The University of Minnesota

AGRICULTURAL EXPERIMENT STATION

BULLETIN 148

BARLEY INVESTIGATIONS

BY

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DIVISION OF AGRONOMY AND FARM MANAGEMENT

UNIVERSITY FARM, ST. PAUL

APRIL 1915

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Coöperation between the Minnesota Agricultural Experiment Station and the Bureau of Plant Industry of the United States Department of Agriculture for the investigation and improvement of barley began in 1898.

The acreage and production of barley in Minnesota has steadily increased since the early settlement of the state. The increase has been particularly rapid since 1900. There has been a decrease in the average yield per acre in recent years. The production of the crop is widely distributed over the state, but is greatest in the southeastern section.

The 6-rowed bearded varieties of barley are most generally grown in Minnesota, though 2-rowed bearded and hooded (beardless) varieties are grown to some extent. The 6-rowed bearded varieties usually produce the largest yields.

A large proportion of the barley on the Minneapolis market is of low grade. This condition would be materially changed if more attention were given to the crop, particularly between the time of cutting and that of marketing.

Varietal tests at the Minnesota Experiment Station have shown that the largest yields have been produced by varieties of the 6-rowed bearded class. In all, 158 varieties and selections have been tested in the field plots for periods ranging from one to thirteen years.

Manchuria (Minnesota No. 105), the highest-yielding commercial variety of 6-rowed bearded barley, produced an average of 48.2 bushels per acre for the thirteen years from 1899 to 1911, inclusive. Other stocks of the Manchuria, or similar to it, exceeded all other varieties in yield. Minnesota No. 105 was exceeded in yield, however, by some pure lines selected from it. The best of these, Minnesota No. 184, produced an average yield of 48.8 bushels for the five years from 1906 to 1910 inclusive, as compared with 39.4 bushels for Minnesota No. 105 for the same period. None of the 2-rowed barleys yielded as well as the best of the 6-rowed, except that Minnesota No. 230, a pedigreed selection of French Chevalier, exceeded Minnesota No. 105 in average yield by 0.8 bushel for the three years, 1908 to 1910 inclusive.

Both pure-line selection and hybridization have been used in the work of improvement. Records are kept of the behavior of each strain as long as it is retained at the Station. These records are summarized as occasion demands.

The nursery tests are made in centgener plots, consisting of 100 plants each. The seeds are planted singly, four inches apart each way, in square beds, with a specially devised machine.

All the land used for nursery tests is included in a seven-year rotation, which insures fair uniformity of land for the nursery strains.

In making crosses, most of the spikelets are removed from the spike, the beards cut from those remaining, and the ends of the glumes of each flower to be handled, cut off. The anthers are then removed and the spike covered with tissue paper, and left for from one to three days. When the stigmas are receptive, the pollen from the selected male parent is introduced and the spike again covered.

An experiment in selecting early-maturing and late-maturing plants from the same original hybrid stock was begun in the nursery in 1902 and increased to plot tests in 1909. The average difference in time of maturity was 4.4 days in the eight-year period. Except that the later-maturing grain was of better grade, there was no advantage apparent on either side.

Comparison of improvement by selection alone and by crossing followed by selection, has been made on a large scale in the nursery since 1903. The results are still rather inconclusive, but crossing of plants within varieties and strains of 6-rowed barley seems successful from the standpoint of yield. Hybrids between 6-rowed and 2-rowed varieties did not give similar results.

BARLEY INVESTIGATIONS

By C. P. Bull

INTRODUCTION

No definite projects were outlined when the coöperative work in barley investigation with the United States Department of Agriculture was started in 1898. The Office of Cereal Investigations of the Bureau of Plant Industry contributed to the general support of the plant-breeding work and shared in the results. In 1907 the work was reorganized. The various phases of crop improvement at University Farm were placed under general projects, and coöperative arrangements were made with the respective offices of the Bureau of Plant Industry which were involved; thus all grain-breeding investigations were coöperative with the Office of Cereal Investigations.

In presenting the records, the results have been summarized wherever possible. There is little to warrant a conclusion being drawn from the data of one season; at least three years' tests are necessary to give reliable data, while the results of four or more years are still more valuable.

BARLEY PRODUCTION IN MINNESOTA

For more than a quarter of a century wheat has been the principal farm crop of Minnesota. Little thought was given to the need of diversity in crop production or of live stock for the maintenance of soil fertility. Gradually the wheat-producing capacity of the soil was so lowered and weeds became such a menace to the crop that it became necessary to introduce other crops in order to make farming profitable. The coarse grains, barley and oats, were naturally the first to be added, for the grain-farming idea was so firmly fixed that the introduction of live stock and the growing of cultivated crops, grass, and other forage crops were not considered. Thus barley, because of its early maturity, came into favor as a crop to subdue weeds, while the ease with which it could be marketed made it valuable as a cash crop. At the same time it was found to be equal to wheat or better in returning a net profit per acre. Later, as the number of live stock increased, barley became recognized also as a desirable feed, so that a larger and better

market was afforded for the crop. Consequently, the area devoted to barley has increased rapidly in recent years, particularly in the last decade.

Table I shows the acreage, production, and farm value of barley in Minnesota in 1860, 1870, 1875, 1880, and annually from 1885 to 1911.[1]

TABLE I

BARLEY CENSUS IN MINNESOTA

Year	Area	Average Yield	Average Yield for 5-Year Period	Production	Average Farm Price per Bushel	Average Value per Acre
	Acres	*Bushels*	*Bushels*	*Bushels*		
1860	.....	.....	.....	109,668	.....	.....
1870	40,000	24.5	.....	980,000	.....	$13.23
1875	40,000	28.0	.....	1,120,000	$0.76	21.28
1880	117,180	27.0	.....	3,163,860	.58	15.66
1885	337,525	23.8	.....	8,033,000	.41	9.76
1886	367,601	23.0		8,455,000	.42	9.66
1887	378,629	19.3		7,308,000	.46	8.88
1888	386,202	20.9	22.26	8,110,000	.57	11.97
1889	358,510	25.6		9,100,683	.35	8.89
1890	369,265	22.5		8,308,462	.55	12.37
1891	384,036	27.3		10,484,183	.43	11.74
1892	399,397	24.9		9,944,985	.42	12.31
1893	419,367	22.1	26.76	9,268,011	.36	7.96
1894	461,304	23.5		10,840,644	.41	9.63
1895	484,369	36.0		17,437,284	.24	8.64
1896	416,557	27.2		11,330,350	.20	5.44
1897	362,405	25.5		9,241,328	.24	6.12
1898	322,540	28.4	25.70	9,160,136	.33	9.37
1899	325,765	25.0		8,144,125	.31	7.75
1900	324,788	22.4		7,275,251	.38	8.51
1901	840,334	25.8		21,680,617	.45	11.61
1902	907,561	28.6		25,956,245	.37	10.58
1903	1,098,194	25.3	27.02	27,783,170	.37	9.36
1904	1,131,093	28.4		32,123,041	.32	9.09
1905	1,074,538	27.0		29,012,526	.32	8.64
1906	1,128,265	28.0		31,591,420	.35	9 80
1907	1,185,000	22.5		26,663,000	.67	15.08
1908	1,300,000	25.0	24.02	32,500,000	.59	12.25
1909	1,339,000	23.6		31,600,000	.52	11.09
1910	1,285,000	21.0		26,985,000	.60	12.60
1911	1,475,000	19.0		28,025,000	.96	18.24

As shown in Table I, the acreage and production of barley in Minnesota increased fourfold between 1885 and 1910, yet the average annual yield per acre for the 5-year period from 1906 to 1910 was less

[1] Compiled from the Yearbooks of the United States Department of Agriculture and from the reports of the Bureau of the Census.

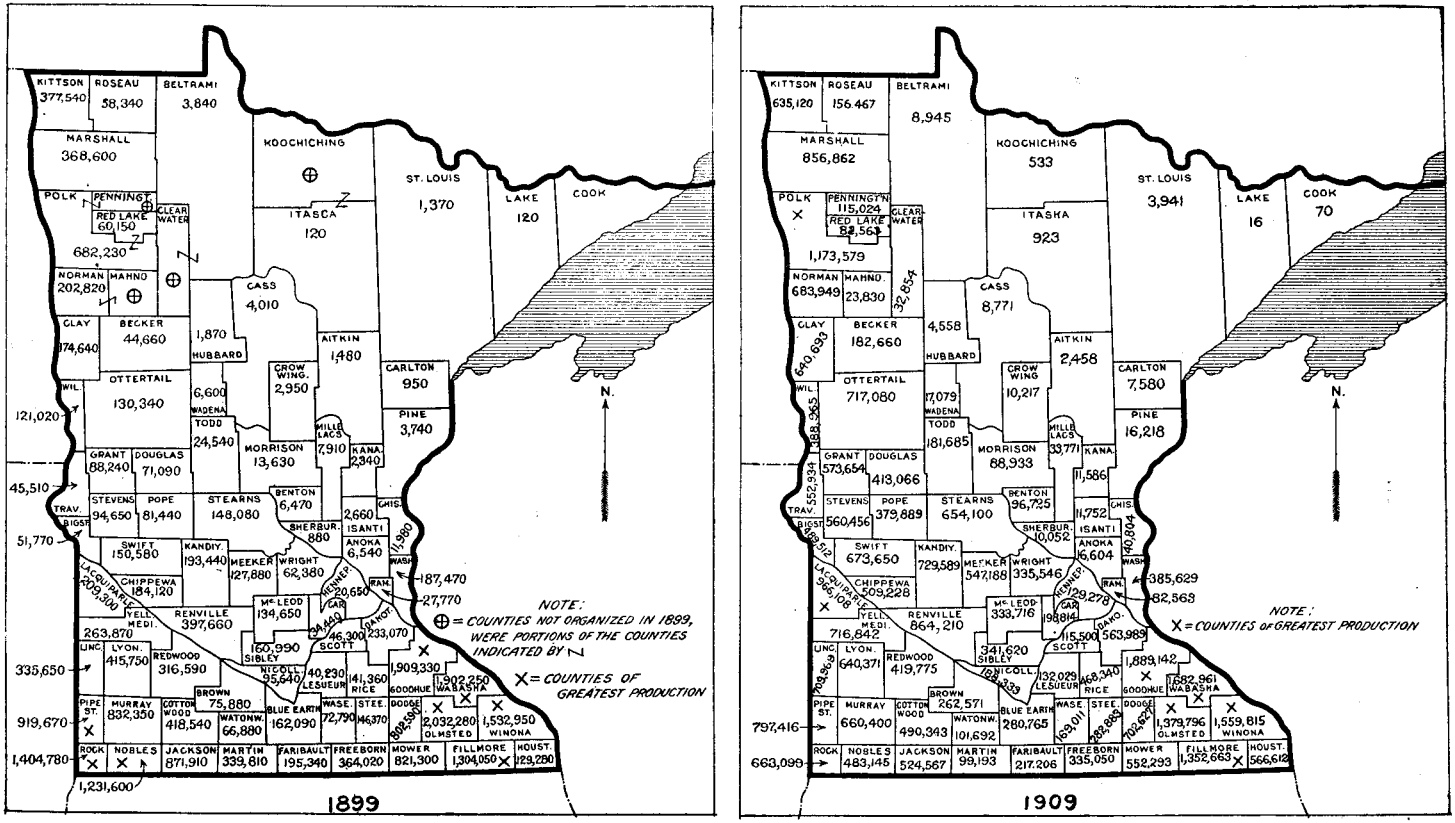

Fig. 1. Production of Barley, in Bushels, by Counties, Minnesota, 1899 and 1909

than that for any previous 5-year period since 1890. The acreage has rapidly increased, while the production, the price per bushel, and the value per acre have fluctuated widely. It is apparent that the value per acre in recent years, notwithstanding the decline in yield, is greater than during any preceding 5-year period. The rapid increase in total production has not been the result of an increase in average yield per acre, but has resulted entirely from the increase in acreage. The selection of good seed has apparently been neglected, but this condition is now changing, for there has never been a time when improved farming methods were given the attention they now receive. There is yet room for improvement.

Some idea of the development of barley-growing in Minnesota can be gained by a comparison of the data presented in Figure 1, which shows the production by counties as reported in the census of 1900 and that of 1910. Barley production in the eight southeastern counties has decreased about one million bushels in the last decade. The southwestern part of the state shows on the whole a slight decrease, while Nobles, Pipestone, and Rock counties have fallen off materially. On the other hand, barley production in the northwestern part of the state, the Red River Valley, has increased more than 100 per cent. Similar increases and decreases are shown in the counties of the central portion of the state. The increase in the production of barley in the northeastern counties is especially noteworthy, for the opinion has heretofore prevailed that these were not agricultural areas. They offer, however, an unusual opportunity for the growing of barley and rye because these crops mature early, fit well into short-course crop rotations, and may be fed profitably on the farm.

CLASSES OF BARLEY GROWN IN MINNESOTA

Three classes of barley are of economic value, viz., the 6-rowed bearded, the 2-rowed bearded, and the hooded or beardless. These are shown in Figure 3. A fourth class, bearded hull-less, also called black hull-less, is often grown for feed. The principal classes are subdivided into groups, and these groups into varieties. The varieties are still further differentiated into so-called strains, which are very closely related to the parent variety but differ according to the line of selection followed by the grower. In the 6-rowed class, for instance, the Manshury, Mensury, Mandscheuri, Mandscheuria, Houghston's Golden Queen, Oderbrucker, etc., are all recognized as essentially the same variety, the Manchuria, although given other names.

Although the 2-rowed barleys were grown quite extensively in Minnesota when the state was first settled, the 6-rowed varieties soon became recognized as better yielders and rapidly replaced them. The

2-rowed varieties are not recommended. It is impossible to tell just what proportion of Minnesota's annual barley production is of one class or another, but the great bulk of the crop is of the 6-rowed class. So universally is this class grown that those who grow 2-rowed varieties find difficulty in selling the grain at a profit in the open market on account of the difference in malting qualities. This difference makes the risk of mixture in the elevators one that the companies will not take. In lots of 1,000 bushels or more, 2-rowed barley is handled

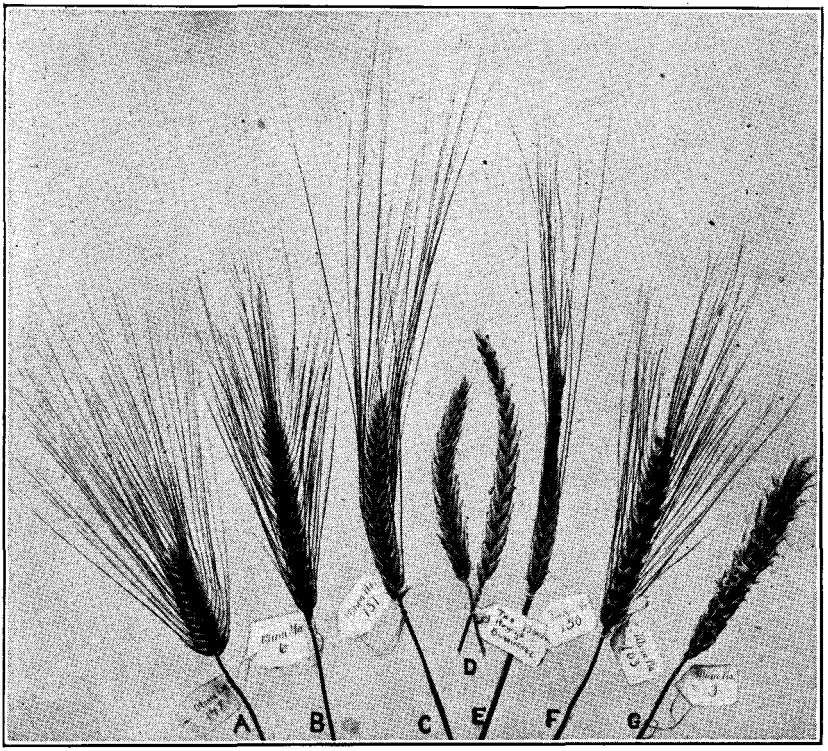

Fig. 2. Heads of the Principal Classes of Barley Tested

A. Erect or true 6-rowed bearded, sometimes called club barley (Minnesota No. 148)
B. Nodding 6-rowed bearded (Minnesota No. 6, Manchuria)
C. Erect 2-rowed bearded (Minnesota No. 151, Primus)
D. Two-rowed hooded (Minnesota No. 83, Dakota Silver Beardless)
E. Nodding 2-rowed bearded (Minnesota No. 150, Hannchen)
F. Nodding 6-rowed bearded (Minnesota No. 105, Manchuria)
G. Six-rowed hooded (Minnesota No. 13)

with comparative safety from mixture, as it is then in sufficient quantity to be placed in a separate bin in the elevator, to be shipped in a car by itself, and to occupy an entire malting vat at the malt house. A few farmers in Minnesota raise the hull-less barley for feeding purposes, but it is seldom found on the market. The hooded (beardless)

barley is not adapted to Minnesota, though it is occasionally grown. Figure 4 shows kernels of 6-rowed common or hulled, 2-rowed common, and hull-less or naked barley, the three classes grown in the state. The varieties which have given the best results at the Experiment Station are all of the 6-rowed class.

THE NEED FOR IMPROVEMENT

The average yield of barley per acre in Minnesota is much smaller than it should be. The average yield per acre for the ten years from 1902 to 1911, inclusive, was 24.84 bushels. Those who have coöperated

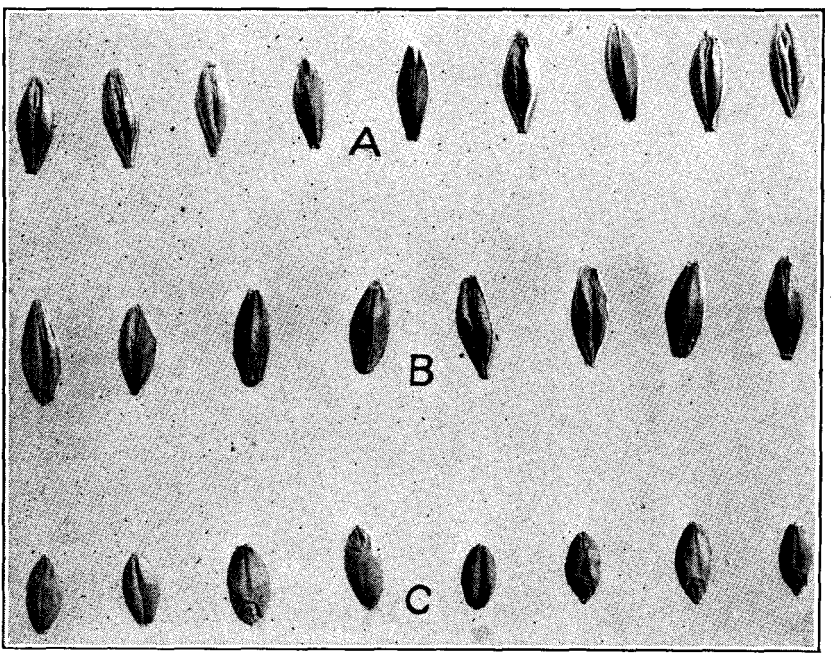

Fig. 3. Kernels of the Three Classes of Bearded Barley Grown in Minnesota
A. Common 6-rowed B. Common 2-rowed C. Hull-less or naked 6-rowed

with the Station in growing barley from selected seed report yields ranging from 35 to 45 bushels per acre for the same period. The yields of the best two 6-rowed varieties at the Experiment Station for the past 13 years have been 48.2 and 46.3 bushels per acre, while the best varieties of the 2-rowed class have yielded 41.1 and 40.3 bushels. These results were obtained on silt loam of only medium fertility and underlaid with a sandy and gravelly subsoil.

Carelessness in handling the crop after it is cut lowers the grade of the grain. Much better grades and prices would be obtained if

the crop were cut at the proper time, shocked properly, and stacked or thrashed at the first opportunity. Because these factors are neglected, the great majority of the shipments of barley grade only "No. 3," "No. 4," and "Feed." Entirely too large a proportion is of the last grade, which is of poorer quality than No. 4 and usually sells at a lower price.

The records of the state grain inspection department show that 16,416 cars of barley were received on the Minneapolis market in the fiscal year ending August 31, 1912. It is natural to suppose that a large part of this grain was produced in Minnesota. Of this total, 7,324 cars, or 44.5 per cent, were graded as No. 1 feed barley; 3,599 cars, as No. 2 feed; and 1,907 cars, as No grade. The total number of cars of these three grades was 12,830, or 78.1 per cent of the total receipts for the year. No 1 feed, the highest of the three grades, "must test not less than 40 pounds to the measured bushel and be reasonably sound and reasonably clean." Of the higher grades composing the remaining 21.9 per cent of the year's receipts, 38 cars were graded No. 2 Chevalier; 787 cars, No. 3 Chevalier; 181 cars, No. 3; and 2,580 cars, No. 4. When only a little more than one fifth of the barley received at an important market grades No. 4 or better, it is evident that there is much need for improved methods of producing and handling the crop, for improvement in the quality of the varieties now grown, and for the use of adapted varieties.

VARIETAL TESTS

OBJECTS OF THE TESTS

The two main objects in conducting varietal plot tests are (1) to ascertain the relative producing power and adaptability of commercial varieties, and (2) to test the comparative yielding power of selected strains.

Efforts have been made to obtain all promising varieties and test their relative producing power and adaptability to environmental conditions in the hope of obtaining superior foundation stocks for further development. Several such foundation stocks have been brought to light. Minnesota No. 6, a 6-rowed variety of the Manchuria type, obtained from the North Dakota Agricultural Experiment Station, was the first of these. It was increased rapidly and distributed to Minnesota farmers with very satisfactory results. Later, Minnesota No. 105, a 6-rowed barley of the same type, was obtained from the Ontario Agricultural College, at Guelph, Ontario. It proved to be more satisfactory than Minnesota No. 6, and therefore succeeded it as the variety offered to the farmers. Since the distribution of Minnesota No. 105, the tests have shown no varieties or strains superior to it

except some of the selections, as shown in Table VII. These pedigreed stocks will be increased and offered to farmers in place of Minnesota No. 105. The stock of Minnesota No. 105 will, however, be maintained, for its record recommends it for continued use as a "check-plot" variety, as a foundation stock for breeding, and as a standard variety for the Northwest.

METHODS OF TESTING

There are numerous methods of testing the varieties of field crops. These depend more or less upon the contour of the land and the original plotting of the experimental fields. University Farm is divided permanently into fields, which are designated as "Field A", "Field B", etc. Each field is divided permanently into series, designated as "Series I", "Series II", etc. Each series is in turn subdivided, as the crops are sown, into plots, designated as 1, 2, etc. The series vary in total area according to their length, but are always 8 rods, or 132 feet, in width. As far as possible, the series are arranged in the fields to obtain the greatest degree of uniformity in soil conditions. Permanent roads, one rod wide, are laid out between fields, and permanent twelve-foot or sixteen-foot roads are maintained between the series. A two-foot alley is left between the plots. With these roads and alleys, access to the plots and the handling of the crops are made convenient.

The plots are one-twentieth of an acre in size, except when the quantity of seed on hand will not plant so large an area at the required rate of seeding. As the drill in use sows a strip one rod wide at each round, this size of plot is convenient, for one round across the series sows the desired area. This size of plot is also economical to cut with a binder and to thrash with ordinary thrashing machinery. The element of error is small when a plot of this size is used, while the danger of mixtures from neighboring plots is nullified because sheaves are saved and thrashed separately for seed and care is taken to clean the machinery thoroly between operations on the several plots. In keeping records of the varieties it is easy to identify them by their position; e. g., a variety is described as being produced on Field A, Series IV, Plot 2, which may also be written A, IV, 2, with equal clearness and accuracy.

CHECK PLOTS

In the varietal plots, some means of checking the performance of one variety with another is necessary when the two are some distance apart, thus affording opportunity for variation in soil conditions. To supply a means for thus comparing the plots, check plots are used. At the present time every fifth plot, plots 1, 6, 11, etc., is planted as a check. The variety used in seeding the checks should be one which

has been grown long enough in the locality and has been sufficiently well graded annually to insure uniformity in its producing power. In other words, a variety used as a check should be so nearly uniform that its production will vary directly with the soil conditions. If such a variety is secured, the element of error is greatly minimized. In the varietal tests of barley at University Farm, Minnesota No. 105 is used as the check variety.

METHODS OF PLANTING AND HARVESTING

The land is prepared for all plots in as uniform a manner as possible and as perfect a seed bed is made as the immediate soil conditions will permit. Fall-plowed land is preferred. The plots are sown with a drill, usually from about May 1 to May 5. Beginning on the south or east end of the series, depending on the layout of the fields, a border plot one-half rod wide is sown; a two-foot alley is left and plot

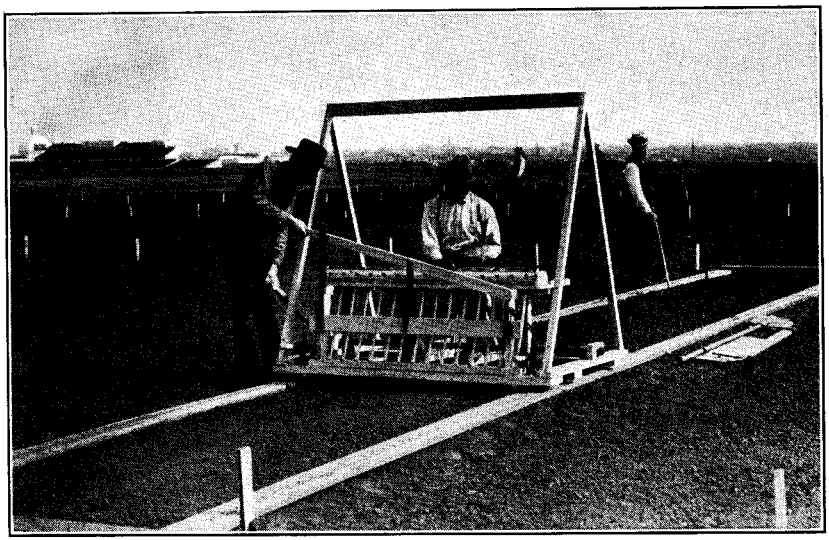

Fig. 4. Centgener Planter
The operator is placing seed in the cups.

number 1, a check plot, is sown; then another two-foot alley, after which a varietal plot is sown. Thus all the varieties are planted in their turn. At the end of the series, another border plot is sown, as in the beginning, to make the conditions uniform and to protect the plots from injury. As the plots are sown a marking-stake with a label similar to those used in the breeding work is placed in the center at one end of each plot, thus identifying it.

The data given in Table II are recorded for each plot. Space is provided at the bottom of each page in the record book for general notes, such as preparation of the land and previous crop.

TABLE II

METHOD OF RECORDING VARIETAL TESTS OF SMALL GRAINS IN THE UNIVERSITY FARM YEARBOOK

FIELD X, SERIES V — BARLEY VARIETIES, 1910

VARIETAL NAME	MINN. NO.	PLOT NO.	RATE OF SEEDING	DATE SOWN	DATE RIPE	DAYS MATUR'G	DATE HARVESTED	HEIGHT	LODGING	CHARACTER OF LODGING*	TYPE	WEIGHT PER BUSHEL	YIELD			
													Per Plot		Per Acre	
													Straw	Grain	Straw	Grain
			Bushels					*Inches*	*Percent*			*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Manchuria.....	105	Border	2	5–5	8–10	95	8–12	30	.....	.....	6-r.	.....	.....	.....	.....	.....
	105	1	2	5–5	8–10	95	8–12	32	2	.....	6-r.	.....	.....	.....	.....	.....
	6	2	2	5–5	8–10	95	8–12	34	10	.....	6-r.	.....	.....	.....	.....	.....

*Indicated by a sketch showing inclination of plants.

A self-binder is used in harvesting. Great care is taken to remove all straws and heads of grain from the machine after one plot is harvested before another is entered. The sheaves of each plot are shocked

Fig. 5. Centgener Plots of Mature 6-Rowed Barley
Each stake represents the progeny (100 plants) of a selected plant

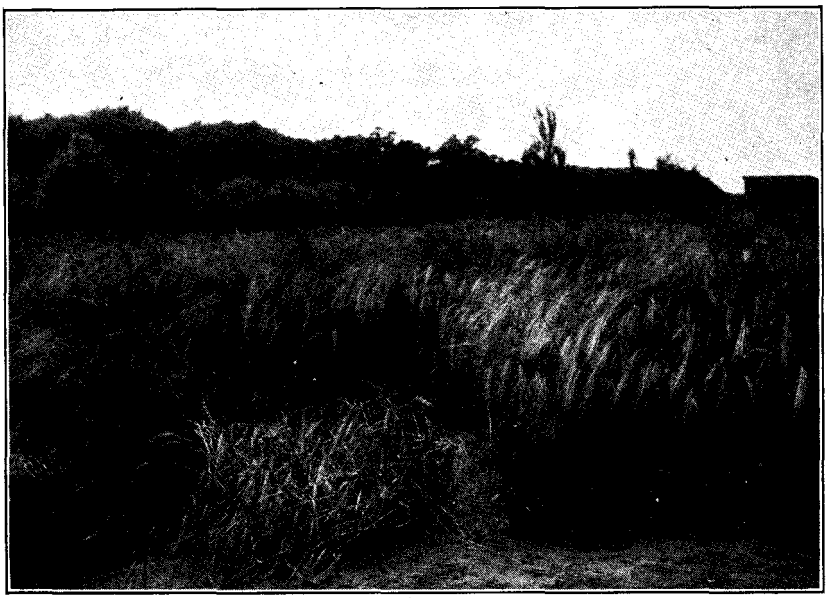

Fig. 6. Centgeners of Barley, Showing Differences in Strength of Straw

separately and marked with the plot stake. They remain thus until thrashing-time.

The thrashing of the twentieth-acre plots is done with a small thrashing machine of the ordinary type. It is reconstructed slightly to prevent the lodging of kernels which might cause mixtures of the varieties. The grain is sacked, weighed, and tagged, the weight is recorded, and the sacks are hauled to the seed house. For the seed supply for the next year, a few sheaves from each plot are left to be thrashed in a small, specially constructed plot thrasher, which is lined completely with tin and so made as to prevent the lodging of kernels within it. It is built upon the same plan as the centgener thrasher, a diagram of which is shown in Figure 7.

VARIETIES INCLUDED IN THE TESTS

Since the year 1892, 403 varieties and strains of barley have been listed in variety-test and nursery plots. During this period 158 varieties and strains of all classes of barley were tested in variety-test

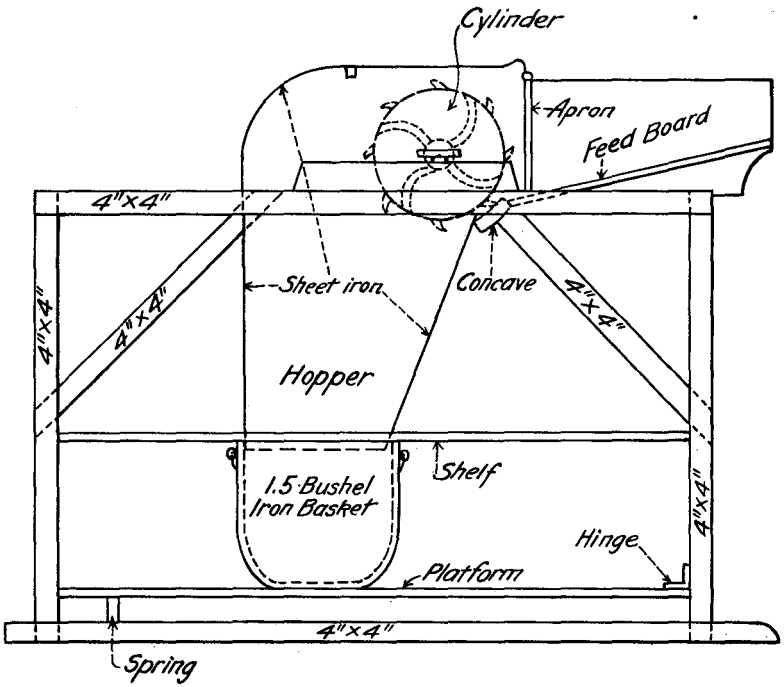

Fig. 7. Centgener Thrasher, with the Side Removed to Show the Parts

plots at University Farm. These have been obtained from nearly all parts of the world. Many samples from foreign countries have been received through coöperation with the United States Department of Agriculture and reciprocal seed exchange with foreign countries.

The varietal name given when the seed reached the Station, the

date received, and the source are recorded. The serial number given each stock as it is received and listed is called the Minnesota number and constitutes the identification mark of the variety at University Farm. Newly developed strains are also given a Minnesota number when taken from the nursery to the varietal test plots and if found worthy are distributed under the Minnesota number, as Minn. No. 23 corn, Minn. No. 25 flax.

RESULTS OF THE TESTS

For convenience in comparing the producing capacities of the varieties of barley which were included in the tests, the classes have been grouped as follows:

(1) Commercial 6-rowed bearded barleys which have been received from one source or another as standard sorts in sufficient quantities to plant plots of one-twentieth or one-fortieth of an acre, as reported in Table III.

(2) Commercial 2-rowed bearded barleys, obtained as in section 1, also reported in Table III.

(3) Pedigreed strains of 6-rowed bearded barleys each of which has been developed from a single plant of a promising variety, reported in Table IV.

(4) Pedigreed strains of 2-rowed bearded barleys, developed as in section 3, also reported in Table IV.

(5) Hybrid 6-rowed bearded barleys which have been developed from hybridization followed by selection from individual plants, reported in Table V.

(6) Hybrid 2-rowed bearded barleys developed as in section 5, also reported in Table V.

(7) Miscellaneous commercial stocks, reported in Table VI.

(8) The highest-yielding varieties of each of the seven classes, grouped together in Table VII, showing the comparative yields of the best varieties tested, and the relative yielding capacity of the several classes of barley in Minnesota compared with Minnesota No. 105, for the respective years in which each was grown.

TESTS OF COMMERCIAL VARIETIES

Table III shows the annual and average yields obtained from plot tests of 31 commercial varieties of 6-rowed bearded barley for periods of one to thirteen years, and of 34 commercial varieties of 2-rowed bearded barley for periods of one to seven years, from 1899 to 1911, inclusive. It will be noticed in Table III that Minnesota No. 105, the Manchuria, is the highest-yielding variety for the three years from 1909 to 1911, with the exception of Minnesota No. 327, a selection of the Manchuria.

TABLE III

YIELDS IN BUSHELS PER ACRE OF COMMERCIAL VARIETIES OF BEARDED BARLEY, 1899 TO 1911

Thirty-One 6-Rowed Varieties Grown for One to Thirteen Years

Name	Source	Min. No.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	Av. Y'ld *	Av. 1909-1911
Manchuria (Manshury)	Exp. Sta., Fargo, N. Dak.	6	46.6	45.8	54.6	54.1	46.3	45.8	62.0	40.0	....	....	....	....	....	48.3	....
Odessa	Not known (probably Guelph, Ontario)	21	60.0	51.3	45.4	40.0	46.0	....	....	....	....	....	....	....	....	48.5	....
Oderbrucker	Agr. College, Guelph, Ont.	31	47.5	53.3	45.0	27.5	....	....	....	....	....	....	....	....	....	43.3	....
Manchuria (Mandscheuri)	Agr. College, Guelph, Ont.	32	62.9	52.0	60.0	48.9	43.0	....	40.0	....	....	....	....	....	....	51.1	....
Scotch Improved	Agr. College, Guelph, Ont.	36	50.0	52.5	47.5	41.0	37.1	....	....	....	....	....	....	....	....	45.6	....
Common	Agr. College, Guelph, Ont.	39	53.7	57.5	51.7	42.5	43.0	....	....	....	....	....	....	....	....	49.6	....
South African	Ephraim Clow, Humboldt, Minn	99	43.7	64.6	25.0	16.1	....	....	....	....	....	....	....	....	....	37.3	....
Houghston's Golden Queen	D. H. Houghston, Hunter, N. Dak	100	67.0	53.7	51.7	58.6	51.1	43.0	43.7	35.4	40.0	48.3	41.6	28.7	43.7	46.3	36.7
Oderbrucker	Agr. College, Guelph, Ont.	104	45.8	43.3	44.6	38.0	42.3	....	....	....	....	....	....	....	....	43.5	....
Manchuria (Mandscheuri)	Agr. College, Guelph, Ont.	105	66.2	53.3	60.0	58.1	48.5	44.8	54.4	38.6	44.4	38.4	47.5	28.1	44.3	48.2	40.0
Sisolsk	S. P. I. No. 2962, U. S. Dept. of Agr	109	....	27.5	42.5	45.4	40.4	40.6	....	....	....	....	....	....	....	39.3	....
Ross	J. A. Ross, received by T. A. H., Crookston, Minn.	127	....	....	....	....	42.3	32.0	62.5	47.9	40.4	....	....	....	....	44.9	....
Manchuria (Manshury)	L. L. May & Co., St. Paul, Minn	153	....	....	....	....	....	33.7	42.5	....	....	....	....	....	....	38.1	....
Blue	Northrup, King & Co., Minneapolis, Minn	195	....	....	....	....	....	....	50.0	41.2	37.5	....	....	....	....	42.9	....
Daniels	Northrup, King & Co., (received from S. Africa)	196	....	....	....	....	....	....	44.1	....	50.8	43.3	36.6	....	....	43.7	....
Tennessee Winter No. 568	Exp. Sta., Manhattan, Kan.	243	....	....	....	....	....	....	....	....	....	10.4	....	....	....	10.4	....
Tennessee Winter No. 368	Exp. Sta., Manhattan, Kan.	244	....	....	....	....	....	....	....	....	....	12.9	....	....	....	12.9	....
Scotch	S. P. I. No. 20816, U. S. Dept. of Agr	252	....	....	....	....	....	....	....	....	....	32.5	....	....	....	32.5	....

TABLE III—*Continued*

Name	Source	Min. No.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	Av. Y'ld *	Av. 1909-1911
Canadian Lake Shore	S. P. I. No. 20817, U. S. Dept. of Agr.	253	....	....	....	....	....	....	....	....	....	33.4	....	....	....	33.4	....
Gottland	S. P. I. No. 20482, U. S. Dept. of Agr.	267	....	....	....	....	....	....	....	....	....	36.8	35.0	20.0	....	30.6	....
Oderbrucker	Exp. Sta., Madison, Wis.	268	....	....	....	....	....	....	....	....	....	40.6	40.0	26.2	33.5	37.5	33.3
Manchuria Pedigree	S. P. I. No. 20824, U. S. Dept. of Agr.	303	....	....	....	....	....	....	....	....	....	37.0	36.6	34.3	....	35.9	....
Wis. No. 55, Oderbrucker	Exp. Sta., Madison, Wis.	325	....	....	....	....	....	....	....	....	....	....	40.8	20.0	44.4	35.0	35.0
Wis. No. 3, Silver King	Exp. Sta., Madison, Wis.	326	....	....	....	....	....	....	....	....	....	....	43.3	31.4	38.3	37.6	37.6
Wis. No. 76, Manchuria (Manshury)	Exp. Sta., Madison, Wis.	327	....	....	....	....	....	....	....	....	....	....	40.8	42.0	41.6	41.5	41.5
Wis. No. 77, Odessa	Exp. Sta., Madison, Wis.	328	....	....	....	....	....	....	....	....	....	....	38.3	30.4	38.3	35.6	35.6
Manchuria	Exp. Sta., Orono, Me.	330	....	....	....	....	....	....	....	....	....	....	37.5	31.4	40.4	36.4	36.4
Manchuria	Exp. Sta., Bozeman, Mont.	331	....	....	....	....	....	....	....	....	....	....	41.6	32.2	41.7	38.5	38.5
Manchuria (Manshury)	Northrup, King & Co., Minneapolis, Minn.	359	....	....	....	....	....	....	....	....	....	....	....	26.6	37.7	31.6	....
Blue Ribbon	Northrup, King & Co., Minneapolis, Minn.	360	....	....	....	....	....	....	....	....	....	....	....	29.3	37.0	33.1	....
Read's Triumph	Northrup, King & Co., Minneapolis, Minn.	361	....	....	....	....	....	....	....	....	....	....	....	15.4	30.4	22.9	....
Thirty-Four 2-Rowed Varieties Grown for One to Seven Years																	
Champion of Vermont	Exp. Sta., Fargo, N. Dak.	7	49.1	43.3	38.0	34.2	....	....	....	....	....	....	....	....	....	41.1	....
French Chevalier	Dominion Exp. Sta., Brandon Canada	15	51.2	44.2	32.1	33.9	....	....	....	....	....	....	....	....	....	40.3	....
Standwell	Garton Bros., England	115	....	55.0	29.2	18.9	....	....	....	....	....	....	....	....	....	34.3	....
Invincible	Garton Bros., England	116	....	52.9	23.3	14.4	....	....	....	....	....	....	....	....	....	35.1	....
Kitzing	S. P. I. No. 5590, U. S. Dept. of Agr.	117	....	....	35.4	30.8	39.0	....	....	....	....	....	....	....	....	35.1	....

TABLE III—*Continued*

Name	Source	Min. No.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	Av. Y'ld *	Av. 1909-1911
Kitzing	S. P. I. No. 5591, U. S. Dept. of Agr.	118	....	....	33.8	34.2	46.3	....	....	....	....	....	....	....	....	38.1	....
Lower Frankish	S. P. I. No. 5592, U. S. Dept. of Agr.	119	....	....	32.1	28.8	37.1	....	....	....	....	....	....	....	....	32.7	....
Pilsen	S. P. I. No. 5756, U. S. Dept. of Agr.	120	....	....	32.5	27.7	38.3	....	....	....	....	....	....	....	....	32.8	....
Moravian	S. P. I. No. 5793, U. S. Dept. of Agr.	121	....	....	40.0	34.2	33.0	....	....	....	....	....	....	....	....	35.7	....
Svanhals	S. P. I. No. 5474, U. S. Dept. of Agr.	122	....	....	36.6	21.8	23.8	....	....	....	....	....	....	....	....	27.4	....
Princess	S. P. I. No. 5472, U. S. Dept. of Agr.	123	....	....	29.6	22.5	27.9	....	....	....	....	....	....	....	....	26.6	....
Chevalier II	S. P. I. No. 5473, U. S. Dept. of Agr.	124	....	....	32.5	29.5	23.7	....	....	....	....	....	....	....	....	28.5	....
Brush	A. E. Brush, received by T. A. H., Crookston, Minn.	126	....	....	....	....	29.1	37.0	45.4	....	....	....	....	....	....	37.1	....
Hanna	S. P. I. No. 10402, U. S. Dept. of Agr.	147	....	....	....	....	....	37.1	45.8	33.5	12.5	34.3	44.1	29.1	....	33.7	....
Chevalier II	S. P. I. No. 10584, U. S. Dept. of Agr.	149	....	....	....	....	....	37.0	45.8	29.1	20.8	....	....	....	....	33.2	....
Hannchen	S. P. I. No. 10585, U. S. Dept. of Agr.	150	....	....	....	....	....	29.2	51.2	29.1	12.5	32.7	....	....	....	30.9	....
Primus	S. P. I. No. 10586, U. S. Dept. of Agr.	151	....	....	....	....	....	25.4	40.0	25.0	9.2	25.0	....	....	....	24.9	....
Princess	S. P. I. No. 10583, U. S. Dept. of Agr.	152	....	....	....	....	....	49.1	48.3	33.5	9.2	31.3	....	....	....	34.2	....
Highland Chief	L. L. May & Co., St. Paul, Minn	154	....	....	....	....	....	36.6	46.6	28.7	20.0	....	....	....	....	32.9	....
Chevalier	John Harris, a student	192	....	....	....	....	....	....	....	26.6	18.7	....	....	....	....	22.6	....
Austrian Hanna	Aug. Uihlein, Milwaukee, Wis.	193	....	....	....	....	....	....	....	39.5	14.6	....	....	....	....	27.0	....

TABLE III—*Continued*

Name	Source	Min. No.	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	Av. Y'ld *	Av. 1909-1911
Frankish Brewing	S. P. I. No. 13346, U. S. Dept. of Agr	197	....	....	....	....	....	....	....	37.9	29.1	40.6	38.3	....	....	36.3	....
Chevalier II	S. P. I. No. 19781, U. S. of Agr	205	....	....	....	....	....	....	....	....	....	37.1	32.5	....	....	34.8	....
Gutekorn	S. P. I. No. 19783, U. S. Dept. of Agr	207	....	....	....	....	....	....	....	....	....	41.8	40.8	17.9	....	33.5	....
Minnesota Hanna	J. Steffens, Racine, Minn.	234	....	....	....	....	....	....	....	....	....	30.5	....	....	....	30.5	....
Sexradigt	S. P. I. No. 19784, U. S. Dept. of Agr	236	....	....	....	....	....	....	....	....	....	28.8	....	....	....	28.8	....
Prize Pedigree Chevalier	John King & Co., Coggeshall, England	242	....	....	....	....	....	....	....	....	....	41.6	....	....	....	41.6	....
Hanna	S. P. I. No. 12993, received through C. P. Norgord, Madison, Wis	247	....	....	....	....	....	....	....	....	....	34.3	....	....	....	34.3	....
Svanhals	S. P. I. No. 22305, U. S. Dept. of Agr	261	....	....	....	....	....	....	....	....	....	30.0	40.6	27.2	....	34.6	....
Primus	S. P. I. No. 22303, U. S. Dept. of Agr	262	....	....	....	....	....	....	....	....	....	21.6	31.6	22.0	....	25.0	....
Princess	S. P. I. No. 22304, U. S. Dept. of Agr	263	....	....	....	....	....	....	....	....	....	38.3	30.0	25.4	....	31.2	....
Hannchen	S. P. I. No. 20480, U. S. Dept. of Agr	304	....	....	....	....	....	....	....	....	....	30.8	38.3	29.3	....	32.8	....
Garton's	Garton Bros., England	305	....	....	....	....	....	....	....	....	....	32.0	45.0	24.9	....	33.9	....
Highland Chief	Northrup, King & Co., Minneapolis, Minn	372	....	....	....	....	....	....	....	....	....	....	....	....	35.0	35.0	....

* Comparisons based on the average yield should not be made, as all varieties were not grown the same years.

Other varieties in Table III may show higher average yields than Minnesota No. 105, as for instance Minnesota Nos. 32 and 39, but Minnesota No. 105 has been grown for a greater number of years, some of which were unfavorable. When compared with these high-yielding varieties for the same years during which they were grown, Minnesota No. 105 will be found to exceed them in yield, as shown in Table VII.

The varieties with long, nodding heads (the Chevalier type) have produced the highest yields in the 2-rowed class, as shown in Table III. Most of these, however, were included in the earlier tests, when few varieties with wide, erect heads (the Goldthorp type) were grown. In recent years, certain of the latter, such as Minnesota Nos. 261, 305, and 372, have produced fully as good yields as the varieties of the Chevalier type.

TESTS OF PEDIGREED STRAINS FROM COMMERCIAL VARIETIES

Table IV shows the annual and average yields of 47 pedigreed strains from commercial varieties of 6-rowed bearded barley which have been grown for one to nine years and the yields from 11 pedigreed strains of 2-rowed bearded barley tested for one to eight years.

The best yields obtained in all the varietal tests of barley were those of the 6-rowed bearded selections reported in Table IV. With few exceptions, the average yields exceed those of the best-yielding varieties of the commercial 6-rowed class (Table IV). This is perhaps to be expected, since most of the strains, the yields of which are given in Table IV, are selections from Minnesota Nos. 6 and 105. The group summaries indicate that Minnesota No. 105 is a superior stock, and field observations confirm these figures.

The averages of the pedigreed strains of 2-rowed barley given in Table IV do not show appreciably higher yields than those of the commercial varieties shown in Table III. This would imply that the work of selection in developing the strains in Table IV was of little value. The lack of variation was due in part to the fact that many of the commercial varieties were already pedigreed when received, so that little further improvement was to be expected, and in part to the difference in the seasons included in the tests. The years from 1899 to 1905 were better crop years than those from 1906 to 1910; hence the varieties in Table III which were grown in 1899 to 1905 have an advantage over the strains or varieties grown in later years, of which 1909 to 1911 were especially unfavorable to grain crops.

TESTS OF PEDIGREED STRAINS FROM HYBRIDS

Table V shows the yields obtained from 19 pedigreed hybrid strains of 6-rowed bearded barley, and from 12 pedigreed 2-rowed bearded hybrids.

TABLE IV

YIELDS, IN BUSHELS PER ACRE, OF PEDIGREED STRAINS OF COMMERCIAL VARIETIES OF BEARDED BARLEY

Forty-Seven 6-Rowed Strains, Grown for One to Nine Years

Name	Minn. No.	1903	1904	1905	1906	1907	1908	1909	1910	1911	Average	Av. of Group
Selection from Minnesota No. 6, Manchuria	129	50.3	37.3	60.0	41.6	38.7	46.9	35.0	22.2	44.6	41.8	.....
Selection from Minnesota No. 101	130	23.3	34.7	55.4	55.4	40.8	31.3	.....	.....	.....	40.1	.....
Six selections from Minnesota No. 6, Manchuria..	134	.....	41.4	55.0	45.8	35.4	.....	.....	.....	.....	44.4	43.6
	135	.....	41.4	54.5	45.8	41.6	.....	.....	.....	.....	45.8	
	136	.....	32.5	51.6	41.6	41.6	.....	.....	.....	.....	41.8	
	157	.....	.....	.....	38.9	36.2	43.3	.....	.....	.....	41.1	
	158	.....	.....	.....	44.1	41.6	43.9	.....	.....	.....	43.2	
	159	.....	.....	.....	45.0	43.7	47.0	.....	.....	.....	45.2	
	160	.....	.....	.....	45.8	44.1	45.8	.....	.....	.....	45.2	
	161	.....	.....	.....	49.1	45.8	45.2	.....	.....	.....	46.7	
Twenty-three selections from Minnesota No. 105, Manchuria	162	.....	.....	.....	43.0	47.1	44.5	.....	.....	.....	44.8	45.5
	163	.....	.....	.....	42.9	47.1	41.6	.....	.....	.....	43.8	
	164	.....	.....	.....	42.5	40.0	.....	.....	.....	.....	41.2	
	165	.....	.....	.....	50.0	39.5	43.8	.....	.....	.....	44.4	
	166	.....	.....	.....	50.0	46.2	45.8	.....	.....	.....	47.3	
	167	.....	.....	.....	44.0	45.8	45.8	.....	.....	.....	45.2	
	168	.....	.....	.....	49.1	51.2	43.5	.....	.....	.....	47.9	
	170	.....	.....	.....	59.5	43.3	46.2	.....	.....	.....	49.6	
	171	.....	.....	.....	.....	51.6	39.3	.....	.....	.....	45.4	
	172	.....	.....	.....	.....	50.8	35.0	.....	.....	.....	42.9	
	173	.....	.....	.....	59.1	29.2	.....	.....	.....	.....	44.1	
	174	.....	.....	.....	.....	54.1	46.8	36.6	.....	.....	45.8	
	175	.....	.....	.....	55.8	46.6	50.0	40.8	34.5	42.9	45.1	
	176	.....	.....	.....	.....	47.9	47.6	.....	.....	.....	47.7	
	177	.....	.....	.....	60.0	42.4	44.1	.....	.....	.....	48.8	
	178	.....	.....	.....	48.7	44.2	38.3	.....	.....	.....	43.7	
	179	.....	.....	.....	51.6	50.0	40.8	.....	.....	.....	47.4	
	181	.....	.....	.....	50.8	43.7	42.7	.....	.....	.....	45.7	
	182	.....	.....	.....	47.9	39.5	37.7	.....	.....	.....	41.7	
	183	.....	.....	.....	49.1	41.6	40.4	.....	.....	.....	43.7	
	184	.....	.....	.....	50.0	.057	48.3	42.5	46.2	.....	48.8	

TABLE IV—*Continued*

Name	Minn. No.	1903	1904	1905	1906	1907	1908	1909	1910	1911	Average	Average of Group
Four selections from Minnesota No. 6, Manchuria	185	.....	.....	.....	53.0	44.5	43.9	.....	.....	.....	47.1	
	186	.....	.....	.....	47.0	44.5	42.5	.....	.....	.....	44.6	44.2
	188	.....	.....	.....	45.0	45.8	39.3	43.1	.....	.....	43.3	
	189	.....	.....	.....	37.5	43.7	44.3	.....	.....	.....	41.8	
Three selections from Minnesota No. 105, Manchuria	208	.....	.....	.....	.....	.....	41.2	41.6	41.8	33.8	40.8	
	209	.....	.....	.....	.....	.....	56.6	40.8	46.6	44.2	47.0	43.6
	210	.....	.....	.....	.....	.....	55.2	37.5	34.7	44.6	43.0	
Manchuria	211	.....	.....	.....	.....	.....	55.6	37.5	32.9	44.2	42.5	.....
Selection from Minnesota No. 100	231	.....	.....	.....	.....	.....	40.8	31.6	30.2	.....	34.2	.....
Selection from Minnesota No. 105, Manchuria	212	.....	.....	.....	.....	.....	56.2	39.2	37.9	47.5	45.2	.....
American Malting	298	.....	.....	.....	.....	.....	.....	38.3	29.7	38.3	35.4	.....
Two selections from Minnesota No. 6, Manchuria	315	.....	.....	.....	.....	.....	.....	15.0	25.6	44.2	28.2	26.3
	316	.....	.....	.....	.....	.....	.....	13.3	23.9	36.2	24.4	
Three selections from Minnesota No. 105, Manchuria	317	.....	.....	.....	.....	.....	.....	19.1	28.7	39.2	29.0	
	318	.....	.....	.....	.....	.....	.....	19.1	23.1	38.3	26.8	27.2
	319	.....	.....	.....	.....	.....	.....	17.5	24.7	35.0	25.7	
Eleven 2-Rowed Strains, Grown for 1 to 8 Years												
Duckbill Bald	125	33.9	38.4	56.2	30.0	30.8	26.4	51.6*	23.7	.....	36.3	.....
Hanna	213	.....	.....	.....	.....	.....	28.9	44.1	.....	.....	36.5	.....
Princess	215	.....	.....	.....	.....	.....	25.5	29.1	.....	.....	27.3	.....
Highland Chief	216	.....	.....	.....	.....	.....	33.1	.....	.....	.....	33.1	.....
Hannchen	217	.....	.....	.....	.....	.....	24.8	.....	.....	.....	24.8	.....
Cheney	227	.....	.....	.....	.....	.....	29.1	42.5	.....	.....	35.8	.....
Australian White	228	.....	.....	.....	.....	.....	23.3	.....	.....	.....	23.3	.....
Champion of Vermont	229	.....	.....	.....	.....	.....	28.8	40.8	25.4	.....	31.6	.....
French Chevalier	230	.....	.....	.....	.....	.....	38.3	50.0	28.1	.....	38.8	.....
Chevalier	299	.....	.....	.....	.....	.....	.....	40.8	25.4	.....	33.1	.....
Austrian	300	.....	.....	.....	.....	.....	.....	46.6	28.3	.....	37.4	.....

* The averages are not comparable, as all varieties were not grown during the same period of years.

TABLE V

YIELDS, IN BUSHELS PER ACRE, OF PEDIGREED HYBRID STRAINS OF BEARDED BARLEY

Nineteen 6-Rowed Hybrid Strains, Grown for 3 to 5 Years

Name	Minn. No.	1904	1905	1906	1907	1908	1909	1910	1911	Average*	Average of Group
Six-rowed smooth × two-rowed Indian Head.	141	38.0	42.0	40.4	43.7	.....	.....	.....	.....	41.0	*
	142	30.4	32.9	34.7	.....	41.6	.....	.....	.....	34.7	
	190	.....	.....	37.9	36.6	34.7	26.6	.....	.....	43.9	
	191	.....	.....	33.7	36.2	34.1	.....	.....	.....	34.6	33.7
	224	.....	.....	.....	.....	32.5	29.1	20.4	.....	27.3	
	225	.....	.....	.....	.....	33.9	29.1	22.7	.....	28.5	
	226	.....	.....	.....	.....	30.0	22.5	25.4	.....	25.9	
Minnesota No. 6 × Chevalier.	220	.....	.....	.....	.....	41.4	30.8	25.4	.....	32.5	32.2
	221	.....	.....	.....	.....	39.5	31.6	24.7	.....	31.9	
Champion of Vermont × Minnesota No. 6.....	223	.....	.....	.....	.....	38.5	34.1	24.5	.....	32.3	.....
Six-rowed smooth × two-rowed Indian Head.	311	.....	.....	.....	.....	.....	17.5	28.9	38.8	28.4	
	312	.....	.....	.....	.....	.....	13.3	26.6	35.0	24.9	
	313	.....	.....	.....	.....	.....	15.8	22.7	25.0	21.1	25.3
	314	.....	.....	.....	.....	.....	16.6	26.2	38.3	27.0	
Minnesota No. 105 × Minnesota No. 6..	320	.....	.....	.....	.....	.....	21.6	28.7	39.2	29.8	
	321	.....	.....	.....	.....	.....	17.5	28.3	30.8	25.5	26.2
	322	.....	.....	.....	.....	.....	9.1	31.2	29.6	23.3	
Minnesota No. 6 × Minnesota No. 105.....	323	.....	.....	.....	.....	.....	29.1	26.2	40.8	32.0	30.5
	324	.....	.....	.....	.....	.....	20.8	24.7	41.0	28.9	

Twelve 2-Rowed Hybrid Strains Grown for 2 to 8 Years

Two-rowed × Branching Duckbill.....	131	34.1	45.1	37.5	29.5	.....	.....	.....	.....	35.3	.....
Black × Long Two-rowed...	132	33.5	42.9	30.8	29.1	.....	.....	.....	.....	34.1	.....
Two-rowed × Branching Duckbill.....	137	34.5	51.2	31.2	29.1	33.5	49.1	29.3	.....	36.8	.....
Black × Long two-rowed...	138	17.9	34.1	23.7	.....	.....	.....	.....	.....	25.2	.....
Six-rowed smooth × two-rowed Indian Head.	140	22.3	32.9	34.5	33.3	.....	.....	.....	.....	30.7	
	143	20.4	31.6	33.5	40.0	26.8	.....	.....	.....	32.4	
	144	25.0	38.7	30.2	35.8	.....	.....	.....	.....	32.4	32.3
	145	31.2	42.9	34.1	35.4	26.6	46.6	20.8	30.8	33.5	
	146	26.0	39.1	33.5	30.8	.....	.....	.....	.....	32.3	
Minnesota No. 6 × Champion of Vermont	218	.....	.....	.....	.....	31.8	35.0	.....	.....	33.4	
	219	.....	.....	.....	.....	46.6	44.1	28.3	.....	39.6	35.9
	222	.....	.....	.....	.....	33.5	36.6	34.5	.....	34.8	

* These averages are comparable only when the varieties were grown during the same period of years.

The hybrid strains included in Table V are from crosses between those varieties which gave the greatest promise at the times when the crossing was done. While some of the average yields are relatively high, none of the strains are as promising as was anticipated. Attention is again called to the fact that the seasons of 1909 to 1911 were adverse, for in the case of a considerable portion of the hybrid strains two or all of the three years' yields were made during these years. In addi-

tion, one parent of many of the hybrids was of the 2-rowed class, the varieties of which do not yield as well as those of the 6-rowed class. It is natural to expect that some of the hybrids will outyield the commercial 2-rowed varieties when grown in the same series of years; the advantage indicated, however, is slight. The yields of the hybrids are slightly lower than those of the pedigreed 6-rowed strains, owing undoubtedly to the influence of the inferior yielding power of the 2-rowed parent. The results thus far obtained indicate that little is to be gained in yield from crossing the 2-rowed with the 6-rowed varieties.

TESTS OF MISCELLANEOUS VARIETIES

Table VI shows the annual and average yields of 4 commercial varieties of hull-less and of hooded barley. None of the varieties of these classes, so far as tested, appear to be of value under Minnesota conditions. The Black Hull-less is superior to the other varieties included in this test.

TABLE VI

YIELDS, IN BUSHELS PER ACRE, OF FOUR MISCELLANEOUS COMMERCIAL VARIETIES OF BARLEY

Name	Minn. No.	Class	1907	1908	1909	1910	1911	Average*
Himmelsby	204	6-rowed bearded hull-less	9.1	15.4	....	....	....	12.2
Silver Beardless	214	2-rowed hooded common	....	26.7	....	....	....	26.7
Black Hull-less	329	6-rowed bearded hull-less	....	....	35.8	28.7	27.5	30.6
White Hull-less	332	6-rowed hooded hull-less	....	....	25.8	26.2	22.5	24.8

* The averages are not comparable, as all varieties were not grown for the same period of years.

SUMMARY OF VARIETY TESTS BY CLASSES

Table VII shows the average yields of the best-yielding varieties of each class of barley grown, as given in detail in the foregoing tables and, for comparison, the average yield of Minnesota No. 105 (Manchuria) barley for the same periods.

As shown in Table VII, Minnesota No. 105, a strain of the 6-rowed variety (Mandscheuri) received from the Ontario Agricultural College in 1897, has outyielded all other varieties for any period of years, with the exception of two pedigreed strains of the 2-rowed type and several pedigreed selections from the original stock of the variety itself. The two pedigreed 2-rowed strains, Minnesota No. 230, a selection of French Chevalier (Minnesota No. 15), and Minnesota No. 219,

TABLE VII

COMPARISON OF YIELDS OF MINNESOTA NO. 105 AND OTHER VARIETIES

Class and Name	Minn. No.	Years Compared	Average Other Varieties	Yield Minnesota No. 105
			Bushels	*Bushels*
Commercial 6-rowed bearded varieties:				
Manchuria	105	1899 to 1911	.....	48.20
Odessa	21	1899 to 1903	48.54	57.20
Manchuria	6	1899 to 1907	48.30	49.30
	32	1899 to 1905	51.10	56.75
Common	39	1899 to 1903	49.70	57.20
Commercial 2-rowed bearded varieties:				
Champion of Vermont	7	1899 to 1902	41.10	59.40
French Chevalier	15	1899 to 1902	40.30	59.40
Kitzing	118	1901 to 1903	38.10	55.50
Prize Pedigreed Chevalier	242	1909	41.60	47.50
Pedigreed 6-rowed bearded:				
Manchuria, Selections from Minn. 105	168	1906 to 1908	47.90	40.45
	170	1906 to 1908	49.60	40.45
	176	1907 to 1908	47.70	41.40
	177	1906 to 1908	48.80	40.45
	184	1906 to 1910	48.80	39.40
Pedigreed 2-rowed bearded varieties:				
Duckbill	125	1903 to 1910	36.30	43.08
Hanna	213	1908 to 1909	36.50	42.95
French Chevalier	230	1908 to 1910	38.80	38.00
Austrian Hanna	300	1909 to 1910	37.40	37.80
Hybrid 6-rowed bearded varieties:				
6-rowed Smooth × 2-rowed Indian Head	141	1904 to 1907	41.00	45.55
	142	1904 to 1908	34.70	44.10
	191	1906 to 1908	34.60	40.47
Champion of Vermont × Manchuria	223	1908 to 1910	32.30	38.00
Minnesota No. 6 × Minnesota No. 105	323	1908 to 1911	32.00	39.97
Hybrid 2-rowed bearded varieties:				
2-rowed × Branching Duckbill	137	1904 to 1910	36.80	42.25
Manchuria × Champion of Vermont	219	1908 to 1910	39.60	38.00
	222	1908 to 1910	34.80	38.00
Miscellaneous commercial varieties:				
Black Hull-less	329	1909 to 1911	30.60	39.96

* The average yields here shown are taken from Tables IV to VI, inclusive.

a selection from a hybrid of Manchuria (Minnesota No. 6) and Champion of Vermont (Minnesota No. 7), slightly exceeded Minnesota No. 105 for the three years from 1909 to 1911, inclusive. All the pedigreed strains of 6-rowed barley which exceeded Minnesota No. 105 for any period were selections from that variety itself. These included Minnesota Nos. 168, 170, 176, 177, and 184. Minnesota No. 184 averaged 9.4 bushels per acre more than the original stock of Minnesota No. 105, for the five years from 1906 to 1910, inclusive.

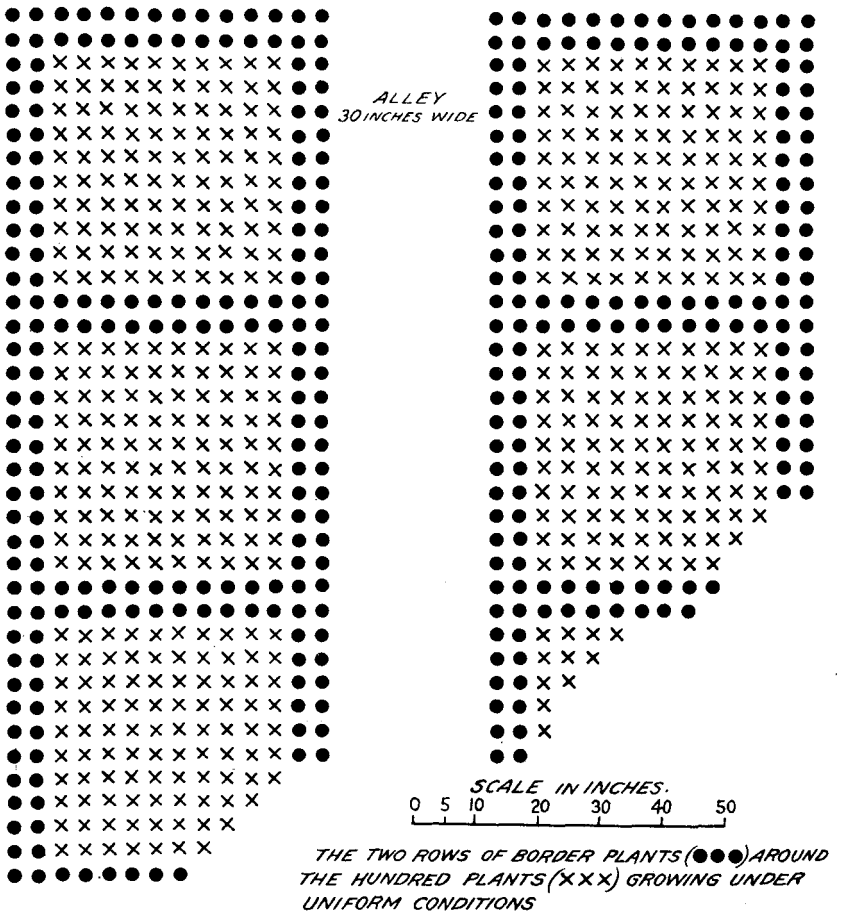

Fig. 8. Arrangement of Plants in Centgener Beds, with Two Rows of Border Plants

THE IMPROVEMENT OF BARLEY

The work of barley improvement at University Farm was begun in 1893, when a few varieties were obtained and tested for yield. The efforts have, until recent years, been toward increased productivity, purity of seed stock, resistance to lodging, and general adaptability to Minnesota conditions. To this end, 403 individual stocks have been tested in the field or in the nursery. The greater number of these have been discarded as the progress of the work indicated the relative importance of the tested stocks.

The number of varieties included in the annual tests has varied from 15, in 1898, to 68 in 1907. The work is now progressing rapidly. The large number of new and selected stocks which are being taken to the field from the nursery renders the work more interesting and promising than ever before. The growth of the improvement work is shown in Table VIII.

TABLE VIII

NUMBER OF CENTGENERS IN EACH GROUP GROWN IN THE BARLEY NURSERY

Year	Group	Number of Centgeners	Total Number of Centgeners	Number of Plants
1893	I	11	11	1,100
1897	I	33		
	II	40	73	7,300
1902	I	147		
	II	147	294	29,415
	I	35		
1907	II	31	243	27,793
	IV	177		
1910	I	143		
	II	800		
	III	4	1,753	114,340
	IV	806		

RECORDS

In systematizing the barley improvement investigations, the general outline known as the centgener method, originated at this Station, has been used[2], viz:

Group I. Pure-line selections
Group II. Crosses and hybrids
Group III. Miscellaneous tests
Group IV. Special experiments of nursery methods or breeding

Serial numbers, as 1, 2, etc., together with the abbreviation of th

[2] This method is described in Bulletins Nos. 62 and 107 of this Station, both now out of print, and in the Yearbook of the U. S. Dept. of Agr. for 1901, page 217.

year when the test was started, also serve in the final classification. Thus I. 10-'05 is readily interpreted. In a similar way the book and other tabulation records used in the barley-improvement work are essentially those previously referred to. The accession or number book, the nursery yearbook, the field variety book, the summary and grand summary sheets, with the exception of the newly introduced "head-to-row" test records, comprise the list.

In all records, figures are used to express the character values if the impression can be thus conveyed with a reasonably high degree of accuracy. This makes a comparison of stocks easy.

The preparation of the soil and the planting, harvesting, and threshing operations differ but little from the original methods followed in the nursery centgener work. Minor details have been changed to render the work easier and cheaper. The greatest departure and improvement has been the use of the one-horse cotton-disk in stirring the soil and breaking the crust formed during the winter and spring.

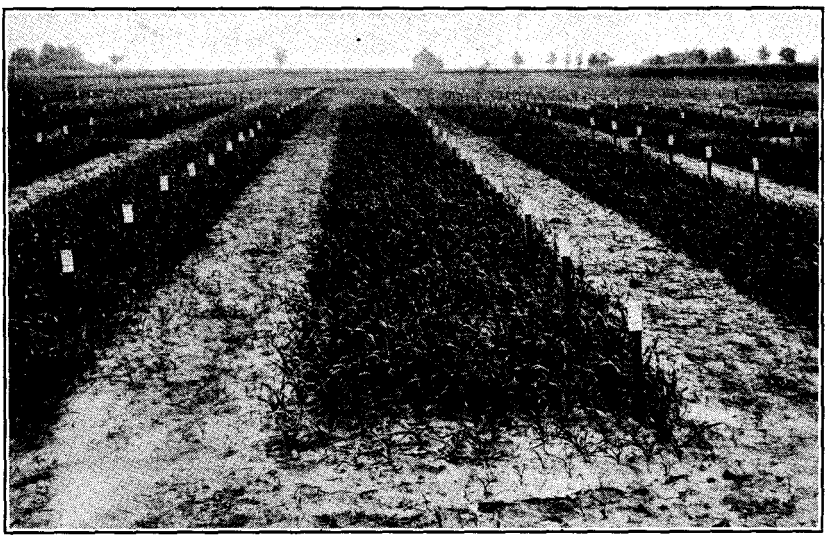

Fig. 9. Centgeners of Young Barley at University Farm

Note the stakes which mark the centgeners, and the alleys and border plants which separate them.

HEAD-TO-ROW TEST

The head-to-row test of barley has but recently been used at University Farm. Opportunity is afforded for testing a large number of individuals at a very low cost, while the area of land occupied by a row is approximately one-fifth that of a centgener. This method of

preliminary testing gives greater returns for the time and effort expended than can be realized from the centgener method alone. Selections have already been made from some of the superior varieties in the field-plot tests. The tabulated notes used in making head selections for head-to-row tests are shown in Table IX.

TABLE IX

SPECIMEN FORM

BARLEY, MINN. No._____ VARIETY_____

HEAD-TO-ROW TEST

Group IV_____year

Spike No.	Length of Spike	Total No. of Spikelets	BARREN SPIKELETS PER SPIKE			KERNELS		
			At Base	At Top	Total	Number	Weight	Plumpness

NURSERY MANAGEMENT

THE ROTATION SYSTEM

When the breeding work was started at University Farm, the field work was changed from one series to another on Fields A, C, E, F, G, and H, but as all lines of field work developed it became more and more difficult to secure a series where the conditions for crop production were sufficiently uniform. In 1907 a seven-year rotation was planned and at once put into operation on seven of the most nearly uniform series on Fields F and G. Although the rotation system may be satisfactory, the former plan of changing the crop-breeding plots from field to field seems to be preferable. This, however, is seldom possible for a long term of years because of the general extension of experimental work. At University Farm it seemed advisable to include the breeding plots of Minnesota No. 13 corn, sugar beets, winter wheat, and the spring cereals in the nursery rotation system. The rotation system is given in detail in Table X.

The rotation has continued sufficiently long to indicate that the succession of crops is favorable to the cereals. The results from beets and corn are not so good as they should be, as the soil is not sufficiently

TABLE X

SEVEN YEAR ROTATION FOR FIELD-CROP BREEDING NURSERIES

Year	Field F, Series IV	Field F, Series V	Field F, Series VI	Field G, Series IV	Field G, Series VI	Field G. Series III	Field G, Series V
1907	Peas, followed by winter rye[1]	Rye, followed by clover in spring[2]	Corn nursery[3]	Peas, followed by winter-wheat nursery[4]	Winter-wheat nursery, followed by rye[5]	Sugar-beet nursery[6]	Spring-grain nursery[7] (10 tons manure)
1908	Rye, followed by clover in spring	Corn nursery	Peas, followed by winter-wheat nursery	Winter-wheat nursery, followed by rye	Sugar-beet nursery	Spring-grain nursery (10 tons manure)	Peas, followed by winter rye
1909	Corn nursery	Peas, followed by winter-wheat nursery	Winter-wheat nursery, followed by rye	Sugar-beet nursery	Spring-grain nursery (10 tons manure)	Peas, followed by winter rye	Rye, followed by clover in spring
1910	Peas, followed by winter-wheat nursery	Winter-wheat nursery, followed by rye	Sugar-beet nursery	Spring-grain nursery (10 tons manure)	Peas, followed by winter rye	Rye, followed by clover in spring	Corn nursery
1911	Winter-wheat nursery, followed by rye	Sugar-beet nursery	Spring-grain nursery (10 tons manure)	Peas, followed by winter rye	Rye, followed by clover in spring	Corn nursery	Peas, followed by winter-wheat nursery
1912	Sugar-beet nursery	Spring-grain nursery (10 tons manure)	Peas, followed by winter rye	Rye, followed by clover in spring	Corn nursery	Peas, followed by winter-wheat nursery	Winter-wheat nursery, followed by rye
1913	Spring-grain nursery (10 tons manure)	Peas, followed by winter rye	Rye, followed by clover in spring	Corn nursery	Peas, followed by winter-wheat nursery	Winter-wheat nursery, followed by rye	Sugar-beet nursery

manured for either crop, and occasionally, if dry weather follows, the plowing under of the rye is injurious to the beets. The system will probably be changed in the near future and special rotations arranged for the root crops and the corn. The barley nursery is planted with the wheat, oats, and flax nurseries. The greatest difficulty is in obtaining uniformity of soil conditions. When there is lack of uniformity, the condition is remedied as soon as possible.

CROSSING

The manipulation of the barley flowers to secure cross-fertilization is not particularly difficult, but a knowledge of the arrangement of the parts of the flower and of the natural time of fertilization is necessary. The empty glumes, the flowering glume, the palea, the ovary with its plumed stigma, the three anthers, and the lodicules constitute the floral parts. They are arranged as shown in Figure 8. The flowering glume and the palea are locked close together at the margins, thus making the removal of the anthers and the insertion of the pollen delicate and tedious operations. The writer has tried numerous ways of making the operation rapid and effective and has found that it is most easily performed if the ends of the flowering glume and palea are cut off so as to leave a slight opening. This cutting must be done carefully, for if the opening is made too large the stigma is likely to dry and fertilization will not take place.

The equipment necessary for the work of crossing barley and other cereals is simple. It consists of a pair of dissecting scissors with ¾-inch, small, pointed blades; a pair of tweezers with a rather weak spring and short, sharp points; a common lead pencil; a supply of tissue paper and of stringed labels, 1 by 1½ inches; and a good hand lens. A tray for holding the equipment and a camp stool or box to sit on will be found convenient. Sometimes an umbrella, so mounted on a stake as to shade the operator, will make the work more comfortable and greatly lessen the strain upon the eyes.

NOTES FOR TABLE X

[1] Peas, followed by winter rye. Early in the spring the ground is prepared and seeded to Canada field peas. The peas may be harvested for hay or for seed. In September the ground is plowed, prepared, and sown to Minnesota No. 2 rye.

[2] Rye, with clover sown in the spring. Medium red clover seed is sown in the rye early in the spring. The rye is cut for seed in July; the clover is plowed under in September.

[3] Corn nursery. The ground is disked and prepared for corn. In May, the centgeners of Minnesota No. 13 corn are planted. If a part of the series is not filled by the centgeners, it is planted to bulk Minnesota No. 13 corn from remnants of the selected ears.

[4] Peas, followed by winter-wheat nursery. Peas are planted as described in the first footnote. As soon as the crop is cut, the ground is plowed and prepared immediately for the planting of the winter-wheat nursery.

[5] Winter-wheat nursery, followed by rye. As soon as the wheat is harvested and conditions will permit, the ground is disked and sown to Minnesota No. 2 rye.

[6] Sugar-beet nursery. The rye is plowed under before it reaches a height of 6 inches. The land is then disked and harrowed, the subsurface packed, and the beets planted at once. The land is plowed again in October as soon as the beets are harvested.

[7] Spring-grain nursery (manure). As early as conditions will permit, the land is prepared and planted to centgeners of wheat, oats, barley, and flax. When the crops are off the ground, 10 tons of thoroly composted barnyard manure are applied and the ground is then plowed.

After deciding which stocks or varieties to cross, it is necessary to select the plants which are to be used as the parents. As the pollen is normally shed from the anther before the head emerges from the leaf sheath, this selection must be made early in the development of the head. (See Figure 11, C, D, E, and F; and Figure 12, A.) At this stage the tissues are exceedingly tender, a fact which makes the removal of the anthers (emasculation) a delicate matter. Before emasculating, the beards of all the flowering glumes are removed with

Fig. 10. Sexual Parts and Developing Grain of Barley

A. The ovary, stigma, and anthers within the flowering glume, the palea having been removed. The empty glumes appear on either side.

B. The ovary, stigma, and anthers in the proper stage for crossing.

C. The organs after fertilization has taken place. Note the curling of the stigma and the positions of the anthers.

D. A partially developed seed. The anthers are still in evidence but the stigma has withered.

E. A fully developed kernel. The anthers are dry and are soon lost when the glumes are removed.

the scissors. The spikelets in the upper and lower portions of the head are also cut off, leaving only those at a few joints in the central portion of the rachis. It is best to leave the lateral spikelets as a protection to the central spikelets, which are the ones usually used in crossing, until the anthers are removed from these central ones. The lateral spikelets are then removed. The tops of the glumes are clipped from the central flowers, the tweezer points are inserted in the opening, and the jaws allowed to open slightly. This forces the glumes apart and, when properly done, leave the anthers in view. One of the anthers is now grasped gently with the tweezers and removed with an upward pull. This operation is repeated until all the anthers are out. In this work, the stigma must not be injured. When the flowers are

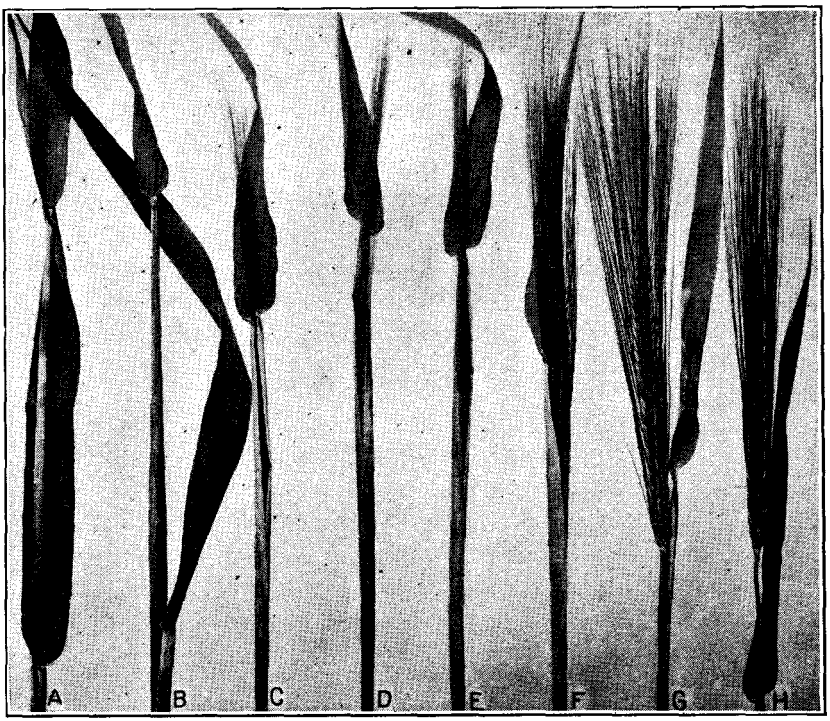

Fig. 11. Development of Heads of Barley During the Pollination Period

A. Head too young for crossing, the leaf sheath not yet swelled
B. Nearly mature enough for crossing
C. The three or four most mature flowers are ready to pollinate
D. In prime condition for emasculation
E. Too mature for crossing
F. Head with but few flowers unfertilized
G. Head emerging from the sheath with the grains filling
H. Head fully developed

in the proper condition, the anthers are green with a very slight tinge of yellow. If they are yellow, it is quite possible that self-pollination has taken place. In this case, or if the anther is broken in removing it, the flower should be discarded. The best results are obtained if the work is done in the morning.

After emasculation, a sheet of tissue paper about 4 by 5 inches should be wrapped carefully around the head and tied with a surgeon's knot at the base, as shown in Figure 12, D. This is to protect it from injury and chance pollination. The string of the label is looped around the stem just above the top leaf sheath. On this tag the date, the number of flowers pollinated, the plant number, the plant number of the male parent, and the initials of the operator are recorded. After the head is covered it is left until the stigma is in the receptive stage. This will be in from one to three days, according to the weather. In bright, sunshiny weather but one or two days will be necessary to bring the flowers to the proper stage.

When the stigmas are ready for pollination, the tissue covering is removed from the emasculated head, and ripe anthers are taken from a head of the plant selected to be the male parent and inserted into the flowers to be pollinated. When all the flowers have been thus treated, the head is again covered and the date is marked upon the tag. This ends the work of crossing. At harvest time, the head is taken to the laboratory, where the seeds are counted and put in an envelope for planting the following spring. A breeder may usually consider himself fortunate if 50 per cent of the crossed flowers produce seed.

SPECIAL NURSERY EXPERIMENTS

In the special nursery breeding (Group IV), two experiments have been completed as follows: (1) IV-1, breeding by selection for early and for late maturity; (2) IV-6, breeding by selection alone compared with hybridization followed by selection. Another experiment, IV-10, breeding from plants with one, two, three, four, five, and six culms, respectively, is now under way.

BREEDING FOR EARLY OR LATE MATURITY

In securing stocks for experiment IV-1, individual plants were obtained from a hybrid of Six-Rowed Smooth and Two-Rowed Indian Head barley. Two early-maturing and two late-maturing plants were selected from each of seven different stocks of the hybrid, and four early and four late plants from another stock, thus making thirty-six selections in all. Centgeners of these were grown annually until 1909. Nursery stock numbers 14, 20, 33, and 34 were then selected for increase in varietal tests and given Minnesota numbers 313, 314, 311, and 312,

respectively. In selecting the foundation stocks care was taken to get plants as nearly uniform as possible in all respects. From year to year, selections of the earliest-maturing plants from early centgeners and the latest-maturing plants from late centgeners were carefully made, none but good plants in either being taken. Except for this selection,

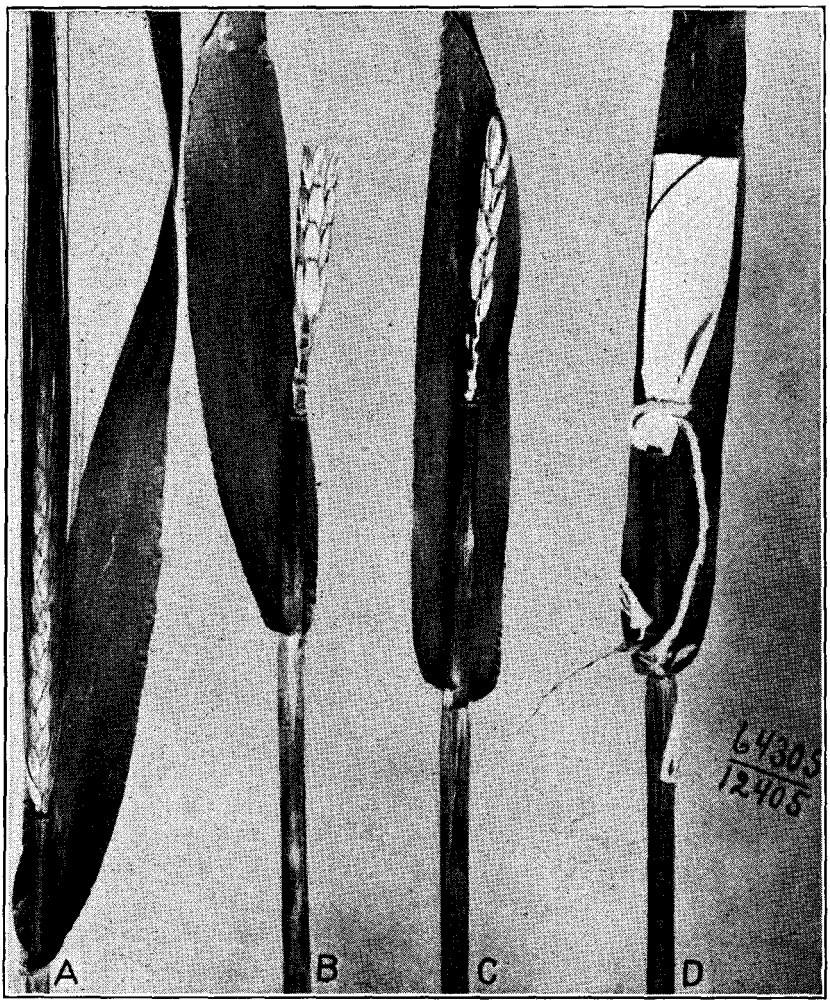

Fig. 12. Preparation of Head of Barley for Crossing

A. Head with enfolding leaf sheath removed

B. Side view of head with terminal and basal spikelets removed, leaving a few of the best in the center

C. Edge view of head shown in B

D. Emasculated head covered with tissue paper to protect it from injury and to prevent the possible introduction of foreign pollen.

TABLE XI

RESULTS OF SELECTING EARLY-MATURING AND LATE-MATURING PLANTS FROM THE SAME ORIGINAL STOCK

Grand Summary Sheet of Centgener Notes, 1902 to 1909

Year	Growing Period*	Number of Hills Planted	Height	Strength	Stiffness	Smut	Grade	Rust Resistance	Number of Plants Harvested	Weight of Grain per Plant
Early selections			*Inches*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*		*Grams*
1902	87.2	100	30	71	56	.....	.....	64	81	3.26
1903	88.5	100	33	54	56	.....	71	96	71.	4.34
1904	90.6	100	39	64	44	.5	71	.....	72	4.05
1905	119.1	100	36	71	59	.7	69	98	93	3.13
1906	85.3	100	36	.....	36	.....	67	100	90	3.08
1907	90.2	100	29	76	69	.....	60	100	83	3.27
1908	86.8	100	37	74	36	.....	53	99	73	3.44
1909	79.0	100	32	76	69	.....	68	100	79	3.46
Average	90.8	100	34	69.4	53.1	.15	65.6	94	80.2	3.51
Late selections										
1902	87.5	100	31	70	56	.....	.....	61	82	3.25
1903	90.9	100	33	56	67	.....	78	96	68	4.43
1904	93.2	100	41	58	48	.2	76	.....	71	3.95
1905	121.2	100	37	70	63	.4	73	98	95	2.85
1906	93.5	100	36	.....	64	.....	75	100	89	3.18
1907	97.0	100	29	71	70	.....	76	100	63	3.12
1908	94.2	100	36	82	82	.....	62	95	65	2.80
1909	84.6	100	36	78	73	.....	78	100	73	3.68
Average	95.2	100	35	69.3	65.3	0.075	74	93	75.7	3.41

TABLE XI—*Continued*

Nursery Records of Two Early-Maturing and Two Late-Maturing Strains, 1906 to 1909

Year	Growing Period*	Number of Hills Planted	Height	Strength	Stiffness	Smut	Grade	Rust Resistance	Number of Plants Harvested	Weight of Grain per Plant
Early selections			*Inches*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*		*Grams*
Nursery-stock No. 33..	85	100	33	76	55	.....	57.0	100	75	3.70
Nursery-stock No. 34..	85	100	33	74	55	.....	59.0	100	82	3.55
Average.....	85	100	33	75	55	.....	58.0	100	78.5	3.62
Late selections										
Nursery-stock No. 14..	93.0	100	30	71	66	.....	58.0	99	66	3.64
Nursery-stock No. 20..	90.5	100	35	79	67	.....	59.0	99	72	3.82
Average.....	91.7	100	32.5	75	66.5	.....	58.5	99	69	3.73

* Number of days from planting to maturity.

the centgeners were harvested in the usual manner, as previously described. The annual summaries are assembled and averaged in Table XI. The yields of the four selections grown in field plots are given in Table XII.

Except in the length of the growing period and in the grade of the grain, no striking difference in the average performance of the two selections is shown in Table XI. A difference of 4.4 days in the length of the growing period for the average of all stocks for the eight years was obtained, while the grade of the grain of the late selections averaged 8.4 per cent better than that of the early selections. In the table of averages of the four selected stocks (Table XI), the difference in date of maturity is 6.7 days, or 2.3 days more than the average of all stocks. The average yield is 0.11 gram per plant greater for the two early selections, while the average of all stocks showed a difference of 0.10 gram per plant in favor of the late selections. The average yield under field conditions for 1909 and 1910 (Table XI), is 1.25 bushels per acre higher for the early selections, but the results are not conclusive, since only two years' yields are shown and these are contradictory. In 1909 the late-maturing strains gave the larger yield, while in 1910 the reverse was true. The tests are being continued.

COMPARISON OF IMPROVEMENT BY SELECTION AND BY CROSSING

The strains in the experiment to determine the value of improvement by selection as compared with crossing followed by selection have only recently been tested in field plots, so that any conclusions must be based largely on results obtained in nursery tests. The work was started in 1903 with Minnesota Nos. 6 and 105 barleys. These stocks were grown at University Farm for several years and were considered valuable varieties. Approximately 2,500 plants of Minnesota No. 6 and 5,000 plants of Minnesota No. 105 were used in the foundation beds from which to make the pure-line selections. Fifty plants were selected from each of the two beds and given nursery stock numbers, 1 to 99 respectively, one plant being lost. From 1904 to 1908, these stocks were planted in centgeners in Group I. Crosses and reciprocal crosses were made in 1903 between plants of Minnesota No. 6 and Minnesota No. 105. In 1904 the resulting seeds were planted in the nursery, one foot apart each way. The progenies of the individual plants were kept separate and selections of the best plants were made for the type beds of the succeeding year. The grand summary of the centgener results on the pure-line selections and hybrids is given in Table XIII.

TABLE XII

ANNUAL AND AVERAGE YIELDS OBTAINED IN PLOT TESTS OF EARLY-MATURING AND LATE-MATURING STRAINS, WHOSE NURSERY RECORDS ARE SHOWN IN TABLE XI

MINNESOTA No.	NURSERY STOCK-No.	YIELDS PER ACRE, IN BUSHELS		
		1909	1910	Average
Early selections:				
311	33	17.5	28.9	23.2
312	34	13.3	26.6	19.95
Average...	.....	15.4	27.75	21.57
Late selections:				
313	14	15.8	22.7	19.25
314	20	16.6	26.6	21.4
Average...	.....	16.2	24.45	20.32

The data shown in Table XIII indicate that as a whole the crosses are not as high in yield as the pure-line selections. The average yield of the two types of crosses is 0.18 gram per plant less than that of selected stocks for the same years. The grade of the grain of the crosses is slightly better, while the strength and stiffness of the straw are slightly inferior. The results from the selected stocks show that there is nothing gained in yielding power by continued centgener selection after three years. As soon as the stocks have shown their inherent power, the improvement of that immediate selection is finished and the seed may be increased and distributed. This test should require from two to four years, after which one or more years are necessary to produce the stock in sufficient quantity for distribution.

In Table XIV the centgener notes for five pure-line (Nursery stock numbers 9, 14, 57, 60, and 98), and five hybrid selections (numbers 115, 157, 161, 198, and 199), for the three years from 1906 to 1908, inclusive, are summarized. The yields in bushels per acre for each of these ten strains, obtained in field-plot tests in 1909 and 1910, are also given.

The data in Table XIV show that the average yield per plant of the five cross-bred stocks is 0.20 gram better than that of the five pure lines, while the strength and stiffness of the latter are higher by 5 per cent and 5.6 per cent, respectively. The grade, however, is 4 per cent better for the crosses, which were also slightly earlier in maturing. These differences do not seem to be sufficient to warrant a definite conclusion as to maturity, strength, stiffness, and grade. In yield, the difference, though small, must be given attention. The difference of 0.20 gram is an average for the individual plant. Assuming that 490,040 plants to the acre are grown under nursery conditions (4×4

TABLE XIII

SUMMARY OF CENTGENER RESULTS FOR 1906 TO 1908

Designation	Growing Period*	Hills Planted	Height	Strength	Stiffness	Smut	Grade	Rust	Plants Harvested	Yield per Plant
	Days		*Inches*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*		*Grams*
Crosses										
Nursery-Stock Nos. 100 to 169 (Minn. No. 105 × Minn. No. 6)	87.1	100	35.5	75.3	67.3	.....	62.0	1.6	82 7	3.91
Nursery-Stock Nos. 170 to 199 (Minn. No. 6 × Minn. No. 105)	87.7	100	35.1	75.4	70.4	.....	63.3	2.0	85.6	3.95
Average	87.4	100	35.3	75.35	68.85	.....	62.65	1.8	84.15	3.93
Pure-line selections										
Nursery-Stock Nos. 3 to 48 Minn. No. 6	89.6	100	34.9	81.2	73.7	.....	60.8	.5	81.6	4.16
Nursery-Stock Nos. 51 to 99 Minn. No. 105	88.9	100	36.3	80.6	70.1	.....	60.5	.6	82.3	4.06
Average	89.25	100	35.6	80.9	71.9	.....	60.65	0.55	81.95	4.11

* Average number of days from planting to maturity.

TABLE XIV

SUMMARY OF CENTGENER RESULTS FOR 1906 TO 1908 OF THE FIVE PURE-LINE SELECTIONS AND FIVE HYBRIDS WHICH WERE LATER TRANSFERRED TO THE FIELD PLOT TESTS

Designation		Growing Period*	Hills Planted	Height	Strength	Stiffness	Smut	Grade	Rust Resistance	Plants Harvested	Yield per Plant
				Inches	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*		*Grams*
Pure-line selections											
Nursery-stock No. 9	Minnesota No. 6..	89	100	38	84	76	.....	58	100	74	4.48
Nursery-stock No. 14	Minnesota No. 6..	89	100	36	79	71	.....	62	100	85	4.36
Nursery-stock No. 57	Minnesota No. 105..	91	100	34	88	72	.....	60	100	84	4.81
Nursery-stock No. 60	Minnesota No. 105..	89	100	35	80	69	.....	59	100	75	4.57
Nursery-stock No. 98	Minnesota No. 105..	88	100	36	75	78	.....	56	100	77	4.18
Average		89.2	100	35.8	81.2	73.2	.....	59	100	79	4.48
Crosses											
Nursery-stock No. 115	Minn. No. 105 × Minn. No. 6	88	100	36	75	78	.....	67	97	80	4.68
Nursery-stock No. 157	Minn. No. 105 × Minn. No. 6	87	100	37	79	70	.....	59	98	76	4.62
Nursery-stock No. 161	Minn. No. 105 × Minn. No. 6	85	100	33	74	55	.....	58	100	54	4.79
Nursery-stock No. 198	Minn. No. 6 × Minn. No. 105	87	100	38	74	63	.....	64	100	86	4.72
Nursery-stock No. 199	Minn. No. 6 × Minn. No. 105	87	100	36	79	72	.....	67	100	89	4.61
Average		86.8	100	36	76.2	67.6	.....	63	99	77	4.68

* Number of days from planting to maturity.

TABLE XV

ANNUAL AND AVERAGE YIELDS OF FIVE PURE-LINE SELECTIONS AND FIVE HYBRID BARLEYS GROWN IN FIELD PLOTS IN 1909 AND 1910

NURSERY-STOCK NO.	MINN. NO.	YIELD PER ACRE, PURE LINE (BUSHELS)			NURSERY-STOCK NO.	MINN. NO.	YIELD PER ACRE, HYBRIDS (BUSHELS)		
		1909	1910	Average			1909	1910	Average
9	315	15.0	25.6	20.3	115	320	21.6	28.7	25.15
14	316	13.3	23.9	18.6	157	321	17.5	28.3	22.9
57	317	19.1	28.7	23.9	161	322	9.1	31.2	20.15
60	318	19.1	23.1	21.1	198	323	29.1	26.2	27.65
98	319	17.5	24.7	21.1	199	324	20.8	24.7	22.75
Average.....		16.8	25.2	21.0	Average.....		19.62	27.82	23.72

inches apart), the increased yield on this basis would be 171.6 pounds or 3.56 bushels to the acre. Under field conditions more plants are grown to the acre, thus reducing the difference of 0.20 gram per plant, but it is safe to assume that the reduction of difference in yield per plant would be practically compensated for by the increased number of plants. Therefore, from the nursery results it is evident that crossing, even though three years more are required, will prove the better method for ultimate improvement. This does not, however, preclude the value of the pure-line method of breeding, which is undisputed.

In the field test in this experiment, shown in Table XV, the comparison of average yields from field plots of the crosses from the pure lines shows an increase of 2.7 bushels per acre in favor of the crossed stocks, thus substantiating the nursery records.