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TOWARDS A MORE EFFICIENT UTILIZATION OF GENIC MALE STERILITY IN BREEDING HYBRID BARLEY AND WHEAT

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ABSTRACT

The author suggests that in nature cytoplasms may occur which can restore fertility in male sterile lines in which male sterility is based on one recessive gene *ms*. If indeed such a "fertilizing" cytoplasm should be found a male sterile (S) *ms ms*-line could be increased using the male fertile counterpart (F) *ms ms* as a male. Thus the female rows in hybrid seed production fields consist of male sterile plants only. A method is outlined to trace a fertility restoring cytoplasm and to introduce it into a male sterile line.

1. INTRODUCTION

Barley and wheat although self-pollinators may be considered to be serious candidates for hybrid breeding, as appeared from research in this field carried out during the last decade particularly in the United States of America.

Preparing a lecture on hybrid wheat for the Study Circle of Plant Breeding at Wageningen the author reached an idea bearing on a more efficient utilization in hybrid breeding of male sterility which is based on one recessive gene *ms*. The main difficulty in utilizing this so-called "genic" male sterility is the maintenance of the *ms ms*-line, being only possible as a heterozygote *Ms ms*. This implies that the female rows in a production field of hybrid seed always consist of 75 percent male fertile plants and 25 percent male sterile ones instead of the desired 100 percent male steriles. Therefore the male fertile plants must be removed. The discovery by WIEBE (personal communications, 1964, 1965) of a close linkage (7 percent recombination) between the male sterility locus *ms 16* in barley and the locus for DDT-resistance *ddt* enabled him to remove over 90% of the fertile females in an early stage by spraying with DDT. By use of this linkage and management procedures he was able to get about 93% male steriles of the surviving plants in the female row. In spite of the practicability of this elegant method it does not offer a final solution to the above problem.

In a recent publication RAMAGE (1965) points out that balanced tertiary trisomics carrying the *Ms*-allele on the extra-chromosome and an *ms*-allele on the two normal chromosomes, could be used in hybrid seed production. As the extra chromosome carrying *Ms* is rarely transmitted through the male, about 70% of the selfed progeny of such a trisomic in barley would consist of the desired male sterile diploids. In addition the cross *ms ms*-line × trisomic ♂ would result into nearly 100% male steriles. Practical use of this cross requires abundant pollen production by the trisomic.

The ideal of getting 100% male steriles would be simply realized if a chemical could be produced (WIEBE, personal communication, 1965) or a cytoplasm could be found (this author) capable of restoring fertility in a male sterile *ms ms*-line. The idea of a cytoplasmic restorer will be discussed in this article.

2. A new approach to the problem

The basic principle of the idea referred to in the introduction is that the characters of an organism are determined by the interaction of genes and cytoplasm. This has been established for the so-called "cytoplasmic" male sterility. Why would not it hold true for "genic" male sterility as well? If so, the *Ms*-alleles of the *ms*-loci may be called restorer genes. In addition the cytoplasm of the varieties studied so far has to be considered a sterile cytoplasm. Thinking out this theory consistently one reaches the conclusion that cytoplasms which can restore fertility in male sterile *ms ms*-lines may be expected to occur in nature. These "fertilizing" cytoplasms, which in the following will be indicated as *F-cytoplasms*, might be found either in normal varieties not yet studied or in related species or genera. If such an F-cytoplasm should be discovered the maintenance of an *ms ms*-sterile would be a simple procedure as would be the establishment of seed production fields with female rows consisting of male sterile plants only.

3. Tracing an F-cytoplasm

It is apparent from table 1 that a carrier of F-cytoplasm can be traced by crossing it as a female with a heterozygous *Ms ms*-line and studying fertility in the resulting F_2-populations. The results obtained are independent of the *ms*-genotype of the carrier, if homozygous.

TABLE 1. TRACING A "FERTILIZING" CYTOPLASM. SEE TEXT. F = FERTILIZING CYTOPLASM, S = STERILIZING CYTOPLASM, *ms* = RECESSIVE MALE STERILITY LOCUS, *Ms* = DOMINANT ALLELE OF *ms* ACTING AS A FERTILITY RESTORER.

Genotypes parents		Genotypes in F_1-population (all fertile)	Percentage of F_2-populations	
Female	Male		with all plants fertile	segregating 3:1
(F) *ms ms*	(S) *Ms ms*	(F) *Ms ms* + (F) *ms ms*	100	0
(F) *Ms Ms*	(S) *Ms ms*	(F) *Ms Ms* + (F) *Ms ms*	100	0
(S) *Ms Ms*	(S) *Ms ms*	(S) *Ms Ms* + (S) *Ms ms*	50	50

Note. (S)*ms ms* is a male sterile and therefore does not need to be checked for the presence of F-cytoplasm.

4. Introducing an F-cytoplasm into a male sterile line

An F-cytoplasm can be introduced into a male sterile line using a heterozygous *Ms ms*-line, as follows.

First step: backcrossing the carrier of F-cytoplasm as a female with the heterozygous *Ms ms*-line until the genotype of this line is recovered, e.g. after n generations. Then the idiotype of BC_n is (F) *Ms ms*.

Second step: selfing BC_n. This will result in a population consisting of 25% (F) *Ms Ms* + 50% (F) *Ms ms* + 25% (F) *ms ms*. The desired idiotype is (F) *ms ms*.

Third step: testcrossing the selfed BC_n-population on (S) *ms ms* as a female. This gives the following results:

(S) *ms ms* × (F) *Ms Ms* → 0% male steriles
(S) *ms ms* × (F) *Ms ms* → 50% male steriles
(S) *ms ms* × (F) *ms ms* →100% male steriles

Thus the plants with (F) *ms ms* can be detected. These plants can be used to increase at will the male sterile (S) *ms ms* by the cross (S) *ms ms* × (F) *ms ms* which produces (S) *ms ms*-plants only.

5. Discussion

The frequency of occurrence of male sterility in barley and wheat is quite different. Twenty-three independent sources of *ms*-genes have been found in barley which occupy the same number of different loci (Wiebe, personal communications, 1964, 1965). In wheat only one case of genically determined male sterility is known to the author (Pugsley and Oram, 1959) and its genetic basis is still rather obscure. In contradistinction to genic male sterility several useful cytoplasmic sources of male sterility have been found for hexaploid wheat (Kihara, 1951, Fukasawa, 1953, Wilson and Ross, 1962). In barley however cytoplasmic male sterility useful for breeding hybrid barley could not be obtained yet (Suneson and Wiebe, personal communication, 1964). Therefore it may be concluded that finding a cytoplasm capable of fertilizing male sterile *ms ms*-lines would be most important, particularly in barley breeding. In wheat complete fertility restoration in cytoplasmic male sterile lines is difficult to realize due to the rare occurrence of fertility restoring genes (Wilson and Ross, 1961) and the influence of minor genes and environment on fertility restoration (Schmidt and Johnson, 1963). Therefore also in wheat the system of *ms*-genes + fertilizing cytoplasms might be more promising than the current system of sterilizing cytoplasms + restorer genes. In view of the foregoing an intensive search for F-cytoplasms is recommended.

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Samenvatting

Naar een meer efficiënt gebruik van mannelijke steriliteit (ms ms) *bij het kweken van hybride rassen van gerst en tarwe.*

Het idee wordt gelanceerd, dat in de natuur waarschijnlijk plasmata voorkomen, die de fertiliteit kunnen herstellen van mannelijk steriele lijnen, waarin de mannelijke steriliteit berust op één recessief gen *ms*. Indien zulk "fertiliserend" plasma zou worden gevonden, zou de vermeerdering van een mannelijk steriele (S) *ms ms*-lijn kunnen geschieden met de mannelijk fertiele pendant (F) *ms ms*, zodat dan in zaadproductievelden de moederrijen alleen bestaan uit mannelijk steriele planten. Een methode wordt gegeven, waarmee zulk fertiliserend plasma kan worden opgespoord en ingekruist in een mannelijk steriele lijn.

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