Aust. J. Biol. Sci., 1975, **28**, 413–16

Cytogenetic Analysis of Two Chromosomal Male-sterility Mutants in Hexaploid Wheat

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Abstract

The two chromosomal male-sterility mutants referred to as Pugsley's male-sterile and the Probus male-sterile fail to complement one another. Partial monosomic analysis revealed that both mutants are located on chromosome 4A. A strong homoeoallelic 'echo' was received from chromosome 4B with the Probus mutant, *ms1b*, but not with Pugsley's mutant, *ms1a*.

Introduction

Chromosomal male-sterility mutants are valuable variants in any agricultural plant, since they have the potential for contributing to breeding procedures including production of hybrid varieties.

The number of simply inherited chromosomal male-sterility mutants in hexaploid wheat, *Triticum aestivum* L. emend. Thell., is low principally because of the polyploid nature of this species. Those that have been recorded are listed by Briggle (1970) and by Driscoll (1973). Although further male-sterility mutants have been recently induced with ionizing irradiation (Driscoll, unpublished data), of those that are recorded only two are monofactorially inherited, experience no serious adverse selection at the male gamete phase, and have no undesirable pleiotropic effects. These two recessive mutants were isolated by Pugsley and Oram (1959) and by Fossati and Ingold (1970). The first mutant occurred spontaneously and is commonly referred to as Pugsley's male-sterile. The second mutant was induced with ionizing irradiation in the variety Probus and will be referred to as the Probus male-sterile. The two mutants appear similar in gross morphology in that both involve indehiscent anthers. This paper reports on the genetic relationship of these two mutants and their chromosomal location. Location to homoeologous group is essential for the use of a chromosomal male-sterile in producing hybrid varieties (Driscoll 1972).

Materials and Methods

Pugsley's male-sterile was backcrossed into the cultivar Chancellor by Briggle (1970) and this was accompanied by selection for single-gene inheritance. This stock, supplied by Dr L. W. Briggle, was used in these experiments. The Probus male-sterile was supplied by Drs A. Fossati and M. Ingold. The monosomic stocks used in this study were Federation monosomics 4A, 4B, 5A and 5D supplied by Dr R. A. McIntosh and Chinese Spring monosomic 5B supplied by Dr E. R. Sears. These five chromosomes are the most likely ones to harbour a single gene for male-sterility (Driscoll 1974).

Individuals homozygous for Pugsley's male-sterile were pollinated by normal wheat in order to produce known heterozygotes. These were used as pollen parents in crosses to individuals homozygous for the Probus male-sterile. The resulting offspring were examined for complementation.

Heterozygotes of each mutant were crossed as males to the five monosomics mentioned above with the exception of monosomic 5D × Pugsley's male-sterile. Heterozygotes of the Pugsley's male-sterile were obtained as outlined for the intercross mentioned above. In the case of the Probus male-sterile, fertile plants were selected at random from a segregating fertile : sterile family. Only crosses emanating from male plants that subsequently produced a segregating fertile : sterile selfed progeny were retained. Monosomic F_1s of these crosses were selected by root-tip chromosome number analysis. These plants were later scored as male-fertile or male-sterile on the basis of anther dehiscence or indehiscence. The various steps in this analysis are shown in Fig. 1.

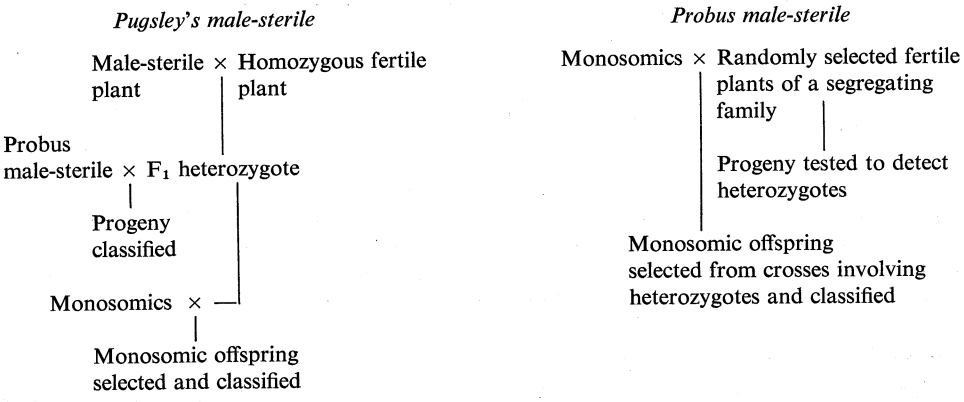

Fig. 1. Summary of the steps involved in the cytogenetic analysis.

Results and Discussion

The offspring derived from homozygous Probus male-sterile × heterozygous Pugsley's male-sterile segregated nine fertile : six sterile. Approximately half the pollen in the above cross would have carried the Pugsley's male-sterile allele. The fact that approximately half the offspring were male-sterile establishes that the two defective genes are either allelic or homoeoallelic. This is further clarified by the partial monosomic analysis shown in Table 1. The sterile plants occurring in the 4A crosses obviously involve union of an egg devoid of chromosome 4A with a sperm bearing a recessive allele for male-sterility. Thus the two mutants are located on chromosome 4A and from the observation on the intercross they can be regarded as alleles of one another.

Table 1. Fertility of monosomic offspring from crosses of specific monosomics with known male-sterility heterozygotes

NT, not tested

Monosome	Pugsley's mutant		Probus mutant	
	Fertile	Sterile	Fertile	Sterile
4A	5	6	4	4
4B	12	0	12	0
5A	7	0	5	0
5B	8	0	5	0
5D	NT	NT	6	0

The only other family that segregated male-steriles involved monosomic 5B × Probus plant No. 49. This atypical family, which has been excluded from Table 1, contained five 41-chromosome individuals, three of which were sterile and two of

which were fertile. All three steriles entered homoeologous pairing at meiosis whereas the one fertile examined meiotically paired with 19 bivalents and one trivalent. The sterility in this particular family is due to loss of the 5BL gene(s) for male fertility along with loss of the 5BL gene(s) for cytological diploidization. Probus plant No. 49 is regarded as having been heterozygous for this 5B deletion.

The occurrence of some plants of an intermediate phenotype in the cross of monosomic 4B × Probus heterozygotes is of considerable interest. Many anthers of these plants failed to dehisce whereas other anthers liberated functional pollen. These plants are regarded as having involved monosomy for 4B and heterozygosity for the Probus male-sterile on chromosome 4A. By contrast all 12 individuals of the corresponding cross involving Pugsley's male-sterile were fully fertile. Complete interpretation of this difference is not possible at this time. The different origins of the mutants may be involved: Pugsley's male-sterile, of spontaneous origin, may involve an intragenic change with some residual activity and the Probus male-sterile, of X-ray induction origin, may involve deletion of the locus. More complex interpretations are possible such as the Probus mutant involving loss of two loci, Pugsley's mutant involving the loss of one locus and chromosome 4B possessing only one locus, namely the one retained in the Pugsley's mutant. The relationship of the male-sterility loci of chromosomes 4A and 4B will require a complex explanation as observations on the various nullisomic–tetrasomic combinations within group 4 indicate that chromosome 4A carries a gene or genes essential for male fertility not present on chromosome 4B nor on chromosome 4D (Sears 1966). Furthermore, Zeller and Baier (1973) have reported fertility in a line in which rye chromosome 5R is substituted for chromosome 4A.

Nevertheless, on the basis of the failure of complementation in the intercross and on identical chromosomal location, Pugsley's male-sterile and the Probus male-sterile may be regarded as involving allelic mutants. The symbol *ms1a* is applied to Pugsley's male-sterile. The symbol ms^{1a} has previously been applied to the Probus male-sterile (Fossati and Ingold 1970); however, under the rules adopted for gene symbols for wheat (McIntosh 1973) this would become *ms1b*.

Acknowledgments

This research was supported by the Wheat Industry Research Council and was carried out under the FAO/IAEA Co-ordinated Research Programme on Improvement of Mutation Breeding Techniques (Research Agreement No. 1242).

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Manuscript received 25 March 1975