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BREEDING CORN.

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Minnesota is destined to be among the foremost states in corn production, if the future can, in a measure, be predicted from the evidence of statistics. It is but a few decades since it was the general opinion that corn could not be matured farther north than the southern boundary of the state But the farmers have persistently obtained and selected varieties from south and east, until corn has been acclimated. In this way, the corn belt has been extended north into sections where it was thought that dent varieties of corn could never be raised.

Minnesota produces annually, on the average, about 35,000,000 bushels, with an average yield of 28.8 bushels per acre, which is less than three bushels below that of the average for the corn belt states. This is produced upon only 107,677 farms out of a total number of 154,659 farms in the entire state. In other words, there are thirty-three per cent. of the farms of the state which as yet do not grow corn.

To give an idea of the rapid development in the growing of corn in Minnesota, the following data from the twelfth census of the U. S. Department of Agriculture is here given.

Production of Corn in Minnesota.

Year.	Rank.	Acreage.	Production.	% of Total.	Ave. Yield.
1850	32	.....	16,725	.....	.....
1860	25	....	2,941,952	0.3	.....
1870	25	.....	4,743,117	0.6	.....
1880	22	438,737	14,831,741	0.8	34.0 bu.
1890	20	901,690	24,696,446	1.2	27.3 bu.
1900	13	1,451,580	47,256,920	1.8	33.0 bu.

At the average value of corn in 1899, the 47,256,920 bushels grown in 1900 was worth to the state $11,337,150. Dividing this by the total number of farms in the state, we get a value of $73.34 for each farm. But since there were only two-thirds, or 107,677 farms of the state producing corn, the value for each was $105.28. The actual benefit derived from a corn crop is not alone measured in the value which the ripe grain will bring in the market. Corn takes a place in the rotation of crops that no other crop can fill and furnishes food peculiarly valuable for live stock. In all parts of the state it is a most valuable crop for fodder and silage, making large crops of fine roughage in the northern part of the state where corn is not always safe as a grain crop.

Since the acreage is constantly increasing there will be an ever increasing demand for seed corn, both for growing corn for ears and for growing fodder corn. The call for seed in the past has been for varieties that would mature. In the future, the farmers who buy seed corn will be more particular about the type, the breeding and especially the yield. They are fast recognizing the increased value of improved strains, and will want such seeds to plant for the production of their annual crops. The Minnesota Experiment Station has long advised the use of clean, well bred seeds of all crops, and has amply demonstrated the advantage of good seed through the introduction of Minn. No. 163 and Minn. No. 169 wheats, which have swelled the yields of wheat from ten per cent to twenty-five per cent, and of Minn. No. 13 corn, where these varieties have been grown. The increase of Minnesota No. 13 corn per acre has been proven to be five or more bushels on many farms. The increased demand for the seed and the numerous commendable reports received from those who have grown it are also substantial evidence of its superior value. The following table, compiled from the results of variety tests at University Farm during the past nine years, shows the immense advantage of carefully selected varieties over those not selected.

Yields Given in Bushels Per Acre.

Variety.	Ave. of Four First Years.	Ave. of Five Years Immediately Following.	Increased Product'n from Selected Seed
Minn. No. 13.	48.6	64.9	16.3
Minn. No. 24.	53.0	49.9	
Dif. in favor No. 24	4.4		
Dif. in favor No. 13		15.0	

It will be noticed from the figures that the yields during the first four years' trial (1894-'97, inc.) average larger for Minn. No. 24 than for Minn. No. 13. But the average for the next five years gives an increased yield of 15.0 bu. of Minn. No. 13 over Minn. No. 24. After the first few years Minn. No. 13 was submitted to rigid selection for better yielding qualities, while Minn. No. 24 was carried along without selection, which resulted in a decreased average yield. On the other hand, the breeding of Minn. No. 13 increased the average yield 16.3 bu.; demonstrating that the breeding of corn in a systematic and intelligent manner is immensely remunerative. Granting that Minn. No. 13 would maintain an average yield of 48.6 bu.; and not deteriorate as did Minn. No. 24, the value per acre at an average price of thirty cents would be $14.58. At the same average price, the yield of this variety as increased by selection would be valued at $19.34, an increase of $4.76 or thirty-two per cent. per acre.

Corn is not the easiest crop to handle in a breeding nursery, especially in the north where earliness must be sought to insure maturity. yet it is one of the most gratifying crops in the immediate, visible results of careful endeavor. It is impossible to grow two or more varieties of corn in a field, or in adjoining fields, without their becoming hybridized. Wheat, oats, barley, etc., are very closely pollinated plants and seldom hybridize, but corn, like millet, or apples, and plums is very freely cross-pollinated. These characters are due to the position of the sexual organs of the plant and to their movements at the time of pollination. In wheat, oats, and flax, the pollen and the ovule (male and female organs) are borne on the same flower, and folded in the same ghumes. But in a corn plant, the pollen is borne in anthers upon the top or tassel, while the ovules in the ovaries are on the ear farther down the stalk. The pollen of corn must depend upon gravity and other agencies, principally the wind, to carry it to the silks. As the air is seldom absolutely quiet, the pollen grains, as they fall from the tassel, are usually carried away from the plant upon which they were borne, to the pistils or silks of another plant. For this reason, the management of nursery corn is difficult. It cannot be bred pure unless it is removed twenty or more rods from the other varieties, or is otherwise isolated by groves, etc.

Farmers, generally, have not fully appreciated the advantage and opportunity that nature has offered in the improvement of corn. Many have done more or less to keep up the standard of quality, and some have improved their varieties by saving the best ears; but effective statistical methods have not been employed by farmers. The common practice among the farmers who save corn for seed has been to pick out the largest ears when the crop was being hauled or stored in the crib. Since the ear is a fairly good indication of a plant's inherent power to yield, and since, by saving the best ears, the best seeds have generally been se-

cured, the method has been a safe way of keeping up the average production, and of somewhat increasing the earliness and yield. But better and more rapid methods of improvement have recently been devised and are easily within the reach of farmers who are energetic and desire to be leaders in the production of field crop seeds. The Minnesota Experiment Station has amply illustrated the value of statistical methods in plant breeding in the taking of notes and keeping records in breeding wheat. (Bulletin No. 62.) Under these improved plans a plant is not measured by what it alone will do, but more especially by what its progeny will do along desired lines. Open fertilized crops require different methods of nursery management from closely pollinated ones. By reason of the long continued practice of cross-fertilization, i.e., the ovaries fertilized by pollen from another plant; it is a known fact that corn will actually deteriorate and "run out," if forced to self-fertilize or inbreed. Therefore, it is not practicable to form varieties from single mother plants. Many individuals should always be planted.

Securing Foundation Varieties.

In starting to breed corn, first secure a variety that is adapted to the locality in which the work is to be done. Other things being equal, get the largest yielding variety obtainable which is early enough to mature in the locality, and thus commence as high in the scale of yield and value per acre as possible. People have been too prone to secure seed from any source. In many cases seed has been used simply upon the recommendation of the salesman, whose chief object is to sell his product, and too often without regard to the vitality or germination qualities or to the adaptability of the variety to the climatic conditions. Iowa, Nebraska, or Illinois seed, or any southern grown seed, should not be used in Minnesota. Even southern Minnesota seed is not adapted to grow for seed purposes in the middle and northern parts of the state. The variety for the major portion of a man's crop should be chosen from those varieties which have been successful in the neighborhood. New stocks should be thoroughly tried and compared with the common ones and compelled to prove themselves superior and adapted before they displace the "staid and tried." No farmer on a farm of average size should start into breeding more than one variety of corn. Farmers on large farms may with discretion confine their attention to a very few kinds.

Initial Selecting for Nursery Planting.

Having decided upon the variety to be used as the foundation stock for breeding dent corn, it is usually advisable to grow as large a field as is practicable from carefully selected kernels. These kernels may be selected by hand or by machine, picking over a bushel by hand if necessary, using only the best formed and largest ones. They should be wedge-shaped and relatively one-third longer than broad; the corners at the cap should not be rounded, but square.

From this field the very best from all the desirable ears should be selected to plant centgeners* the next spring. For this purpose 25 to 100, or more, mother ears should be used. Especial attention should be given to the yield of corn from each ear. Due attention should also be given

*Centgeners—A term used to designate the progeny of a single mother plant.

the form and type and the filling out of the butts and tips of the ears, but yield of good sound corn should not be sacrificed for type character. On the other hand, type and uniformity must not be too much neglected in a pedigreed variety bred for commercial seed. However, it will be found that the score card points of form, yield, etc., are to some extent correlative. People take to a new variety more readily if it makes a good appearance, as well as bears a record of high average yield; hence the need of type as to form, color, etc.

The score card and accompanying notes will serve as an aid in the selection of ears from a field of the foundation variety, and in succeeding years from the nursery centgeners, with which to continue the breeding. The Experiment Station will be glad to assist in devising special score cards for new varieties under nursery selection by corn breeders, and to otherwise assist in breeding varieties adapted to localities in the state and correspondence is solicited. The seed ears should be well dried and so stored that the vitality of the seeds will not be impaired. Shell off the butts and tips of the ears chosen to plant the nursery centgener, and plant only the large, well formed kernels.

Planting the Breeding Nursery.

Plant the centgener plots from the choice mother ears in rows, either in a seed corn nursery by themselves, or as a distinct part of the main field of selected seed corn of the same kind. In the latter case the mixing in of pollen will be only from stocks of the same variety. Lands for the corn nursery should be as even in character as it is possible to get them. Recently manured fields should be avoided, since it is difficult to scatter manure evenly, and some plants not inherently strong may be chosen because of yield enhanced by a chunk of manure near where they grow. Manure should be applied to some previous crop. For convenience in keeping records of the ears, give each of the original mother ears a nursery stock number, as I., II., III., etc. Select 200 or more seeds from each ear to plant in one or two rows, according to the length of the row. Plant in rows the ordinary distance apart and the kernels, one in a place, 18 inches apart in the row, to give each stalk an equal chance with each other stalk. This gives opportunity to judge the average yield of the plants from each mother plant, and also to judge the product of each kernel. Place a stake at the head of each centgener and label it; as "Nursery Stock Number I, Centgener 101," "N. S. No. II, Cent. No. 301," etc., or simply "I-101; II-301," etc., allowing 200 places for the 200 plants of each centgener. Numbering the centgeners in this way gives opportunity to give plant numbers, which are necessary as will be seen later. A system of numbering stocks in plant breeding nurseries has been devised at this Experiment Station and is being prepared for publication.

Cultivation.

Good land of uniform character should be chosen for the seed corn nursery or breeding patch. The cultivation need not be different from the cultivation given the field of corn. The only requisites are conservation of moisture, freedom from weeds and a good physical condition of soil.

Detasseling.

There are always present in the field, stalks which do not bear ears, but do bear pollen. These are called barren stalks and should not be allowed to scatter pollen over the silks of the stalks which bear the fruit. That this can be corrected is shown by the fact that Minnesota No. 13, after being bred for several years, had in 1903 less than one per cent of barren stalks; while some fields which were counted had twenty per cent, or one-fifth of these stalks present. A reduction of one-fifth of a 50 bushel yield, or 200 bushels, on a 20 acre field, amounts, at 30 cents per bushel, to a loss to the grower of $3.00 per acre, or $60.00. The proper time to detassel the barren, and the weak stalks is when the tassels are just well out of the leaf sheaths. At this time no pollen is ripe and a glance at the stalk will readily determine whether or not an ear will develop. By cutting off or pulling out the tassels from these barren stalks, the danger of establishing undesirable hereditary characters in the next year's crop is partially eliminated. Detasseling takes but a very short time and pays in the breeding nursery.

Selecting Best Centgeners.

The following is a table of notes, partly filled out, to indicate the way in which notes should be taken on the centgeners of corn in the breeding nursery:

Nursery Stock No.—1903	Plant No.—1903	Centgener Plot No.—1904	Date Planted.....	Date Ripe.....	Days to Mature..	No. Plants Harvested	Total Weight of Corn in lbs.	Average Weight Per Plant
I.	103	201	May 17	Sept. 3	109	142	117.8	.83 lbs.*
II.	302	301	May 17	Sept. 4	110	157	103.1	.65 lbs.
II.	305	401	May 17	Sept. 3	109	138	109.2	.79 lbs.
III.	404	501	May 17	Sept. 1	107	151	137.4	.91 lbs.*

NOTE.—Centgeners marked (*) indicate centgeners which have been selected from which to choose ears for further selection.

These notes serve much as a score card in judging the average value of the different centgeners. Any centgener which appears weak or not promising can be detasseled before the tendency toward weakness has been carried to the others through cross-pollination. By keeping these notes systematically upon sheets of paper from year to year, a history of each nursery stock number is obtained. With a few years of such records the relative prepotent value of each original mother ear and of each subsequent mother ear may be obtained by averaging the yields, etc., of two or more generations of the progeny of each grown in the same year. Thus a table of average value may be devised.

Harvesting the Centgeners.

When the corn has become thoroughly ripe, or if it is fairly well dented and there is danger of frost, cut and shock it in medium-sized, well made shocks. Shock each centgener separately and count and record the number of plants in each centgener. When the corn is well cured,

husk and weigh the ears from each centgener. Divide the weight by the number of plants to determine the average yield per plant grown from each mother plant or ear. This average weight will be a measure of the breeding value of each parent and will form a basis for the selection of superior qualities. Average other qualities in the same way.

Discard all but the ten very best centgeners, from each of which choose five to ten of the best ears. Test these by the score card, paying most attention to yield. Select later in the winter twenty-five or more of the best ears to plant centgeners the third year, taking the greater number from centgeners of higheset average yield, but taking at least one from each of the ten.

Selecting Ears.

In making the selection of ears, those which stand highest on the score card, as given below, should be chosen, giving greatest consideration to yield of grain per plant, especial note being made of the form of the ear and the filling out of tne tip and butt. It may be difficult to get much uniformity of appearance for a few years until the high yielding ability has been firmly bred into the selected stock, but the type can afterward be gradually made uniform, if it has not already been secured. General variety characteristics of best yielding ears and plants should be noted and attention given to securing ears uniform in appearance, as this is an important factor in a pedigreed stock.

A record of systematic notes of the ears can be kept in such a way that each centgener may be traced back to its maternal ear originally selected. This is done by using centgener numbers subordinate to the nursery stock number, and following the same general plan from year to year. The best ears are used for planting the nursery; all other good ears are used for planting a small field or select portion of a large field, and the choice ears of this, in turn, are used to grow in large fields for sale. Thus the breeder will have select seed to grow superior crops of high yielding ability and will be able to sell at seed corn prices a good portion of his crop.

Table showing the average yields of shelled corn per plant, of 25 centgeners, grown on University Farm, 1903.

Centgener Number.	Ave. Wt. per Plant.	Centgener Number.	Ave. Wt. per Plant.
2601	.45 lbs.	5001	.60 lbs. x
2701	.38 "	5201	.51 "
2801	.49 "	5301	.49 "
2901	.50 "	5401	.59 " x
3301	.64 " x	5901	.52 "
3401	.46 "	6001	.54 "
3501	.54 "	7201	.66 " x
3801	.38 "	7301	.67 " x
4101	.55 "	7501	.57 " x
4201	.58 " x	7601	.57 " x
4301	.52 "	7701	.60 " x
4901	.54 "	7801	.70 " x

From this table it is apparent that there is ample chance to select ears from centgeners which are vastly superior to the majority. Those marked with an (x) were chosen from which to select ears to use to plant centgeners in 1904.

MINNESOTA SCORE CARD.

FOR EARS OF CORN.

(1) *Market Condition*—(10 points).

The ears should be sound, firm, well matured and free from all fungus disease, or from otherwise defective kernels.

(2) *Form of Ear*—(10 points).

The ears should be cylindrical, tapering slightly toward the point. The proportion of length to circumference should be as 4 : 3. Rows of kernels should run straight from butt to tip.

(3) *Size of Ear*—(10 points).

Varies with variety. The ears should be at least eight inches long and six inches in circumference at the middle.

(4) *Variety Characteristics*—(10 points).

The ten ears should possess similar characteristics and be true to the breed represented.

(5) *Tips*—(10 points).

The tips should be well rounded and filled with regular rows of uniform kernels, not too tapering nor twisted.

(6) *Butts*—(10 points).

The rows of kernels should extend regularly over the end and there should be a fairly deep depression when the shank is broken off. enlarged or open butts are objectionable. Contracted butts are also objectionable.

(7) *Kernels*—(Uniformity 5; Shape 5 points).

The kernels should be fairly uniform in shape, indentation, color, etc., from tip to butt of the ear. They should be more or less wedge-shaped and not rounded on the corners.

(8) *Color*—(Grain 10; Cobb 5 points).

The grain should be of a uniform color, true to the variety, free from all signs of admixture and of good lustre.

White corn should have a white cob. Yellow corn should have a red cob.

(9) *Space*—(Between rows and between kernels—5 points).

The furrow between the rows should be small.

Space between the kernels near the cob is objectionable.

(10) *Percent of grain to ear*—(10 points).

To be determined by weight. Maturity, size of cob, and form of kernels affect the proportion. At least 80 per cent. of the total weight of the ear should be corn.