The Genetic Improvement of Rapeseed in China

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Abstract: Rapeseed is a major edible oilseed and protein crop in China. Its oil is 35% of the total vegetable oil in China, and its meal is 25%. The rapeseed production in China has been increased steadily since 1980s, especially in 1990s. The yearly averagee planting acreage of rapeseed is 6.25 million hectares, from 5.70 - 6.90 million hectares, three times of the 1950s - 1960s'. The total production has been increased 10 times since then. At present, the total vegetable oil production is 8.5 million tons, meanwhile the consumption is about 11 - 12 million tons, so there is still a shortage of 3 - 4 million tons every year. There are about 144 double and single low cultivars registered officially in China during 1985 - 2002, and 67 are OP's cultivars and 77 are hybrids. The potential yield of the double low OP's cultivars is about 5% higher than that of the normal cultivars(check, double high), and yield of the hybrids are 15% - 20% higher than that of the checks. It is predicated that: the planting acreage can reach 7 - 8 million hectars in 5 - 10 years; double low cultivars will replace double high normal cultivars; hybrids will replace OP's cultivars; cytoplasm male sterility and genic male sterility are still the two important system for heterosis application; the studies on transgenic rapeseed will become important and high yield, high oil content and good resistance to diseases will be more important breeding goals in China. [Life Science Journal. 2006;3(1):78 - 80] (ISSN: 1097 - 8135).

Keywords: rapeseed; genetic improvement; China

1 Brief Introduction of Rapeseed Production

Rapeseed is an important edible oil and protein crop in China. Its oil is 35% of the total vegetable oil in China, and its meal is 25%. The rapeseed production in China has been increased steadily since 1980s. The yearly averagee planting acreage of rapeseed is 6.25 million hectares, from 5.70 - 6.90 million hectares, three times of the 1950s - 1960s'. The total production has been increased 10 times since then(Table 1 and Table 2).

Table 1. Rapeseed production in the World

Nations	Area (10^6 hm^2)	Yield (kg/hm^2)	Total Yield (10^4 t)
World	25.057	1469.5	3690.1
China	6.807	1434.9	977.7
India	6.560	888.3	579.6
Canada	4.826	1449.3	700.3
Autralia	1.117	1327.4	145.1
Europe	4.387	2628.0	1155.6

Several reasons have been promoting the development of rapeseed production since 1990s. Firstly, with the development of Chinese economy, the national and international market demand for edible oil has been increased greatly. Secondly, the planting acreage of winter wheat in the country was decreased because the demand for wheat was decreased. There is potential land for farmers to plant more rapeseed. Thirdly, the rotation of rice-rapeseed made the changes of rotation systems, as a result that a lot of areas of rice-rapeseed rotation has replaced other crops.

Table 2. The production and consumption in China

Year	Production (10^4 t)	Consumption (10^4 t)	Shortage (10^4 t)
1994 - 1995	615	963	338
1995 - 1996	680	937	257
1996 - 1997	684	1000	316
1997 - 1998	746	1130	384
1999 - 2000	832	1120	288
2001 - 2002	850	1200	350

Finally, more and more rapeseed cultivars with high yield and good quality were registered. These cultivars brought a lot of benefit to farmers.

At present, the production of edible oils in China is about 8.5 millions (rapeseed oils about 3.5 million tons) while market demand is 11 - 12 million tons (9 kg per person). There is a shortage of 3.0 - 4.5 million tons. Comparing to the consumption of 15 - 16 kg oils per person in the Southeast Asia, the demand might be 18 - 20 million tons in the countries. This analysis indicates that there is a great of market potential for edible oils in China.

2 Quality Improvement in Rapeseed

The rapeseed production has been increased steadily since 1950s and 1960s in China, *Brassica napus replaced Brassica campestris* (the cultivation of *B. campestris* was over 80% before 1960s). In 1970s, *B. napus* became popular (over 80%). In the early 1990s, a lot of single low or double low OP's (open-pollinated) varieties were extended, meantime, some single low or double low hybrids were registered. After 1995, the planting acreage of single low varieties was decreased and the acreage of double low varieties (include OP's varieties and hybrids) were increased.

In 1975, the low erucic acid variety, "Oro", was introduced into China. In 1980, the double low variety, "Tower", was also introduced into China. Both of them are the spring type and are planted only in a spring rapeseed area which are unsuitable for the winter rapeseed area, such as the Yangtze River basin. The winter rapeseed area is over 80% of total rapeseed areas, a short-day photoperiod in China. Due to the varities from Canada and Europe with strong photoperiod sensitiveity, they need a long-time photoperiod to flower, so their maturity time is longer than that of semi-winter and winter types, and their growth are not so good. Some winter type varieties from Europe have also been introduced to China, and their maturity date is also delayed because of lack of enough strong photoperiod in this region. So we have to breed some cultivars for adaption to condition in China.

The first public rapeseed program in China was initiated in 1980. The first Chinease double low cultivar Yuyou No. 2 in *Brassica napus* was released in 1985. Since then, a series of cultivars with improvement in yield, resistance to diseases, quality and agronomic type, have been released. Now, there are about 144 double and single low cultivars registered officially in China during 1985 – 2002, of which 67 are OP's cultivars, and 77 are hybrids. The potential yield of the double low OP's cultivars is about 5% higher than that of the common quality cultivars (check, double high).

3 Application of Heterosis

The development of F1 hybrids in maize, sorghum and sunflower gave dramatic increasee in yield over the open-pollinated varieties by exploiting heterosis or hybrid vigour. In the case of sorghum and sunflower the discovery of cytoplasmic male sterility (CMS) systems in each species quickly led to the development and introduction of hybrids. It is expected that a CMS system could be found in *Brassica* that would enable the development of hybrid in double low rapeseed. A good candidate crop for hybrid development should:

– be self pollinated so as to enable the development of inbred lines.

– be capable of cross pollination so as to enable the easy production of hybrid seed.

– have a low seeding rate and therefore permic low cost seed per hectare.

– have good heterosis for yield.

– have a good pollination control system to enable the easy production of F1 hybrids.

Rapeseed (*Brassica napus*) has all these traits but is lacking a good pollination control system to make hybrids. Although a range of different methods has been put forward as means to produce hybrids such as self incompatibility (SI), genic male sterility (GMS) and the use of chemical hybridizing agents (CHA), the successs and simplicity of CMS in other crops suggested that this would be an ideal method to make hybrids. Luckily, in 1972, a new (CMS) system, "polima A", was discovered by professor D. T. FU (Huazhong Agricultural University) in China. Initial work was showed that there was a single dominant gene for restoration which did not occur in normal cultivars. All cultivars behaved as B lines or had some degrees of partial restoration so could be classified as poor maintainers. In fact, some good restorative genes for polima A were discovered in Chine and other countries. Polima system is the first practicable cytoplasmic male sterility systems in the world. It led to the release of the first hybrid , Qinyou No. 2, in 1986. The first single low hybrid, Huaza No. 3, released in 1991. The first double low hybrid, Huaza No. 4, registered in 1994. Since then, a series of cultivars with improvement in yield, resistance to diseases, quality and agronomic type, have been released. Now, there are about 77 double and single low hybrids registered officially in China during 1985 – 2002. The potential yield of the double low hybrids is 15% – 20% higher than that of the normal checks.

Despite of the success of these hybrids, it was very clear that the polima CMS system had limitations. The challenge was to find germplasm which could produce A lines with stable male sterility. It was very difficult to breed A lines with stable male sterility and even the best ones produced some pollen at either low or high temperatures (or both). The petal morphology of the A lines attracted bees to gather nectar but they do poor job of transferring pollen. This means that seed yield in hybrid production fields would be low and unpredictable. To overcome the disadvantage of polima CMS, a range of different methods have been put forward such as GCMS (genic and cytoplasmic male sterility) and dominant genic male sterility gene (DGMS) to improve the stability of the male sterility. Two new GCMS systems (dominant genic and polima CMS male sterility, recessive genic and polima CMS male sterility) have been established. With these new GCMS, the polima line 1141A and its two hybrids (Huaza No. 3, Huaza No. 4) have been improved. The genetically improved A line has more stable male sterility. The genetically improved two hybrids (Huaza No. 3, Huaza No. 4) have higher yield, better quality and better tolerance to the disease of *Sclerotinia*. The DGMS has been used to establish a random-mating population of polima CMS maintainers by using some polima CMS maintainers to cross twice with the DGMS.

4 Future Direction

(1) The planting acreage might reach 7 – 8 million hectares in the coming 5 – 10 years. The acreage of transplanting rapeseed will decrease because the cost of labour is going up. So the raise of total production would be limited.

(2) Double low cultivars will replace double high cultivars in 3 – 5 years. The breeding goal is to increase oil and protein content, resistance to diseases, higher yield and decrease the glucosinolates content.

(3) The breeding of yellow seed coat has been in a great advance in many institutions. It is predicated that the acreage of double low cultivars with yellow seed coat will be extended widely in 3 – 5 years.

(4) The major breeding goal is to utilize heterosis with good quality. Cytoplasmic male sterility and genic male sterility are still two important systems for hybrid breeding . The planting acreage of hybrids will be over 75% in 5 – 10 years.

(5) The studies on transgenic rapeseed will become important. At present the nation still limits the extension of the transgenic plant. If the nation could approve genetic modification of rapeseed, herbicide tolerant varieties would be the first transgenic rapeseed cultivars in market.

(6) The processing level of rapeseed will be improved greatly by introducing equipment and improving technology.

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