ACTA AGRICULTURAE BOREALI-SINICA 1993,8(Suppl.):40—44

The unstability of cytoplasmic male sterility of *Brassica napus* L.

Song Wenguang(宋文光),**Guan Rongzhan**(管荣展),**Ren Lejian**(任乐见)

Industrial Crops Institute,Henan Academy of Agricultural Sciences,Zhengzhou 450002

Received January 5,1993

Summary The unstability of cytoplasmic male sterilities(CMS) of *Brassica napus* L. was studied from 1989 to 1992,and the results indicated:1. The occurrence of trace-pollen plants in sterile materials was caused by nuclear polygenes of the maintainers;2. Progenies of partial sterility type showed segregation of sterile,partially sterile(with trace pollen)and fertile plants;3. High and low temperature CMS lines were crossed and its progenies manifested complex segregation;4. There was a tendency to increase the fertility with successive selfing of the high temperature CMS line.

Key words *Brassica napus* L.,cytoplasmic male sterility,unstable sterility,partial sterility type

Introduction

The fertility of cytoplasmic male sterilities in *Brassica napus* originating from Polima A, Shan 2A,TCMS,MICMS,SCMS,can be restored by a pair of dominant genes(Liu Houli, 1985;Fu Tingdong,1989;Li Dianrong,1984;Fu Shouzhong,1989). There exist trace-pollen plants in these sterile materials(Fu Tingdong,1989;Yang,1987,1990). T. Shiga(1972) and K. F. Thompson(1972) suggested that sterility was sensitive to temperature (Fu Shou-Zhong,1989) after their studying SCMS and TCMS respectively. Fu Tingdong and Yang Guangsheng studied the sterility performance sensitive to temperature with shan 2A,polimaA,inferred that the occurence of trace-pollen plants was caused by the polygenes(Fu Tingdong,1989;Yang,1987,1990)

We investigated high temperature and low temperature sterility and partial sterility type,and styled these fertility types as unstable cytoplasmic male sterility.

Materials and methods

The experiment was conducted in Zhengzhou,P. R. China. The cytoplasmic male sterile lines investigated included 252A,06A,029A,32A and 384A;252A was a double-low CMS line derived from newly found CMS plants by Song. 06A and 29A were high- and low-temperature CMS lines,respectively. By using different maintainers,06A and 29A were bred out from the same CMS plants as 252A. 32A and the double-low 384A were obtained from continously backcrossing to the Shan 2A and PolimaA CMS materials,repectively. The corresponding restorers investigated were 252C and 32C. 252B,the maintainer of 252A,and other five maintainers(B_1,B_2,B_3,B_4,B_5)were used. P117 was used to investigate the partial sterility type.

The influence of maintainers on the sterility was investigated at flower appearing stage because the maintaining effects could be identified during that stage. Maintainers of

low temperature CMS line were not used for they might make conclusions more sophisticated in these investigations. The investigation of the unstable cytoplasmic male sterility was conducted at flower appearing stage, full-flower stage and the end of flowering period. Since the unstability of CMS was controlled by polygenes, the percentage of plants of different sterility types was used to illustrate the segregation.

Results

Effects of maintainers on the sterility of sterile materials

Three CMS lines, 252A, 384A and 32A, were crossed with five maintainers B_1, B_2, B_3, B_4, B_5 (Table 1). According to the field observation, crosses of CMS lines × maintainers often showed sterility segregation, some of the plants showed complete sterility. The higher the percentage of completely sterile plants in these crosses at flower appearing stage was, the better the maintaining effect of the maintainer was (Table 1).

Table 1. Percentages of sterile plants in CMS lines × maintainers (in 1990)*

	B_1	B_2	B_3	B_4	B_5	Mean
252A	23.5	100	14.7	5.9	0	28.9
384A	5.9	100	8.8	2.9	14.7	26.3
32A	17.8	100	5.9	17.7	14.7	31.2
Mean	15.7	100	9.8	8.8	9.8	

* 34 plants in each cross were examined

B_2 among the five maintainer lines possessed the best maintaining effect, B_1 followed and the other three maintainers had lower percentages of sterile plants, which indicated that maintainers could greatly affect the sterility. There was no apparent difference among 252A, 384A, 32A, CMS lines. As the three CMS lines contained the cytoplasms of 252A, PolimaA and Shan2A, respectively, it might be deduced that these cytoplasm did not greatly affect the sterility. The main factor affecting sterility was nuclear genes of the maintainer, and special genetic background of the maintainer would result in better maintaining effects.

The inheritance of the partial sterility type

F_1 (252A × P117) displayed a partial sterility type in which all plants yielded trace pollens during the whole flowering period. F_1 plants were selfed (F_2), sibcrossed (F_2'S) and backcrossed to 252B (BC) (Table 2). The segregation of F_2 was consistent with that of F_2'S. Sterility at flower appearing stage (10 April), full-flower stage (15 April) and the end of flowering period (22 April) was almost the same. No expected segregation ratio has been found. Since F_1 plants were intermidiate between sterile and fertile plant, its male parent P117 must contain partially restoring genes. In F_2 population, more than half of the plants showed the sterility similar to that of F_1, and percentages of completely sterile plants (S) and fertile plants (F) were both small, thus the character of the partial sterility was controlled by polygenes. This result accorded with that of Fu T. D. (1989). The number of partial sterile plants of BC (with trace pollen, PS) was slightly more than that of F_2, and this percentage obviously inceased from flower appearing stage to the end of flowering period. The explanation of this phenomena might be attributed to the excellent maintainer 252B and its sentitivity to temperature.

Fertile plants of F_2 were selfed (F) and crossed with completely sterile F_2 plants (S ×

F)(Table 3). Sterile plants emerged at the end of flowering period in F_3 family from fertile F_2 plants. S×F was similar to BC mentioned above. Descent generations from F_2 reflected the sterility segration features manifested in F_2 and BC generations.

Table 2. The sterility performances in the progenies of 252A×P117 (in 1991)

Generation	Number of plants observed	Stage	S	PS(%)	F	S:PS:F
F_2	60	10,April	6.7	76.6	16.7	1:11.4:2.5
	60	15,April	5.0	51.7	43.3	1:10.3:8.7
	60	22,April	8.3	76.7	15.0	1:9.2:1.8
F_2'S	60	10,April	11.7	65.0	23.3	1:5.6:2.0
	60	15,April	11.7	70.0	18.3	1:6.0:1.6
	60	22,April	11.7	71.6	16.7	1:6.1:1.4
BC	90	10,April	18.9	74.4	6.7	2.8:11.1:1
	90	15,April	19.2	75.2	5.6	3.4:3.4:1
	90	22,April	24.4	72.3	3.3	7.4:21.9:1

Table 3. The sterility performances in the progenies of F_2 family (in 1992)

Cross	Number of plants observed	Stage	S	PS(%)	F	S:PS:F
F	96	6,April	—	91.7	8.3	0:11.1:1
	96	12,April	—	75.0	25.0	0:3:1
	96	18,April	17.7	72.9	10.4	1.6:7.0:1
S×F	64	6,April	6.3	91.6	2.1	3:43.6:1
	64	12,April	6.3	91.6	2.1	3:43.6:1
	64	18,April	56.3	35.3	8.3	6.8:4.3:1

Selfing high temperature CMS line

06A was a typical high temperature CMS line which yielded trace pollen at flower appearing stage, but had no pollen at all after full-flower stage. In 1990, the plumpness of selfed seeds of 29A was low, 60 weak plants of the progeny of 06A were obtained. At flower appearing stage(9, April, 1991), trace pollen was observed on the pistils of every plants. At full-flower stage, 61.7% plants were completely sterile, and others had trace pollen. At the end of flowering period, completely sterile plants accounted for 93.4 percent and other plants were found having small amount of pollens. Just at full-flower stage, 4 plants were selfed, but three of them did not yield seeds, and only one plant produced wrinkled seed. In the following season, we gained 13 plants among which 12 were fertile, and one plant showed sterility with trace pollens. It seemed that there was a tendency to increase the fertility with successive selfing of the high temperature CMS line.

Cross between high and low temperature CMS lines

29A was a low temperature CMS line which was sterile only before full-flower stage. (06A ×29A)F_1 plants with trace pollens increased from 18.7 to 72.7 percent during flowering period, otherwise the sterile and fertile plants reduced (Table 4). At full-flower stage fertile plants(F) and plants with trace pollen(PS)were selfed, and fertile plants were crossed

with completely sterile plants (S×F) (Table 5). 2 out of the 5 selfed plants with trace pollen yielded seeds which further produced 51 plants. The sterility segregation varied greatly in the three F_2 families during the flowering period, so the genetic regulation of this cross was extremely complex.

Table 4. The sterility performances of (06A×29A)F_1 (in 1991)

Stage	S	PS(%)	F	S:PS:F
10, April	28.0	18.7	53.3	1:0.7:1.9
15, April	9.3	35.3	26.0	1:3.8:2.8
22, April	7.0	72.7	20.3	1:10.4:2.9

Number of plants observed was 300.

Table 5. The sterility performances in the F_2 families (in 1992)

Family	Number of plants observed	Stage	S	PS(%)	F	S:PS:F
PS	51	6, April	62.7	21.6	15.7	4.0:1.4:1
	51	12, April	49.0	21.6	29.4	1.7:0.7:1
	51	18, April	66.7	21.6	11.8	5.7:1.8:1
F	128	6, April	23.4	7.8	68.8	1:0.3:2.9
	128	12, April	15.6	21.9	62.5	1:1.4:4.0
	128	18, April	6.3	3.1	90.6	1:0.5:14.4
S×F	80	6, April	43.8	18.7	37.5	1:0.4:0.9
	80	12, April	39.6	14.6	45.8	1:0.4:1.2
	80	18, April	—	77.1	22.9	0:3.4:1

Discussion

Cytoplasmic male sterility is controlled by a pair of alleles that is major genes, but there exists unstable sterility during flowering period. Unstable sterility mentioned above includes high and low temperature sterility and partial sterile type. Unstable sterility may be controlled by polygenes. The present studies suggest that unstable sterility may have the following features:

1. Maintainers may greatly influence the sterility, but sterile cytoplasm does not affect the maintaining effect. Unstable sterility may be controllred by nuclear genes which are polygenes.

2. The polygenes controlling unstable sterility are sensitive to temperature so as to develop into high and low temperature CMS lines.

3. Different unstable sterility types are caused by their corresponding polygenes.

4. The inheritance of unstable sterility materials is complex.

5. The presence of major sterile genes may be concealed by the polygenes for the sterile plants can be observed in the progenies of selfed fertile plants.

6. The study on research of selfing high temperature CMS line indicates that the polygenes may congregate by the way of selection, then make the CMS line fertile. The problem emerged in the utilization of Shan 2A (Fu T. D., 1990) can be explained by this theoretical suggestion.

One of the following factors can completely change the sterility of CMS lines: 1. major genes controlling sterility; 2. polygenes; 3. evironmental factors; 4. sterile cytoplasm. An excellent cytoplasmic male sterile line should contain sterile cytoplasm, a pair of sterile major alleles and fewest polygenes. On the other hand, if the genetic and evironmental conditions are fit for rapeseed plants, sterility will naturally appear, but we can't erase the contribution made by the first man who found the sterile genes.

References

Fu Shouzhong, Qi Cunkou, Tang Jihong. (1989) Breeding of cytoplasmic male sterile line MICMS in *Brassica napus* L. *Acta Agronomica Sinica*, 15(4): 305—309(in Chinese)

Fu Tingdong, Yang GS. (1989)Development and studies on three polima cytoplasmic male sterile lines in *Brassica napus* L. *Journal of Huazhong Agricultural University*, 8(3): 201—207(in Chinese)

Li Dianrong. (1984)Research and utilizition of CMS line 1763A and 6223A in *Brassica napus* L. *Shanaxi Agriculture Sciences*, 1: 7—10(in Chinese)

Liu Houli. (1985)Rapeseed genetics and breeding. Shanghai Science and Technology Press

Yang GS, Fu Tingdong. (1990)Studies on the Shaan 2A cytoplasmic male sterility of *Brassica napus* L. *Journal of Huazhong Agricultural University*, 9(2): 141—147

Yang GS. (1987)Influence of environmental factors on cytoplasmic male starilty in *Brassica napus*, *Oil Crops of China*, 3: 15—19