

Rapeseed Production and Progress of Double-low Variety Breeding Program in China

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We are feeling very much honored to be invited to attend the GCIRC technical meeting here at Cambridge, because this is a good opportunity for us to present our own work and also learn advanced experiences from our friends. Hereby, we would like to extend our gratitude and respects to the hosts and the chairman of the meeting, as well as to the experts and old friends present here. Now, I'll talk briefly about the rapeseed production and double-low breeding program of our country.

A. RAPESEED PRODUCTION

Being one of the origins of rapeseed, China has a long history of cultivation. In a long historical period, it was grown as vegetable, and gradually developed to be used as both vegetable and oil crop found in the records of mid 6 A.D. Because of its extensive adaptability, early maturity and also it can be grown in winter and spring, so farmers can get one crop of oil crop in the low temperature seasons, rapeseed is an important oil crop in our agricultural production and becomes an important source of edible vegetable oil.

Since the founding of the People's Republic of China, the central and governments at all levels have paid much attention to the research of rapeseed. Large number of early-maturing and high-yielding new varieties with *B. napus* as the main type have been bred and released and the relative high-yielding cultivation technique has been created to solve the low-yielding problem and facilitate the multi-cropping system, thus greatly promoting the rapeseed production of our country. The total growing area in 1982 reached 4,260,000 ha and the output, 55.87 million tons. Both the area and output have increased by 2.8 and 7.6 times respectively over that of 1949, making China a country with the largest area and highest production of rapeseed in the world. The average per hectare output of seeds reached 1,320.25 kg, which is higher than the world level. The output of seed oil makes about 40% of the total of the major kinds of edible vegetable oil in the whole country except soybeans.

At present, rapeseed is distributed in three major rapeseed ecological regions. First, the southern winter rapeseed region with the Yangtze River valley as the centre, including Yunnan-Guizhou plateau, Sichuan-Shaanxi basin, coastland in the south of China and the upper, middle and lower reaches of Yangtze River, which is the principle production region among all the traditional rapeseed production areas. In this region, rapeseed is mostly grown after rice or cotton in double cropping system and early and mid rice in three-cropping system. To facilitate the seasons, many places use the method of seedling transplant for both rice and rapeseed. The rapeseed area in this region makes about 60% of the total of the country with *B. napus* as the major type. *B. juncea* and *B. campestris* are mainly found in Yunnan-Guizhou plateau and coastland in south of China. Because of the suitable climate of proper temperature, rich rainfall, short low-temperature period in winter and fast temperature rising-back in spring, rapeseed can pass winter safely and grow fast afterwards. It belongs to the type of twice-growth in winter and spring or getting strong in winter and growing in spring, having light-green leaves, straight young seedlings and high and large plant type. But, in the mid-lower reaches of Yangtze River, there are plenty of rainings and long raining days in spring time, causing serious sclerotinia, so it is necessary to adopt strict controlling method and select resistant varieties.

Second, northern winter rapeseed region with the Yellow River and Huai River valley as the centre, including Longdong of Gansu province, Wei River valley in Shaanxi, the plateau in north of Wei River and most of areas of Henan, Shandong, and Hebei and the northern part of Anhui and Jiangsu. Rapeseed is mostly grown between grains in the system of three-crops in two years and five crops in three years, the system of double-cropping of rice and rapeseed is next to it. The area is about 30% of the total of the whole country and *B. napus* is the major type, *B. campestris* next to it. In this region, the temperature stays low for rather long time in winter and spring, prevention of freeze injury and seedling protection should be emphasized. The

growth in this period is characterized by lying on ground and the growing point is under ground. After spring, as the temperature rises, growth is quickened and also in the condition of long sunshine time, big temperature difference between day and night, as well as short raining during flowering period, high yield is easy to be achieved.

Third, northern spring rapeseed region with the north-western part of our country as the centre, including Qinghai-Tibet plateau, the interior area of inner Mongolia and Xingjiang and the plain area in the north-east of China, which is one of the original rapeseed production areas. Covering a large area, this region has variant natural climate and the distribution of rapeseed type and variety is extremely complicated. There are *B. campestris* small rapeseed with short growing period (90-120 days) in Qinghai-Tibet plateau and drought resistant *B. jucean* type in the interior plateau of inner Mongolia and Xingjiang. The agricultural area in the east of Qinghai has become the major *B. napus* spring rapeseed production area of China. In recent years, rapeseed has also been grown in some places of Xingjiang, inner Mongolia and northeast. Single cropping is practised in rapeseed production of this region. In the north-eastern plain, rapeseed is interplanted or grown in multiple cropping with dry crops, and is now changing to single cropping. The spring rapeseed area in this region makes about 10 % out of the total.

B. DOUBLE-LOW BREEDING PROGRAM

In the three and half decades after the founding of new China, there was a rapid development in rapeseed production and the output raised strikingly. However, ours is a country with a population of 1 billion, compared with the other advanced countries the average amount of rapeseed oil per capita is still rather low. Particularly, quality-improvement research was ignored and most of the current varieties are high erucic acid (45-50 %) and glucosinolate (12-18 ‰), the nutritious value is low and the valuable residue following oil extraction (cake) is not used as a source of animal feed. After the smashing of the "Gang of Four", our government has attached great importance to quality breeding and listed the breeding and expanding of new double-low varieties as a key research project of the country, all the research institutes concerned are involved for a coordinated research. Since 1978, we have been abroad for subject study and got friendly help from scientists of France, West Germany, Poland, Canada and Australia, especially the fund support provided by IDRC of Canada and warm instructions by Dr. Downey, Dr. Morice, Dr. Robbelen, Dr. Krzymanski, Dr. Thies, Dr. McGregor and Mr. Buzza etc. All these

have played an active role in our double-low breeding work. Hereby, I wish to give our heartfelt thanks to them on behalf of Chinese rapeseed scientists.

1. The target and requirements of our double-low breeding program

Chemical quality : erucic acid < 1 %, glucosinolate < 1 %. Oil content should not be lower than the current high erucic acid varieties.

Seed output : the yield of single and double-low varieties should be close to or equal to that of the current high erucic acid varieties grown widely in China (ie. 1800-2250 kg/ha).

Maturity : early, mid-early and mid-maturity are required to fit into three cropping and double cropping cultivation systems in different places.

Resistance : winterhardiness and lodging resistance are required and particularly the resistance to sclerotinia and virus disease should not be lower than the current high erucic acid varieties grown widely.



2. A number of single-or double-low new varieties and lines have been bred

- 1) A number of new non-erucic acid varieties have been bred and can be used and released in production

Beginning from 1978, on the basis of the experiences of other countries, using the method of artificial cross (including backcross), cross and selection, directive selection of single seed and plant and

generation-increase breeding, the first group of non-erucic acid lines have been bred. Through testing and appraisal at different levels and in many ways for continuous 3 years from 1982 to 1985, including national and provincial regional test, field demonstration and seed production in isolated areas, the following 6 non-erucic acid lines have shown best performance and been decided to be released to different ecological regions at provincial appraisal.

81008 : An early and mid-maturing winter rapeseed variety (*B. napus*) bred by the Institute of Oil Crops Research (IOCR) of Chinese Academy of Agricultural Sciences (CAAS). It is bred through directive breeding for many generations from the cross between "Oro" and "Shanghai 2413" line. It is suitable to be grown in the broad three cropping areas in Yangtze valley. The performance in the upper reaches of Yangtze River is the best, as the yield is superior in the large area and provincial level regional test, which is 1950 kg/ha in large area test, 4.4 % higher than the local high erucic acid variety "Xinan 302". In Yunan, Guizhou and Sichuan provinces, the output is 2527.5 kg/ha, 264.37 kg/ha and 1749 kg/ha respectively, 3.14 %, 7.17 % and 15.3 % higher than the local high erucic acid control variety. It has the characteristics of good adaptability, early maturity and lodging resistance and it is the first non-erucic acid variety which shows a good performance in several provinces and higher yield than the local high erucic acid varieties. In last winter and this spring, it was evaluated respectively in the three provinces and listed to be local releasing variety.

81002 : A winter rapeseed variety of non-erucic acid (*B. napus*) bred by IOCR of CAAS. "Ganyou 5", a popularized variety of high erucic acid with satisfactory yield also bred by IOCR, is used as parent and planted between rows of foreign non-erucic acid variety in an artificially-controlled area and let them cross naturally, then outstanding variant single plants were selected for directive breeding and selection. Its genetic background is similar to "Ganyou 5", only the maturity is about two days later. In the three-year national regional trial in the three big regions (ie. mid-reaches of Yangtze, lower reaches of Yangtze and area of Yellow and Huai River), the yield is a bit inferior to the local high erucic acid variety, being 5.29 %, 5.78 % and 8.4 % lower respectively, but higher than the other non-erucic acid varieties. In the field demonstration in some of the counties of Hubei, Anhui and Jiangsu provinces, the yield equals to the local high erucic acid variety. It is now the second new non-erucic acid variety which can adapt to the condition of several provinces. Beginning from last autumn, it has been released and expanded.

In addition, there are several other non-erucic acid varieties which grow well in one province or certain areas.

81007 : A non-erucic acid winter rapeseed variety (*B. napus*) bred by IOCR. In the regional trial for two years in Hubei province, the yield is the second just next to the control variety (Ganyou 5). The most important characteristics is its high resistance to sclerotinia, the disease index is only about 10 % in serious years, 5-6 % in normal years. It is an ideal material of resistance to sclerotinia among our current high or non-erucic acid varieties. Only the maturity is about 3 days later than the control variety.

410 : A non-erucic acid winter rapeseed variety (*B. napus*) bred by the Academy of Agricultural Sciences of Anhui Province. In the regional trial in north of Huai River, the yield increased by 2.5 % over the local control variety, but it is slightly late in maturity. Now it began to be grown extensively in some areas of Anhui province.

430 : A new non-erucic acid winter rapeseed variety (*B. napus*) bred by Jiangsu Academy of Agricultural Sciences. In the regional trial within Jiangsu province, the yield decreased by 9.75 % in comparison with the local high erucic acid variety "NinYou 7". It has good lodging resistance and excellent agronomic characteristics, but easy to be attacked by disease. It has been evaluated and released within the province.

82487 : A new non-erucic acid winter rapeseed variety (*B. napus*) bred by Shaanxi Academy of Agricultural Sciences. In the regional trial in Shaanxi province (southern part not included), the yield goes up 7.6 % over the local high erucic acid variety. With strong cold resistance and extensive adaptability, it can be grown in the western part of the province.

82-11 : A new line of non-erucic acid winter rapeseed (*B. napus*) bred by Guizhou Academy of Agricultural Sciences. In the regional trial in the upper reaches of Yangtze and provincial regional test, the yield ranks the third, just lower than non-erucic acid variety "81008" and high erucic acid control variety, but close to "81008" in maturity.

Furthermore, since 1970s, foreign varieties have been introduced to the spring rapeseed area in Qinghai province and north of China. The Canadian single and double-low varieties are the most adaptable varieties, among them "Oro". "Tower" and "Altex" are the best. The yield of "Oro" stays at 2625 kg/ha in most of the sites, the top one is 4693.5 kg/ha. Now it is decided to be released to

the major irrigated areas and part of semi-arid areas of Qinghai province, as well as other suitable areas. "Tower" and "Altex" are also very good varieties, which can fit the spring sowing condition of different ecological areas in north of China. Qinghai, Xingjiang, inner Mongolia and Gansu provinces and autonomous region have begun to test and grow them in large areas. They have become the first group of double-low varieties put into production.

2) A number of double-low lines have been bred for national breeding program

On the basis of single-low variety breeding, in recent years, thanks to the master of glucosinolate analysis techniques, a number of new double-low lines of *B. napus* and *B. campestris* have been bred by the central-China Agricultural College, Jiangsu, Shanghai, Henan, Sichuan and Qinghai provinces. Some of them are now in the stage of provincial regional trial and multi-site test. IOCR of CAAS has bred a number of double-low winter rapeseed (*B. napus*) lines. According to the accurate all quantitative test of GLC and TMS, the content of erucic acid is close to 0%, and the glucosinolate, 4.89-8.64 $\mu\text{mol/g}$ (ie 0.8-0.9 mg/g). In this year's flowering and bearing period, in the condition of continuous raining and serious sclerotinia, four double-low lines and two double-low plant lines showed satisfactory disease resistance with only 4-5% disease index.

3. Good result has been achieved in combining the breeding program of good quality and heterosis

The research of rapeseed heterosis of our country began in later 1960s. The following methods are used: cross incompatible line, two lines of nuclear male sterile, three lines of cytoplasmic male sterile, killing stamen with chemicals and pure self-crossing line of parthenogenesis. With the success in single and double-low breeding, in recent years, we have combined single and double-low varieties with hybrid breeding through testing cross and selected some hybrid cross lines of low erucic acid. Hunan Academy of Agricultural Sciences, using the non-erucic acid varieties such as French "Polemor", Canadian "Tagete" and "81008" of IOCR, has bred three non-erucic acid A lines (ie Be251A, Be253A and Be254A) and relative B lines and several R lines got from the cross of "81008", in the way of crossing and backcrossing to put non-erucic acid characteristic into the original A line "Xiang'ai". The result of proportional crossing combination shows a yield increase of 18.7-44.6% over the control variety. IOCR of CAAS has also successfully bred non-erucic acid A lines and B lines of CMS of Radish system through backcross and careful selection, and A line

(3053A), B line (5025B), and R line (5035C) of Polimar system through interspecific cross. The yield of the cross increased by 20-25% than the control variety. The two lines of male sterile bred by CIOR and Shanghai Academy of Agricultural Sciences have gained a yield increase of 35% and 33%, and Shanghai started to do field demonstration in production.

Other institutes in Sichuan, Jiangsu and Shaanxi provinces and Central-China Agricultural Institute have got incompatible lines of single and double-low and nuclear male sterile, cytoplasmic male sterile A lines and relative B lines. Sichuan University has bred good hybrid crossing lines in the research of self-crossing line of parthenogenesis. At present, they are selecting stable A line and B line and crossing lines of strong heterosis.

4. Development in breeding single and double-low *B. napus* yellow-seed rapeseed

Since late 1970s, the characteristics of yellow seed coat were discovered in the evaluation of cross-bred progenies. Professor Liu Houli of Central-China Agricultural Institute has done a lot of systematic research work of it. Now a number of non-erucic acid *B. napus* yellow-seed lines and some double-low yellow-seed single plant materials have been bred respectively by CCAC and IOCR, having plump seeds and normal plant type and leave colour. The agronomic characteristics is also very good. However, the colour of seeds only looks brown-yellow or ginger colour, it is difficult to find pure yellow seed like the yellow-seed variety of *B. campestris* and *B. juncea*. This needs to be further studied whether it is caused by the genetic character of *B. napus* yellow-seed variety, or the genes which control *B. napus* yellow colour of seed coat are not purified and stabilized.

5. Some problems existing in single and double-low breeding program

1) The relation between quality and early maturity and high yield

Among the first group of non-erucic acid lines of *B. napus* winter rapeseed, except a few of them, most are late in maturity and have lower yield than the local high erucic acid variety, which draws an extensive attention in the country. Scientific research indicates there is no obvious genetic correlations between good quality and high yield, but in reality, good-quality varieties appear late in maturity and lower yield. It is not only because the breeding years of first group varieties are not long enough, and the growing characteristics of non-erucic acid varieties are not fully studied so that necessary cultivating technique fail to be adopted, but also because of the choice of

parent materials. The first group of non-erucic acid varieties bred by our country all used good-quality varieties from European and North American countries as parents of low erucic acid resources, so the offspring of cross have the ecological type of Europe and North America. Due to the big difference in climate and cultivation system, though growing well in the Yangtze valley, their late flowering often meets high temperature, and also because of the limitation of multi-cropping system, early maturity is required thus high yield is not easy to achieve for late maturity. In recent years, we have used Australian materials as parents of low erucic acid resource for crossing, as Australia has similar geographical and ecological condition with the Yangtze valley, then cross it again with materials got from the cross between European parents, or backcross it with early-maturing and high yielding varieties of high erucic acid of our country, then strengthen the directive selection of the segregated plants of alloplasm with good agronomic type and early maturity, which are the offsprings of single plants and non-

erucic acid and low erucic acid. In this way, we can breed good-quality lines with Asian ecological type which are early in maturity and superior in yield.

2) The relation between quality and disease resistance Yangtze valley is the major rapeseed production area of our country, but often hit by sclerotinia, which gets more serious in raining years. Good-quality variety is more often attacked by it than the local high erucic acid variety, it is very important to select disease resistant variety in double-low breeding program. In these few years, we have evaluated through natural induction all our current inbred lines, parental materials and offspring of cross, and found two non-erucic acid lines "81007" and "81006" and one high erucic acid line which have high sclerotinia resistance, then used them to do double-low single cross, backcross and composite cross. This year is the most serious disease year, we again selected a number of sclerotinia resistant and duration plants and lines of single-low and double-low. It is expected to make a breakthrough in solving the problem.