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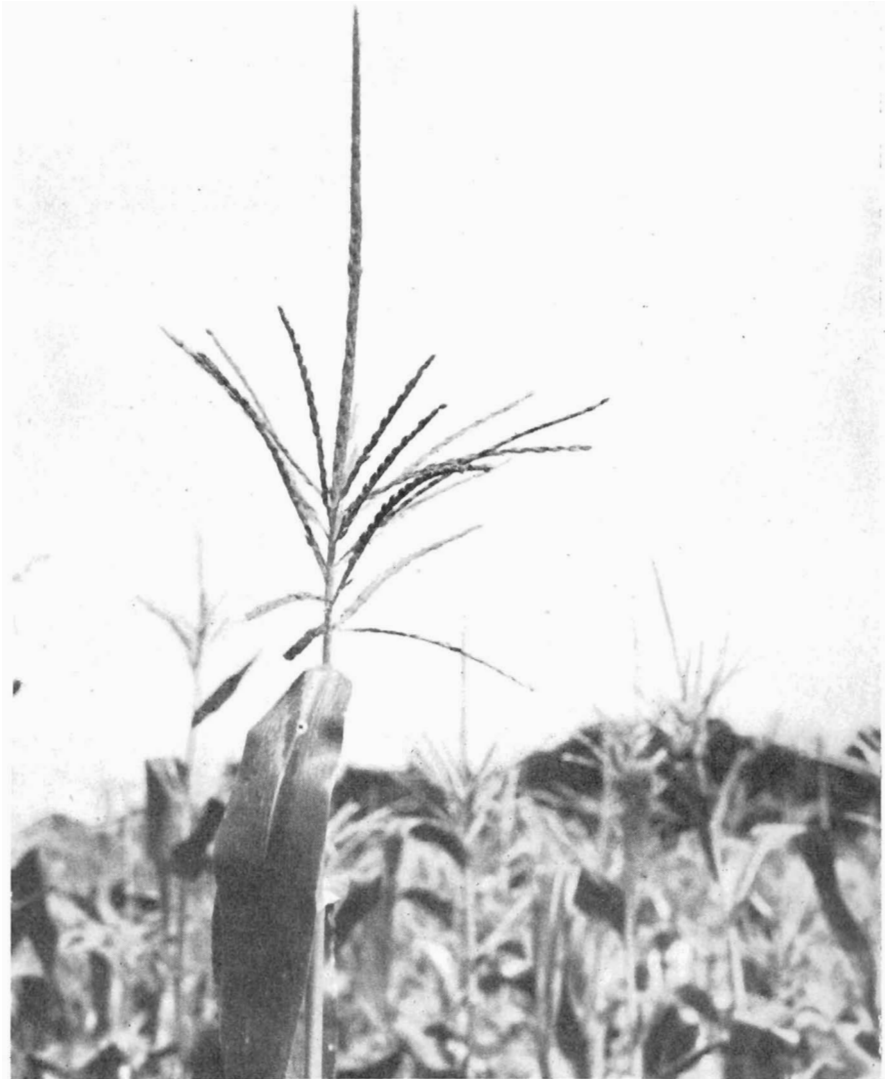
THE PRODUCTION OF HYBRID
CORN SEED WITHOUT DETASSELING

The cover picture shows normal tassel
shortly after maximum pollen shedding.

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FIGURE 1

A sterile tassel showing no anthers exposed. Compare this with the
normal tassel on the cover shown in the same stage of development.

THE PRODUCTION OF HYBRID CORN SEED WITHOUT DETASSELING

D. F. Jones [1] and P. C. Mangelsdorf [2]

A major problem involved in the production of hybrid seed corn is that of removing the tassels of one of the parents in a crossing field. In the early years of the hybrid seed corn enterprise it appeared that the labor and expense involved in detasseling might become a serious obstacle to the large-scale production and widespread use of hybrid corn. This fortunately has not proved to be the case. Nevertheless, tassel removal on a scale sufficient to produce the eight million bushels of hybrid seed needed to plant some 65 million acres of corn annually is an operation of considerable magnitude. Each summer the hybrid seed corn industry must find and train thousands of casual laborers for this purpose. One seed firm alone employs more than 20,000 laborers during the tassel-pulling season. It has been estimated that on the peak day of the season some 125,000 persons in the United States are engaged in removing tassels from corn plants. When there are labor shortages, or when rainy weather prevails during the detasseling season, the producer of hybrid seed corn has a serious problem on his hands, and the quality of his product may suffer from unavoidable self-pollination. One large producer, during a particularly rainy summer, expressed the opinion that detasseling is "the peskiest and most expensive part of the business of raising seed corn".

For more than 30 years the writers, working sometimes jointly, sometimes independently, have given attention to possible methods of avoiding or eliminating the operation of detasseling, and have conducted numerous experiments to this end. It is the purpose of this bulletin to set forth these experiments and to describe several methods, one of which has finally proved successful for eliminating detasseling, at least in part.

Shull discovered the basic importance of inbreeding in controlling heredity and in isolating valuable pure lines in corn and found that maximum vigor and productiveness could be recovered by crossing lines resulting from such inbreeding. East extended these findings to various types of corn, and to other plants as well, and demonstrated that exceptionally high yields could be obtained. East, and later Hayes, attempted the production of hybrid seed from inbreds in farm fields but gave it up as impracticable, with the inbreds then available, and returned to experimentation on the crossing of varieties, a method used much earlier by Beal in Michigan. Hayes, however, still had faith in the value of inbred strains and upon moving to Minnesota developed there an extensive program of inbreeding corn and encouraged others in the Corn Belt to do the same.

Beginning in 1915 the senior writer, who succeeded East and Hayes at the Connecticut Station, made an extensive study of the effects of inbreeding

and crossing in corn, using all of the inbred strains then available and testing these in nearly all possible combinations. Some of these first generation crosses of inbreds were so uniformly productive, and so attractive in other respects, that it seemed there must be some way in which they could be used commercially. Since many of the crosses were made between inbreds out of the same variety, and since it had been amply demonstrated that varieties of different types combined well in crosses, it seemed quite reasonable to expect that single crosses could be crossed with other single crosses to produce satisfactory hybrids, providing that the inbred strains in the different single crosses had been derived from distinct varieties.

Accordingly, after the inbreds had been increased and crossed in many combinations, and the single crosses tested along with varietal crosses in 1916, a crossing field was planted in 1917 at the Station Farm in Mt. Carmel in which 23 single crosses and 4 inbreds were detasseled and the field pollinated by one single cross for the production of three-way and four-way combinations of inbreds. In the previous year a crossing field of inbreds and varieties, all cross-pollinated by one inbred strain, had given good yields of seed on the varieties, but the yields of the inbred seed parents were discouragingly low. However, many of the crosses of these low yielding inbreds were outstanding in the yield tests. For all of these reasons it seemed obvious that the next step was to use single crosses of inbreds as seed parents in the 1917 crossing field. In order to produce abundant pollen at the proper time, it was also decided to use a single cross for the pollen parent and a cross of two of East's old original Leaming inbreds was chosen for this purpose. One of the four-way hybrids produced in this crossing field in 1917 had a single cross of two Burr White inbreds as the seed parent. When grown in 1918, this combination of four inbreds out of two distinct types of corn was outstanding in yield, in ability to stand erect, and in freedom from moldy ears. This cross, later named Double Crossed Burr-Leaming, became the first commercial hybrid corn produced by combining four inbred strains.

While the double cross solved the problem of seed production, it rendered the problem of detasseling more formidable than ever. The removal of the tassels from the tall, first generation hybrid plants proved to be a much more difficult task than the detasseling of the small inbred plants. It was at this point that the senior author first began investigations on possible methods of producing hybrid corn seed without detasseling. The methods tested and the results obtained are described in the following pages.

SEPARATING SELFED AND CROSSED SEED

When approximately equal numbers of two kinds of corn are grown in the same field, the crop will consist of selfed (or sibbed) and crossed seed in approximately equal amounts. If an effective method of separating the crossed seed from the selfed seed could be discovered, the operation of detasseling could be eliminated. Two methods were tried.

Separating by Specific Gravity

Collins and Kempton (2), Jones (5) and others had shown that on ears resulting from mixed pollinations, where the crossed and selfed seeds could be distinguished by endosperm or aleurone colors, the crossed seeds were frequently significantly heavier than the selfed seeds. Since part of the difference in weight resulted from a variation in specific gravity, it was thought possible to separate selfed and crossed seeds by this means. Seed of a mixed planting of a white corn and a yellow corn was divided into several fractions on the basis of specific gravity. All of the seed was first floated in a concentrated solution of sodium nitrate. By diluting the solution gradually, several fractions were precipitated separately. The percentage of crossed (yellow) and selfed (white) seeds was determined in each fraction. A slight correlation between specific gravity and percentage of crossed seed was found but the separation was far from satisfactory and the method was abandoned.

Separating by Color

Next an attempt was made to separate crossed and selfed seeds by endosperm color. At that time (1921) electric seed-sorting machines employing photoelectric cells were being developed to remove discolored and off-type seeds from beans and other crops. By planting the yellow and white types in equal quantities, approximately one half of the seeds resulting from natural pollination on the white seeded parent would be cross-fertilized and could be detected by their yellow color. A mixture of such seed was sent to a company in Michigan manufacturing seed-sorting machinery, which reported that the mixture could be separated with almost complete accuracy when the seed was presented to the "electric eye" dorsal side up, but that yellow seeds were often classed as white seeds when they came into the machine germ side up. Thus, at the most, only about one fourth of the crop harvested could be used for seed, and since the market was limited to a mixed yellow and white hybrid, it did not seem to be widely practicable and has not been commercially used.

PREVENTING POLLEN PRODUCTION

By Chemicals

The next attempt was to destroy the tassels before pollen is released. Various chemicals that had been used to prevent fruit setting in other plants were tried. Mineral oil, acetone, glycerine and a trade preparation called "Eljetol" were applied in the whorl of leaves at the time the tassels could be felt. In every case where the tassels were inhibited or prevented from shedding pollen by the treatment the foliage was so badly injured that this method was abandoned. More recently maleic hydrazide has offered new hope that some substances may be found that will do this satisfactorily (11).

By Heat Treatment

A new approach to the problem resulted from an accidental discovery that some corn plants that were started in the greenhouse and transplanted to the field in an early seedling stage were much shortened in height and pollen sterile at the end of the season. The only explanation for this result was that the greenhouse ventilators had been left closed and that the seedlings had been exposed to very high temperatures. An experiment was devised to test this. Seeds were germinated until the shoot was about one fourth of an inch in length. These seeds were placed in an incubator for varying lengths of time at temperatures ranging from 130 to 150°F. Seedlings that survived this treatment were planted in the field and in many cases were completely pollen sterile. However, in later tests heat treated plants were so variable in fertility and so reduced in yield that this method was given up as unsatisfactory.

GENETIC MALE STERILITY

There are many forms of genetic male sterility (6) which effectively prevent pollen production and investigations on employing these as a substitute for detasseling began quite early. Since most of the genetic types of male sterility are recessive, and since the sterility, therefore, disappears in the hybrid, one possible method seemed to be that of crossing two sterile inbreds by first restoring fertility temporarily in one of them by some physiological treatment. In an attempt to do this, extracts from normal tassels were injected into male sterile plants at various stages of growth, but with no results. Since most of the gene products remain within cells, and do not diffuse through cell membranes, it may be impossible to restore fertility in this way. However, this method, if it could be developed, would be so useful that it merits more attention. If a recessive gene sterile plant could be made temporarily fertile, its pollen could then be used to fertilize another gene sterile inbred plant propagated by backcrossing to produce a pollen sterile single cross. This could be used as a seed parent without treatment of any kind. There would also be no problem of restoring fertility in the final crop grown from this seed.

Another possible method of using genetic male sterility is by temporarily restoring fertility with other genetic factors. This method has been used with seed sterility. In the production of dioecious corn, for example, in which half of the plants produce only pollen and half only seed by the proper combination of two recessive genes, tassel-seed and silkless, it was found to be possible to produce progenies that are all male type (7). These plants produce normal tassels but the ears are entirely barren of seed. Such seed-sterile plants are grown each year in our demonstration plots. To anyone not familiar with gene action it is somewhat puzzling to have completely seed-sterile plants propagated by seed. Actually, it is quite simple. In this case there are two genes both recessive to normal, but one is epistatic to the other. This makes it possible to maintain the stock by backcrossing and to produce all seed-sterile plants by crossing female plants homozygous for two recessive genes by homozygous male plants recessive for one gene. For example, $sk \; sk \; ts_2 \; ts_2$ by $sk \; sk \; Ts_2 \; Ts_2$.

Up to the present time we have found no commercial use for a seed-sterile corn plant. It would be extremely interesting and might be commercially profitable to produce such plants in the watermelon, for example, as has been done by the use of a different method.

Since completely seed-sterile plants propagated by seed are produced genetically, it seemed equally possible to produce pollen-sterile plants propagated by pollen in the same way. One had only to find the right genes. A search for such genes was begun about ten years ago and has been continued every year since, but without success.

Linkage of Male Sterility with Endosperm Color

In the meantime, the close linkage of the male sterile-1 gene with yellow-white endosperm gene locus was discovered. By maintaining stocks heterozygous for both pollen sterility and endosperm color, it is possible to produce single crosses of both pure white or pure yellow color that are completely pollen sterile except for 6 per cent of cross-overs and hetero-fertilized seeds in which the embryo differs in genotype from the endosperm. In this process it is necessary to separate seed by color. Only half of the seed parent single cross seed can be used. There are also errors due to faulty color classification, especially in some crosses. Moreover, it is difficult to incorporate a single chromogene in an inbred without altering the plants in other respects. For all of these reasons the use of this sterile gene has not been carried to commercial production and experiments on it have been abandoned for the time being.

CYTOPLASMIC STERILE PLANTS

Attention was next directed to forms of cytoplasmic male sterility. A condition of pollen sterility found in a Peruvian variety due to something outside of the chromosomes, had been described by Rhoades (12). Similar types had been found by Mangelsdorf at the Agricultural Experiment Station in Texas, by Gini in Argentina, by Brieger in Brazil and by Jenkins of the United States Department of Agriculture. The original cytoplasmic sterility described by Rhoades appears to have been lost. Seeds from the Texas, U. S. Department of Agriculture and Brazilian types of sterility were obtained and many of the standard inbreds widely used as seed parents have been converted to the cytoplasmic sterile condition by crossing and backcrossing.

A similar type of cytoplasmic sterility has also been found in flax, onions, carrots and sugar beets, as well as a number of species used primarily for genetic investigations, such as Oenothera and Epilobium. Cytoplasmic sterility in onions has been used successfully by H. A. Jones in the production of seed from which a crop of hybrid bulbs can be grown. It will undoubtedly be used for many crops where the product for which the plants are grown is other than the seed.

Employing cytoplasmic sterility in plants grown, not for their vegetative parts, but for their seed, presents additional problems. A field of male

FIGURE 2

A uniform single cross with no anthers visible at any time, resulting from a cross of a cytoplasmic sterile inbred by a normal fertile inbred free from fertility restoring genes.

sterile corn, for example, would also be functionally seed sterile, producing little or no grain. At first there seemed to be no practicable solution to this critical problem. In corn, especially, no way was found to restore fertility in the final crop grown for grain. Furthermore, many of the cytoplasmic sterile inbreds and single crosses first produced were so variable in pollen production that the method did not seem to be practicable even if pollen fertility could be restored. For all of these reasons the first attempts to use this type of sterility in corn were abandoned.

METHODS OF USING CYTOPLASMIC MALE STERILITY IN CORN

Variation in Fertility

At the Connecticut Station it has been found that cytoplasmic sterile corn plants from different sources differ appreciably in their ability to maintain sterility when incorporated into the same inbreds. Variation in pollen production shown by these cytoplasmic steriles is due not only to differences in the plasmagene (4), but also to genes in the chromosomes that have the ability to restore pollen production in varying degrees (8, 9) as shown in Tables 1 and 2.

TABLE 1. POLLEN PRODUCTION OF CYTOPLASMIC STERILE MAIZE PLANTS

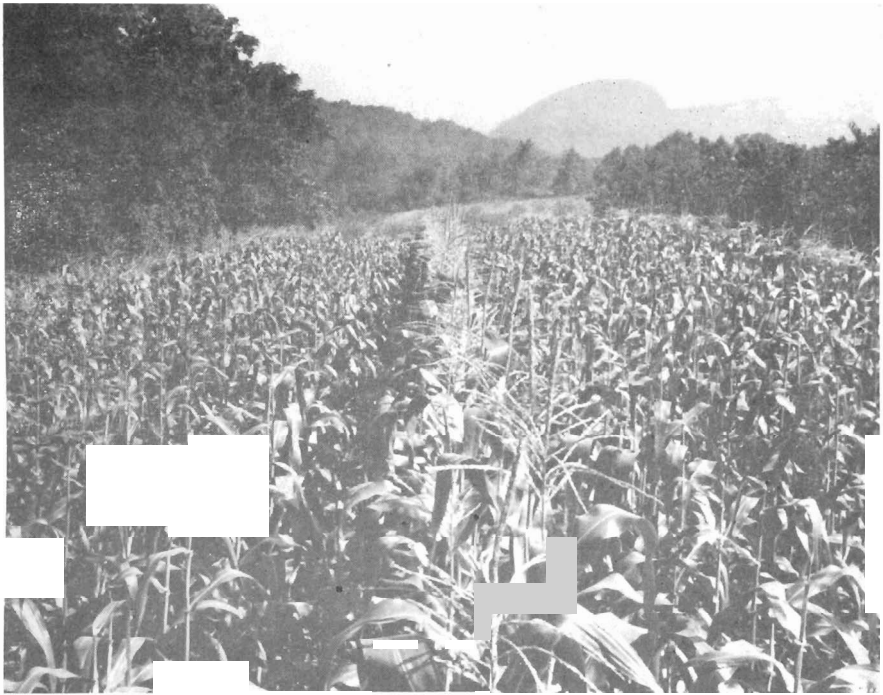| Pedigree	Range in Per Cent Normal-Appearing Pollen											
	0	1	10	20	30	40	50	60	70	80	90	100
	Number of Plants											
A^{Sd}	8	1	..	..	.	..	..	..	..	..	..	..
A^{S6}	7	2	..	..	..	..	..	..	..	..	..	..
A^{S6}	11	..	..	..	..	..	..	..	..	..	..	..
A^{S5}xA71	..	..	3	..	..	..	2	5	..	3	..	..
A^{S6}xA73	..	2	9	..	1	..	..	..	..	..	..	..
A^{S5}xA374	5	5	..	..	..	..	..	..	..	..	..	..
A^{S6}xWM13	3	9	..	..	..	..	..	..	..	..	..	..
A^{S5}xWM13	..	..	..	..	..	..	..	..	..	..	..	8
$(A^{S4}$xB164)C102	1	2	1	3	3	1	1	..	..	1	..	..
$W22^{T2}$	11	..	..	..	..	.	..	..	..	..	..	..
$W22^{T1}$xA340	..	..	..	..	..	..	2	..	..	5	2	..
$W22^{T1}$xA375	2	1	..	..	..	..	..	..	..	..	..	..
$C106^{T2}$	7	..	..	..	..	..	..	..	..	..	..	..
$(C106^{T2}$xOh41)Oh41	3	..	..	1	1	1	..	..	1	1	2	4
Kys^{T4}xC142	7	2	..	..	..	..	..	..	..	..	..	..
1193^{B}xC142	..	..	..	3	3	1	1	..	..	..	..	..
1193^{B}xK4	..	..	..	..	..	3	1	..	..	..	..	..

FIGURE 3

A seed production field with the normal seed parent rows detasseled.

In Table 1 three different sources of cytoplasmic pollen sterile maize plants are compared in backcrossed lines and in outcrosses. The source of the sterility is indicated by the superscript letter. S (superscript) is a type received from M. T. Jenkins of the United States Department of Agriculture, originally found in teopod crossed by a linkage tester. T is a type found by P. C. Mangelsdorf at the Texas Agricultural Experiment Station in Mexican June, and crosses of this variety with other types of maize. B is a form of sterility obtained from F. G. Brieger in Brazil, found in a South American variety. The figure following the letter gives the number of generations the inbred has been backcrossed to the line designated.

Three separate sub-lines of Illinois A, maintained in a highly sterile condition for six generations, were examined by removing a small portion of the main spike at the tassel, fixing in acetic acid and alcohol, staining and examining three anthers of each under a microscope. One of these lines had no normal pollen grains in the 11 plants examined. The other two lines had one and two plants with 1 per cent or less of normal appearing pollen. None of these plants extrude anthers and no functional pollen is produced.

FIGURE 4

The same hybrid, Connecticut 540, produced on seed parent plants with sterile tassels. This field, and the one shown in Figure 3, were grown in 1949 at the Experiment Station Farm at Mt. Carmel, Conn.

When this line was crossed by A71, thirteen F_1 plants ranged from 10 to 80 per cent normal pollen. A number of plants were self-fertilized and produced well filled ears. The same line crossed by A73 produced 12 plants ranging from 1 to 30 per cent normal appearing pollen; crossed by A374 and one plant of WM13, no plants produced more than 1 per cent normal pollen. The same progeny crossed by another plant of WM13 produced eight plants, all with 90 to 100 per cent normal pollen. Apparently WM13 is segregating for pollen restoring genes since the A line has been long inbred and shows no appreciable pollen production in any lines.

Similar results were obtained from the W22 inbred converted to the Texas type of cytoplasmic sterility. After two backcrossings, the inbred produced no normal pollen. The first generation of the cross by A375 produced only one plant with no more than 1 per cent of pollen, but the cross by A340 produced nine plants varying from 50 to 90 per cent of full sized, dark staining pollen.

The C106 inbred, equally sterile in backcrosses, gave a range of pollen production from complete sterility to complete fertility in a cross and

FIGURE 5

The same field as shown in Figure 3, with the normal plants
detasseled on each side of the pollinator row in the center.

backcross to the Ohio 41 line. This indicates that the Ohio 41 plant used
for the backcross was heterozygous for pollen restoration.

The Brazilian type of sterility has shown much pollen production un-
der our conditions. No completely sterile progenies have so far been ob-
tained. When crossed with C142, a long-inbred and very uniform line of
California Rice Pop, it produced from 20 to 50 per cent normal pollen
on all plants. This same pollen of C142 on Kys^{T1} inbred produced no
more than 1 per cent of pollen on two plants. Here the difference seems to
be in the potency of the plasmagene, although this remains to be proved
by further tests.

Paired Progeny Selection

From results of this kind it was soon realized that the fertile plants,
whose pollen is used to maintain the sterile plants by backcrossing, must
be selected for the complete absence of any of these pollen restoring genes.
This led to a method of paired progeny selection in which the individual
plant used to supply the pollen for the backcross is also self-fertilized and

FIGURE 6

The same field as shown in Figure 4, with the sterile tassel seed
parent rows on each side of the pollinator row in the center.

grown alongside the sterile progeny from a single backcrossed plant. If
this backcrossed progeny is completely sterile and desirable in other re-
spects, both the sterile progeny and its fertile counterpart are selected for
further propagation. If the sterile progeny shows any undesirable char-
acters, both members of the pair are discarded.

This paired progeny selection is the key to the successful use of cyto-
plasmic sterility. By the use of this method, together with the best avail-
able sterilizer stocks, it has been possible to convert practically all of the
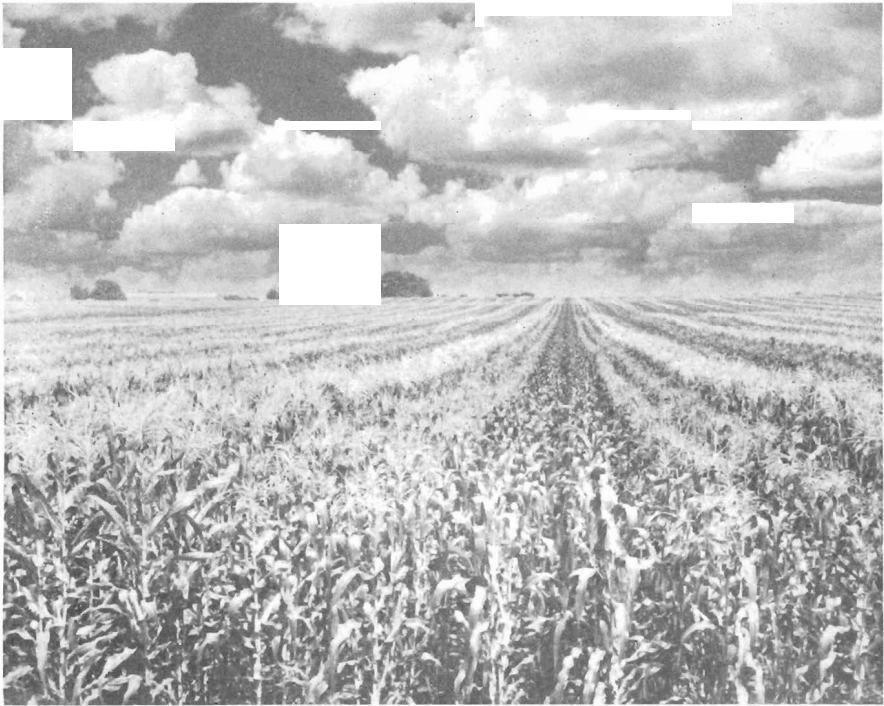standard inbreds now widely used as seed parents in single crosses.

FIGURE 7

A seed production field in Illinois grown in 1951 with two pollinator rows shedding
pollen, two sterile tassel seed parent rows adjoining, two fertile seed parent rows
in the center of each eight-row block with tassels removed, then two sterile rows,
followed by another pair of pollinator rows, and so on across the field. (Photograph
from the Funk Bros. Seed Co., Bloomington, Ill. This field produced under the direction
of Dr. J. R. Holbert.)

Converting Sterile Inbreds

From three to five backcrosses are adequate to convert an inbred to
the sterile condition, leaving it unchanged in other respects. This con-
version is much faster with a plasmagene than with a chromogene since
all that is necessary is to put a complete genome into a sterile cytoplasm.
No linkage is involved as in the transfer of chromogenes. By selecting
the backcrossed plants that most closely approach the recurrent parent,
conversion can be accomplished quickly. For example, a late southwestern
sterile dent variety which, in Connecticut, grows more than 10 feet tall
and silks in September, has been converted to a sterile early sweet corn
inbred less than three feet high, silking about the middle of July. The
sterile and fertile versions of this inbred are identical in all respects ex-
cept that one produces abundant pollen, the other none at all. This amaz-
ing transformation took place in three generations. This shows how com-
pletely the details of structure and function are controlled by the genes
in the chromosomes.

TABLE 2. SEGREGATION OF POLLEN STERILE AND POLLEN FERTILE PLANTS

Pedigrees	Sterile	Fertile
	Number of Plants	
(C106 Sterile×Ky21)-1 Selfed	4	9
[(C106 Sterile×Ky21)C106 Fertile]-1 Selfed	4	12
Total	8	21
Selfed Ratio	1	2.6
(C106 Sterile×Ky21)C106 Fertile	28	28
C106 Sterile×(Ky39×Ky21)	11	7
Total	39	35
Backcrossed Ratio	1.1	1.0
[C106 Sterile(Ky39×Ky21)]-1 Selfed-1 Selfed	0	10

Producing Sterile Single Crosses

The plasmagene for pollen sterility is also under partial, if not complete, control of the chromogenes. To produce a sterile single cross, it is necessary to select sub-lines within the standard inbreds for their freedom from pollen-restoring genes. Many inbreds, even those that have been selfed for many generations, are still segregating for these pollen-restoring chromogenes as has been shown. Special strains must be selected and tested in repeated crossings by the paired progeny method. These selected sub-lines are then increased and used to produce the sterile single crosses. This method is equal in importance to the use of special stocks to propagate the sterile inbreds by backcrossing.

These sterile seed parent single crosses have been tested under a wide variety of environmental conditions by growing them in Connecticut at different planting dates, both in the field and in the greenhouse during the winter, in Florida, Mexico and Uruguay, as well as in many parts of the Corn Belt. Many single crosses have been completely sterile under all of these conditions. Others show from 1 to 5 per cent of plants with some exserted anthers which contain a small amount of pollen that will function when not in competition with normal pollen. When tested in mixtures with normal pollen it rarely functions (8). Complete sterility is an important point and needs more thorough testing under a wide range of environmental conditions.

Restoring Pollen Fertility

The restoration of pollen fertility in the final crop is accomplished by one of two ways. The first involves mixing a portion of normal fertile seed with sterile seed. The two components of this mixture may be of the same chromogenic composition or they may differ in one or even two of the

FIGURE 8

The same field as in Figure 7 showing the plants of an eight-row series at the ends of the rows. (Photograph from the Funk Bros. Seed Co., Bloomington, Ill.)

inbred strains used in making the cross. It is important that both lots be produced on the same seed parent and grown under similar conditions so that the two lots of seed will grade the same. The best proportion of sterile and fertile seed is now being tested in isolated fields.

The second method of restoring pollen fertility is by incorporating pollen restoring chromogenes in one or both of the pollen parent inbreds. This is more difficult to do as these genes must be transferred, after crossing over has freed them from any undesirable genes to which they may be closely linked. This takes a longer time than to produce sterile inbreds. It is also possible in some instances to select within the inbreds now used as pollinators for genes having the ability to a high degree to restore pollen to the cytoplasmic sterile seed stocks. Single genes are available in many inbreds to restore pollen production completely to the most sterile single crosses (Table 2).

Effect of Sterility on Other Characters

An important point remains to be considered. Do these plasmagenes that bring about pollen sterility, with the appropriate nuclear constitution,

have any effect on the plants other than preventing pollen production? The sterile pollen condition has a definite advantage in avoiding injury to the seed producing plants. There is no breakage of leaves nor removal of leaves with the tassels when these are pulled out and secondary infections that frequently result from such injury are eliminated. This may easily save several bushels of seed per acre (1, 3, 10). In addition to avoidance of mechanical injury, there is the possibility that some nutriment is diverted from pollen production either to seed production or to the stalk, enabling it to stand better, resist stalk rot and corn borer breakage. The sterility plasmagenes may have other desirable or undesirable effects on the plants (Table 3).

TABLE 3. A COMPARISON OF CYTOPLASMIC POLLEN STERILE AND POLLEN FERTILE MAIZE PLANTS HAVING SIMILAR GENOTYPES

Plants Grown	Sterile	Fertile	Character
5 inbreds	70.1	72.3	Height of plant in inches
7 crosses of 2 inbreds	97.7	102.6	Height of plant in inches
7 crosses of 2 inbreds	58.3	58.5	Days to first silk
3 crosses of 3 inbreds Mt. Carmel, Conn.	108.9	111.7	Yield in bushels per acre
1 cross of 3 inbreds Edelstein, Ill.	103.3	99.1	Yield in bushels per acre
3 crosses of 4 inbreds Mt. Carmel, Conn.	119.0	126.3	Yield in bushels per acre
2 crosses of 4 inbreds Edelstein, Ill.	117.3	115.8	Yield in bushels per acre
5 crosses of 4 inbreds Windsor, Conn.	64.5	61.1	Yield in bushels per acre
Average Yield	102.2	102.8	

Preliminary results indicate that male sterility has no major effect on the plants other than to prevent pollen release. In amount of growth, time of flowering and in production of grain, sterile and fertile plants of the same chromogenic composition are closely alike (Tables 3, 4 and 5). Tests for these qualities have been made on sterile and fertile inbreds and crosses of two, three and four inbreds, and the results are given in Table 3. The yields reported in this table were obtained in 1949. The additional yields given in Tables 4 and 5 were obtained in 1950. In each case the yields reported are averages of replicated plots grown in randomized blocks of approved statistical design.

In some sterile inbred lines there is a tendency to shorten the stalk height. This is more apparent in the internodes above the ear and especially in the last one, the peduncle of the tassel. Ear height and time of flowering seem to be very little affected. The shortening of the stalk is not

TABLE 4. A COMPARISON OF HYBRIDS MADE ON STERILE AND FERTILE SEED PARENTS
Grown at Windsor, Connecticut, 1950

Number	Pedigree	Av. Yield Bushels Per Acre		
		Sterile	Fertile	Difference
Conn. 540	(A×A158)(Wf9×W22)	160	164	— 4
Conn. 555	(Wf9×W22)(A158×I205)	171	152	+19
Conn. 831	(Wf9×P8)(Hy×C103)	138	161	—23
Conn. 832	(Wf9×P8)(C106×C103)	153	131	+22
Conn. 833	(Wf9×P8)(C102×C103)	156	151	+ 5
Conn. 871	(Wf9×38-11)(C106×C103)	148	167	—19
Conn. 873	(Wf9×38-11)(Hy×C106)	**148**	**155**	**— 7**
Conn. 874	(Wf9×38-11)(C102×C103)	196	167	+29
Exp. Hybrid A	(Wf9×W22)(M14×Kr)	160	144	+16
Exp. Hybrid B	(Wf9×R2)(M14×Kr)	150	112	+38
Exp. Hybrid C	(Hy×C106)(Wf9×P8)	109	89	+20
Exp. Hybrid D	(Hy×C106)(W22×Wf9)	157	145	+12
	Average (12)	154	145	+ 9
			LSD	53

TABLE 5. SUMMARY OF REGIONAL TRIALS GROWN IN 1950

Hybrid	Av. Yield in Bushels Per Acre			Location
	Sterile	Fertile	Difference	
Conn. 830	67.5	68.1	— .6	Conn., Md., N. J., Pa., W. Va.
Conn. 870	76.9	70.7	+6.2	Conn., Md., N. J., Pa., W. Va.
Conn. 873	72.1	66.1	+6.0	Conn., Md., N. J., Pa., W. Va.
Conn. 870	95.5	90.4	+5.1	Delaware
Conn. 871	85.8	88.3	—2.5	Delaware
Conn. 873	86.3	85.5	+1.2	Delaware
Conn. 874	91.4	92.1	— .7	Delaware
Conn. 540	81.0	79.0	+2.0	Delaware
Holmes 11	73.3	75.0	—1.7	Pa., Mass.
Conn. 540	114.0	108.8	+5.2	Belmond, Iowa
Conn. 540	57.5	56.2	+1.3	Conrad, Iowa
Conn. 870	77.2	72.8	+4.4	Audubon, Iowa
Conn. 870	58.6	55.8	+2.8	Conrad, Iowa
Conn. 870	108.5	105.4	+3.1	Prairie City, Iowa
Holmes 11	107.9	99.8	+8.1	Belmond, Iowa
Holmes 11	79.0	84.4	—5.4	Audubon, Iowa
Holmes 11	68.1	71.6	—3.5	Conrad, Iowa
Holmes 11	105.4	109.0	—3.6	Prairie City, Iowa
Conn. 870	123.2	119.8	+3.4	Edelstein, Ill.
Holmes 11	109.7	104.2	+5.5	Edelstein, Ill.
Pioneer 336	112.1	114.2	—2.1	Johnston, Iowa
Pioneer 339	105.5	106.5	—1.0	Johnston, Iowa

characteristic of all sterile inbreds or of crosses made from them so that it does not seem to be a necessary accompaniment to this condition. Some sterile lines are slightly taller and more productive than their fertile counterparts and at the same time are equally uniform and fixed in their type. There is always the possibility that the sterile lines have not been completely converted to type and some remaining chromogenic heterozygosity may persist for many generations. In a few cases the sterile inbreds and crosses from them have been noticeably smaller and later in maturity. It may also be possible that there are other plasmagenes having an effect on growth independent of the sterility plasmagene. Up to the present time there was no good way to test for these and no interest in looking for them. Now that cytoplasmic differences have been demonstrated they will be looked for and we have little doubt they will be found. Whether or not these differences actually exist must be proved by careful tests.

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