Production of hybrid corn

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SUMMARY

1. The earlier methods of breeding corn, such as mass selection, ear-to-row selection and varietal hybridization were unsuccessful because of inadequate control of parentage.

2. The present method of breeding, which utilizes inbred lines, provides a complete control of parentage.

3. Inbred lines are developed by controlled self-pollination accompanied by rigid selection. After the inbred lines have become relatively uniform they are tested in hybrid combinations to determine their commercial value. Top cross tests provide a basis for the discarding of many new lines. The remaining lines are tested in single cross tests which provide additional information on the value of the lines and also make possible the prediction of desirable double cross combinations.

4. Inbred lines which have been shown to combine well but which have certain specific weaknesses can be improved by outcrossing to lines strong in these specific characters, followed by backcrossing and selfing.

5. Comparable tests of first and second generation double crossed seed indicate an average reduction in yield of about 15-20 percent from the use of second generation seed.

6. During the period 1932 to 1934 the inbred lines comprising four double crosses were released by the Iowa Agricultural Experiment Station. The performance records for these hybrids (Ia. 931, Ia. 939, Ia. 942 and Ia. 13) in the Iowa Corn Yield Test are presented. The performance records of six new hybrids are reported, showing them to be superior to the established hybrids in yield or some other character.

7. Since 1934, 10 additional lines have been released by the Iowa Agricultural Experiment Station.

8. The different commercial hybrids have been shown to vary considerably in value. Results obtained in the Iowa Corn Yield Test are suggested as one of the best guides for relative performance under Iowa conditions.

9. The best assurance of satisfactory performance and adaptation available to the buyer of hybrid seed corn is certification. Certification insures that the seed is of the strain that it is represented to be; that the parent seed stocks are true to type, that crossing was thorough and under proper isolation and that the hybrid has met certain definite performance requirements.
Production of Hybrid Corn

BY G. F. SPRAGUE

Corn is a cross-pollinated crop; that is, pollination of the silks of any ear is largely accomplished by pollen from some other plant. When allowed to reproduce normally the resulting plants exhibit variation in all measurable characteristics. Each plant has received an assortment of hereditary potentialities from its two parents, some good and some bad. Even plants of excellent appearance may carry undesirable elements in a masked condition. These undesirable characteristics will reappear in later generations as a result of the reassortment of the hereditary material. If the undesirable elements are not masked, the affected plant may be low in yield or even barren. The frequent occurrence of barren plants or plants with small ears in open-pollinated varieties is responsible for most of the difference in yielding ability between such strains and the best hybrids.

The mode of pollination has been the major factor responsible for the failure or success of past and present systems of corn breeding. The methods which have been used may be classified under the general heading of mass selection, ear-to-row selection, varietal hybridization and selection within and among inbred lines.

MASS SELECTION

Mass selection is accomplished by saving seed from desirable plants of the main crop, bulking the seed so obtained and planting it en masse. This method of breeding probably has been practiced since the domestication of the corn plant and has been effective in modifying plant and ear type, maturity and certain other characteristics but has not been particularly effective in increasing yields during the past century. The failure to increase yields was due largely to two causes. First, yielding ability is inherited in a very
complex manner, and it would be very difficult if not impossible to find plants possessing only desirable characteristics. Our inability to distinguish such plants when they do occur complicates the selection process. Second, the majority of the plants of desirable appearance have been naturally crossed with less desirable types so that the resulting progeny exhibit low yielding or barren plants as before. Even if all undesirable plants could be removed from the field before pollen shedding, it would take many hundreds of generations to eliminate all undesirable characteristics, as these may be present in a masked condition in even the best-appearing plants and will continue to appear in succeeding generations.

**EAR-TO-ROW BREEDING**

The ear-to-row method of corn breeding came into prominence about 1900. This method recognized that the appearance of the parent plant and ear was an unsatisfactory guide as to its yielding ability and the general desirability of its progeny. With the ear-to-row method the appearance of the plant as the basis for selection was supplemented by the performance of its open-pollinated progeny. In practice the method consisted in selecting ears of desirable appearance from good plants and comparing the performance of these individual ears in yield tests. Large differences were found in the yielding ability of different ears, and only the progeny from the best of these was used for further selection. Many modifications of this general method were introduced to prevent pollination by inferior plants and to prevent inbreeding. In spite of these modifications, experiments covering a period of years indicated very little gain in yielding ability over strains isolated by mass selection. Successive repetitions did not produce cumulative increases in yield. The original ears which produced high-yielding progeny were hybrids of unknown parentage which could not be duplicated. As with mass selection, desirable plants produced progeny, part of which was low in yielding ability and possessed undesirable characteristics. Selection, as practiced, was not effective in eliminating these types, and this method of corn breeding was gradually discontinued.
**VARIETAL HYBRIDIZATION**

Varietal hybridization was never used on an extensive scale. Comparisons were made with crosses ranging in relationship from different strains within a variety to flint or flour x dent types. In general, crosses of strains within a variety did not result in increased yields. Crosses between varieties sometimes produced increased yields, but the results obtained applied only to the two strains crossed. Combinations of flint or flour types intercrossed or crossed with dent corn produced the largest yields. As flint and flour types adapted to the central Corn Belt were not available, the use of this method of breeding was largely confined to the northern part of the Corn Belt.

**SELECTION WITHIN INBRED LINES**

The development of inbred lines and the use of hybrids among such lines have now supplanted the breeding methods just mentioned. The scientific basis for this method of breeding was established by G. H. Shull and E. M. East. Although these men were interested in theoretical problems of inheritance, they observed the marked reduction in vigor which accompanies inbreeding and the complete restoration of this vigor in certain crosses among inbred lines. The bearing of these results on corn improvement was pointed out, but the very poor inbred lines available at that time made the commercial utilization of hybrid corn appear very costly. The use of double crosses, suggested by D. F. Jones, and the development of better lines and better breeding technics by numerous workers, made the commercial production of hybrid corn feasible. Hybrid corn offers one of the very excellent examples of the value of research to practical agriculture.

**POLLENATION AND FERTILIZATION**

It is necessary to have a thorough understanding of the flowering habits of corn to appreciate how inbred lines are developed and how hybrid seed may be produced on a commercial scale. Pollination must be controlled to effect any type of systematic mating, whether this be selfing or crossing. The tassel bears the pollen which contains the male sex...
cells of the plant (fig. 1). Pollen shedding usually begins in from 1 to 4 days after the tassel emerges. At the time of shedding each pollen grain contains two sperms. The ear bears the female sex cells, or ovules, each of which develops into a single grain of corn after fertilization (fig. 2). The silks, the greatly elongated stigmas and styles of the female flowers, are receptive to pollen before they emerge from the ear shoot and remain receptive for a period of 10 days to 2 weeks if fertilization is delayed. Fertilization is accomplished by a pollen grain falling on a silk, where it germinates (fig. 3). The pollen tube penetrates the silk and grows down its length to the ovule where the sperm are discharged. One sperm fuses with the egg to give rise to the embryo or germ. The second sperm fuses with the polar nuclei to give rise to the endosperm, the starchy portion of the corn kernel. Under open-pollinated conditions each kernel of an ear may have a different male parent. With the temperatures usually prevailing during July and August, fertilization is accomplished about 20 to 30 hours after pollination.

TECHNIC OF INBREEDING

The inbreeding or selfing necessary for the production of inbred lines may be accomplished most easily and safely by
Fig. 2. The pistillate or female inflorescence of corn.
A. The young ear shoot with husks removed showing the attachment of the silks.
B. An enlarged section through a group of ovules, showing more detailed structure.
hand pollination. This requires that both the ear shoots and tassels be bagged. Ear shoots should be bagged or covered as soon as they emerge from the leaf sheath, to prevent stray pollen from falling on the silks and bringing about miscellaneous fertilization of the female flowers. In some strains it will be necessary to loosen the bag after a day or so to prevent the developing shoot from growing up through the bag.

Pollen is obtained by covering the tassel, after shedding begins, with a bag clipped in place. Pointed or square bottom bags, glued with a water-proof adhesive, are used for this purpose. Tassels bagged one day will provide pollen for use the day following. The technic used in pollination varies somewhat with different corn breeders. The important feature is that the pollen be applied to the silks with as little exposure to contamination from outside pollen as possible during the operation.

Two different pollination technics are used at the Iowa Agricultural Experiment Station. The first of these to be described is known as the “bottle method.” The ear-shoots are first covered with glassine bags about 2½ x 6 inches in size. When the silks have emerged and the tassel is shedding freely, the tassel and about 6 to 8 inches of stalk are cut from the plant. The ear-shoot bag is removed and the shoot cut off about 1 inch below the tip of the husk. The freshly cut surface of the silks exude moisture and any stray pollen falling on them during the exposure bursts before germina-

Fig. 3. The germination of pollen grains on a corn silk.
Pollination can take place. The tassel, enclosed in a 12-pound bag, is then placed over the cut shoot. The cut end of the tassel is inserted in a 2-ounce bottle filled with water which has been hung on the stalk at the point of ear attachment. The water keeps the tassel alive and shedding pollen for 2 or 3 days which is sufficient to insure the pollination of the ear. The bag with the enclosed tassel must be adjusted so that when pollen is shed it falls directly on the silks. The bottle method of pollination is illustrated in figs. 4 to 10.

A second, more widely used method of controlled pollination is as follows: Glassine bags are placed on the shoots as previously described. When the silks have reached a length of 1 or 2 inches the glassine bag is raised slightly and the tip of the shoot, about 1 inch below the tip of the husk, is cut off. The shoot bag is then replaced. The tassel bag is placed over the tassel and clipped in place. Corn pollen is short-lived so that stray pollen on the tassel at the time of bagging will be dead by the next day. The day following the cutting of the shoot the silks will have grown out sufficiently to form an even brush. Pollen is then transferred from the tassel bag to the silks, the tassel bag being placed
over the ear and fastened in place (figs. 11 and 12). There are several methods used in this transfer of pollen, any one of which is satisfactory in the hands of experienced operators. One procedure is to remove the shoot bag, pour on the pollen, and then place both the shoot and tassel bag over the ear. In a second method the top of the shoot bag is torn off, the pollen applied, the shoot bag crumpled down and covered with a tassel bag. With still a third method the tassel bag is folded crosswise about one-third of the distance from the bottom, with the pollen in the bottom of the bag. The tassel bag is then placed over the shoot and the shoot bag removed without touching or exposing the silks. The bottom of the tassel bag is then flipped upwards and shaken vigorously, causing the pollen to fall on the silks.

Regardless of the method used a slight amount of contamination may be expected. The careless placing of shoot bags before pollination and faulty adjustment of the large bags after pollination are more important sources of contamination than the pollination technic used. The prevalence of insects such as grasshoppers and chinch bugs increases the amount of contamination by foreign pollen.

Fig. 5. An ear shoot at the proper stage for cutting back preparatory to pollination.
PRODUCTION OF INBRED LINES

Inbred lines are produced by self pollination. Inbreeding or selfing is of importance only in that it provides a means of isolating desirable hereditary characteristics and affords a convenient method of maintaining these characteristics after they are once isolated. The role of selection at the beginning of, and during the inbreeding process, cannot be overemphasized. Material to be used for the production of inbred lines should represent the best germ plasm available. In the extensive breeding program started at the Iowa Agricultural Experiment Station about 1922 the best source material available was high-yielding, open-pollinated varieties. More recently the better single and double crosses have been used as source material. It may be pointed out, however, that there are still many corn varieties, unrelated to the varieties previously sampled, which probably could be used with profit.

After selection of suitable material the best plants are self pollinated or inbred by one of the methods outlined above. The plants which were self pollinated are again carefully culled at harvest time as many will then exhibit faults which
were not apparent earlier in the season. Numerous studies have indicated that the appearance of a plant is a poor indication of its combining ability. This difficulty requires that inbreeding be done on a sufficiently large scale to insure that, even with the discarding of many lines because of poor combining ability, enough good lines will be isolated to insure the success of the program. Selection is effective, however, for such necessary qualities as stalk and root strength, freedom from disease and general plant vigor.

All open-pollinated corn varieties, and advanced generations of hybrids to a lesser extent, are highly variable. This variability is due to the fact that the individual plants have received somewhat different assortments of heritable characteristics. When inbreeding is begun this variability is emphasized because inbreeding tends to uncover a large number of undesirable types which have been masked by cross pollination. Inbreeding also tends to intensify parental characteristics in the resulting inbred progeny.

The ears which are finally saved from the first selfing are planted the following year in progeny rows, one row for each selfed ear saved. On emergence many of these progeny rows will exhibit undesirable characters such as white, yellow, striped and dwarf seedlings. Additional undesirable types

Fig. 7. A close-up view of the same plant shown in fig. 6.
will become apparent as the plants attain their full growth. Often the entire row exhibiting such defects may be discarded. If superior plants are present, however, these may be inbred with reasonable assurance that the undesirable traits can be eliminated.

Selection and further inbreeding usually are confined to the best plants within the best rows. This process of ear-to-row planting, inbreeding and selection usually has been continued for three or four generations before any attempt has been made to measure combining ability of the line in hybrids.

During the course of inbreeding there is a marked reduction in vigor. This reduction is greatest in the first generation, amounting to approximately one-half of the total decrease which will occur from the open-pollinated to the pure line condition. In each succeeding generation the loss in vigor is approximately half as great as in the preceding generation. After four to five generations of inbreeding further decreases in vigor are so small as to be of little consequence. The plants comprising a single inbred line are relatively uniform, but the differences among lines are often quite striking (fig. 13).

**TESTING OF INBRED LINES**

After inbred lines have been obtained the next step is to evaluate their commercial possibilities. This can be done only by testing them
in hybrid combinations. Upon crossing, the vigor lost during inbreeding is restored and in desirable combinations is markedly greater than in the open-pollinated varieties from which the inbreds were derived. There is a marked tendency for inbreds to transmit to their hybrid progeny the characteristics which they exhibit as inbred lines. Combinations between weak-stalked or disease-susceptible inbred lines commonly produce weak-stalked or disease-susceptible hybrids. In general, the most productive hybrids come from crosses involving the most productive lines.

Three types of crosses are commonly used in testing the combining ability of an inbred line. These are top crosses, single crosses and double crosses.

A top cross represents a combination between an inbred line and a variety. A variety is used as the top cross parent because it is variable for most of its characteristics and thus provides a broad background of genetic diversity for testing new material. Such combinations usually are produced by growing the inbred lines in an isolated field with some open-pollinated variety and detasseling the inbred parents. Seed harvested from these lines is used in yield tests. Relative performance with respect to yield, lodging, disease resistance, etc. determines

Fig. 9. The bag with the tassel enclosed is being placed over the cut shoot. The cut end of the tassel is inserted in the bottle which has been filled with water.
whether a particular line shall be discarded or subjected to additional tests. One the basis of this first test a large percentage of the lines may be discarded as unsuited for commercial production.

The lines considered worth further testing then are combined in all possible single cross combinations (a single cross is a cross between two inbreds). These single crosses are compared in yield tests to measure their relative performance with respect to acre yield, disease resistance, lodging resistance, etc. On the basis of such tests of single crosses, additional lines may be discarded as being unsuited for commercial production. The inbred lines are combined into single crosses in all possible combinations to facilitate predicting the performance of double crosses (a double cross is a cross between two single crosses): The desirability of some method of predicting double cross performance can be illustrated by a simple example. Among 16 inbred lines it is possible to produce 120 different single crosses and 5,460 different double crosses, excluding reciprocal combinations. It is quite feasible to produce and test 120 single crosses, but it would be impractical if not impossible to produce and test 5,460 double crosses.

Fig. 10. After the tassel is placed over the cut shoot the bag is then clipped in place and the pollination is completed. In about 3 days the bottles can be collected and used again for subsequent pollinations.
PREDICTING THE YIELDS OF DOUBLE CROSSES

Fortunately it is possible to predict double cross performance from single cross yield data with a considerable degree of accuracy. The method used is illustrated with four lines, A, B, C and D. These can be combined to produce six single crosses (disregarding reciprocals):

1. A x B
2. A x C
3. A x D
4. B x C
5. B x D
6. C x D

and three double crosses (likewise disregarding reciprocals):

(A x B) (C x D)
(A x C) (B x D)
(A x D) (B x C)

The performance of the double cross (A x B) (C x D) may be predicted from the data on the four possible non-parental single crosses. The reason for using these particular singles is apparent when we consider that, in the double cross, factors or genes contributed by line A, and having an affect on yield, can combine only with factors contributed by lines C and D. Hence our interest in the combinations (A x C) and (A x D).

Similarly desirable factors contributed by line B can combine only with factors contributed by lines C and D. Thus the average of the four non-parental single crosses A x C, A x D, B x C and B x D gives a close approximation to the performance of the double cross (A x B) (C x D).

The performance of any double cross combination can be
predicted in a similar manner if single cross data are available. Only those double crosses having the best predicted performance are made and tested. By confining the testing to the best double crosses the number of combinations is reduced sufficiently so that testing is feasible. It should be emphasized that prediction is not an infallible guide to performance. The yield of any double cross combination varies with seasonal conditions. Furthermore the appearance of a hybrid is an important factor in determining whether or not it will be commercially acceptable. Thus it is necessary that these predictions be confirmed or disproved by actual yield trials covering at least a 2-year period.

If inbreeding is done on a large enough scale there is reasonable certainty of finding desirable double cross combinations among the lines obtained. The best of these combinations, after their worth has been proved, are ready for production on a commercial scale.

Another method of inbreeding and testing lines is being used at the Iowa Agricultural Experiment Station. At the time of the first selfing the selected plants are outcrossed to testers which may be either single crosses or double crosses. These testers are chosen because of specific weaknesses. The top crosses so produced (selfed plant x tester)
are compared in yield tests. This procedure yields information on the combining ability of the selfed plant and also provides a measure of the ability of the line to correct the faults of the tester parents. A large percentage of the lines can be discarded on the basis of their performance in these top crosses. The remaining lines then are planted on a larger scale to increase the efficiency of selection during further inbreeding. Desirable plants may again be selfed and out crossed to testers. In practice this method may require about the same number of years from the first inbreeding to the tested hybrid as does the older method previously described, but the time may be shortened materially if the data on single crosses among early generation lines may be used successfully in predicting the performance of double crosses. The method appears to have a real advantage in permitting

Fig. 13. A comparison of several “fixed” inbred lines showing the differences between lines and the uniformity from plant to plant within lines.

the testing of new material early in the process of inbreeding and insures that all subsequent inbreeding and testing will involve material known to combine well in hybrids.
COMMERCIAL PRODUCTION OF HYBRIDS

It is obvious that the methods used by the corn breeder to control pollination are not suited to large-scale commercial production. Isolation and detasseling are satisfactory commercial substitutes for the shoot-and-tassel bag. The inbred seed necessary for the production of single crosses usually is produced in isolation. Effective isolation may be influenced by such factors as natural barriers to wind movement, such as trees, etc. and by border rows, but the greatest single factor is distance. Pollen has been known to travel considerable distances through the air, and a distance of 40 rods from all other corn should certainly be the minimum. Greater distances are preferable when they can be obtained.

Single-crossed seed also is produced in isolated plots. The inbred having the best seed characteristics usually is selected as the seed parent. The male parent, in addition to other desirable characteristics, must be a good pollen producer. The common ratio of parent rows for single-cross production is one or two rows of the seed (female) parent to one row of the male. All isolated plantings for seed production should be drilled rather than check planted to facilitate the easy detection and complete removal of off-type plants.

The tassels are removed from the female rows as soon as they emerge or before pollen shedding begins. The removal of leaves when the tassel is pulled should be kept to a minimum as it has been shown that there is a close relation between the number of leaves removed and reduction in yield. Some strains under drouthy conditions, however, may start to shed pollen before the tassel has completely emerged. When such a condition exists it is necessary to pull the tassels before shedding regardless of the damage to the plants. The single-crossed seed which will be used for double-cross production is harvested from the detasseled rows. In theory the grain produced by the pollen (male) rows is inbred seed of the male parent and satisfactory for subsequent use. In practice it has been found difficult to maintain the purity of such material. As a consequence it has limited-breeding value and should be used only for feed.

Double-crossed seed is produced in a similar manner (fig. 14). Different single crosses are used as the male and female
parents and the ratio of female to male rows usually is three or four to one. An important consideration in the choice of the single cross which will serve as the female parent is the grading qualities of the seed produced. Other characteristics being equal the best female parent will be the one which yields the highest percentage of medium sized, flat kernels.

**IMPROVEMENT OF ESTABLISHED LINES**

After a hybrid is in commercial production it often is found that one or more of the lines involved have specific weaknesses which limit the value of the hybrid. In many cases these faults can be corrected by outcrossing to a line that corrects the faults, followed by backcrossing and selfing. To illustrate the operation of this method let us assume that line A, which is used in a good double cross, is rather susceptible to lodging, and that we wish to improve the line in this respect. Line A, then, is crossed to some non-lodging line, which we shall identify as C, and the hybrid is crossed back to line A. These back-crossed ears are planted ear-to-

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**Fig. 14.** A double-cross seed-production field after detasseling is completed. The ratio of female to male rows was 4 to 1.
row and the best plants in the best progenies again crossed to line A. Selection is of vital importance in maintaining the desirable stalk and root qualities contributed by parent C. Back crossing to line A insures the recovery of the essential part of line A's combining ability. The number of back pollinations which may be used with safety depends on the line involved, the complexity of inheritance of the factor being introduced and the efficiency of visual selection. In practice, from one to three generations of back pollination are used. This must be followed by an additional two or three generations of self pollination to fix the desirable characteristics introduced from the non-recurrent parent. Success in such an improvement program is dependent very largely on the efficiency of selection during back pollination and selfing. The improved lines resulting from such a procedure should be tested again to determine whether they still combine satisfactorily. In actual experiments with this breeding method it has been shown possible to correct the faults of a particular line and also increase the yield of the resulting hybrid.

Fig. 15. Producing single-crossed seed on detasseled plants in two-row 'blocks. The plants were grown from inbred seed produced by open-pollination in isolated plots.
Fig. 16. Increasing the seed of an inbred line by open-pollination in an isolated field. The plants were grown from hand-pollinated seed. A distance of 70 to 80 rods from other corn is highly desirable.

SEED SIZE

Many of the kernels on any ear of corn will differ in size and shape. When the corn from a commercial seed-production field is shelled it is graded into different sizes; large, medium and small rounds and large, medium and small flats, etc. to permit a uniform rate of planting. The question often is raised as to the relative value of these different grades. As all are the produce of a cross between the same male and female parents, all have the same potentialities for yielding ability, disease resistance, etc.

In tests comparing these different grades under similar conditions, seed size has not been an important factor affecting yield. Now that planter plates are available which will handle practically any size or shape in a satisfactory manner the decision as to the seed to buy should be based largely on the per acre seed cost.

USE OF SECOND GENERATION SEED

Occasional reports are received indicating satisfactory results from the use of seed saved from a commercial field of double-cross corn (second generation seed). These observations usually are not based on carefully conducted yield tests but are based on the performance of hybrid seed in 1 year with the performance of second-generation seed the year following. Many experiment stations have conducted tests
comparing the relative yield of first and second-generation, double-crossed seed. All results are in agreement and indicate an average reduction in yield of about 15 to 20 percent from the use of second generation seed.

The reduction in yield arises from the fact that the four lines comprising a double cross represent a very restricted sample of the hereditary constitution of the parent variety. Thus, open pollination within a double cross permits the mating of related types resulting in a mild form of inbreeding. Even this degree of inbreeding decreases vigor and reduces yield.

HYBRIDS DEVELOPED AND RELEASED BY THE IOWA STATION

In the period from 1932 to 1934 the inbred lines for four double crosses, known as Iowa Hybrids 931, 939, 942 and 13, were released for commercial production. Each of these hybrids represented a considerable improvement in yielding ability and resistance to lodging over the standard open-pollinated varieties. The 6-year average performance record for each of these four hybrids is presented in table 1.

Since 1934 eight additional lines have been released and several new hybrids made available for commercial production. Some of the older hybrids are dropping out of production as newer and better ones become available. The per-

| TABLE 1. PERFORMANCE RECORDS OF THE FIRST FOUR CORN HYBRIDS RELEASED FROM THE IOWA STATION, COMPARED WITH THE BEST AVAILABLE OPEN-POLLINATED VARIETIES IN THE IOWA STATE CORN YIELD TEST; AVERAGE FOR THE 6 YEARS PERIOD 1935-1940 INCLUSIVE. |
|---|---|---|---|---|---|---|
| Iowa 931 | Section | Acre yield bu. | Stand % | Moisture % | Lodging % | Dropped ears % | Damaged seed % |
| Variety average | N | 70.75 | 86.4 | 20.2 | 18.0 | 5.6 | 2.5 |
| Iowa 939 | N | 61.90 | 83.4 | 20.2 | 36.7 | 1.9 | 3.1 |
| Iowa 942 | NC | 69.76 | 80.3 | 20.0 | 14.1 | 2.9 | 2.5 |
| Variety average | NC | 65.26 | 79.3 | 18.8 | 18.7 | 3.7 | 2.5 |
| Iowa 939 | S C | 65.93 | 81.9 | 17.0 | 13.6 | 2.0 | 3.1 |
| Iowa 942 | SC | 61.63 | 80.3 | 16.0 | 17.9 | 2.4 | 4.2 |
| Iowa 13 | SC | 71.44 | 86.5 | 17.2 | 26.7 | 2.5 | 4.1 |
| Variety average | SC | 56.73 | 80.1 | 15.3 | 29.9 | 2.3 | 3.3 |
| Iowa 13 | S | 57.41 | 85.9 | 15.1 | 22.5 | 2.7 | 3.1 |
| Variety average | S | 54.41 | 78.8 | 17.3 | 30.9 | 2.6 | 2.8 |

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Sprague: Production of hybrid corn

Table 2. Performance records for six new hybrids in comparison with the older station hybrids of similar maturity.
formance records of standard and new commercial hybrids are presented each year in the Iowa bulletin summarizing the corn yield test. These reports should be studied carefully by everyone interested in the comparative performance of corn hybrids.

In recent years a number of new hybrids have been introduced which are superior in one or more important respects to the original hybrids first released. Some of these hybrids are still so new that their value under farm conditions has not been completely established. The performance records of these hybrids are presented in table 2.

Iowa 4316, as an average of three comparisons, has exceeded Iowa 931 in yield and has considerably more resistance to lodging. It is slightly later in maturity and therefore probably not well suited for planting in northeast Iowa. This hybrid was produced on a limited acreage in 1941.

The hybrids Iowa 4057 (303), Iowa 4059 and Iowa 4164 (306) have been in limited production for the past 2 years. They are rather similar to Iowa 939 in yielding ability and
Fig. 18. Hybrids differ markedly in strength of stalks and roots. These pictures of two hybrids in the same field were taken on the same day.

maturity but possess somewhat greater resistance to lodging and ear dropping.

Iowa 4020 appears to have some promise for the southern part of Iowa. In comparable tests it has equalled Iowa 13 and Iowa 3110 in yielding ability, is lower eared and markedly more resistant to lodging.

SEED PRODUCTION A SPECIALIZED JOB

Many farmers have undertaken to develop inbred lines as a hobby. During the period of inbreeding and selection a considerable number of lines can be produced with relatively little effort. Difficulties arise, however, when the testing program is begun. The number of combinations which can be produced from a few lines and the accumulation of ade-
quate performance records usually involve more time and expense than the average farmer can devote to such work. Inbreeding and testing the resulting lines in hybrid combinations usually will require a period of at least 10 years before proved hybrids can be offered for sale. The cost of developing and testing new lines and the uncertainty of producing superior hybrids make corn breeding rather too specialized an undertaking for the average farm operator.

The production of hybrid seed also involves a considerable capital outlay. Production in excess of one's own planting needs requires adequate drying and grading facilities to insure a high-quality product. When the expense of obtaining seed stocks, isolation and detasseling are considered the grower cannot afford to risk the poor seed or loss of an entire crop which may result from an early freeze. This means the construction of a drying and storage plant. Similarly, to meet competition it is necessary that the seed be carefully graded for length, width and thickness. Each farmer must determine whether it is more economical under his conditions to buy or to produce his hybrid seed requirement.

**KNOW YOUR HYBRIDS**

Hybrids differ greatly in their commercial value. Some are very good, but the great majority range from mediocre to poor. The cost of hybrid seed is justified only if the hybrids will perform materially better than the best of the open-pollinated varieties.

The various state experiment stations throughout the Corn Belt supervise or sponsor tests to provide comparable performance data for experimental and commercial hybrids. In Iowa a state-wide corn-yield test has been conducted for over 20 years, the Iowa Corn and Small Grain Growers Association, the Iowa Agricultural Experiment Station and the United States Department of Agriculture, cooperating. The reports published annually include performance records for the current year and also average results for a period of years. Prospective purchasers of hybrid seed corn should study the results of these performance tests.

Adaptation is just as important in hybrid corn as in open-pollinated varieties. The fact that a particular combination
has done well in some other state having the same general length of growing season is no assurance that that particular hybrid will perform satisfactorily in Iowa. The only reliable way to evaluate a hybrid is to test it under the conditions where it will be grown.

The best assurance of satisfactory performance and adaptation available to the buyer of hybrid seed is certification. Certification insures that the seed is of the strain it is represented to be, that the parental seed stocks were true to type, that crossing was thorough and under proper isolation and that the hybrid has been grown in performance test plots where it has met certain definite requirements as to superiority of stalk strength and yielding ability.