Corn Hybrids Result From Crossing Carefully Selected Parent Lines

Interest in corn hybrids has, for a number of years, been growing. Hybrid seed corn has resulted from the efforts of corn breeders to reduce the cost of corn production by making possible materially larger acre yields of higher-quality corn. Naturally there has been more publicity about this effort in the Corn Belt and surrounding States, where hybrids already are in commercial production, than elsewhere. The number of requests for information coming to the United States Department of Agriculture, however, indicate a widespread interest in hybrid corn, its possibilities and limitations.

Corn hybrids have several things in common with the mule. The mule is the first-generation hybrid between the mare and the ass. Having no pride of ancestry or hope of posterity, it must live for the present only. This it does with vigor, to the great benefit of its owner. Corn hybrids are the first-generation hybrids between two or more inbred strains of corn. The inbred parent strains are so inferior they can not be a source of pride. Although the hybrids produce posterity, the second and later generations can not be used for seed without a loss in yield. Corn hybrids, then, must be produced anew in each generation. During that generation a good hybrid produces a materially larger acre yield of good-quality corn than do the best ordinary varieties, to the considerable benefit of its grower. Finally, neither all mules nor all corn hybrids are good.

Reproduction in Corn

In order to understand just what hybrid corn is, it is necessary to know how the corn plant reproduces. Each kernel of corn results from the fertilization of an egg by a sperm. The egg is at the base of the silk and the sperm is carried by the pollen. It therefore is customary to speak of the plant on which the ear is produced as the female parent and of the plant or plants supplying the pollen as the male or pollen parents.

Ordinarily, corn is wind pollinated, the pollen being carried at random through the air and some of it falling on receptive silks. Selecting an ear from a good plant, accordingly, is selecting the female parent only. Each kernel on the ear may have been pollinated from a different male parent plant. It is this condition that has made it impossible to select varieties of corn that breed true for any but the most simple characters. The breeder sees only what the female parent is like; the pollen parent is unknown. Moreover, many characters are not expressed in the hybrid condition. Thus, a true-breeding red corn crossed with a white corn produces nothing but red ears in the first generation. Nevertheless, if such a cross is grown in the next generation, about one-fourth of the ears will be white and three-fourths red. The breeder sees then only what the female parent looks like, not what the selected ear will produce.

In spite of these difficulties, the better varieties of corn have been developed to a relatively high state of productiveness by careful selection over a long period. This has been done by reducing the proportion of unfavorable characters to such a low level that any one is expressed but seldom. Always, however, even in the best varieties, most of the plants are below par because of one or more unfavorable characters, and some of the plants are barren or produce nubbins because of serious inherited faults.

Controlled Pollination

The development of a good hybrid comprises (1) selecting the best possible inbred lines and (2) finding the best hybrid combination of one kind or another for commercial utilization. The final hybrid thus is the product of many years' careful selection and experiment. During this breeding period all pollinations are made by hand. Ear shoots and tassels are protected from stray pollen by covering them with paper bags. (Fig. 19.) At the proper time pollen is applied to silks to make the desired mating, and the pollinated ear shoot is again protected. In this way the parentage on both sides is definitely controlled.

FIGURE 19.—Method of covering corn ear shoots with paper bags to control pollination

Selection of Inbred Lines

The first step in hybrid-corn breeding is the isolation of inbred lines or strains. Plants of one or more varieties of corn are self-pollinated, pollen being placed on the silks of the same plant from which it came. The best of the resulting ears are planted, an ear to a row, and plants within these rows again are self-pollinated, and so on for several generations. Each year, however, only the best plants from the best rows are selected for continuing the various strains.

Among the most noticeable immediate effects of self-pollination are the decrease in the size of the plants and ears and the many peculiar characters that come into expression. With continued inbreeding there is a marked increase in the uniformity of the plants within any progeny row, although the differences from row to row are extreme. Some strains are discarded almost at once because of grossly unfavorable characters. Others are better and are continued. So far, however, among the thousands of inbred strains that have been isolated, none has been found even approaching ordinary corn in size or production. After some five to seven generations of self-pollination the strains breed practically true for whatever characters they possess. Every plant of any strain is practically like every other plant. After this it is unnecessary to self-pollinate in propagating a strain. Pollination between plants of a strain is then essentially like self-pollination.

It is these inbred strains, themselves very inferior, that are the basis of hybrid seed corn. They are of value in several ways. In the first

place, they are uniform from year to year. This gives the corn breeder his first fixed material with which to work. Again, the different inbred strains have some outstandingly good characters. Thus, some regularly produce long ears, others have stiff stalks or good roots or are resistant to disease, and the like, and it is these good characters that the corn breeder must bring together into desirable combinations. Finally, no two have exactly the same set of undesirable characters. As already mentioned, many characters are not expressed in the hybrid condition. This is particularly true of characters unfavorable to growth and production. Consequently, when two inbred strains having different sets of undesirable characters are crossed or hybridized, many of these characters are suppressed in the first hybrid generation.

Finding Good Hybrid Combinations

To a certain extent the breeder can select inbred strains for crossing on his knowledge of their characters. Beyond this, however, he must rely for the present on testing large numbers of hybrids to find those strains that combine best. The inbred strains producing the poorer hybrids are discarded. Those producing the best hybrids are again crossed and the hybrids tested more adequately. Eventually, through continued elimination and selection, a few lines that combine to advantage in several combinations are found. (Fig. 20.) Finally, some two or three combinations that have been among the best in a given locality during several seasons are placed in commercial production.

Different Kinds of Hybrids

Inbred strains may be combined into different kinds of hybrids. The simplest of these is the single cross, or hybrid between two strains. Thus, designating the female parent first in the customary way, A×B designates the single cross of strain A pollinated by strain B. The seed of the cross is that produced on the plants of strain A and may not appear noticeably different from self-pollinated seed of A. The vigor of hybridity becomes evident, however, shortly after germination begins.

The 3-way cross is the hybrid of a single cross between two inbred strains as one parent, and a third inbred strain as the other parent. It is customary to use the single cross as the female and the third inbred strain as the male parent in producing a 3-way cross. Thus (A×B)×C designates the single cross A×B pollinated by strain C. The crossed seed produced on the vigorous A×B plants is superior in quality and quantity to that produced on inbred plants as in single crosses. (Fig. 21.)

Double crosses are hybrids between two single crosses, involving four different inbred strains. Thus, the double cross or hybrid (A×B)×(C×D) designates the hybrid of the single cross A×B pollinated by the single cross C×D. Here, both the male and female parent plants are vigorous hybrids. The seed quality and production are high, as in 3-way hybrids, and there is every possible assurance of abundant pollen from the male parent, which is not true when this parent is an inbred strain.

The cross of a commercial variety by an inbred strain has been variously designated as a top cross, inbred-sire cross, and the like. In limited experiments, some such crosses have yielded more than ordinary varieties but less than comparable double crosses. Their chief

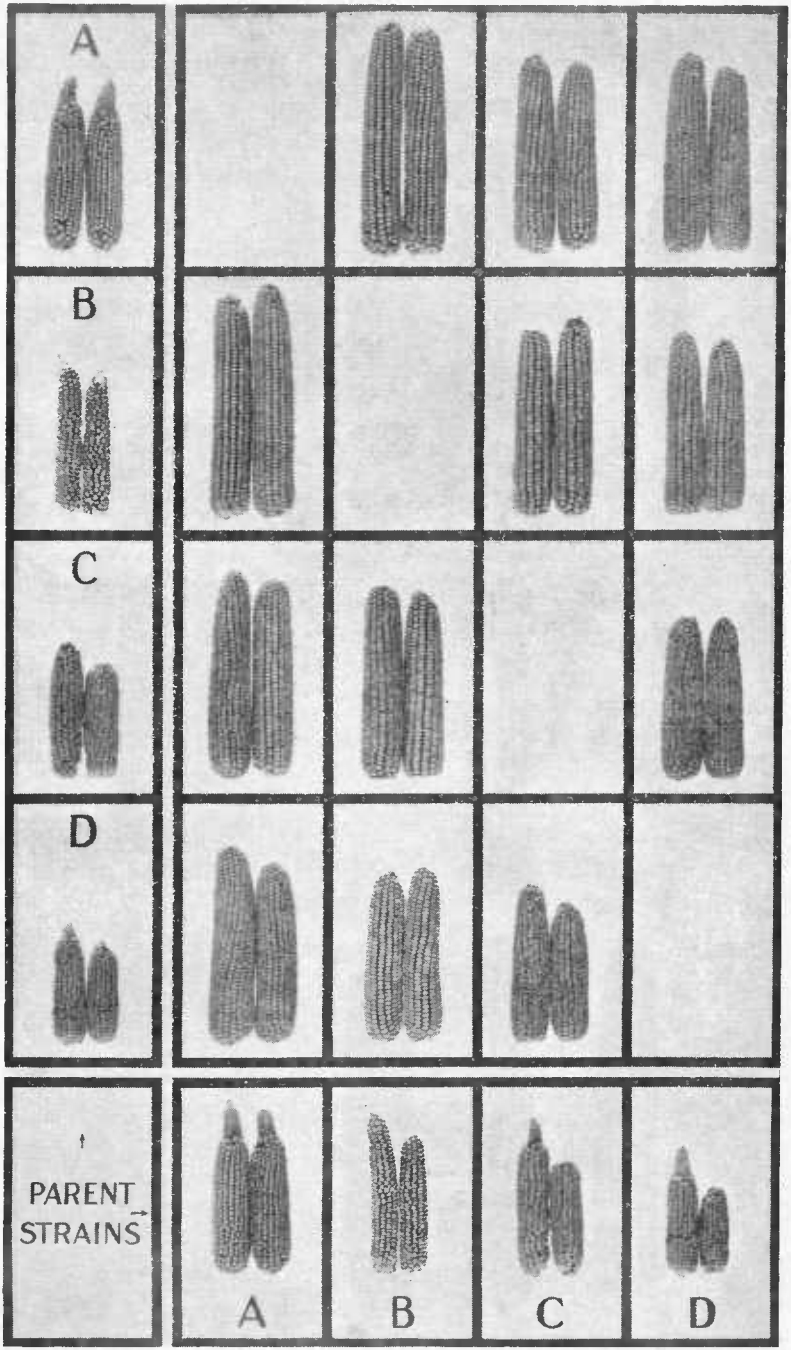

FIGURE 20.—Representative ears of four inbred lines of corn and of the six single-cross hybrids among them. The ears of the inbred parents, A, B, C, and D, are along the left and across the bottom margins. The hybrids are in the appropriate squares at the intersection of the leads to the parents, each hybrid being shown twice. The two ears (inbred D and Hybrid CD) banded together are from the same plant

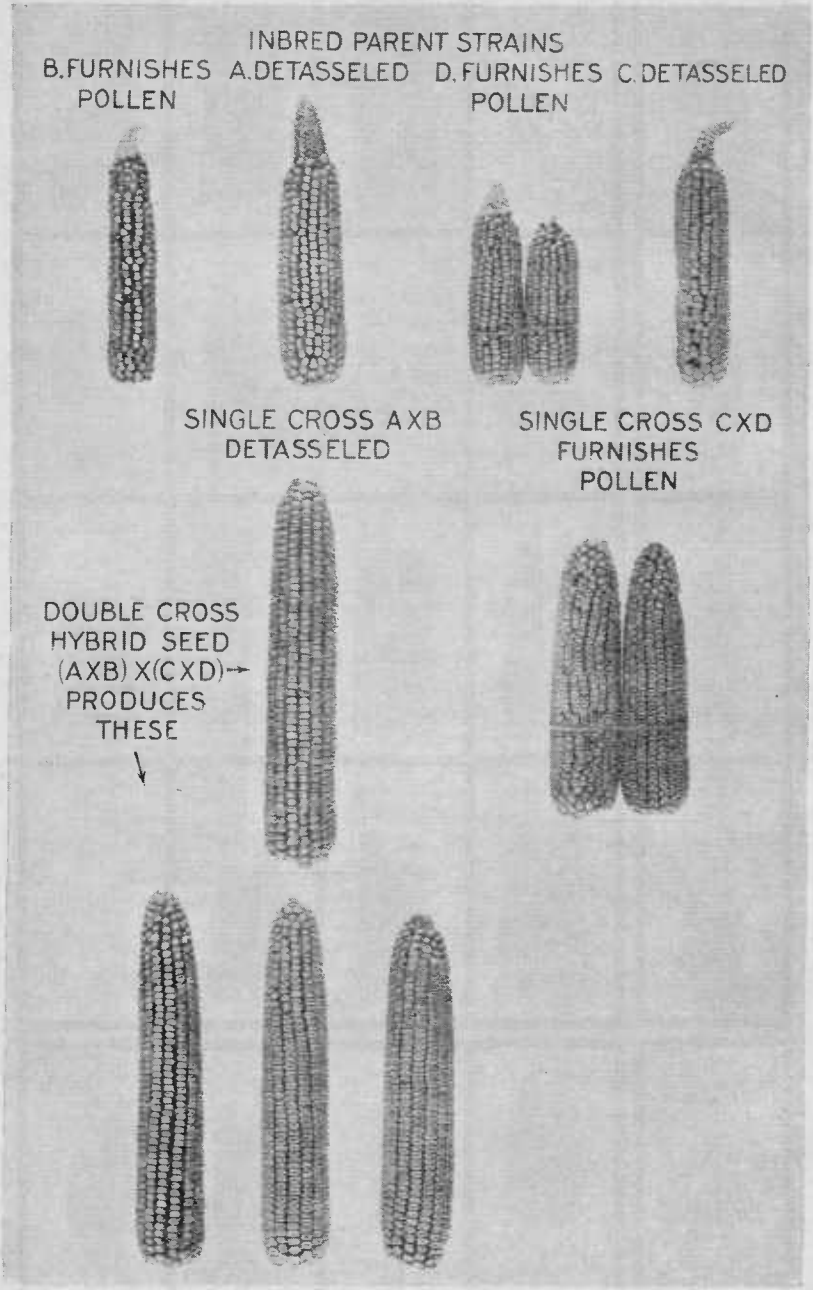

FIGURE 21.—Illustration of the production of double-cross hybrid seed corn. The ears of the parent inbreds at the top breed true if self-pollinated. A pollinated by B, and C pollinated by D, however, produce the single crosses shown. Single cross (A×B) pollinated by single cross (C×D), as illustrated, is the double-cross seed used for producing the commercial crop. Ears banded together are from the same plant

value at present appears to be in the fact that it is easier to find one inbred that will combine well with some standard variety than to find three or four inbreds that will produce a good 3-way or double cross.

Advantages of Different Hybrids

Any of these hybrids can be used for planting for commercial corn production. The single cross is at a disadvantage because of the low yield of seed and its consequent high cost. Moreover, the irregular size and shape and the generally small kernels of present field-corn inbreds make the commercial utilization of single crosses impractical. Single crosses produce the most uniform plants and ears of any of the hybrids. They accordingly have special value where uniformity is most important. Thus, uniformity is highly desirable in sweet corn for canning, and, to some extent, single crosses between inbred strains are being used commercially for this purpose. In field corn, however, 3-way and double-cross hybrids will be used unless much better inbred strains are developed.

The 3-way cross has no particular advantage over the double cross. It is slightly more uniform but not importantly so, and probably the main reason for the production of 3-way crosses commercially has been that it was easier to find three reasonably good inbred strains than four. The serious disadvantage of the 3-way cross is that an inbred strain must be relied upon to supply pollen for the cross. Unless an inbred that can be counted on for this purpose is available, the 3-way cross is impractical. Even a reasonably good pollinating strain requires a somewhat larger proportion of male parent plants with a somewhat higher cost of seed production. For the present and for some time to come, therefore, the double cross seems to be the most practical source for hybrid seed corn.

The user of hybrids need not worry about whether he is getting single-cross, 3-way-cross, or double-cross hybrid seed, if it is of good quality (quality including size and shape suitable for machine planting) and if it has a definite record of productiveness. The producer of hybrid seed will be governed largely by his individual facilities and the inbred strains that are available to him.

Producing Hybrid Seed Corn

Regardless of what kind of hybrid seed is involved, only the first generation of the hybrid should be sold or used for commercial planting. Only from this generation, i. e., the seed that was actually cross-pollinated by an unrelated strain or hybrid, is the maximum benefit of hybrid vigor to be obtained. The second generation of any hybrid, that is, the seed produced by the first generation, may be expected to yield from about 10 to 25 per cent less than the first generation, the exact decrease depending upon the particular hybrid. It is this fact that necessitates producing the hybrid anew for each season's use.

Hybrid seed is produced for commercial use by growing rows of the two parents in an isolated field and detasseling the plants of the female parent. In general, a field for this purpose should be not less than 40 rods from other corn unless there are buildings, trees, or other barriers between, or unless the two fields do not tassel at the same time. From two to four rows of the female parent can be planted to every row of male parent. If an inbred strain is to furnish pollen, it is safer to plant

not more than two rows of the female parent. If a vigorous hybrid is to be the male parent, four rows of the female parent can alternate safely with one row of male in the Corn Belt. As the seed comes only from the female-parent rows, this is a good reason for using a vigorous male parent.

Detasseling at Blossoming Time

During blossoming time the field is gone over at regular intervals and all tassels are pulled from the female parent plants before they shed pollen. With few exceptions the tassels emerge enough so that they can be seen before they begin to shed. A quick upward pull at this time takes the tassel out cleanly without damage to the plant. Tassels pulled too early are likely to bring with them part of the top of the plant, with some damage. On the other hand, it is not safe to wait too long, lest the tassels begin to shed before they are pulled. Therefore it is necessary to go over the field practically every day until detasseling is completed.

For large-scale hybrid-seed production the inbred strains and primary single crosses also are produced in isolated fields. This need not be considered here. For small-scale production, as for home use, it is probable that stocks of the inbred parents and single crosses can be maintained more easily by hand pollinating. A 1-acre unit for producing seed of the double cross $(A \times B) \times (C \times D)$ may be taken as an example. With three rows of the female parent $A \times B$ to every row of the male parent $C \times D$, one man easily could take care of the necessary detasseling. On the very safe basis of an estimated acre yield of 40 bushels, the three-fourths of the plants detasseled will produce 30 bushels of double-crossed seed. With a loss of one-third in culling, this will provide a minimum of 20 bushels, or enough to plant between 120 and 140 acres.

To provide single-crossed seed for the 1-acre field each year and to maintain the parent strains would require only some 200 or fewer pollinations. Thus, 20 plants of each of the parent strains would be ample to maintain these stocks. An additional 90 plants of strain A to be cross-pollinated by strain B, and 30 additional plants of strain C to be pollinated by strain D, would supply enough single-crossed seed for the acre, with a liberal margin of safety.

Yields of Hybrids

It is clear that the labor and expense of hybrid-seed production can be justified only if the hybrids will yield materially more than the best open-pollinated varieties. Yields from the Iowa corn yield test show the extent to which the yield is increased. The Iowa corn yield test has been conducted for several years by the Iowa Corn and Small Grain Growers' Association in cooperation with the Iowa Agricultural Experiment Station and the United States Department of Agriculture. Upon payment of the required fee, anyone can enter his corn and have it tested in one or more of the 12 districts into which the State is divided. Entries are divided into two classes, open-pollinated and hybrid. These are tested in such a way that the yields are entirely comparable.

Among the 701 entries scattered through 11 districts in 1931, there were 460 hybrid and 241 open pollinated, the latter presumably representing the best varieties grown in the different parts of the State.

The 12 districts are shown in Figure 22. The average acre yield of the higher yielding third of the open-pollinated entries in each district is given in figures at the bottom and to the left of the three vertical bars.[5] The superiority in acre yield in bushels of the best open-pollinated entry in the district is indicated by the height of the left-hand bar and is stated in figures above that bar. In the extreme northwestern district the average acre yield of the upper third of the open-pollinated entries was 36 bushels. The best variety yielded 2 bushels more than this, the upper third of the hybrids yielded 5 bushels more, and the best hybrid yielded 8 bushels more than 36 bushels.

It seems safe to assume that the yield of the best open-pollinated entry in each district represents the most that could be obtained from open-pollinated varieties in that season and locality. The much larger yields of the better hybrids are self-evident. As an average for the 11 districts in 1931, the upper third of the open-pollinated varieties yielded 56 bushels, the best open-pollinated varieties yielded 59 bushels, the upper third of the hybrids 62 bushels, and the best hybrids 68 bushels. On this basis, the upper third of the hybrids yielded 10.7 per cent and the best hybrids 21.4 per cent more than the upper third of the open-pollinated varieties. These results are not unique. Similar differences have been obtained in Iowa as well as in many other States, in previous years. It seems to be conclusively shown that materially larger acre yields can be had from corn hybrids.

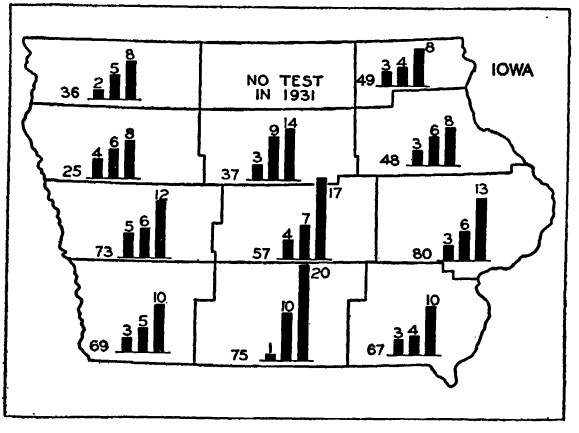

FIGURE 22.—Acre yields, in bushels, of the higher-yielding third of the open-pollinated varieties in 11 districts of the Iowa corn yield test in 1931 (values at the bottom and to the left of the three vertical bars) and the excess acre yield of the best open-pollinated variety (left-hand bar), of the higher-yielding third of the hybrid entries (middle bar), and of the best hybrid entry (right-hand bar)

Not All Hybrids Are Productive

It should be emphasized here that not all hybrids are productive. The foregoing comparisons are based on the better hybrids. If one can know he is getting a better hybrid, that is all that is of interest. This fact must be known from the previous performance or from the reliability of the source from which hybrid seed is obtained. The lowest yield in each of the six districts in the southern half of Iowa in 1931 was made by a hybrid entry. A grower buying hybrid seed just because it is hybrid has no assurance that he will not have to pay a tremendous price for it in low yield.

It should also be emphasized that adaptation is just as important in hybrid seed corn as in ordinary varieties. Hybrids adapted to southern Iowa are too late-maturing to be grown safely in northern Iowa.

[5] Data from the following publication: ROBINSON, J. L., and BRYAN, A. A. IOWA CORN YIELD TEST RESULTS FOR 1931. Iowa Corn and Small Grain Growers' Assoc., Ames, Iowa, Rpt. 12, 32 p. 1932.

The fact that a hybrid is productive in Ohio is little evidence of its value in Missouri or Kansas.

Finally, hybrid seed corn will not produce large yields in spite of poor soil and poor culture. The plants are more efficient in general. But where fertility or moisture is available for an acre yield of no more than 20 bushels of corn, this condition is the limiting factor whether the seed be a variety or a hybrid. The purchase of hybrid seed to plant on unproductive soil rarely will be profitable.

Sources of Hybrid Seed

This article is written to give information on what hybrid seed corn is, not as propaganda for its immediate and general use. Such propaganda would be premature in many localities, inasmuch as hybrid seed or the parent inbreds are available in only a relatively few States at the present time. The United States Department of Agriculture and many of the State experiment stations, however, have corn-breeding programs aimed at the production of hybrid seed corn, and within a very few years such seed should be more widely available. Already several commercial seed companies are offering hybrid seed for sale and a few of the State experiment stations are distributing hybrid seed for trial and single crosses for production of double-crossed seed on the farms. Anyone interested in hybrid seed corn should write to his State agricultural experiment station for information on the availability of hybrid seed adapted to his locality.

The development of inbred strains for the production of hybrid seed is a more elaborate project than most farmers are justified in undertaking. Occasional individuals with the necessary time and facilities may be interested in this phase of corn breeding. It is suggested that such individuals obtain United States Department of Agriculture Bulletin 1489, Corn Breeding, which contains a more detailed discussion of the principles and practice of this and other methods.[6]

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BARLEY Acreage Is Increasing Because of Crop Feed Value

Farmers to-day think much more highly of barley as a feed than they did 15 years ago. This change has been gradual. Despite a lessened commercial demand, acreage and production of barley have increased. The quantity of barley fed on the farms where it is grown is much greater now than in 1918. Dairy farmers are using more and more barley. There has even been a recent increase in the acreage in the Eastern States, where heretofore barley has been considered of more or less dubious value.

The increased use of barley as a feed has been accompanied by the production and distribution of higher-producing varieties by Federal and State experiment stations. Trebi barley produces high yields under a wide range of conditions. It has spread from a single locality in Idaho, where it was first commercially grown in 1917, until it is widely distributed in the United States and Canada.

Smooth-awned varieties have been produced by State and Federal plant breeders as a direct offering to the feeders. Nearly a dozen are

[6] Department Bulletin 1489, Corn Breeding, may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25 cents.