Relationship of trace pollen with agronomic characters in a cytoplasmic male sterile line of rapeseed (*Brassica napus*)

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ABSTRACT

To fulfil the potential of sterile line, experiments were carried out to study the effects of trace pollen on vigour, flower and organ size, and agronomic characters of the high-quality rapeseed cytoplasmic male sterile line 681A (*B. napus*) and its hybrids. The results showed that high levels of male sterility in the cms line 681A were associated with reduced vigour, smaller flower organs, shorter siliques, less seeds per pod, an overall poorer agronomic performance, and lower seed yields of 681A and its hybrids. A better route of seed production for the CMS line with trace pollen is proposed. Hybrid seed should be produced in other regions with more stable temperatures during the flowering period by using sterile line without pollen.

Key words: Rapeseed cytoplasmic male sterility pollen growth

INTRODUCTION

Rapeseed (*Brassica napus*) has a remarkable heterosis and a great coefficient of propagation. Hybrid seeds of rapeseed are easily produced. Therefore, hybrid rapeseed can be commercially exploited more rapidly than other hybrid crops. Research on utilization of rapeseed heterosis is extensively carried out at home and abroad. Many male sterile lines, cytoplasmic or nuclear, have been developed and used as the female parent in hybrid seed production. The commercially released hybrid rapeseed varieties such as Qinyou 2, Huaza 3, Huaza 4 were bred by using the male sterile lines.

The three-line hybrid varieties which are based on a cytoplasmic male sterile (CMS) line and its maintainer line and restorer line are a major type of hybrid rapeseed. The three lines widely used are of Polima CMS type which will produce trace pollen and seed impurity when influenced by fluctuation of temperature. Rapeseed breeders have to take an effort to select the stable CMS lines which should be temperature-insensitive as well as desired in agronomic and quality characters in order to solve the problem of trace pollen.

A novel CMS line, 681A is derived from a spontaneous male sterile mutant of the double-low rapeseed cultivar Xiangyou 13 bred by us. Genetic studies showed that this line is identical to a Polima CMS line in restorer-maintainer relationship. Like a Polima CMS line this line also produces trace pollen under the low temperature. Furthermore, there is association of degree of male sterility with botanical and agronomical characters in this line. The botanical and agronomic characters change as degree of male sterility increases in this line. Here we report growth characteristics, floral morphology and agronomical characters of three types of 681A plants and their corresponding hybrid plants which will lay a foundation of more efficient use of 681A.

MATERIALS AND METHODS

The experiments were carried out on the experimental farm of Hunan Agricultural University, Changsha. The 681A plants were classified into three types, plenty (P)-pollen, trace (T)-pollen and no (N)-pollen, according to pollen amount in their anthers. Ten plants of each type were measured for floral organ sizes at the flowering stage and agronomical characters at maturity in spring,1997. Another 5 plants of each type were emasculated by hand and pollinated with restorer pollen in the same season. The seeds from the 5 plants of the same type were mixed and planted together with the restorer line in fall, 1997 with a random block design. Pre-winter plant growth, floral organ sizes, agronomic characters and plot seed yields were determined at the appropriate stages.

RESULTS

Relationship of pollen amount in the anthers with floral organ sizes and plant agronomic characters in 681A As shown in table 1, the N-pollen and T-pollen 681A plants have much smaller floral organs whereas the P-pollen plants have petals and stamen 80% long as those of the restorer line. However, all types of 681A plants have pistils similar in length to those of the restorer line. All types of 681A plants have poorer agronomic characters compared to the restorer line and the poorer agronomic characters, the higher degree of male sterility of 681A plants.

Table 1 Floral organ sizes and agronomic characters of different types of 681A plants and the restorer line used in crossing

	Floral organ sizes (cm)				Agronomic characters				
plant type	petal length	petal width	stamen length	pistil length	height (cm)	primary branches	siliques /plant	silique length(cm)	seeds /silique
N- polen	0.90	0.50	0.50	1.10	146	5.0	283	4.2	12.4
T-pollen	0.94	0.50	0.62	1.15	147	5.0	289	4.7	14.5
P-pollen	1.28	0.62	0.81	1.16	154	6.2	321	5.6	15.8
Restorer	1.50	1.00	1.15	1.20	170	8.0	379	6.5	20.2

Growth vigor, floral organ sizes and agronomic characters of hybrids plants derived from different types of 681A plants A s shown in table 2, the hybrid plants derived from N-pollen 681A plants did not show obvious heterosis in pre- winter growth vigor, agronomic characters and seed yield and had slightly smaller petals, shorter siliques and less seeds per silique compared with the restorer line. However, this type of plants had more siliques per plant than the restorer line. This type of plants therefore produced seed yield almost equal to the restorer line. The hybrid plants derived from both T- and P-pollen 681A plants had a remarkable heterosis because of strong pre-winter growth, taller plants, more branches and siliques per plant and therefore outyielded the restorer line by 11.4%and 16.3%, respectively. In addition, there was no clear difference in floral organ sizes between these hybrid plants and the restorer line. These results indicated that the degree of heterosis of the hybrid plants was inversely correlated with degree of male sterility of the 681A plants as a maternal parent.

Table 2 Comparison of Growth vigor, floral organ sizes and agronomic characters between the hybrids plants derived from different types of 681A plants

Items investigated	N-pollen plants× restorer line	T-pollen plants× restorer line	P-pollen plants× restorer line	restorer line
Pre-winter growth				
Leaf length (cm)	24.7	25.6	26.4	24.2
Leaf width (cm)	12.9	14.2	16.3	12.6
Leaf area (cm^2/plant)	381.4	436.0	464.4	390.4
No. green leaves	9.3	9.5	9.8	9.2
Floral organ size				
Petal length (cm)	1.59	1.60	1.65	1.64
Petal width (cm)	0.80	0.97	1.05	1.11
Stamen length (cm)	1.02	1.04	1.03	1.03
Pistil length (cm)	1.07	1.04	1.06	1.05
Agronomic characters				
Plant height (cm)	167.2	171.6	173.5	168.8
Primary branches/plant	7.2	8.1	9.2	6.6
Siliques/plant	397.5	403.2	421.1	365.4
Silique length (cm)	4.1	5.8	6.9	7.0
Seeds/silique	14.3	18.7	20.1	19.2
Seed yield (g/1.5m^2)	253	274	286	246

DISCUSSION

The Yangtze River Valley is a major rapeseed production area in China, where it is often cold and rainy or cloudy during the flowering stage of rapeseed. Rapeseed CMS lines are so sensitive to low temperature that they can produce pollen grains under low temperature and set seeds by self-pollination. This brings hybrid rapeseed seed production with a great difficulty. To solve this problem, rapeseed breeders are devoted to breeding the stable male sterile lines which will not form any pollen even under low temperature. In the end, the agronomic characters of the CMS lines become undesirable and heterosis of the hybrids derived from these CMS lines is reduced although their sterility has been improved. This is confirmed in this study. To develop strong heterotic hybrid rapeseed varieties and produce high-purity hybrid seeds we propose that hybrid rapeseed seed production should be moved to northwestern China where it is warm in summer and the CMS lines no longer produce any pollen when grown.