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WHAT CAN THE FARMER DO TO IMPROVE HIS CORN?

In the January issue of The Visitor, Mr. F. H. Steinmetz summarized briefly the results from a few recent investigations regarding the relations between visible ear characters and yield. The conclusions presented indicate that selection of ears on the basis of score-card type is of no particular value as a means of increasing yield. The question which naturally arises next in the mind of the teacher is, "What can the farmer do to improve his corn? Dr. H. K. Hayes, professor of plant breeding, University of Minnesota, has prepared the material for this and the next issue of The Visitor which will help to bring us up to date on the information now available concerning corn improvement and corn breeding.—A. M. F.

corn growers is, "How can I keep my variety in a state of improvement and can it be further improved by selection?"

Ear To Row Breeding

The selection method of corn improvement was introduced into the United States between 1890 and 1896 by Hopkins of Illinois. The method consisted in growing under comparable conditions a progeny row of each ear selection in order to determine the yielding ability of selected ears. Subsequent selections were made from the higher yielding rows. The method is known as the ear-to-row plan.

Kiesselbach in 1922 presented data which indicate that ear-to-row breeding is of little value as a means of improvement of an adapted variety. At the Nebraska station, Hogue's Yellow Dent has proved, on the average, the highest yielding variety. Table 1 presents the results obtained by Kiesselbach:

Table 1.—Effect of Ear-to-Row Breeding on Yield of Hogue's Yellow Dent Corn (After Kiesselbach)

Kind of breeding	Average yield per acre, bu., 1911-17
Original Hogue's Yellow Dent	53.6
Continuous ear-to-row selection since 1903	53.3
Increase of single high-yielding row selected in 1906	47.7
Increase from 4 strains selected in 1906	55.0

Methods of Selection and Their Probable Value

The great economic value of the corn crop has led to the production of many varieties, and corn is now being grown in many regions where formerly the crop was a failure. These facts support the conclusion that the production of varieties adapted to various regions has been of great aid to the farmer.

Adapted varieties are available for most sections of the Corn Belt and for these regions it does not seem desirable or necessary to produce more varieties. The list of varieties is already much too long and what is needed is a standardization of varieties and the discard of the more undesirable ones. In many localities the more desirable varieties are known and the natural question in the minds of many

The original Hogue's was carried on by selecting well developed ears for seed. Continuous ear-to-row breeding appeared to be of no value. The increase of the high-yielding strain and subsequent isolation of the strain resulted in a reduction in yielding ability which presumably was a result of inbreeding. The increased yield obtained from four high-yielding strains which were isolated and increased was not very large. Similar results were obtained from Nebraska White Prize except that the increase and subsequent selection from eight high-yielding strains yielded on the average three bushels less than the original corn. These experiments of Kiesselbach certainly cause one to doubt the value of ear-to-row breeding as a means of increasing yields of adapted corn varieties.

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Results from Experiments at Illinois

In the Illinois Agricultural Experiment Station Bulletin 271, the following summary is made with regard to the results in Illnois from investigation in selecting corn for yield by the method of the ear-row breeding plot. The summary is based on data obtained in an experiment extending over a period of ten years.

"The possibility of improving the yield of corn by continuous ear-row selection has been rather generally assumed, and no little effort has been expended in attempting to produce higher yielding strains thru one or another of the various possible modifications of this method of breeding.

"The remarkable results in altering, thru ear-row breeding, certain special characters such as protein and oil content of the grain and height of ear on the stalk, led to the assumption that yield might be influenced by a similar process of selection. In view of a doubt as to whether breeding for these special characters and breeding for yield represent truly analagous cases, it seemed desirable to secure some actual experimental evidence. To this end a test was made covering ten years of selection for yield by the method of the ear-row breeding plot.

"The results of this investigation led to the conclusion that the simpler method of mass selection, that is, picking seed ears from standing stalks in the field, ordinarily will be just as effective in improving the yield as the more complicated method of continuous ear-row breeding.

"The experiment involved the use of an unnamed variety of no particular breeding but adapted to the region. A high-yield and a low-yield breeding plot were founded upon the basis of the relative productiveness of the seed ears as determined by a preliminary ear-row test. Continued selection in these two opposite directions resulted in a marked separation of the two strains with respect to yield. The high yield strain, however, did not significantly surpass in yield a control strain propagated from the original stock by careful field selection without pedigree breeding."

Conclusions

"The outcome of this investigation leads to two conclusions concerning practical methods of corn breeding:

"1. Continuous selection by means of the ear-row breeding plot cannot be recommended as a means of increasing the yield of a well-adapted variety of corn.

"2. By continuous mass selection the yield of a well-adapted variety of corn can be maintained and perhaps somewhat increased.

"The practical recommendation to the corn grower who desires to maintain the productiveness of his crop on a high plane, or possibly to increase his yields, is to use mass selection as the most effective simple method of selecting corn for yield."

Investigations at Minnesota Experiment Station

Experiments were carried on in seed selection of an adapted variety at University Farm during the years 1920-1923. The methods of selection used and the results are as follows:

Rustler White Dent was chosen for the study as it is a variety which showed considerable deviation in ear type and as it had not been selected previously by the ear-to-row method. It had the advantage of being adapted to the climatic conditions of Central Minnesota, which was necessary as the problem was planned as a means of learning how best to select seed of an adapted variety.

The methods used in the Rustler selection test were as follows: As far as possible, the field in which each method of selection was carried on was separated from other fields of corn, selection being continuous from year to year. The selected seed, for the different methods, was stored in a comparable way, except as noted later, and only seed from ears which showed high germination ability by actual trial was used for planting. The comparable yield trials for the different methods of selection were made on the same field. Three-row plots, each row approximately 36 hills long, were used, the central row being used for the yield comparison. Three systematically distributed plots were used each year except in 1920, when four plots were grown. The methods of selection used are as follows:

1. Selection of good ears at husking. Three seeds were planted in each hill and

the corn was cut and shocked when mature. Later in the fall the better appearing ears were thrown into a pile and reserved for seed when the corn was husked. This method was isolated from other corn fields.

2. Selection during seed corn week* from perfect stand hills and vigorous stalks. Only well-matured ears were chosen but no close selection to ear type was made. The ears were stored immediately in a well-ventilated room, each ear having individual space for proper curing. The lower series of Field X was used each year and similar selected seed was used to plant the adjacent series on which silage corn was grown. This method was isolated from other methods.

3. As in method 2, except that the selected stalks were shocked and the ears husked later in the fall.

4. Selected as in method 3 in the field during seed corn week. After husking, the ears were carefully examined for ear type. Only ears of high score-card type were used for planting the following year. Selection was made for good butts, medium denting, straight rows, cylindrical ear, 14 to 16-rowed ears, and good ear length. Field C, the manured half-acre, was used for this method through co-operation with the farm crops section. Some cross-pollination may have occurred between the plants on this field and those in the ear-to-row plot, altho the fields were a considerable distance apart.

5. Method 5 is called "Montgomery's method" as the plan was suggested originally by Montgomery. It consists of an ear-to-row test the first year, followed by a mixture of seed of the remnants of the 25 better yielding ears as determined by the ear-to-row test. Approximately 100 ears were used for the original ear-to-row selection. In subsequent years the method pursued is similar to plan 3. By selecting from that part of the field which was the farthest from the ear-to-row plot the isolation was fairly good.

6. Williams' method. The purpose of this plan is to isolate high-yielding ears by the ear-to-row plan, cross the remnants of the three highest yielding ears the following year and multiply the crosses in a seed plot the following year. The seed plot is considered the place to produce commercial seed. The ear-to-row plot, the crossing plot, and the multiplying plot are used each year. The crossing plot and multiplication plot were well isolated from other corn fields.

From Williams' plan two sorts of seed have been used for the yield trial: (1) F_1 crossed seed produced by crossing the remnants of the three higher yielding ears. (2) Increase plot seed obtained by planting F_1 crossed seed. Field T was used for this increase thru co-operation with the farm crops section.

Yield trials were made by the use of replicated plots. Results are presented in Table 2.

The conclusions appear fairly obvious. By one method of comparison the chances are 37.1 that selection for score-card type of ear has led to a slight reduction in yield even tho the plants were first selected on a yield basis from perfect stand hills.

Ear-to-row breeding with an adapted variety does not appear worth while from the farmer's standpoint. (See Minnesota Bul. 210.)

Table 2.—Method of Selection of Seed of Rustler Dent Corn in Relation to Yield

	Yield in bushels per acre				
	1920	1921	1922	1923	Ave.
1. At husking	50.2±1.6	64.1±1.3	48.9±1.3	54.9±1.9	54.5±0.8
2. Perfect stand hills for yield seed stored immediately	47.9±1.5	64.1±1.3	49.2±1.3	56.5±1.9	54.4±0.8
3. Perfect stand hills for yield seed cured in shock	48.1±1.5	63.7±1.3	48.9±1.3	56.5±1.9	54.3±0.8
4. As in 3 in field, selection later for score-card type	46.6±1.4	63.7±1.3	47.2±1.2	55.1±1.9	53.2±0.7
5. Montgomery's method	49.5±1.5	66.0±1.3	49.5±1.3	55.9±1.9	55.2±0.8
6. William's method, F^1 crossed seed	47.0±1.4	65.7±1.3	49.1±1.3	60.3±2.1	55.5±0.8
7. William's method, increase plot	.....	60.9±1.2	48.2±1.2	52.3±1.8	.....

Adapted Varieties. The use of the best variety or varieties available is recognized by all to be of great importance. When such varieties are not available they can be obtained by the use of the best possible variety and by selection in the field for the characters desired. Home-grown seed is valuable. An illustration from Nebraska results proves this point.

* The period set by the Agricultural Extension Division for selection of seed under field conditions.

Table 3.—Effect of Acclimatization on Corn

Character of seed	Yield in bu., per acre
Show corn from Illinois, Indiana, and Ohio (5 varieties)	39.8
Seed from growers in state (5 varieties)	45.6
Local varieties near experiment station (7 varieties)	48.8

The following seed plot method is suggested for the corn grower who saves his own seed (from Hayes and Garber, *Breeding Crop Plants,* p. 290) :

"1. (a) Give special attention to a part of of the field, or use a seed corn plot.

(b) Plant and cultivate carefully, using the hill method.

(c) Each fall before frost select enough seed for the following year's seed plot from stalks which give a good yield and which grow in perfect stand hills.

(d) Discard only the very undesirable ears and store each selected ear in a careful manner.

(e) Test all seed for germination, and where ear, stalk and root rots are a problem, select disease free seed by the germination test."

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H. K. HAYES

READING ABILITIES

Practically all the teachers of agriculture in the Minnesota high schools have given mental ability tests and reading tests to the students enrolled for instruction in agriculture. Each teacher is urged to make the results from these tests the basis for a careful study of the needs of each student. Perhaps the best opportunity a teacher has to give individual help in reading difficulties is during the study period.

Students of relatively high mental ability usually make better use of the study period than do the students who are less gifted. The problem of the teacher is to arouse an appreciation on the part of the less gifted students of the desirability of putting forth extra effort in improving their rate of reading and in their ability of extracting meaning from the printed page. As an aid in stimulating activity on the part of the students to improve in reading speed and comprehension the teacher should put on frequent reading tests and these tests should be followed by a careful diagnosis of the apparent difficulties of the students. The reading material selected for the test should be taken from the textbook or reference book in use for the regular classwork. As a guide in diagnosing student difficulties the following are suggested as representative of certain specific reading abilities regarded as desirable for a student to possess if the study period is to be the most valuable to him. The specific abilities are selected from the list presented by Professor P. M. Symonds,* Columbia University. Each teacher will no doubt be able to make a number of additions to those listed.

Ability to answer questions, the answers to which are found in the material.
Ability to select a test title for a paragraph.
Ability to find the sentence in a paragraph which answers a given question.
Ability to tell what question a paragraph answers.
Ability to find word or phrase that limits or qualifies a statement.
Ability to outline.
Ability to skim.
Ability to recognize inconsistencies.
Ability to follow directions.
Ability to anticipate meanings.
Ability to recognize equivalent ideas differently expressed.
Ability to summarize.
Ability to locate material.
Ability to read a graph.
Ability to read a table.
Ability to read a diagram.
Ability to follow the description of a picture or a diagram.
Ability to read a map.

* Symonds, Percival M., Study Habits of High School Students, Teachers College Record, Vol. XXVII, No. 8, p. 715.