Breeding and utilization of recessive genic male sterile dual-purpose Line 20118AB in *Brassica napus* L.

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Abstract

A new recessive genic male sterile dual-purpose line 20118AB which the ratio of fertility segregation is stable 1:1 and 3:1 by the sterile plants($ms_1ms_1ms_2ms_2RfRf$) crossed with the fertile plants($Ms_1ms_1ms_2ms_2RfRf$ or $ms_1ms_1Ms_2ms_2RfRf$) and fertile plants selfed, respectively was found. The fertility of a sterile line of 20118A was controlled by two pairs of recessive duplicate sterile genes($ms_1ms_1ms_2ms_2$) and one pair of recessive epistatic fertile gene(rfrf). The genotype of the maintainer line was $ms_1ms_1ms_2ms_2rfrf$. The genotypes of the restorer line were Ms_1Ms_1_ _and _ _Ms_2Ms_2. Hybrid seeds can be produced by using this system. Firstly, the homozygous dual-purpose line was kept by sib-mating and the sterile line could be obtained by removal 50% fertile plants in the two-type line. Secondly, the full sterile line($ms_1ms_1ms_2ms_2Rfrf$) could be produced by the cross between the sterile line and the maintainer line. Lastly, hybrid seeds were produced through the cross between the full sterile line and restorer line. Three double low hybrid varieties have been bred by Shanghai Academy of Agricultural Sciences using the system Up to 2006.

Key words: *Brassica napus* L., Recessive genic male sterile, Two-type line, Recessive duplicate effect, Recessive epistatic effect

Introduction

Using and breeding of new double low hybrid rapeseed varieties is now the key point of rapeseed scientific research and production in the world(Li Shulin,1985,Li Dianrong,1993, Fu Tingdong,2001). Since Fu Tingdong et al (1981)first reported discovering Polima cytoplasm male sterility in *Brassica napus* L.in 1972, rapeseed breeders in World have paid much attention to rapeseed heterosis. Up to 2006, rapeseed breeding and research organizations in China had successively bred more than 100 hybrid rapeseed varieties. The planting area of hybrid rapeseed varieties in Chna also occupies over 55% . The rapeseed sterility systems mainly used in China are cytoplasm male sterility, dominant genic male sterility and recessive genic male sterility(Li Shulin,1985, Hou Guozuo,1990, Li Dianrong,1993, Li Shulin,1993, Wang Hua,1993, Sun Chaocai,1997, Chen Fengxiang,1998, Fu Tingdong,2001).The inheritance and use of the double low recessive genic male sterile two-type line 20118AB were reported in this paper.

Material and methods

Tested materials were a recessive genic male sterile two-type line 20118AB (the ratio of fertility segregation is stably 1:1 and 3:1 by the sterile plants crossed with the fertile plants and fertile plants selfed, respectively.) and 3 maintainer lines, M-6029, M-6034 and M-S-21041, bred by Shanghai Academy of Agricultural Sciences and 98 single or double low rapeseed varieties introduced from the domestic and foreign countries.

Test cross: Crosses between male-sterile line 20118A and the different varieties had been made. Sterile plants from male-sterile line 20118A and F_2 of test-cross were crossed with the maintainer lines, M-6029, M-6034, M-S-21041, respectively.

Sib-mating: Sib-mating crosses in the two-type line 20118AB and in the segrergating generations of test crosses were also made.

Selfing: The F_1, F_2 and male parents of test crosses and male parents of sibmating crosses were all selfed. The tests of goodness fit for the descendants of fertility segregations obtained by above methods was done.

Results

Fertility expression of F_1 in sib-mating and selfing of the two-type line 20118AB

In 1995, ten sibmating and selfing crosses between sterile plants and fertile plants in 20118AB were made respectively. The fertility segregation of F_1 was 1 fertile plant to 1 sterile plant in sibmating crosses and 3 fertile to 1 sterile in selfing crosses (Table 1).

Fertility expression of F_3 in test crosses between sterile line 20118A and other rapeseed varieties

In 1996-1999, 98 combinations were made between the sterile plants of 20118A and different rapeseed varieties. The fertility expressions of all F_2 of 98 combinations were fertile. Some plants in the F_1 from different test crosses were selfed. The fertility segregation ratio of fertile to sterile was 61:3 in 6 F_2 lines and 15:1 in 2 F_2 lines. Selected fertile plants in the lines of the segregation ratio of fertile to sterile by 61:3 were continuously selfed. 72 F_3 lines were obtained. Among them, 44 lines were

all fertile, 9 lines of fertility segregation ratio were 61:3, 6 lines were 15:1, 9 lines were 13:3 and 4 lines were 3:1(table 2). The results showed that the fertility of male-sterile line 20118A was controlled by two pairs of recessive sterile genes with duplicate effect and 1 pair of recessive fertile gene with epistatic effect .

Table 1 Fertility expression of F_1 in sib-mating and selfing of two-type line 20118AB

Combinations	Test code	Total plants (plant)	Fertile plants (plant)	Sterile plants (plant)	χ^2	
					1:1	3:1
20118×20118B	20056	77	40	37	0.05	
	20067	16	12	4	3.06	
	20068	72	38	34	0.13	
	20069	46	20	26	0.54	
	20070	147	72	75	0.03	
	20071	46	29	17	2.63	
	20072	107	61	46	1.83	
	20072	153	83	70	0.94	
	20074	85	45	40	0.19	
	20075	91	47	44	0.04	
20118B⊗	20093	215	153	62		1.49
	20098	158	112	46		1.22
	20099	140	104	36		0.01
	20100	87	64	23		0.03
	20101	79	58	21		0.04
	20102	124	100	24		1.82

Table 2 Fertility expression of F_3 in test crosses between sterile line 20118A and different rapeseed varieties

Combinations	No. of F_3 plant lines (line)	Fertility expression of F_3 families				
		All fertile	3:1	13:3	15:1	61:3
20118A×5001	38	23	2	5	3	5
20118A×S-20135	34	21	2	4	3	4

Breeding of maintainer lines of 20118A

The fertility segregation ratio of the combinations, 20118A×5001 and 20118A×S-20135, in F_2 was 61:3. The fertility segregations of the plant lines in F_3 had full fertile, 61:3, 15:1, 13:3 and 3:1, respectively. In 2000~2001,sibmating crosses were made in which the combinations of fertility segregation were 61:3 and 13:3, and the corresponding male parents were selfed, respectively. The descendant's fertility segregations were listed in table 3. The results showed that the fertility segregation of F_1 crossed between the sterile plants and S-21041 was 104 sterile, 2 fertile, and for M-6029 and M-6043 was full sterile, respectively. Corresponding male parents were all fertile by selfing (Tabe 3).

The use of the recessive genic male-sterile line 20118A

The fertility of 20118A is controlled by two pairs of recessive duplicate sterile genes and one pair of recessive epistatic fertile gene. When the genes of ms_1 and ms_2 are recessive homozygous $ms_1ms_1ms_2ms_2$, and the gene of rf is dominant homozygous RfRf or heterozygous Rfrf, the plants are sterile(genotype is $ms_1ms_1ms_2ms_2$RfRf or $ms_1ms_1ms_2ms_2$Rfrf). When rf gene is recessive homozygous rfrf, rf has epistatic effect to ms_1 and ms_2. The plants with the genotype of $ms_1ms_1ms_2ms_2$rfrf is all fertile and also a maintainer line. The genotypes of the restorer line are Ms_1Ms_1_ _ and _ _Ms_2Ms_2 . Used this system, hybrid seeds can be produced. First, the homozygous two-type line was kept by sib-mating and the sterile line could be obtained by removal 50% fertile plants in the two-type line. Second, the full sterile line($ms_1ms_1ms_2ms_2$Rfrf) could be produced by the cross between the sterile line and the maintainer line. Lastly, hybrid seeds were produced by the cross between the full sterile line and restorer line(Fig.1).

Discussion

At present, the types of recessive genic male sterile rapeseed with multitudinously restoring resources were reported by 1 pair of gene, 2 pairs of genes and 3 pairs of genes(Hou Guozuo,1990, Li Shulin,1993, Wang Hua,1993, Sun Chaocai,1997, Chen Fengxiang,1998,). The maintainer gene has not been found in rapeseed controlled by 1 pair and 2 pairs of recessive genes. The maintainer line of recessive genic male sterility which controlled by two pairs of recessive duplicat sterile genes and one pair of recessive epistatic fertile gene had been discovered and three double low hybrid rapeseed varieties, "Huyouza No.1", "Huyouza No.2" and "Xiangnong 03", had also been bred by Shanghai Academy of Agriculture Sciences

In the two-type line 20118AB, the genotype of sterile plant is $ms_1ms_1ms_2ms_2$RfRf, and the fertile plant's is $Ms_1ms_1ms_2ms_2$RfRf or $ms_1ms_1Ms_2ms_2$RfRf, The fertility segregation through sibmating between the sterile plants and fertile plians in the two-type line 20118AB is stable 1:1.The full sterile line($ms_1ms_1ms_2ms_2$Rfrf) can produce by the 20118A and the maintainer line, but it is only used once in the rapeseed breeding process. The author thinks that the full sterile line should be better called as a temporary line.

Table 3 Fertility expression of F_1 in sib-mating from the crosses between 20118A and 5001

Year	Combination	Test code	Totalplants (plant)	Fertile plants (plant)	Sterile Plants (plant)	χ^2 Fertile plants/sterile plants)	Selfing progenies of corresponding male parents			
							Total plants (plant)	Fertile plants (plant)	Sterile Plants (plant)	χ^2 Fertile plants/sterile plants
2000	(20118A×5001)A×(20118A×5001)B	S-20117	68	45	23	5:3(0.25)	50	41	9	13:3(0.01)
		S-20118	91	47	44	1:1(0.04)	61	47	14	3:1(0.05)
		S-20122	87	64	23	3:1(0.03)	70	53	17	3:1(0.00)
		S-20124	142	108	34	3:1(0.04)	90	84	6	15:1(0.003)
		S-21031	131	104	27	13:3(0.19)	92	88	4	61:3(0.01)
		S-21034	78	40	38	1:1(0.01)	103	103	0	
		S-21041	106	2	104		105	105	0	
2001	(20118A×5001)A×(20118A×5001)B	6002	90	43	47	1:1(0.10)	70	54	16	3:1(0.08)
		6004	79	58	21	3:1(0.04)	199	186	13	15:1(0.00)
		6005	87	60	27	5:3(1.29)	172	142	30	13:3(0.12)
		6006	67	54	13	3:1(0.84)	115	115	0	
		6008	84	74	10	7:1(0.00)	151	151	0	
		6009	46	30	16	5:3(0.05)	140	116	24	13:3(0.14)
		6013	101	83	28	3:1(0.01)	189	181	8	61:3(0.02)
		6025	77	40	37	1:1(0.05)	214	214	0	
		6029	25	0	25		251	251	0	
		6034	117	0	117		225	225	0	
		6035	79	42	37	1:1(0.20)	143	143	0	

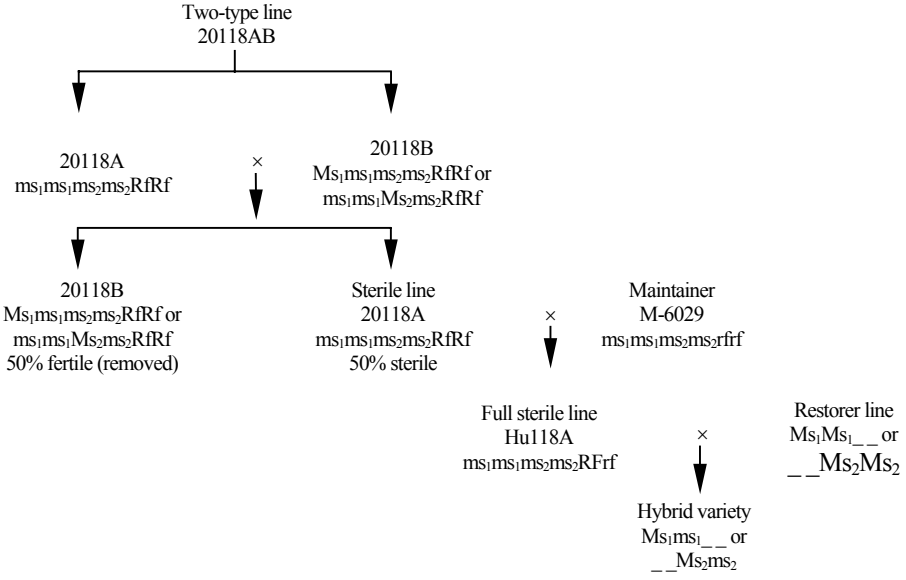

Fig. 1 The utilizing model of the genic male sterile two type line 20118AB

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