth
	Deg.	In.	In.	In.
7/10	66.3	1.39	14.50	1.45
7/21	70.2	0.21	15.00	1.50
7/31	60.6	1.59	11.67	1.17
8/11	69.3	0.28	16.50	1.65
8/21	67.4	0.26	5.66	0.57
8/31	66.0	2.50	9.66	0.97
Average	66.6	....	....	1.33

In 1924, during the corresponding period in July, the average daily growth was 1.44 inches, very close to than of 1925. There seems to be some correlation between mean temperature and rapidity of growth, modified by volume of rainfall. On the warmer days the plants frequently grew 2 inches a day. But in spite of favorable temperatures, the prevailing drouth of midsummer doubtless retarded growth materially. Most of the July moisture came during the first and last weeks. The effect of the cool days of late July can be followed in the slow growth during that period. The most rapid growth of the season, recorded early in August, was probably due to the late July rains followed by rising temperatures. The rains of late August, beginning August 27, speeded up the heading process and occasioned the spurt of growth in late August when maturity would normally ensue. Sunflowers have a habit of remaining dormant during cold and dry periods. This tendency was well demonstrated in August, 1925, when growth was seemingly suspended and plants failed to head or headed slowly. Unlike corn, which would normally be cut following "firing," sunflowers showed a surprising power of recovery and ability to resume growth and added materially to the tonnage after September 1.

Sunflowers on spring plowing in 1925 averaged 11.77 tons per acre, which compares very favorably with the crop on fall plowing. From observations over a three-year period, spring plowing for sunflowers seems justified on the heavy soils, but soil and weather conditions are usually so variable in the spring as to make fall plowing a safer policy. On virgin soils, sunflowers are much more thrifty than corn.

In the variety tests, a comparison was made in 1925 between Mammoth Russian sunflower; Zenith Special, of local origin; and Dwarf Northern, the seed of which was ripened 300 miles north of the Minnesota line. The first variety excels in yield, but Zenith Special blooms more than 20 days earlier. The Dwarf Northern produced more leaves but showed a greater tendency to revert to the multiple blossom of the sunflower of antiquity. This tendency to revert develops very rapidly with volunteer plants or when the crop becomes less domesticated.

A comparative test of corn and sunflowers was attempted in 1924. The corn was frosted but the sunflowers produced 12.65 tons per acre. This test was repeated in 1925 and the respective yields of corn and sunflowers were 9.7 and 11.49 tons.

Considerable interest has been manifested in the relative yield of rutabagas and sunflowers. Two years' data are presented in Table XI.

TABLE XI

YIELDS PER ACRE OF SUNFLOWERS AND RUTABAGAS

Crop	1924	1925	2-yr. Av.
	Tons	Tons	Tons
Sunflowers	9.26	9.70	9.48
Rutabagas	6.50	15.12	10.80

Sunflowers vary much less in yield from year to year than rutabagas. It was particularly difficult to get the latter crop started in 1924. The slight excess in production of roots is probably more than balanced by the greater cost of production.

TABLE XII

YIELDS PER ACRE OF RUTABAGAS

Practice	1924	1925	4-yr. Av.
	Tons	Tons	Tons
Drilling	6.56	10.28	9.41
Check-rowing	5.99	7.06	7.51

Varieties of Corn for Silage

There is much interest in what variety to grow when corn is grown for silage in this region. Two years' data are submitted in Table XIII.

The season of 1924 was decidedly unfavorable throughout for growing root crops. Seed was resown repeatedly and the cold, wet soil both retarded and reduced germination. Growing sugar beets for feed is hardly justified in this latitude. Small amounts of carrots can well be grown for horse feed, altho lower in yield than other root crops. Mangels are desirable for poultry feed. With a large herd, the root crop is too expensive for dairy feeding.

TABLE XIII

YIELDS PER ACRE IN VARIETY TEST OF CORN FOR SILAGE

Variety	No. of tests	2-yr. Av. yield
		Tons
Gehu, flint	6	5.37
North Dakota White, flint	5	6.77
Manitoba	4	6.79
Minn. No. 23, dent	4	6.68
Minn. No. 13	5	7.78
Northwestern Dent	8	7.77

It seems that the usual practice of using either Northwestern Dent or northern grown Minnesota No. 13 for silage is not far wrong. The fact that these averages were secured in part from crops grown in the severe season of 1924 indicates that corn for silage is reasonably sure at Duluth. On the other hand, fields farther from Lake Superior were frosted much earlier than September 10. A comparison of corn and sunflower yields in any case justifies the growing of sunflowers every year in this district, probably to the extent of two thirds of the acreage, merely as an insurance crop.

TABLE XIV

YIELDS PER ACRE OF ROOT CROPS, 1924 AND 1925

Crop	1924	1925	2-yr. Av.
	Tons	Tons	Tons
White Belgian carrot	5.28	20.08	12.68
Chaska Sugar beet	10.03	16.39	13.21
Sutton's Acquisition rutabaga	13.91	31.13	22.52
Sutton's Prizewinner mangel	13.42	28.35	20.88
Sutton's Long Red mangel	13.05	35.42	24.23

HORTICULTURE

In Co-operation with the Division of Horticulture, University Farm

Potatoes

Altho the season of 1924 was favorable for a heavy crop of potatoes over the state, yields at Duluth were low, owing to excessive cold and moisture. Drouth threatened the crop of 1925, but it was saved by the rains of late August. Fertilizer experiments are explained under that particular heading. The cultural studies presented here include the following: (1) Variety testing; (2) hilling vs. drilling; (3) distance between rows; (4) date of planting; (5) spray studies; (6) variation within variety; (7) effect of storage; (8) small vs. large seed; (9) effect of cutting seed end. Variety testing has been under way for seven years, and includes the eight standard varieties for Minnesota.

TABLE XV

YIELDS PER ACRE OF POTATOES IN VARIETY TESTS

Variety	1924	1925	7-yr. Av.
	Bu.	Bu.	Bu.
Bliss Triumph	228.2	132.7	149.7
Early Ohio	188.0	156.4	178.7
Irish Cobbler	289.6	184.0	216.8
Green Mountain	218.6	213.0	233.9
Rural New Yorker	218.6	208.3	186.8
Russet	242.0	214.5	211.1
King	265.1	223.2	236.5
Burbank	238.0	211.2	222.4
Average, all early varieties	....	....	181.7
Average, all late varieties	....	....	218.1

The dry weather that prevailed until late August, in 1925, is reflected in the lowered yields of early potatoes. But the late rains were the making of the late crop, which made much of its growth in September. Vines were not killed before September 20. The late varieties still produce about 40 bushels per acre more than the average of all early varieties. Russet Rural, a potato brought from Michigan, resembling the Rural New Yorker in type and the Russet in color and surface features, averaged 218.2 bushels for the two years. Grand Rapids Cobbler, a potato introduced from a sandy soil, made a corresponding average of 203.8 bushels as compared to 236.8 bushels produced from local clay-soil seed stock during the same season.

It is the usual practice in large fields or wherever the work is done with machinery, to grow potatoes in drills. It is doubtless simpler, easier, and cheaper. Occasionally, however, a man wishes to clean up a weedy field, and potatoes are planted in check rows so that they may be cultivated both ways. Corn is sometimes used instead of potatoes. A comparative test has been conducted at Duluth for five years. The work done in 1925 terminates the project.

TABLE XVI

YIELDS PER ACRE OF POTATOES IN CULTURE TESTS—DRILLS VS. CHECK ROWS

Management	1924	1925	5-yr. Av.
	Bu.	Bu.	Bu.
Drilled	252.3	195.5	211.5
Check-rowed	255.3	197.6	212.8

With almost identical yields under both methods of cultivation, it seems that the practice best adapted to getting the work done should be followed on a given farm.

The 1925 crop was the fourth in the spacing-of-rows project. Table XVII is a summary of yields for the four seasons. The 1924 crop was discarded, so the project continues one more year.

TABLE XVII

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

Spacing	1925	4-yr. Av.
In.	Bu.	Bu.
30	165.5	221.7
36	156.3	199.8
42	147.6	165.5

Potatoes should never be grown in rows more than 36 inches apart on the red drift soils of the northeastern counties. When the acreage is quite extensive, and much machinery is used, the rows should be no closer. That is, 36 inches is a good average distance. When work is

done by hand or with one horse, when the acreage is small and the available land limited and when no labor is hired, the increased yield probably justifies the 30-inch planting.

As has been already established with grain and silage crops, the date of planting has a decisive effect upon yield.

TABLE XVIII

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

Date	1924	1925	3-yr. Av.
	Bu.	Bu.	Bu.
May 15	245.7	162.2	269.6
May 31	287.9	161.9	227.3
June 15	167.9	142.0	161.6
July 1	102.2	80.8	92.4

Fig. 5. Date of Planting Tests with Potatoes

The four small rows at the right were planted on July 1, and yielded 92 bushels per acre; the blossoming rows beyond, planted May 15, yielded 269 bushels; the four rows at the left center, planted June 15, yielded 161 bushels; the blossoming rows at the extreme left, planted June 1, yielded 227.6 bushels. Photograph taken July 31, 1925.

It is usually possible to plant potatoes between May 15 and 30, even on heavy soils, if they have good surface drainage. It is frequently argued that potatoes should be planted about the middle of June in order to reduce trouble from bugs. But this practice apparently costs 100 bushels per acre, as compared with May 15 planting, or 66 bushels compared with June 1 planting. Roughly, for every day of delay in planting after soil and weather conditions warrant proceeding with the work, a loss of 3 bushels a day is entailed, which, at the average farm price for several years, is $1.80.

In 1923 a project was begun in which lots of certified seed were gathered from various parts of the state and grown in quadruplicated plots to learn whether or not certain strains of a given variety might yield higher than others. Most of the work was done with Irish Cobbler,

with a few lots of Rural New Yorker and Russet. (See 1922-23 report.) The work has been continued through 1924 and 1925, with results as indicated in Table XIX.

VARIATION IN YIELDS PER ACRE WITHIN A GIVEN VARIETY OF POTATOES

Variety	No. of samples	Range in yield		Mean average yield	
	1924-25	1924	1925	1924	1925
		Bu.	Bu.	Bu.	Bu.
Irish Cobbler	115	92–179	87–190.8	200.4	184.9
Russet	15	180–215	153–213	140.5	160.7
Rural New Yorker	16	64–217	148–186	164.0	167.0

The results of three years' work under like conditions seem to indicate that certain strains have a greater yielding power than others. All figures are averages of crops grown on four different plots. Of the 43 growers in 1924, 24 reported yields under the average; 35 of the 73 growers in 1925 reported yields below the mean. The highest yield of Cobblers in 1925 is three times the lowest. Tests like these indicate where the good strains are, and which should be discarded, for certified seed classification.

The pressure spray experiments begun in 1923 were continued in 1924 and 1925. The project is a simple one, involving the comparative use of lead arsenate alone and in combination with bordeaux mixture. Spraying continued at 7- to 10-day intervals until the vines grew too large for passage of the machine. In 1924 and 1925 the combination treatment produced but 9 bushels more of Green Mountain potatoes. In 1924 the combination treatment produced 22 bushels more of Irish Cobbler potatoes and in 1925, 11 bushels more. Beyond being somewhat more effective on the early varieties, the pressure sprayer has not as yet shown any positive increase in yields.

When potatoes have been stored in a very cold root cellar, it will hasten sprouting and perhaps even increase the yield to remove them to a warmer situation several weeks before planting. A test of this was conducted at Duluth in 1925. Both kinds of seed stock were stored in three different places. In all cases, the seed that had been placed in the warmer storage produced a larger crop, the average being 182.7 bushels as compared to 144.21 bushels for those left in a cold root cellar until planting time.

The practice has sometimes been recommended, in times of seed scarcity, of planting small potatoes with seed ends cut off. Lots of this kind were prepared and planted in 1923, 1924, and 1925. Corresponding lots of normal large cut seed were planted at the same time. The 1924 plots were injured by water and discarded. The results in 1923 and 1925 are given in Table XX.

TABLE XX

YIELDS PER ACRE OF SMALL, UNCUT SEED POTATOES COMPARED WITH THOSE FROM LARGE CUT SEED

Seed stock	1923	1925	2-yr. Av.
	Bu.	Bu.	Bu.
Small, uncut seed, seed end removed	151.00	175.38	163.19
Large cut seed	189.90	186.01	187.90

This margin of nearly 25 bushels would justify the use of large cut seed in normal seasons. The final potato cultural test project, effect of cutting seed end, is still incomplete.

Variety Tests of Garden Crops

Closely related to the variety testing and cultural studies of field and forage crops is the comparative variety test of garden vegetables. Begun in a small way in 1924 with the root crop, the work was expanded in 1925 to include leaf crops as well. Statistical data are too incomplete for conclusive statements. The table of observations (Table XXI) is offered as a guide in the selection of varieties that give special promise under northeast Minnesota conditions. From two to three times as many varieties of each crop were under test as are reported here. In each case the variety is given in order of importance.

TABLE XXI

VARIETY TEST NOTES, GARDEN CROPS, 1924 AND 1925

Crops	Observation
Beans	Wardwell and Kidney Wax for earliness, Refugee for yield.
Beet	Detroit Dark Red; Crosby Egyptian, Crimson Globe, and Early Wonder give much promise.
Cabbage	Golden Acre; Early Jersey Wakefield for earliness; Flat Dutch, Early Jersey Wakefield, Hollander (disease resistant) for yield.
Carrot	Chantenay, heavy yielder; Danvers half long; Coreless.
Celery	Newark Market, Golden Self-Blanching, Early Blanching, and Giant Pascal.
Cucumber	Danish Pickling, White Spine.
Kohl Rabi	White Vienna for earliness; Early Purple for yield.
Lettuce	Salamander and Big Boston for earliness; Salamander and Iceberg for yield.
Onion	Southport Yellow Globe, Southport White and Red Globe.
Parsnip	Hollow Crown.
Peas	Hundredfold and Alaska for earliness; Hundredfold, Peter Pan, and Thos. Laxton for yield.
Rutabaga	American Purple Top and Yellow Swedish for yield; Bangholm Purple; Yellow Perfection.
Spinach	Bloomsdale and Victoria for earliness; Long Season, New Summer, King of Denmark for yield.
Squash	Crookneck; Des Moines for earliness; Kitchenette later.
Tomato	North Dakota Earliana and John Baer for earliness and yield.
Turnip	Purple Top Strap Leaf; Purple Top White Globe; Danish Bortfelder.

Fruit Culture

Two orchards and some variety testing work with small fruits constitute the fruit culture project at the Duluth station. The "old" orchard was set in 1915 in untamed soil and under pioneer conditions. The "new" orchard was set in 1923 and 1924 in a sheltered location and in improved soil. The 1924 apple crop was the best yet harvested off the old orchard, which has quite thoroly recovered from the forest fire. The 1925 crop suffered from the cold weather at blossoming time in May.

Sunbeam and Latham raspberries thrived better than others, and apparently suffered less loss from disease. Houghton gooseberry was more productive than Como, the next variety of promise. London Market red currant ranks first in variety test, Pomona second, and Diploma third.

Observations of the development and behavior of fruit trees under soil and climatic conditions at the Duluth station may be grouped under four heads.

(1) **Size of stock and planting distances.**—It does not pay to use one-year-old "whip" stock. With rather severe winter exposure, scant snowfall, and a short growing season, good thrifty stock of 5 or 6 feet or larger is desirable. We find trees too closely spaced at 16 feet. In the new orchard there is a minimum of 20 feet between trees.

(2) **Soil management.**—On our new northern farms, it is desirable to farm the land for several years, in fact, put it through one cycle of a three-year rotation. This takes the wildness out of it, improves its physical condition, and perhaps raises the level of soil fertility through the growing of legumes and the incorporation of grass. In later years it may be necessary to seed down the orchard to simplify management. At this station this was done during the war. But an area perhaps five feet in diameter is kept worked up about the tree. From time to time the clover sod is top-dressed, and sod binding is prevented by cutting with a roller harrow, tractor drawn. This permits the free extension of the root system.

(3) **Site.**—Both orchards at Duluth show a more thrifty growth on the southeast slope. This is perhaps due to protection from the severe northwest winds of winter. On the northwest slopes the apple trees are very noticeably smaller and less productive. As a consequence the policy is being followed of replacing with plum stock those that die.

(4) **Varieties.**—Hibernal has shown the best adaptation to this particular locality of all varieties of apples to date, both in vigor of growth and volume of fruit produced. Wealthy, Patten (Greening), and Duchess follow in order. Florence is outstanding among crab apples. A list of the producing varieties for 1924 and 1925 is given in Table XXII.

TABLE XXII

YIELDS OF APPLE VARIETIES, 1924 AND 1925

Variety	No. bearing fruit 1924	1925
Hibernal	64	26
Wealthy	45	26
Patten (Greening)	15	9
Duchess	11	9
Anisim	11	2
Florence crab	7	4
Okabena	8	2
Yellow Transparent	7	0
Lyman's Prolific	5	0
Red Siberian	3	1
Sweet Russet	3	0
Hyslop	3	0

Iowa Beauty and Whitney were each represented by two bearing trees in 1924, and one each of Longfield, Transcendent, and Sweet Russet bore the same year. None of these varieties bore fruit in 1925. Minnesota crab bore fruit on one tree in 1925, none in 1924. A total of 189 trees produced fruit in 1924 and 79 in 1925.

Crop Rotations

In Co-operation with the Division of Agronomy and Farm Management, University Farm)

The one farm management study at the Duluth station is presented under the heading of crop rotations. This project involves studies in triplicate of three-, four-, and five-year rotations, begun in 1919. The three-year rotation is now on its third cycle and the two-year rotation consists of barley, hay (timothy, redtop, alsike), sunflowers, and silage. The four-year rotation has two years of hay and the five-year, three years of hay. Fertilization consists in applying manure at the rate of two tons per acre for each year of the rotation, on the grain stubble once during the cycle of three, four, or five years. One cycle, the three-year, receives 6 tons; the four-year, 8 tons; and the five-year, 10 tons.

TABLE XXIII

YIELDS PER ACRE OF HAY, CROP ROTATION PROJECT

Rotation	1924	1925	6-yr. Av.
	Tons	Tons	Tons
3-year	1.60	1.63	2.03
4-year	1.51	1.31	1.76
5-year	1.48	1.60	1.86

Barley in the three-year rotation has an average yield over seven years of 31.33 bushels per acre. The production of the same crop in the five-year rotation is 28.12 bushels per acre, about three bushels less.

The yields on the four-year rotation are rejected for this biennium, as the crop was so injured by rain as to make the yields questionable for experimental work.

TABLE XXIV

YIELDS PER ACRE OF SUNFLOWERS, VARIOUS CROP ROTATIONS

Rotation	1924	1925	5-yr. Av.
	Tons	Tons	Tons
3-year	6.57	9.05	10.52
4-year	4.43	7.90	8.46
5-year	4.98	9.67	9.25

Three tendencies are evident in the rotation work: (1) There is a gradual decline in yield as a whole with continued cropping, which holds true with all three classes of crops. This may be due to insufficient manuring or to unfavorable growing conditions. (2) The three-year rotation continues to be more productive than the other two. (3) Finally, the five-year rotation seems to produce better yields than the four-year in all classes of crops. The difference is slight and can be accounted for in part, as two plots in the four-year rotation occupy the highest spot in the field—most exposed to winter killing and seemingly less fertile. The 1925 barley crop was the poorest in years. The hay crop declines progressively in yield with the age of the stand. The two-year-old stands average one-fourth ton less than the one-year-old stands and the three-year-old seedings are lighter still.

SOIL FERTILITY INVESTIGATIONS

In Co-operation with the Division of Soils, University Farm

The phosphate-manure project, covering seven years, was completed in 1923 and the results were given in the biennial report for 1922-23. Under the heading above, all soil fertility data on farm and garden crops are assembled and presented. The principal projects are: Clover utilization, rotation without clover or manure; rate of manuring; commercial fertilizers for potatoes in a three-year rotation; garden fertilization; production on virgin soil.

Clover utilization.—This experiment is now eight years old. Three series of six plots each constitute it. In the grass series, Plots 1 and 4 are pastured in late June and early July; Plots 2 and 5 are plowed under in early July with their entire stand of grass; the hay crop of Plots 3 and 6 is harvested and the stubble is returned to the soil. Potatoes and sunflowers occupy one series and follow directly after the hay crop. Oats occupy the third series, follow the cultivated crop, and just precede the grass crop. The third cycle of this rotation will be completed in 1926.

TABLE XXV

YIELDS PER ACRE OF POTATOES AND SUNFLOWERS, CLOVER UTILIZATION SERIES

Plot	Management	1924		1925		6-yr. Av.	
		Potatoes	Sunflowers	Potatoes	Sunflowers	Potatoes	Sunflowers
		Bu.	Tons	Bu.	Tons	Bu.	Tons
1	Grass crop pastured.....	199.38	3.85	130.53	5.86		
2	Grass crop plowed under....	188.46	4.03	103.77	4.76		
3	Grass crop harvested.....	112.44	2.47	89.83	5.50		
4	Grass crop pastured.....	129.79	2.75	103.77	5.50		
5	Grass crop plowed under....	153.79	2.47	96.80	4.58		
6	Grass crop harvested.....	84.86	2.02	101.93	6.79		
Averages							
1–4	Grass crop pastured.....	164.58	3.30	117.18	5.68	170.93	8.55
2–5	Grass crop plowed under....	171.15	3.25	100.25	4.67	159.79	8.13
3–6	Grass crop harvested.....	98.68	2.25	95.88	6.14	152.94	7.87

TABLE XXVI

YIELDS PER ACRE OF HAY, CLOVER UTILIZATION SERIES

Plot	Management	1924	1925	5-yr. Av.
		Tons	Tons	Tons
3	Grass harvested	*	1.7	...
6	Grass harvested	*	1.9	1.54

* Discarded.

TABLE XXVII

YIELDS PER ACRE OF OATS, CLOVER UTILIZATION SERIES

Plot	Management	1924	1925	6-yr. Av.
		Bu.	Bu.	Bu.
1	Grass pastured	23.10	30.95	
2	Grass plowed under.....	42.50	25.80	
3	Grass harvested	55.00	23.15	
4	Grass pastured	48.75	23.15	
5	Grass plowed under.....	51.87	19.63	
6	Grass harvested	58.12	16.25	
Averages				
1–4	Grass pastured	35.93	27.03	45.60
2–5	Grass plowed under.....	47.18	22.69	44.42
3–6	Grass harvested	56.56	19.68	46.98

A comparison of the findings of this experiment and those of the rotation project preceding, will disclose a like tendency toward declining yields of potatoes, sunflowers, and grain. But the hay crop has more than held its own. When hay yields decline, the occurrence is due probably less to lack of fertility than to poor catches of grass and clover in dry springs, and to winter killing due to exposure to winter winds and weather. With prairie conditions existing, the fields are frequently bare of snow all winter, most of the snow being piled in the roads. As cropping continues, the organic matter seems insufficient to prevent packing after heavy rains of spring, with consequent weak and struggling stands of clover and grass. Pasturing continues to be the best policy preceding potatoes and sunflowers. This is probably true

of oats as well. It will be noted that altho six crops have been plowed under, green manure has not yet shown any particular influence upon crop production. It is inferior to pasturing, and judging by comparative yields where the hay has been saved, the crop plowed under has been largely wasted.

Rotation without clover and manure.—This rotation completed its third cycle in 1925. Oats follow barley and this crop in turn follows the cultivated crop of sunflowers and potatoes. Neither legume nor grass seed is sown and no hay crop is grown. The only fertilization is the grain and sunflower stubble that is returned, as neither manure, commercial fertilizer, grass sod, nor green manure has ever enriched the land. The purpose of the experiment is to measure the change in production in the absence of all these.

Barley has failed to yield for two years because the land is too poor to grow it, and the weeds choke it out. Oats and potatoes seem to be persistent growers in spite of soil conditions, yet there has been a distinct decline over a two-year period. Sunflowers, a heavy feeding crop, yield slightly better than barley. In the absence of clover and a thrifty, fast-growing crop, this series has become the weedy spot on the station tract.

TABLE XXVIII

YIELDS PER ACRE IN ROTATION WITHOUT CLOVER OR MANURE

Plot	Crop	1924	1925	1917-25 Av.
A	Barley, bu.	*	*	
B	Oats, bu.†	33.44	12.90	
C	Potatoes, bu.†	66.00	90.10	
D	Barley, bu.	*	*	
E	Oats, bu.	23.12	14.68	
F	Potatoes, bu.	59.76	80.00	
C	Sunflowers, tons†	1.94	5.59	
F	Sunflowers, tons	1.01	2.94	
Averages				
A-D	Barley, bu.	*	*	†
B-E	Oats, bu.	28.28	13.79	31.25
C-F	Sunflowers, tons	1.47	4.26	5.24
	Potatoes, bu.	62.28	87.49	105.90

* Discarded.

† The seven-year average, in 1923, was 8.73 bushels. No barley has been grown since.

Rate of manuring.—The rate of manuring project, begun in 1917 and arranged in a three-year rotation, also completed its third cycle in 1925. Oats, grass, potatoes-sunflowers, constitute the crop succession. Two duplicate blocks of plots receive respectively, 5, 10, and 20 tons of manure per acre on the grain stubble, and two other blocks receive 5 and 10 tons on the grass stubble. In the one case the hay stubble reaps the first benefit, in the other the cultivated crop. The purpose of this experiment is to determine how much manure to use and where to use it.

Fig. 6. Rotation Without Clover or Manure

Without clover-grass sod or manure, barley is a failure; sunflowers fail to germinate; oats and potatoes decline in yield. Photograph taken July 31, 1925.

TABLE XXIX

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

Plot	Management	1924		1925		1917-25 Av.	
		Potatoes	Sunflowers	Potatoes	Sunflowers	Potatoes	Sunflowers
		Bu.	Tons	Bu.	Tons	Bu.	Tons
7	No fertilizer	95.61	1.37	130.90	7.52		
8	5 tons manure after oats...	126.10	3.30	147.42	10.18		
9	10 tons manure after oats	188.14	5.68	150.33	10.18		
10	20 tons manure after oats...	184.32	5.50	131.26	8.99		
11	10 tons manure after hay...	176.36	5.04	134.20	9.25		
12	5 tons manure after hay...	171.64	3.94	110.36	6.24		
13	No fertilizer	124.41	2.93	85.80	4.13		
14	5 tons manure after oats...	129.80	3.57	99.73	7.43		
15	10 tons manure after oats...	150.70	4.58	122.83	10.54		
16	20 tons manure after oats...	216.90	6.97	134.43	8.99		
17	10 tons manure after hay...	215.56	6.14	127.60	9.07		
18	5 tons manure after hay...	193.92	6.05	91.30	7.43		
Averages							
7-13	No fertilizer	110.01	2.15	108.35	5.81	126.49	6.62
8-14	5 tons manure after oats...	127.95	3.44	123.58	8.80	148.56	7.96
9-15	10 tons manure after oats...	129.42	5.13	136.58	10.35	159.33	10.18
10-16	20 tons manure after oats...	200.61	6.23	133.10	8.99	173.49	10.19
11-17	10 tons manure after hay...	195.96	5.59	130.90	9.16	147.58	10.23
12-18	5 tons manure after hay...	182.78	4.99	100.83	6.83	162.45	9.07

TABLE XXX

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

Plot	Management	1924	1925	1918-25 Av.
		Bu.	Bu.	Bu.
7	No fertilizer	32.50	18.75	
8	5 tons manure after oats	37 50	20.65	
9	10 tons manure after oats	42.18	36.70	
10	20 tons manure after oats	58.45	44.80	
11	10 tons manure after hay	54.37	51.55	
12	5 tons manure after hay	49.68	32.20	
13	No fertilizer	30.68	25.00	
14	5 tons manure after oats	31.25	22.50	
15	10 tons manure after oats	44.37	32.50	
16	20 tons manure after oats	41.87	47.20	
17	10 tons manure after hay	35.04	44.25	
18	5 tons manure after hay	32.81	42.40	
Averages				
7-13	No fertilizer	31.56	21.87	39.20
8-14	5 tons manure after oats	34.37	25.04	40.54
9-15	10 tons manure after oats	43.27	34.61	46.50
10-16	20 tons manure after oats	50.16	45.97	54.44
11-17	10 tons manure after hay	45.15	47.89	50.72
12-18	5 tons manure after hay	41.25	37.27	46.07

TABLE XXXI

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

Plot	Management	1924	1925	1919-25 Av.
		Tons	Tons	Tons
7	No fertilizer	0.92	0.55	
8	5 tons manure after oats	1.33	0.85	
9	10 tons manure after oats	1.55	1.25	
10	20 tons manure after oats	1.15	2.15	
11	10 tons manure after hay	0.80	1.55	
12	5 tons manure after hay	0.83	1.50	
13	No fertilizer	0.63	1.15	
14	5 tons manure after oats	1.10	1.10	
15	10 tons manure after oats	1.65	1.40	
16	20 tons manure after oats	1.70	2.15	
17	10 tons manure after hay	1.05	0.80	
18	5 tons manure after hay	1.05	1.45	
Averages				
7-13	No fertilizer	0.80	0.85	1.22
8-14	5 tons manure after oats	0.21	0.98	1.55
9-15	10 tons manure after oats	1.60	1.33	1.96
10-16	20 tons manure after oats	1.43	2.15	2.11
11-17	10 tons manure after hay	0.93	1.18	1.65
12-18	5 tons manure after hay	0.93	1.48	1.59

To simplify interpretations, these three tables are condensed into one, giving the increase that has been realized with each treatment and for each crop.

TABLE XXXII

INCREASE IN YIELDS PER ACRE OVER CHECKS, RATE OF-MANURING PROJECT

Management	Potatoes	Sunflowers	Oats	Hay
	Bu.	Tons	Bu.	Tons
No fertilizer	....	....	....	....
5 tons manure after oats	22.07	1.35	1.34	0.33
10 tons manure after oats	32.84	3.56	7.30	0.74
20 tons manure after oats	47.00	3.57	15.24	0.89
10 tons manure after hay	20.09	3.61	11.52	0.43
5 tons manure after hay	33.96	2.45	6.87	0.37

Analyzing these data, the application of 5 tons after oats seems to give a slightly larger yield of potatoes per ton, but the 10-ton application on grain stubble produces more sunflowers, oats, and hay per ton. A contradictory condition appears where the gross return from 5 tons is greater for the period than the return from 10 tons. This condition we find only with the plots manured on grass stubble. This system of manuring was begun since the 1920 season, has been in operation only about half as long, and the yields secured represent a residual effect from previous management. As a matter of fact, the margin in yields between 5 and 10 tons is rapidly being absorbed, and for 1924 and 1925 the 10-ton plots have led in production. Twenty tons per acre has been justified only in the case of oats and this because the crop is grown the third year after manuring when the residual effects of smaller applications no longer are noticeable. As the application of 10 tons of manure has been followed by at least doubled increase in nearly all cases as compared to 5 tons on grain stubble, and as it has been almost as effective as the 20-tons treatment, we may assume that it is the most satisfactory and economical quantity to use.

The farm price of potatoes, oats, and hay in Minnesota during the 15-year period 1909-24 has been, respectively, 60 cents per bushel, 38 cents per bushel, and $9.48 per ton. If the feeding value of one pound of grain is equivalent to three pounds of silage, the silage is worth $3.16 per ton. Applying these prices to the increased crops following the use of manure, we have the following values for a ten-ton application once in three years: Potatoes, $19.70; silage, $11.24; oats, $2.77; hay, $7.01; a total of $40.72, or $4.07 per ton of manure applied.

Commercial fertilizers.—Tests with commercial fertilizers on potatoes were begun in 1921. Data for five crops are now available. The potatoes are followed by oats and this crop in turn by hay. The fertilizers are applied to potatoes only. This project is an extension of the phosphate work begun in 1916.

Owing to water injury in 1924, it was necessary to discard one check, one phosphate, one nitrogen-potash, one complete fertilizer, one nitrogen-phosphate, and two nitrate plots.

During the five-year period, the complete fertilizer has shown a gradual increase over the check plot. At prices prevailing for potatoes in 1925, the fertilizer will show a profit. As these soils grow older, the potash fertilizer is making a progressively better showing. Phosphate alone seems valueless for potato growing. Three years out of five it produced even less than the check plots and the five-year average increase noted above, 8 bushels, checks very closely to the findings for seven years, 1916-23, with the original phosphate experiments (see 1922-23 reports for yields). Nitrogen alone seems to have been of little benefit, but it is interesting to note that, tho separately they are seemingly ineffective, combined, nitrogen and phosphate made the second largest increase, following directly after the complete fertilizer.

TABLE XXXIV

YIELDS PER ACRE OF POTATOES AND FIVE-YEAR AVERAGE, FERTILIZER PROJECT

Plot	Treatment	1924	1925	5-yr. Av.	Gain over check
		Bu.	Bu.	Bu.	Bu.
1	No fertilizer	150.96	160.54	174.54	....
2	Potash	273.20	239.06	211.59	37.05
3	Phosphate and potash	316.60	231.46	209.12	34.58
4	Phosphate	203.53	229.12	182.58	8.04
5	No fertilizer	171.13	167.62	.....	....
6	Nitrate	231.64	163.21	192.35	17.81
7	Potash and nitrate	251.20	213.03	217.54	43.00
8	Potash, nitrate, and phosphate	353.27	264.19	261.00	87.00
9	Phosphate and nitrate	287.26	228.54	236.08	61.54
10	Nitrate	217.50	196.97		
11	No fertilizer	233.26	.....		
12	Potash	237.94	215.68		
13	Phosphate and potash	260.88	246.07		
14	Phosphate	*	186.57		
15	No fertilizer	*	.....		
16	Nitrate	*	196.39		
17	Potash and nitrate	*	208.83		
18	Potash, nitrate, and phosphate	*	301.01		
19	Phosphate and nitrate	*	288.17		
20	Nitrate	*	197.56		

* Discarded.

Observations are not sufficiently complete for a statistical report on hay and oats. Hay was most abundant in 1925 on the plots which in 1924 received the complete fertilizer, with nitrogen-potash, then with phosphate, lastly with potash. All other treatments including complete fertilizer were nearly identical with the check.

Garden fertilization.—In the truck gardening district of southeastern St. Louis and eastern Carlton counties, the problem of fertilization is growing in importance. The available manure is decreasing with the declining use of horses in city transportation. Soils are

growing older and the area under crop is expanding. There has been a resulting increase in the use of commercial fertilizers and a demand for information as to their intelligent use. The project under discussion was begun in 1922 to satisfy this need. Four crops have been harvested. The comparison has been made on the joint and separate use of fertilizer (4-8-6) and of manure as indicated in the table. This study has been especially conducted with the root crops that are quite widely grown for commercial use. All plots were in duplicate.

TABLE XXXV

YIELDS PER ACRE OF GARDEN CROPS, FERTILIZER PROJECT

Treatement per acre	Carrots	Beets	Rutabagas	Parsnips	Onions	Cabbage	Cauliflower	Lettuce
	Tons	Tons	Tons	Tons	Tons	Tons	Lbs.	Lbs.
No fertilizer	11.18	8.02	16.32	3.89	5.63	10.49	3.27	12
30 tons manure.....	14.93	2.14	20.95	8.99	8.34	12.11	7.90	13
15 tons manure.....	14.77	14.35	19.62	6.12	9.06	12.70	6.89	22
15 tons manure and ½ ton commercial fertilizer	19.23	16.31	21.17	8.17	10.04	12.88	7.47	25
1 ton commercial fertilizer	18.20	15.66	26.82	8.13	7.68	13.70	8.50	25

The data presented represent four crops of carrots and beets; three each of onions, rutabagas, cabbage, and cauliflower. Altho the observations include lettuce and parsnips, the tests cover too short a period for conclusive discussion at this time. An analysis of this table indicates three tendencies: (1) Fifteen tons of manure seems fully as effective as 30 tons over a four-year period, indicating that extremely heavy manuring is a wasteful practice. (2) For all the root crops, including parsnips but excluding rutabagas, the combination treatment of 15 tons of manure and one-half ton commercial fertilizer has proved most effective. (3) For such leaf crops as cabbage, cauliflower, and lettuce, and for rutabagas, one ton of commercial fertilizer has had the most pronounced influence.

Crop production on virgin soils.—The management of a new soil and the proper crop to grow the first year after stumping and breaking are questions that every settler must face. As some crops are hardier, and more vigorous under the handicaps of an untamed soil, a project has been undertaken to determine by comparative test which should be selected. These crops have been grown on the prevailing stony clay loam at Duluth; on the Superior red clay soil at Two Harbors; and on the jack pine sandy loam at Biwabik. A fourth project was begun at Virginia in 1925, but it was confined to variety tests on land farmed for several years. The project is receiving careful study by the land clearing section, Division of Agricultural Engineering, under private farm conditions. Co-operative relations are maintained with more than 100 farmers and yields of the crops that the farmer actually grows for the first time on new land are determined by the square-yard method.

ANIMAL HUSBANDRY

Grazing Heifers on Stump Land Pasture

This project was terminated with the close of the 1925 pasture season. It has continued through a complete ten-year period, a summary for the entire period being included in Table XXXVI. For the most part the livestock units consisted of growing heifers, as the pasture lay at the extreme end of the farm, hence pasture values are interpreted in terms of gains in weight instead of in milk production.

TABLE XXXVI

TEN-YEAR RECORDS—GAINS OF HEIFERS ON STUMP PASTURE

Year	Continuous pasture began	Continuous pasture ended	Total days	Number of cattle	Average age of cattle	Average total gain	Average daily gain
					Mo.	Lbs.	Lbs.
1916	June 12	Oct. 17	103	10	17.2	161.6	1.56
1917	June 1	Oct. 17	138	..	...	74.0	0.53
1918	June 1	Oct. 18	128	6	19.0	175.0	1.36
1919	June 3	Oct. 27	146	8	10.5	172.0	1.18
1920	May 25	Oct. 27	155	9	15.5	168.0	1.08
1921	May 25	Nov. 2	161	8	15.0	162.0	0.98
1922	May 24	Nov. 11	161	8	11.3	189.0	1.17
1923	May 28	Oct. 20	146	10	14.8	230.0	1.57
1924	June 2	Oct. 23	144	5	13.0	148.8	1.04
1925	June 1	Oct. 17	139	5	14.0	139.0	1.00
Averages	June 1	Oct. 21	143	7.06	14.48	161.9	1.14

The number of days pasturage, 143, is for both day and night. This could be expanded in many places to at least 160 days, for the cattle could go on grass about May 25, one week earlier, and if brush or shelter were available, another week or ten days could be added in the fall. Moreover, day pasture usually continues for one month after cattle are confined at night, during October, owing to the autumn storms. There is some variation in gains from year to year owing in part to dry seasons; variation in period of pasturage; and in number of cattle confined. We may safely expect a gain of 160 pounds for yearling stock during the summer pasture season, June 6 to October, under normal feeding conditions, on stump land pasture unimproved except for grass and clover seed sown between the stumps. This gain could be considerably increased when this pasture is cleared and broken and managed under domesticated, permanent pasture conditions.

Livestock

Sheep.—The grade flock of Hampshire sheep, purchased six years ago, has been a profitable investment. From year to year the offspring have been improved by the use of well selected purebred rams. Lambs sold in the early fall of 1924 averaged 133 pounds each. The

lamp crop of 1925 averaged 150 per cent of the flock, with a large percentage of triplets. The original purchase was made for land clearing purposes. This job is now done. The project has been changed to an observation of small flock management on the developed northern farm with sweet clover pasturage in summer, salvage of second crop grass in fall, and winter maintenance on mixed hay and roots. Owing to limited pasturage and the menace of numerous dogs in the thickly populated city area near by, the flock was reduced to the original number of 12 in the fall of 1925.

Dairy cattle.—The dairy herd consists of 25 milk cows, with heifers and young stock bringing the total of females to 38. Of this number, 9 cows and 7 heifers are purebred registered Guernseys. The other 22 are of high grade. The purebred cattle represent the female increase from the three foundation cows purchased in 1914. The Duluth herd has been free from tuberculosis and on the accredited herd list for eight consecutive years. The production records are given of the cows that have been in the herd during the last two years and that have completed one lactation period or more. See Table XXXVII.

The station herd is managed as a commercial enterprise. The cows are housed in stanchions, milked twice daily, and fed a grain ration not to exceed one pound of grain for each 2.5 pounds of milk produced during the winter months; and 1 pound of grain to 3.5 or 4 pounds of milk during the summer season. The objective has been and is to maintain a good and increasing herd production with ample feeding and good care. Male purebred calves are sold at six months and under to farmers establishing foundation herds. Beginning in late July, as the pastures turn dry, roughage crops consisting of rye and vetch, sweet clover, corn and sunflowers are fed to sustain the milk flow during the trying months of the open season. Roots during late fall and sunflower silage in winter constitute the succulent feeds when pasturage is not available. The labor requirements of this herd are cared for by one full-time herdsman with two milkers in the morning and one in the afternoon. When the herd is in winter quarters, another man is employed in the barn, half time. The care of the hogs is included in the duties of these men.

TABLE XXXVII

BUTTERFAT PRODUCTION OF DAIRY HERD, TWELVE MONTHS' RECORD

Name	Kind	Production of butterfat
		Lbs.
Antona	Registered Guernsey	393.06
Antonette	" "	305.69
Dolly	" "	302.98
Mimosa	" "	415.46
Merry Maid	" "	370.35
Alexia	" "	325.95
Minota	" "	278.07
Dairy Maid	" "	349.73*
Daisy	" "	222.71†
Angeline 1-2	Grade Guernsey	305.69
Angeline 1-1	" "	356.68‡
Climax 1-1	" "	366.47
Climax 1-1-1	" "	329.08
Climax 1-1-2	" "	314.35
Genevieve 1	" "	394.71
Genevieve 1-2	" "	430.82
Jewell 2-1	" "	346.84
Jewell 2-1-1	" "	428.23
May 1	" "	508.61
May 1-1	" "	424.75
Nellie 1-1	" "	390.17
Average		360.00

* Eleven months.

† Ill several months.

‡ Angeline was sold in the fall of 1925.

Hogs.—A herd of registered Duroc-Jersey hogs is maintained. The policy followed is to breed for two litters per year, as far as it can be done. There is a heavy demand for spring pigs in this district and a fair movement in fall pigs for the lumber camps and for roasters. The hogs are maintained very largely on low grade fruits and vegetables from commission houses in the city. This garbage, when cooked and fed with screenings, makes a palatable, cheap, and satisfactory ration.

Poultry.—The poultry work of the last biennium has been largely that of alteration and preparation. The old house, built 12 years ago without adequate knowledge of and consideration for the severity of northern winters, was moved to a new and higher location at the main building group in November, 1924. During the present season alteration work has been in progress, consisting in the first place of providing sawdust for greater warmth and dryness. Three pens, 24x16 feet, have been so constructed as to represent three types of houses in ventilation and interior arrangement. These test pen-houses will be in service in the autumn of 1926. Dry floors have been secured by placing the building over a leveled rock fill from 18 to 24 inches deep which raises the building to that extent above ground level. A concrete floor was placed above this fill. This plan eliminates the need of a special concrete wall and makes an excellent depository for surplus stones.

The plan has been followed in the construction of foundations for other small buildings about the institution. Another feature has been an inside and an outside double row of studding in walls to allow an 8-inch sawdust fill and insure more complete insulation.

Experimental work under way consists of temperature studies, comparing inside temperatures for this type of construction with those obtaining outdoors; and a study of production with and without artificial light. This will continue through one year, and is being conducted in the 18x32-foot Minnesota model house similar to the one described.

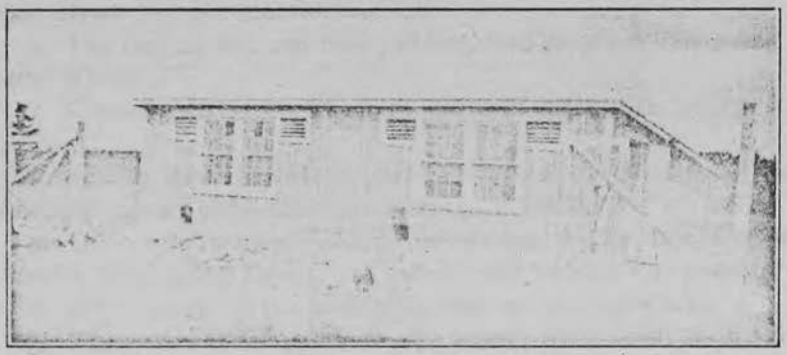


Fig. 7. New Poultry House

This is a modified Minnesota model house with 8-inch double studded, sawdust insulated wall, rock fill covered with cement floor. Size over all, 18 by 22 feet.

INSTITUTIONAL DEVELOPMENT

The last two winters, those of 1923-24 and 1924-25, have been relatively mild and open, with little snow, and work in the open has progressed almost continuously. All wood sawing has been completed on the north 80, all stumps have been burned, the tile main has been laid, together with part of the feeders, and half of the swamp had been broken and seeded to rye, by the early fall of 1925. Stumping was completed in June, 1925, and the entire acreage is free of wood and stumps except about 22 acres, where the piled stumps as well as the pole wood will be sawed for fuel. Six weeks were devoted to this work in November and December of 1925, and the wood was hauled away to permit of breaking in the early spring. About fifteen acres of new land were broken and stoned in 1924, and 25 acres in 1925. The dry summer of 1925 was excellent for this work. Scattered stone piles have been cleaned off the farm and hauled to the Amity ravine. No new buildings have been erected aside from a shed attachment to the machine house. Woven wire fencing has replaced barbed wire in many places, the walks have been completed, and a beginning has been made at grading and landscaping the campus and yards. The electric lighting system

has been extended to all farm buildings, including the unit at the north end of the station tract. The present winter marks the close of the thirteenth year since active development began.

SUBEXPERIMENTAL FIELDS

In the establishment of the Lake County field, at the Lake County Farm, Two Harbors; and of the Biwabik field on the Hanke farm south of the village of Biwabik, this station began a new service in 1924. This work was extended in 1925 to include the Virginia field, located

Fig. 8. First Breaking of Swamp Land for Farm and Garden Crops. Photograph taken July 31, 1925.

on the school farm at that city. The Lake County field is on jack pine sandy loam; the Virginia field is a clay loam, characteristic of the Iron Range country. The policy of the extension experimental service has been to secure crop information on the three principal soil types in the area served by the Duluth station.

The production work on virgin soils, two years' work at Two Harbors and Biwabik, has been reported. In addition to this, variety testing was included at all three places. The Virginia location, which is quite high, seemed more frost-free and better adapted to corn culture for fodder and silage than the other two. Field peas thrived on the Lake County red clay. Alberta White surpassed all other varieties in earliness and yield. Progress, a selection from Java wheat, surpassed its parent in yield at two places. Both varieties seem particularly well adapted to local conditions and both seemed to favor clay soil. Iowar oats surpassed Gopher at all three places. It outyielded Victory as well, except at Two Harbors, where there was a difference of two bushels. The two-rowed barley seems to have some advantage on the clay soils, but the six-rowed outyielded it on sandy loam. It is planned to extend this outlying field experimental work to the west end of the Mesaba Range in 1926.

SUMMARY

1. The summer of 1924 was colder and wetter than the summer of 1925, which was warmer and drier than the average.

2. The season of 1924 was good for hay, grain, and apples; that of 1925, for corn and crops requiring warmth and dryness, as tomato, squash, and pumpkin.

3. The highest yielders of the four principal crops over a seven-year period of test are: Java wheat, 20.64 bushels; Iowar and Gopher oats, 61.4 bushels; No. 184, Imp. Manchuria barley, 38.3 bushels; Swedish Rye, Minn. No. 2, 19.6 bushels.

4. The two earliest and best yielding field peas are Chang and Alberta White.

5. Cleaned oats seed yielded 21 per cent more than bin-run seed, in 1925.

6. Sowing three bushels of oats per acre and 3 bushels of barley produced heavier yields than lighter rates of seeding.

7. Two years' work at Duluth indicate that barley should be sown between May 15 and June 1, and oats as near to May 1 as possible.

8. July 1 should be the latest time limit for seeding alfalfa.

9. Eight years after application, the limed portion of an alfalfa-alsike field produced 36.8 per cent, or one third more tonnage than the unlimed half.

10. In a comparative test of seven varieties, Grimm Alfalfa was the only one to survive the open, deep freezing winter of 1924-25.

11. White sweet clover produces from one fourth to one third more forage per acre than yellow sweet clover.

12. Sweet clover pasture maintained from 2 to 5 head of cattle on a two-acre tract through the season of 1925.

13. Minn. No. 13 and Northwestern Dent produce the largest yields of corn for silage. Manitoba and North Dakota White are the leading flint varieties.

14. Rye and vetch make an early soiling crop.

15. Oats will produce from 6 to 10 tons of green feed per acre.

16. Some sunflowers should be grown as silage insurance crops.

17. Spacing rows 36 inches is most practical in sunflower culture.

18. Sowing sunflower seed with a grain drill produces good yields of good quality but difficult to harvest.

19. Setting a grain drill for 2 pecks of wheat per acre, with rows 36 inches apart, and using about 10 pounds of seed per acre is a cheap and efficient method of sowing sunflowers.

20. The middle of May is the best time to plant sunflowers for silage.

21. Sunflowers and rutabagas produce about an equal tonnage per acre.

22. Drilling sunflowers produces a greater tonnage than growing in check rows.

23. Sunflowers grow about an inch and a third daily during July and August.

24. Zenith Special, developed at this station, leads all other sunflowers in earliness. It is recommended for a soiling crop and chicken feed as it usually ripens seed.

25. Root crops for livestock averaged more than 20 tons per acre in 1925.

26. See Table XV for recommended varieties of garden crops, based on earliness and yield.

27. Late potatoes average 37 bushels per acre more than early potatoes.

28. Drilling and checkrowing seemed equally effective in comparative yield tests of potatoes.

29. Potatoes are most easily grown in rows 36 inches apart, but rows 30 inches apart produced the largest yield.

30. Plant potatoes as soon as possible after the middle of May. Every day of delay means a loss of 3 bushels, or $1.80 farm value.

31. Some strains of Irish Cobbler, certified seed, are three times as productive as certain other strains within the same variety.

32. Pressure spray tests have influenced yield of early potatoes more than of late varieties.

33. Large cut seed potatoes produced 25 bushels more per acre than small whole potatoes with the seed end cut off.

34. Sunbeam and Redpath raspberry, Houghton and Como gooseberry, and London Red currant are promising small fruits at Duluth.

35. Planting 5- to 6-foot apple stock on southeast slopes is good practice in Duluth orchard work.

36. The following varieties of apples have best production records: Hibernal, Wealthy, Patten (Greening), Duchess, Anisim. Florence leads other varieties of crab apples.

37. The three-year rotation is more productive than the four- and five-year rotations.

38. Pasturing clover and grass crops has given higher yields of the following crops than either plowing under or harvesting the crop.

39. Oats, sunflowers, and potatoes show a sharp decline in yield in 1924-25, in the rotation without clover or manure. Barley failed entirely.

40. Ten tons per acre on grain stubble once in the rotation continues to be the most effective rate of manuring.

41. Judging by increased yields and farm prices over a 15-year period, one ton of manure is worth $4.07.

42. Complete fertilizer treatment of potatoes has produced an average annual gain for five years of 87 bushels per acre. The nitrogen-phosphate treatment, of 61.5 bushels.

43. In garden fertilization 15 tons of manure has proved fully as effective as 30 tons.

44. For root crops, excluding rutabagas, the combination of 15 tons of manure and ½ ton commercial fertilizer has proved most productive.

45. For leaf crops and rutabagas, one ton of commercial fertilizer per acre has given largest returns.

46. In producing first crops on virgin soils, grains and grasses have given best response on heavy soils; and cultivated crops—corn, potatoes, and sunflowers—on sandy loam soils.

47. Over a ten-year period of grazing heifers on stump land pasture, they have made an average daily gain of one and one-seventh pounds for 143 days.

48. The mature producing herd of purebred and grade Guernseys have an average 12-months production record of 360 pounds of butterfat.

49. A 150 per cent lamb crop was raised in 1925.

50. Garbage, when cooked and mixed with screenings, has proved satisfactory and economical for hogs at Duluth.

51. Temperature, light, and poultry-house construction studies are now under way.

52. Subexperimental fields are being operated on the Lake County red clay; the jack pine sandy loam south of Biwabik; and the typical clay loam of the Iron Range, at Virginia.

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* On leave, July 1, to Dec. 31.
† Resigned June 31.
‡ Appointed July 1.

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