Genetic improvement of rapeseed in China

ZHOU Yongming, FU Tingdong

National Key Laboratory of Crop Genetic Improvement, Huazhong Agricultural University, Wuhan 430070, China
Email: ymzhou@mail.hzau.edu.cn

China is the largest country for rapeseed production and consumption in the world. The growth areas and total production of rapeseed in China are about 7.0×10^6 hm^2 and 1.1×10^7 t, respectively, both being largest in the world and accounting for one third of globe's. Great progresses have been made in seed yield per unit, total production and quality improvements since the introduction of *Brassica napus* into China. The successful development and extension of hybrids since the discovery of Pol cytoplasmic male sterility (Pol CMS) at large areas has contributed significantly to the elevation of rapeseed production in China. We summarize in this article the rapeseed production and genetic improvement and outline the perspectives of rapeseed breeding and production in China.

1. Development of rapeseed production in China

The growth of *Brassica napus* reached over 85% of total *Brassica* oil crops acreage and became the major type of *Brassca* oil crops in China in 1980s although the crop was only introduced into China in 1940s. Rapeseed production in China has been developed fast in China since 1980s and especially 1990s. Compared with that in 1950-60s, the planting acreage has been raised 3-4 times, and the total yield has been increased more than 10 times (Table 1).

Table 1 Rapeseed planting acreage and yield in different years

Years	Yearly acreage million hectares	Yearly average (kg/ha)	Total yield per year (million tones)
1950-59	1.936	463.5	0.8855
1960-69	1.731	478.9	0.8332
1970-79	2.127	652.0	1.3865
1980-89	4.246	1153.7	4.8990
1990-99	6.249	1331.5	8.3210
2000	7.495	1518.5	11.3810
2001	7.095	1596.8	11.3310
2002	7.143	1477.5	10.5522
2003	7.221	1581.0	11.4200
2004	7.500	1757.6	13.1820
2005	7.240	1802.5	13.0500
2006	6.740	1854.6	12.5000

There are three major reasons for the fast development of the rapeseed industry in China. (1) Market demand. Over last 10 years the consumption of edible vegetable oils increased at an average of 0.5 million tones per year in China. Due to the increasing demand of edible plant oils China needs to import about 3-4 million tones of edible vegetable oils per year. (2) Development and extension of new varieties with high yield and good qualities as well as the improvement of cultivation techniques. With the new varieties and techniques, farmers have gained better economic benefits, which in turn stimulated the growth of rapeseed production. (3) Increased growing acreage of rapeseed in the Yangtze River Basin. Currently, the acreage of rapeseed growth in this region accounts for 80% of rapeseed growth in China. There had been grown wheat in the Yangtze River Basin, but the yield and quality were not good due to the rainy weather during springs. Farmers therefore turned to growing rapeseed from traditional growing of wheat.

2. Rapeseed breeding in China

Rapeseed breeding is facing two reforms in China. One is to replace double high cultivars with double low ones, and the other is to extend hybrid varieties instead of open-pollinated (OP) cultivars.

The introduction of Oro and Tower in later 1970s marked the beginning of quality breeding programs in China. Since then, a number of double low varieties have been registered. Since 1990's the improvement of both quality and yield has been achieved by combined quality improvement with heterosis utilization.

From table 2, we can see that the seed yield of OP varieties has been increased by 18% (-8.0%→10%) compared with CK, Zhongyou821 (double high), from 1994 to 2004. A similar trend can also be seen in hybrid varieties (7.05%→25%=18%). An average 1.8% of the yield advance per year has been achieved in this period and there is similar achievement in OP and hybrid varieties. But the yield of hybrid varieties was 10-15% more than that of OP varieties.

From 2000-2004, there are 170 varieties registered in China. Most of them were hybrids.

Table 2 Comparison of the seed yield between double low (low erucic acid and glucosinolates) varieties and CK in Hubei trials

Years	1992	1994	1998	2000	2004	1994-2004
Double low OP varieties	-8.0%	-8.0%	+1.5%	+6.7%	+10%	+18%
Double low Hybrid varieties	-	+7.05%	+10.18%	+16-19%	+20-25%	+18%

Table 3 Numbers of cultivars registered in China during 2000-2005

Total	OP cultivars	Hybrids				
		CMS	GMS	GC	EMS	Sub-total
217	47	107	47	4	12	170

According to table 3, there were 170 cultivars registered during recent 5 years. OP variety was 47 (about 22%). The ratio of hybrids (170) was about 78%. Among 170 hybrids, 107 cultivars (about 63%) were developed using CMS system (most of them used Pol and Shan 2A CMS), and 47 hybrids (about 27.6%) were based on GMS (genic male sterility) system. The utilization of GMS system was developing quickly. In addition, there were 4 hybrids by using GC (gametocides), and 12 by EMS (ecotype male sterility). The wide application of hybrids recent years has resulted in the significant increase of sees yield per unit.

Table 4 The planting acreages of double low varieties and hybrid varieties

Years	Rapeseed planting acreage				
	Total acreage (million ha.)	DL varieties		Hybrid varieties	
		Acreage (million ha.)	Ratio %	Acreage (million ha.)	Ratio %
2000	7.495	3.8895	51.9	2.933	39.6
2001	7.095	4.0156	56.6	3.443	48.5
2002	7.143	4.5720	64.0	3.549	49.6
2003	7.221	4.9998	69.2	3.600	49.8
2004	7.838	5.598	71.42	5.331	68.01
2005	7.921	5.765	72.78	5.642	71.23

The planting area of double low varieties is enlarging at the present. Among the total planting acreage, over 70% is double low varieties and hybrid varieties. However, the amount of double low seeds for processing is lower than expected because processing factories mixed the seeds from different sources of double low seeds and traditional double high seeds. Pol CMS Hybrids have been grown more than 50% of the total hybrid rapeseeds in China.

In addition, progresses in breeding for disease resistance, yellow seeds and lodge resistance have been made over the last few years.

3. The future trends of rapeseed production and breeding in China

(1) To enlarge the planting area to meet the market demand. At the present, the consumption of edible vegetable oils in China is about 12 million tones per year, but the total output of edible vegetable oils is just 8.5-9.0 million tones. There is a shortage of 3.0-4.0 million tones. We predict that the rapeseed planting acreage will reach to 7.5-8.0 million hectares in next 10 years.

(2) To develop some simple cultural techniques. The transplanting acreage in the Yangtze River Basin will be decreased rapidly because of the transfer of farmers from countryside to city. Meanwhile, several of simple cultural methods will be extended, such as, zero tillage, directly sowing seeds, and intercropping with rice and cotton. Those methods could affect seed yield. The utilization of herbicides is predicted to increase gradually. This means that the transgenic rapeseed with the tolerance to herbicide could be permitted to use at first if Chinese government allows the GMO rapeseed to be grown in China.

(3) Development of hybrids with good quality is the major breeding goal in coming years. The hybrid planting area will be over 60% in next 3-5 years. Besides CMS system, GMS will be used widely. EMS and GC might be used in some scale. The currently used system is polima cms in China, and it belongs to high temperature male sterile type, which has trace pollen under the lower temperature condition, but no pollen under high temperature. There are three methods to solve this problem. One is to develop stable Pol CMS lines by selecting maintainers. The second is to produce hybrid in spring planting area, where the temperature is high during rapeseed flowering. It could increase the hybridization ratio of 5-10%. The third is to utilize GC. Some agents can control the production of trace pollens by only spraying once. In addition, to select some new stable CMS, such as, Ogu CMS is a good way.

(4) To increase the oil content and enhance the disease resistance on the bases of "double low + heterosis". The oil content will be raised up 2-3 percentages in the coming 3-5 years in the Yangtze River Basin. The advance in yellow seed *Brassica napus* has been quick. We predict that the yellow seed *B.napus* will be extended in 3 years

(5) To develop new cultural techniques to make double low rapeseed a value-added crop. There are two successful

techniques developed so far. ① A technique to make double low rapeseed as both vegetable and oilseed crop. This technique should have a good future because of its higher efficiency. When the rapeseed plants grow up about 40cm in height, the main stems are cut about 15-20cm from top and used as a kind of fresh vegetable or for making of dehydrated vegetable. After cutting, some fertilization should be put on to make the plants grow out more branches. In this way, the seed yield is not affected, sometimes, even increased about 3-4%, but the maturity will be delayed about 3 days. In the Yangtze River Basin, especially the countryside around city, the technique will be got more useful. ② We conducted hybrids of rapeseed used as forage after wheat harvested in the poor pastoral areas (above altitude of 2000-2500 meters) along a wide area of Northwestern China (Tibet, Inner Mongulia, Gansu Province), where wheat is harvested in late July, and it is impossible to have another crop because the winter comes early in this area. We used the idea of forage rapeseed hybrid F_2 as planted in early August, so making full use of 70-80 day's light, heat, water and soil source, which can produce up to 37-45 tons/ha of green foliage as livestock feeds. This technology made the period of the fields covered by the crop postpone two months and benefit environmental protection.

(6) To improve the processing technique and scales. There are so many small processing factories with some old equipment and less-advanced techniques right now. With the establishment of new modern factories, they will eventually be sifted out in market competition. The new modern factories will supply market with new and better rapeseed products, and this will promote consumption market to grow at a faster pace. For example, concentrated proteins and phytic acid from rapeseed meal have been produced in some factories. Such techniques will accelerate the development of fine processing of rapeseed products.

References

1. The United States Department of Agriculture. Oilseed: *World Markets and Trade*, 2006, 9
2. Fu Ting-Dong (Chief-Editor). Breeding and utilization of rapeseed hybrid. 2000, Hubei Sci. and Technology Press
3. Fu Ting-Dong, Yang G. S, Tu J.X, Ma C.Z, 2001, The present and future of rapeseed production in China. Proceedings of International Symposium on Rapeseed Science. P3-5, hold in Wuhan, China; and published by Science Press, New York, USA, 2001.
4. Fu Ting-dong, Tu Jinxing, 2002, The research and utilization of fodder rapeseed after wheat harvested in North-west of China. "To promote the establishment of ecological environment in North-west of China". Chinese science & technology council, Sichuan science & technology published, P587-590
5. Zhang Yi, Tang Song, 2003, Analysis of the current status and future strategy of rapeseed production in China, 5th proceedings of Chinese conference on oil crops, 18-23, China Agricultural Press.