Utility of heterosis of two-line hybrid rapeseed in China: approaches and achievements

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Abstract

The author reviewed the approaches and achievements for utility of two-line hybrid rapeseed in China. The approaches of producing hybrid rapeseed include self-incompatibility (SI), dominant genic male sterility (DGMS), recessive genic male sterility (RGMS), ecotype cytoplasmic male sterility (ECMS), thermo and/or photoperiod sensitive genic male sterility (EGMS), and male sterility induced by chemical hybridizing agent (CHA). Almost all these approaches except SI are employed only in China because there are plentiful of labor resource and the cost of hybrid seed is not significantly higher than inbred line for each small farmer. All of these approaches have been put in practice on larger scale in China, but CHA approaches and RGMS system were more successful. However, ECMS and EGMS system are also promising.

Key words: rapeseed, two-line hybrid, Self-incompatibility, genic male sterility, cytoplasmic male sterility, chemical hybridizing agent

There are significant heterosis for seed yield and other agronomic traits in rapeseed. The exploitation of male sterility is a major approach to ensure outcrossing in the female parent and produce hybrid seed economically and on a large scale. Cytoplasmic male sterility (CMS) had been widely used in rapeseed in China. However, some CMS systems may be environmentally unstable in maintaining male sterility and/or male-fertility restoration. Furthermore, the possible association between cytoplasm type and disease susceptibility is widely concerned.

In crop breeding, 'two-line hybrid' has two means. The narrow sense 'two-line hybrid' only include environment sensitive genic male sterility (EGMS, including thermo sensitive genic male sterility (TMS) and photoperiod-thermo sensitive genic male sterility (PTGMS)) system but the broad sense including any system producing hybrid by a couple of female and male lines that were multiplied by selfing, such as self-incompatibility (SI), dominant genic male sterility (DGMS), recessive genic male sterility (RGMS), ecotypic cytoplasmic male terility (ECMS), and male sterility induced by chemical hybridizing agent (CHA) except EGMS,. The advantages of two-line system are the higher yield potential than three-line and three-way system and, for CHA, EGMS, and ECMS, the simplification of procedure for multiplying female parents.

1. Self-incompatibility (SI)

Self-incompatibility system was thought as a potent approach for hybrid breeding due to allowing blending the parents to produce hybrid. However, this approach encountered serious problem such as instability of incompatibility expression and difficulties in multiplication of female parent. This approach had been disfavored due to the great success of male sterility system.

2. Dominant genic male sterility (DGMS)

A dominant male-sterility that can be restored by the epistatic inhibiting gene or the allelic restoreing gene have been found in *B. napus* (Li et al 1988, Hu et al 2004, Song et al 2005). So it is possible to produce two-line hybrid by it. The male sterile is maintain by sibling-cross between 50% homozygous and male-sterile plants and 50% heterozygous and fertile plants. In order to produce hybrid, the plants with the male sterile must be selected in the field before flowering, and then used as the female parents. It is labor intensive but practisbale to remove the 50% fertile plants from the female parent by view of plentifulness of labor resource in China. But the restorer resouces is very few and it is not easy to get a lot of hybrid combination.

3. Recessive genic male sterility (RGMS)

In China, recessive genic male sterility (GMS) based on 117A (Hou et al 1990) and S45A is widely used in breeding hybrid rapeseed. It use similar procedure as in DGMS system for propagating the male sterile line and producing hybrid and also need plenty of labor resource to rogue the 50% heterozygous fertile plants. But the main advantage is any other line can be use as the restorer, so it is very easy to get a lot of hybrid combination with higher yield potential. Many hybrids based on this two system, such as 'Youyan 7', 'Youyan 9','Youyan 10' 'Shuza 6', 'Shuza 7', were registered.

4. Environment sensitive cytoplasmic male sterility (ECMS) or ecotype-sensitive CMS

Yang et al (1995) and Liu et al (2000) find some ECMS type such as 'AB1' and '508-1S' that was sterile in higher

temperature and long daylength and Dong et al (2004) also find a reversely ECMS line '533S' that was sterile in lower temperature and shorter daylength. Some hybrid, for instance, 'Liangyou586' (ECMS) (Liu et al., 2000), 'Huayouza 12', and 'Huayouza 13' (ecotype-sensitive Polima CMS), had been registed recently. However, this system only simplifies the multiplication of female parent, and still need develop many restorer lines. It did not avoid the disadvantages of CMS system.

5. Environment sensitive genic male sterility (EGMS, TGMS, PTGMS)

Xi et al (1994), Wang et al (1997), and Li et al (2002) report some new type in EGMS in *B. napus* and *B. juncea*. We also find three PTGMS lines in *Brassica napus* and the quality were in improvement now (unpublised). The PTGMS line become male-fertile under low temperatures and/or short daylength, hence it can maintain and propagate itself. The advantages of this method are: (i) male sterile line is multiplied by selfing, without a maintainer as CMS line; (ii) any other genotype can be used as paternal parent; (iii) negatives associated with CMS can be avoided. A commmercial hybrid 'Xiangzayou 5' based on TGMS has been registered in China (Xi et al, 2005). It showed that EGMS system is also promising.

6. Chemical hybridizing agent (CHA)

The major advantage of using a CHA to produce hybrids is that, theoretically, almost any normal inbred line may serve as a female parent and it does not require the establishment of a CMS or NMS system. This will substantially reduce the time required for hybrid development.

Some chemicals had been identified as an effective CHA chemicals for rapeseed (Guan et al. 1998, Guan and Stringam 1998, Singh and Chauhan 2004) but it would seem that only zinc methyl arsenate were ever successfully used to produce commercial hybrids in rapeseed (Guan and Stringam 1998). Some commercial hybrids including 'Shuza No.2', 'Shuza No. 3', 'Shuza No.5', 'Yuhuang No.1', 'Yuhuang No.2', 'Xaingzayou No.1', 'Xaingzayou No.6', etc, have been developed using zinc methyl arsenate, and registered in China. This has demonstrated the potential use of CHAs in hybrid breeding. However, methyl arsenate could cause pollution to the environment (Guan 1995). In view of this, development of more effective CHAs without environmental and health risks is still important in the exploitation of heterosis in rapeseed. The authors have identified 15 chemicals that can induce male sterility in rapeseed, and found tribenuron-methyl to be one of the best (Yu et al 2006). Tribenuron-methyl is suggested to be a potential CHA based on the efficacy of inducing over 94% male-sterile rate, very low cost, low residues and low toxicity.

These approaches except SI are employed mainly in China because there are plentiful of labor and the difference between the average seed cost of hybrid and of conventional line is not significant for each farmer who only manage 0.1ha field for rapeseed. All of these approaches have been put in practice in China, but CHA and RGMS approach were more successful up to now. However, as the labor cost increase quickly in China, RGMS will lost its predominance some day. In China, from subtropics to cold zone, from western plateau to eastern lowland, rapeseed was cultivated widely, so it is easy to find different regions for the multiplication of EMS and for hybrid producing. However, application of this system is limited by the instability of atmosphic temprature before and during the anthesis since the decline of temperature could render the fertility.

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