Genetic Studies on GMS in *Brassica napus* L
II. Classification and Name of Sterile Gene

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ABSTRACT

In this paper, the genetic relationships among seven genic male sterile (GMS) lines (*B. napus* L) were studied. The results revealed that the GMS lines 9012A, Y420A, 7024A, Chuan068A, and S45A were different from the GMS line 6AB in restorer-maintainer relationship, and all testers were restorers for the former, most testers were non-restorers for the latter. Therefore the sterile genes for the former were recessive, but for the latter were dominant.

Based on allelism of the sterile genes, the recessive GMS lines 9012A, Y420A, 7024A, Chuan068A, S45A and 117A were divided into three groups, and they all were controlled by recessive duplicate sterile genes (RDSG). Among them, 9012A and Y420A were the first group, and their sterile genes were designated as $^{A}ms_4$ and $^{A}ms_5$; Chuan068A, S45A and 117A were the second group, and the sterile genes were designated as $^{S}ms_2$ and $^{S}ms_3$; 7024A alone was the third group, and the sterile genes were designated as $^{O}ms_6$ and $^{O}ms_7$. The sterile genes were designated as $^{Sh}MS_1$ for dominant GMS line 6AB.

Key words: GMS, recessive duplicate sterile genes, Allelism, *B. napus* L

INTRODUCTION

Male sterility is an important way of heterosis utilization in rapeseed, GMS is attached increasingly importance to heterosis breeding in China because of the good ways of heterosis utilization being created and a lot of advantages of GMS such as stable male sterility, no cytoplasmic negative effect, wide restorers. Three types of GMS and their hybrids were reported in *Brassica napus* in China, which were double recessive genic male sterility (Pan T. et al, 1988, Hou G. et al, 1990), double dominant genic male sterility with dominant epistatic interaction (Li S. et al, 1985) and tri recessive genic male sterility with recessive epistatic interaction (Chen F. et al, 1998a, b), but systematic classification and name of these male sterile genes were not studied. In this paper, the genetic relationships among seven GMS lines (*B. napus* L) were studied, and their male sterile genes were classified and named.

MATERIALS AND METHODS

Six GMS double-purpose lines (DPL) and one GMS F1 hybrids (*B. napus* L.) were collected: Y420AB, 9012AB, Chuan068AB and 7024AB DPLs from CRI-AAAS were discovered by Chen F. in 1990, 1991, 1992 and1995 respectively, S45AB DPL from Sichuan University was reported by Pan T. et al 1988, 6AB(6CA) line with dominant epistatic interaction from CRI-SAAS was reported by Li S. et al 1985, and 6AB is homozygous DPL, 6CA is All Sterile Line of 6AB, Youyan No.7, a hybrid from Guizhou Oil Crop Research Institute, one of whose parent lines is recessive GMS line117A (Hou G. et al 1990).

The testcrosses from fertile plant of one GMS line and the sterile plant of the other GMS lines were made between six GMS DPLs each other, the testcrosses were made between the F1 hybrids Youyan No.7 of GMS line 117A and the sterile plant of six GMS DPLs respectively. The fertility of the progeny of all the testcrosses was investigated. For those with fertility segregation, X^2 values for expected ratios were calculated.

RESULTS AND DISCUSSION

Classification of GMS based on the dominant-recessive relationships of male sterile genes

The restorer-maintainer relationship results of 6 GMS lines showed that 5 GMS lines 9012A, Y420A, 7024A, Chuan068A and S45A could be restored by all testers, but GMS line 6AB(6CA) was restored by only three testers of all fifty testers in this experiment. The above 5 GMS lines had different restorer-maintainer relationship from the 6AB(6CA). According to this result, the GMS lines could be divided into DGMS and RGMS. DGMS including 6AB(6CA), its genes for male sterility were dominant, which was consistent with the research result on 6AB(6CA) by Li S. et al 1985. RGMS including 9012A, Y420A, 7024A, Chuan068A and S45A, their genes for male sterility were recessive, which was in line with the research result on 9012A and Y420A by Chen F. et al 1998a, 1998b and on S45A by Li S. et al 1993.

Allelism of male sterile genes The allelism test results among 5 RGMS lines and RGMS line 117A were showed in Table 1. Based on allelism of the sterile genes, 6 RGMS lines could be subdivided into 3 groups. The first group was 9012A and Y420A, the progeny of the testcrosses between in them had fertility segregation, but all fertility was observed in the progeny of the testcrosses between this group GMS lines and other GMS lines. The results showed that sterile genes in 9012A and Y420A were allelic, but were non-allelic to the sterile genes in other GMS lines. The second group was S45A, Chuan068A and 117A. The progeny of the testcrosses between in them had fertility segregation, but all fertility was observed in the progeny of the testcrosses between this group GMS lines and 2 GMS lines in the first group. The results showed that sterile genes in S45A, Chuan068A and 117A were allelic, but were non-allelic to the sterile genes in GMS lines in the first group. The progeny of testcrosses between the second group GMS lines and 7024A showed all fertility and fertility segregation, which disclosed that the some sterile genes in the 7024A were allelic to the sterile genes in the second group, but the other sterile genes in the 7012A were non-allelic. The last one was 7024A. The sterile genes of 7024A were non-allelic to the sterile genes in the first group. 7024A held some sterile genes allelic to the sterile genes in the second group, and the other new sterile genes non-allelic to the sterile genes in the other GMS lines.

Table 1. Allelism test for the male sterile genes among RGMS lines

Male fertile plants(♂)	Male sterile plants(♀)				
	9012A(B)	Y420A(B)	7024A(B)	Chuan068A(B)	S45A(B)
9012(A)B		66/77	164/0	71/0	185/0
Y420(A)B	141/136		84/0	95/0	
7024(A)B		151/0			116/0
Chuan068(A)B	445/0	97/0	57/49(4)* 21/0(2)*		38/45
S45(A)B	110/0	15/0	31/10	40/44	
Youyan No.7	115/0	65/0	38/14(3)*	83/36	123/29
(117A/restorer)F_1			28/0(2)*		

Note: The data format is NO. of male fertile plants/NO. of male sterile plants from F_1 of testcrosses.
*NO. of testcrosses in brackets.

Table 2. Data of the F_2 from testcrosses between 7024A and eight testers

Segregation ratos of the F_2 plant lines	No. of the F_2 plant lines
15:1	1
61:3	5
3:1	1
13:3	7
225:31	8
931:93	3
45:19	3
199:57	4
9:7	1
43:21	1
Other	1
Total	35

The number of loci of male sterile genes The previous reports (Li S. et al 1985, 1993, Hou G. et al 1990, Chen F. et al 1998) and our data (7024A see table 2, the others omitted here) indicated that sterility for DGMS line 6AB(6CA) was controlled by interaction between one locus dominant sterile gene and other one locus dominant epistatic inhibiting gene, the male sterile genes existing in the first group RGMS and the second group RGMS were two pairs of RDSG, the male sterile genes existing in the third group RGMS lines 7024A were two sets of RDSG (4 loci), one set of RDSG were allelic to RSDG existing in the second group RGMS, the other were non-allelic to all the other RGMS lines. In addition, recessive epistatic inhibiting genes of RDSG existed in the first group RGMS and the third group RGMS, which inhibited the expression of RDSG. The systematic classification and name of the epistatic inhibiting genes would be reported in next paper, which was not discussed here.

Name of male sterile genes According to custom, the rules of GMS gene naming were as follows: The sterile gene was expressed as acronym of “male sterility”. The capital one “MS” for dominant gene, and the lowercase one “ms” for recessive gene; Genes were numbered in the bottom right corner of “MS” or “ms” according to the discovery and report time of sterile genes; Discovery place, scientist or origin of GMS line could be noted in the top left corner of “MS” or “ms”. According the above naming rules, the dominant sterile genes for 6AB were named as $^{Sh}MS_1$, and the recessive sterile genes for 1st group named as $^{A}ms_4$ and $^{A}ms_5$, for 2nd group named as $^{S}ms_2$ and $^{S}ms_3$, and for 3rd group named as $^{O}ms_6$ and $^{O}ms_7$.

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