EXTENSION BULLETIN 195 JANUARY 1939

HYBRID CORN
and
Its Place in Michigan

By

H. C. RATHER,
R. E. DECKER,
A. R. MARSTON, and
J. R. DUNCAN

MICHIGAN STATE COLLEGE

EXTENSION DIVISION

EAST LANSING

Cooperative Extension Work in Agriculture and Home Economics, Extension Service, Michigan State College and the U. S. Department of Agriculture Cooperating.

HYBRID CORN
and
Its Place in Michigan

H. C. RATHER, R. E. DECKER, A. R. MARSTON AND J. R. DUNCAN

In 1881, Dr. Wm. J. Beal, Botanist of the Michigan Agricultural Experiment Station, crossed two distinct varieties of corn and the seed thus obtained produced a crop of unusual thrift and vigor. The results which Dr. Beal obtained when he repeated his crossing experiments were variable, doubtless owing to the mixed heritage of the parent lines with which he worked. However, since that time many corn breeders have contributed to the development of breeding methods which have made the attainment of superior merit in crossed corn much more certain and feasible.

WHAT IS HYBRID CORN?

The term, **hybrid corn,** as employed in modern methods of corn improvement, is used to designate the first generation of a cross involving inbred lines. Strictly speaking, a cross between two different lines of

Fig. 1. A good hybrid is adapted, strong stalked, leafy, vigorous and productive.

corn, is a hybrid. However, the term hybrid corn has come to be associated with superior vigor and such vigor has not been obtained consistently merely by crossing ordinary lines of corn.

When corn is pollinated in the usual and natural way, the pollen, produced on the tassels, is carried by wind and air currents. Some of it finds its way to receptive silks of budding ears and there fertilizes the necessary egg cells to produce kernels of corn. Conceivably, each kernel of a given ear may have received its pollen from a different tassel. Certainly the kernels of each mother ear develop from pollen coming from many different male parents. Thus the ordinary open-pollinated variety of corn is not pure as to its inherited characteristics, but is a composite of corns that are early, corns that are late, tall lines and short ones, lines resistant and lines susceptible to various diseases, and so on. Because ordinary corn varieties are made up of a composite of so many frequently conflicting lines of inheritance, their performance due to heredity is uncertain.

WHY INBRED LINES ARE USED TO MAKE HYBRIDS

In order to eliminate the uncertainty of the mixed heritage of ordinary corn plant breeders have developed a method of purifying the inheritance of corn by inbreeding. Very close inbreeding is readily possible with corn. The pollen produced on a given tassel is carefully gathered in a paper sack placed over the pollen-producing tassel long enough so only viable pollen from this tassel is left in the sack. This pollen is then dusted on receptive silks of the same plant—silks previously protected from stray pollen by transparent sacks which permit the breeder to know when they are ready to be pollinated. In this manner the closest possible inbreeding is attained; the corn is mated with itself.

After several successive generations of inbreeding and selection have been carried on, two marked developments become evident; these inbred lines of corn show materially reduced size and vigor and they become strikingly uniform in their inherited characteristics. This uniformity of inherited characteristics is the goal sought by the breeder. It is indicative of purity of breeding. The performance of these relatively pure inbred lines when mated in crosses will be consistent and certain.

HYBRID VIGOR

When two of these relatively pure inbred lines of corn are crossed, usually the resulting hybrid not only will be much more vigorous and productive than its two inbred parents, but very frequently this hybrid will be much superior to the original open-pollinated lines from which the inbreds were developed. That superior hybrids are frequently obtained is because a large number of favorable growth factors can be combined in the hybrid condition. When the characters which are expressed are those which make for vigor, leafiness, large healthy roots and strong stalks, a vigorous hybrid is produced.

NOT ALL HYBRIDS ARE DESIRABLE

The mere fact that a given line of corn is a hybrid is no guarantee of superior merit. Hybrid corn is not just the name of another variety. Hybrid corn is the result of a different method of breeding. There are early hybrids and late ones, tall ones and short ones, yellow ones and white ones, hybrids with strong stalks and hybrids with weak ones, hybrids resistant to certain diseases, and hybrids that are extremely disease-susceptible. Before any corn grower is warranted in investing

Fig. 2. Not all crosses result in good hybrids. The one at the right had a poor root system. Plant breeders discard such material, retaining for crossing purposes only those lines which combine to produce a strong vigorous hybrid.

one cent in hybrid seed corn, he should have every assurance possible that the particular hybrid seed he buys is of a cross of proved merit adapted in maturity and other characteristics to his particular locality and situation.

Corn breeders cannot know in advance that two untested inbreds will mate to produce a superior hybrid. They can only make the cross and test the progeny. Only by developing large numbers of inbred lines, making a great many crosses, and repeatedly testing those crosses in comparison with corn lines of known value and adaptation is it possible to obtain hybrid lines suitable for commercial production.

STEPS IN THE BREEDING OF A DOUBLE-CROSS HYBRID

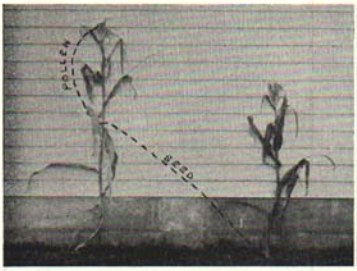

Fig. 3. Corn plant (left), self-pollinated for several generations, produces the inbred (right). Inbreds are small and lack vigor but they are of increasing purity with each successive generation of inbreeding and selection.

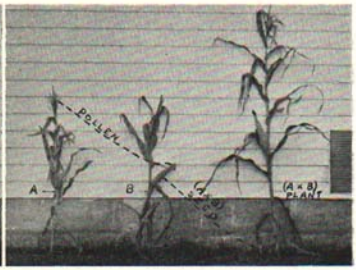

Fig. 4. Pollen from the tassel of Inbred A falls on the silks of the detasseled Inbred B, resulting in the single cross seed (AxB). This seed produces the single cross plant (AxB).

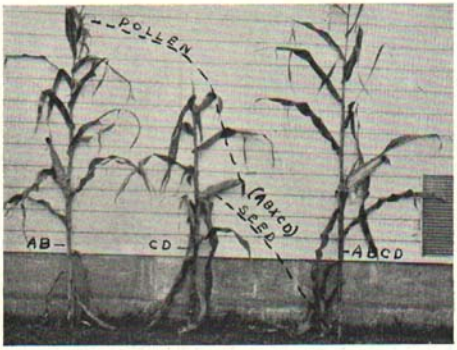

Fig. 5. Pollen from the tassel of single cross AB falls on the silks of the detasseled single cross CD resulting in the production of commercial double-cross hybrid seed (ABxCD). This is the seed which corn growers plant to produce a vigorous high yielding crop for feed or market.

The grain produced by the hybrid plant (ABCD) is not satisfactory for seed.

KINDS OF HYBRIDS

Hybrids made by crossing two inbred lines are called single-crosses. These may be entirely satisfactory from the standpoint of vigor and productivity and they usually are very uniform in appearance. However, the seed to produce a single-cross hybrid comes from an inbred parent which, as a rule, is low in yield and produces small ears and kernels. Thus seed production is expensive. Breeders have found that hybrid vigor can be obtained for one generation by mating two single-crosses. This is called a four-way or double-crossed hybrid. In this case, the seed is produced on a vigorous single-cross plant, seed yields are good, and commercial production of hybrid seed is entirely feasible and practical.

Other crosses sometimes used for the commercial production of hybrid seed are three-way crosses, in which an inbred is used to pollinate a single-cross; and top-crosses, in which an inbred is used to pollinate an ordinary, non-hybrid variety. The chief advantages of these latter two types of crosses is that it is easier to find one inbred to use in a top-cross, or three inbreds used in a three-way cross, than it is to find four inbreds that mate well in a double-cross. Most of the best commercial hybrids in use in the United States, however, are double-crosses generally more uniform and outstanding in appearance than three-way and top-crosses.

HOW HYBRIDS ARE PRODUCED COMMERCIALLY

The production of experimental hybrids is carried on by a process of hand pollination, a procedure entirely too expensive for commercial

Fig. 6. The commercial production of a hybrid is accomplished by detasseling the parent from which the seed is harvested. The male or tassel-bearing parent produces the pollen for the entire field and its ears are not used for seed.

production. However, the field production of hybrid seed is entirely feasible at a reasonable cost for a bushel of seed. A grower wishing to produce a double-cross obtains seed of the two single-cross parents. One satisfactory planting method is to plant four rows of the single-cross, from which the seed ears are to be harvested, to one row of the single-cross which is to be used as the male or pollinating parent. As

Fig. 7. The use of second or subsequent generation seed from hybrid corn is inadvisable because, in the recombination of growth factors which occurs, some vigor, productivity, and uniformity are lost.

In each of these pictures the corn at the left was grown from first generation hybrid seed. The corn at the right was grown from second generation seed of the same hybrid. The ears, sorted into sound ears and culls, in each case were husked from 20 hills in adjoining plots. The yields, calculated to an acre basis were:

First generation hybrid seed—71.8 bushels an acre.

Second generation seed from the same cross—51.4 bushels an acre.

soon as the first tassels appear, they are pulled out of the female or seed-producing parent. The detasseling work must be kept up for a ten-day to two-week period or as long as new tassels show up, the object being to prevent the seed producing parent completely from shedding any pollen. Thus, all of its ears will be pollinated from the male rows on which the tassels are permitted to develop. All ears on the detasseled rows will be crossed with the male single-cross parent and thereby produce double-cross hybrid seed. The corn produced by the male parent is used for feed.

Because of the extra care and labor involved, the production of hybrid seed corn in Michigan is developing as an enterprise for seed corn growing specialists. Farmers interested only in utilization of hybrid seed procure their seed each year from such sources. Production of hybrid seed must be in reasonable isolation to avoid contamination by inferior wind-blown pollen from nearby fields of other corn. The Michigan Crop Improvement Association maintains a system for inspection and certification of seed of those lines of hybrid corn found to be superior for given localities in trials conducted by the Agricultural Experiment Station of Michigan State College.

HYBRID SEED SUPERIOR FOR ONE GENERATION ONLY

One of the characteristics of hybrid seed corn is that it maintains its uniformity and superior vigor for one generation only. A recombination of characters occurs in the second and subsequent generations and causes variations in type, size of plant and maturity, and a reduction in yield. The amount of reduction in yield varies with the particular hybrid line but is great enough so that the use of second and subsequent generation seed is inadvisable.

CHARACTERISTICS TO BE EXPECTED IN A GOOD HYBRID

While the crossing of certain inbred lines of corn may result in an inferior hybrid, plant breeders naturally discard these unsatisfactory crosses and retain the ones which show promise of superior commercial value. A grower purchasing hybrid seed should be interested in knowing that the hybrid he buys is the result of the most careful and thorough methods of breeding and testing and has as many as possible of the desirable characteristics which it is possible to develop in a hybrid line. Characteristics of the superior hybrid lines include:

Uniformity: A well-bred hybrid line will show a much higher degree of uniformity in visible characteristics than an open-pollinated variety. Such uniformity makes for evenness in maturity, a smaller proportion of nubbins and off-grade ears, and greater ease of harvest, especially with mechanical equipment.

Strength of Stalk: Plant breeders have been able to produce hybrid lines with very strong sturdy stalks, very resistant to lodging or breaking over. Growers using stiff-stalked hybrids have reported that this

feature alone warranted the extra investment in hybrid seed because of greater ease of harvest.

Large Roots: Vigorous hybrids generally have a much larger root system than the usual standard open-pollinated varieties. A part of this advantage in vigor of root system in such hybrids is due to resistance to root diseases.

Green Stalks: Some hybrid lines retain the green color and succulence of stalk even when the grain has fully matured. It is possible to make a very high grade of silage with hybrids having this characteristic.

Fig. 8. Left: A standard open-pollinated variety. Right: An adapted, productive hybrid. This picture shows the product of 10 hills of each variety laid out in the order in which they were husked. Note the greater yield, greater uniformity, and freedom from nubbins in the case of the hybrid.

Insect Resistance: It may be possible to develop corn hybrids resistant to damage by certain insects. These possibilities have been under investigation at the Michigan Agricultural Experiment Station for several years, particularly with reference to losses caused by the European corn borer. Although no lines have been found which are in any sense immune to borer infestation, considerable evidence has been accumulated to indicate that certain lines are able to withstand borer attack with less breakage and secondary damage than are others. Possibly all hybrids with unusually sturdy stalks will show resistance to borer induced breakage as well as to stalk breakage from other causes.

Adaptation: Hybrids are not universal in adaptation. Growers planting corn for grain production should make sure any hybrid they purchase has been tested in their locality and has demonstrated its ability to ripen and produce good yields of sound corn. Hybrids used for

Fig. 9. Left: A vigorous, strong stalked, leafy hybrid.
Right: A standard open-pollinated variety.

ensilage can be somewhat later in maturity provided they produce a large leafy plant and will come near enough to maturity to make silage of high quality. The matter of adaptation is of such importance that a more detailed discussion is presented in the following paragraphs.

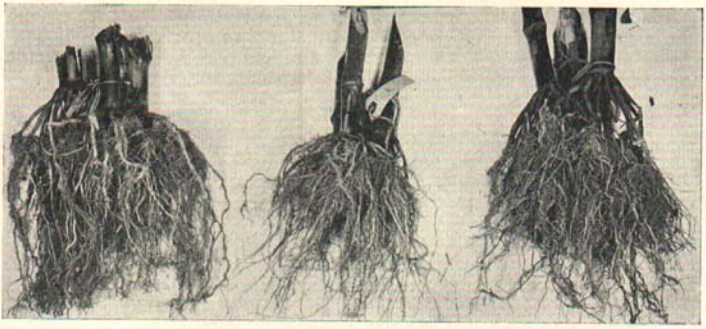

Fig. 10. The roots shown in this picture were taken from adjacent hills of corn.
Left: A hybrid.
Center: A standard open-pollinated variety.
Right: Another hybrid.

FACTORS INFLUENCING CORN MATURITY

The length of time required for any corn from planting date until the grain has fully matured is influenced by many factors including

1. The inheritance of the hybrid or variety
2. Temperature
3. Moisture
4. General character of the soil
5. The balance of plant foods in the soil
6. Time of planting.

Fig. 11. Left: An upstanding hybrid.
Right: A standard open-pollinated variety which has gone to pieces, in part as a result of damage done by the European corn borer.

The fact that a hybrid has proved superior in one locality is no assurance that the same hybrid will prove satisfactory in an area presenting a different environment.

In Michigan, the longest and warmest growing season for corn normally prevails in Monroe County and this locality can grow the latest maturing corn of any place in this state. The summer temperatures which normally prevail at Monroe, however, are exceeded by those in northern Ohio, Indiana, Illinois, Iowa and southern Minnesota and Wisconsin, even though some of these localities lie north of Monroe. This means that hybrids which use the full growing season of these particular out-of-state areas are generally too late to mature grain fully and with safety at Monroe. Hybrids too late for Monroe are too late for the rest of Michigan for grain production, although it is possible that some of these out-of-state hybrids will do well for silage in southern Michigan.

Hybrids developed for central or northern Minnesota or Wisconsin should mature in Michigan, usually at a location farther south than the normal adaptation of the hybrid in its own state. Early hybrids from other sources may, on trial, be found satisfactory in Michigan.

Table 1. Data from 1938 plantings at East Lansing, Michigan, indicating the number of days required in this particular season for certain hybrids and varieties, varying in adaptation, to develop grain of specified moisture contents.

Variety Number	Number of days from the time the corn was planted until the moisture content of the grain was down to:—				
	70%	60%	50%	45%	40%
1. Open-pollinated—adapted to Cadillac area	95	102	110	115	126
2. Hybrid	97	106	113	118	129
3. Hybrid	99	105	115	121	130
4. Open-pollinated—adapted to Lansing to Saginaw area	101	109	119	126	134
5. Hybrid	101	110	120	126	134
6. Hybrid	102	113	124	132	141
7. Open-pollinated—adapted to Monroe to Coldwater area	101	111	124	133	143
8. Hybrid	109	115	124	133	148
9. Hybrid	108	117	131	143	150

NOTE:—This corn was planted May 12. The first killing frost occurred the night of October 6, which was 147 days after the corn was planted.

THE MYTH OF 90-DAY CORN

Hybrids as well as open-pollinated corn varieties are frequently designated as "90-day," "100-day," "120-day" hybrids, with the inference that these hybrids will mature in the period indicated. Such designations have been very unsatisfactory as applied to Michigan conditions. A Michigan farmer expects a 90-day corn to ripen in 90 days from date of planting, under average conditions. This would mean that a 90-day hybrid planted May 15 would be mature on August 13. Many early corns have been tested by this station and none of them has come anywhere near approaching such a record.

Minnesota Hybrid No. 402, one of the earliest hybrids tested in Michigan was planted at East Lansing, May 12, 1938. In 90 days this early hybrid was not yet dented and the grain contained 76% moisture. The rate at which certain hybrid lines and standard open-pollinated varieties reached maturity in 1938 at East Lansing is given in Table 1.

Yield: Finally, of course, a good hybrid is expected to be productive in the area for which it is chosen. The Michigan Agricultural Experiment Station in cooperation with farmers, county agricultural agents, and the Michigan Crop Improvement Association each year conducts adaptation and productivity trials with several varieties of hybrid corn in areas reasonably representative of the different corn growing conditions in Michigan. These are supplemented by a much larger number of demonstration plots of promising hybrids generally conducted with the aid of county agricultural agents, vocational agricultural teachers and their students. Thus a comprehensive survey of the adaptation and merit of promising hybrid lines is secured.

Several hybrids markedly superior to standard open-pollinated varieties have demonstrated their performance in these trials.

Illustrations of the possibilities of yield improvement through the use of hybrid seed are presented in Table 2.

It is not intended to present a list of recommended hybrids in this publication. New ones are being developed, tested, and put into commercial production each year. Brief descriptions of the characteristics and performance of superior hybrids and a list of recommended kinds together with the adaptation of each will be published by the Farm Crops Section of the Michigan Agricultural Experiment Station each year and this information may be obtained directly from the college or from county agricultural agents, and teachers of vocational agriculture.

PROCURING GENUINE HYBRIDS

The state of Michigan, in 1938, enacted the following amendment to its seed law dealing with hybrid seed.

"Section 13, P. A. 34, 1937. HYBRID SEED CORN. The use of the term 'Hybrid' in connection with seed corn offered or exposed for sale shall be restricted to first generation stock of a cross, the parentage of which involves one or more inbreds.

"In addition to the labeling requirements specified in section two, of this Act, every lot, package, parcel or bag of seed corn sold as hybrid seed shall have plainly written or printed on the tag or label,

Table 2. Data from Michigan over-state trials indicating the potential superiority of good, adapted hybrids over good, adapted open-pollinated varieties.

	Southern Michigan (Monroe County)		Central Michigan (Saginaw County)		Northern Michigan (Otsego County)	
	1935					
	Hybrid	Open-Pollinated Variety	Hybrid	Open-Pollinated Variety	Hybrid	Open-Pollinated Variety
Days from planting to first fall frost	137	137	142	142	122	122
Days from planting to harvest	131	131	145	145	143	143
Per cent moisture in grain at harvest	35	33	18	27	44	30
Yield, bushels per acre—basis 14% moisture	61.5	50.9	65.4	52.6	55.6	43.8
	1936					
Days from planting to first fall frost	130	130	126	126	120	120
Days from planting to harvest	137	137	133	133	123	123
Per cent moisture in grain at harvest	20	21	42	45	54	53
Yield, bushels per acre—basis 14% moisture	50.2	52.1	65.9	51.2	38.5	28.3
	1937					
Days from planting to first fall frost	131	131	139	139	124	124
Days from planting to harvest	133	133	139	139	142	142
Per cent moisture in grain at harvest	33	36	31	36	27	40
Yield, bushels per acre—basis 14% moisture	69.2	47.7	79.0	62.3	58.8	43.1
	Average					
Days from planting to first fall frost	133	133	136	136	122	122
Days from planting to harvest	134	134	139	139	136	136
Per cent moisture in grain at harvest	29	30	30	36	42	41
Yield, bushels per acre—basis 14% moisture	60.3	50.2	70.1	55.4	51.0	38.4
Average percentage gain in yield from the hybrid	20.1%		26.5%		32.8%	

in the English language, the name or number by which the hybrid is designated.

"The vendor of the seed shall be responsible for there being on file with the Commissioner of Agriculture, a statement giving the pedigree of the hybrid and the name of the breeder who developed each inbred line involved in the cross."

This law provides a practical basis for the identification of hybrids by pedigree even though a hybrid of the same pedigree may be offered

for sale under more than one trade name or number as is frequently the case. Although it may not be feasible to test all of the hybrids which will be offered for sale in Michigan from various commercial sources, the tests conducted by the Michigan State College are sufficiently inclusive so that information concerning hybrids adapted to each section of the state is being obtained every year and by consulting this information, growers may protect themselves by purchasing seed of only those hybrids of known adaptation and proved merit.

Further to make good hybrids available to Michigan corn growers, the Michigan Crop Improvement Association, an organization of experienced seed growers, carries on the commercial production of hybrid

Fig. 12. Hybrid seed corn growers in Michigan need a well equipped seed house in which to dry and prepare their seed for the market.

seed corn under inspection and certification supervised by the Farm Crops Department of Michigan State College. This certification includes only varieties which, after thorough trial, have been recommended by the Farm Crops Department of Michigan State College and gives assurance of the genuineness of the hybrid and its production from proper parent lines in satisfactory isolation, with detasseling of the female line carried on in a timely and thorough manner.

Such certified seed is marketed through private and cooperative seed companies, elevators and local seedsmen, and by growers themselves. A list of seed sources may be obtained from the Secretary of the Michigan Crop Improvement Association, East Lansing.

Michigan State College of Agriculture and Applied Science and U. S. Dept. of Agriculture cooperating, R. J. Baldwin, Director Extension Division. Printed and distributed under act of Congress, May 8, 1914.

1-39: 25M