Analysis of the superior yield and wide adaptability of high oil yield hybrid zhongyouza 11

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Abstract

Using a three-line system of Polima cytoplasmic male sterility, a hybrid variety Zhongyouza 11 with both high grain yield and oil content was developed. In the national regional variety trials through out the reaches of Yangzi River Valley, which is the main and largest winter rapeseed production area in China, the yield of Zhongyouza 11 reached 2405.7 kg/hm^2, 2697.3 kg/hm^2 and 2770.2 kg/hm^2 in the upper, middle and lower reaches, over yielding the respective control varieties by 11.52%, 12.9% and 14.92% in 2003-2005. The oil yield of Zhongyouza 11 in the national regional trials was 1083.3 kg/hm^2, 1210.2 kg/hm^2, 1224.8 kg/hm^2, over yielding the controls by 29.42%, 27.65% and 20.98%, respectively, in the upper, middle and lower reaches of Yangzi River Valley. The highest oil yield reached 1369.65 kg/hm^2 (in the Middle reach of Yangzi River Valley, 2003-2004), increased by 46.21% compared to the control. At almost all the regional trials, the average yield of Zhongyouza 11 ranked the first among all lines participated. Among 29 experimental locations, the yield of Zhongyouza 11 surpassed the controls at 28 of them in the national regional trials, indicating wide adaptability of this variety. Zhongyouza 11 has become the only one that passed the national regional trials of all three regions along the Yangzi River Valley at the same time by 2005. The erucic acid content of Zhongyouza 11 was 0.26% and glucosinolate content was 18.79 μmol/g in commercial seeds, which reached the canola quality standard of Canadian criterion.

Key words: *Brassica napus*, High oil yielding, Zhongyoza 11, adaptability

As the largest rapeseed production and consumption country, China obtained significant progress in rapeseed variety development, especially in heterosis application for the increase of grain yield. As a result, a bunch of rapeseed varieties with high grain yield were developed, such as Qingyou 2 (Li et al., 1993), Zhongyouza 2 (Li et al., 2002). Most of the hybrid varieties, however, are either not with canola (low erucic acid and low glucosinolate contents) quality, or with low oil content. The majority of hybrid varieties developed recently in China contained around 40% oil in seeds, which is quite low compared to high oil content varieties developed in industrialized countries (Becker et al., 1999). Oil is the main product of rapeseed production. Statistically, oil content contributes two fold more than the grain yield to the increase of total oil yield. Thus, the elevation of oil content in rapeseed variety is of major importance for the elevation of rapeseed production proficiency. Strategies for the breeding of high oil content content variety usually includes yellow seed coat (Zhen et al., 2002), big seeds and heterosis application. Zhongyouza 11, a hybrid variety with high oil content, was developed by three-line cytoplasmic male sterility system, and analyzed for its yield performance and adaptability in the main winter rapeseed production areas in China. This paper describes the performance of Zhongyouza 11 in rapeseed production in China.

1 Material and methods

1.1 Material Three parental lines of Qinyou 2, i.e. Shaan 2A, Shaan 2B and Shaan 2C were used as cytoplasmic, maintainer and restorer donor, respectively, which were kindly provided by Prof. Li Dianrong in Shaanxi Rapeseed Hybrid Research Center. Spring type canola Start was introduced from Canada, variety Zhongshuang 2, lines 227 and R1 were developed in Oil Crops Research Institute, CAAS.

1.2 Breeding procedure Single crosses of Shaan 2B×Zhongshuang 2 and Shaan 2B×Start were made in 1991. The two F_1s were crossed next year and the F_1 of this complex cross (Shaan 2B×Zhongshuang 2)×(Shaan 2B×Start) were self-propagated and test-crossed with Shaan 2A for selection of plants with good maintaining ability and agronomic traits. The self propagation, test cross and fertility determination were repeatedly carried out up to six generations, resulting in a maintainer line 6098B with high maintaining ability, good yield and quality performance. The corresponding sterile line after repeat test cross became 6098A. The restorer line R6 was derived from a triple cross of (Shaan 2C×227)F_1 ×R1,also by pedigree selection and repeatedly test cross for determining the restoration ability. With the assistance of genetic distance evaluation based on molecular markers, the hybrid between 6098A and R6 was made and high yield heterosis was observed in field trials, with a yield surpassed the control Zhongyou 821 by 19.48%.

1.3 Field trials and quality determination The national rapeseed variety trials were executed according to the uniform test scheme using randomized block design with triplicate in 20 m2 blocks. The occurrence of viral and stem rot diseases was investigated in fields at mature stage. Ten individual plants were sampled from each block to check the economic traits, and whole block was harvested for yield measurement. Least significant difference (LSD method) was used for the comparison of

yield of lines. Erucic acid, oil and glucosinolate contents in seeds of lines involved in the regional trials were determined by Quality Inspection and Test Center for Oilseeds Products, Ministry of Agriculture, according to the national standards GB/T 17377-1998 (gas chromatography) and NY/T 4-1985 (residue method) as well as the international standard ISO 9167-1:1992 (E), respectively.

2. Results

2.1 Overall yield performance

The national regional variety trials were carried out during 2003-2005, covering 12 provinces (municipals), including Yunnan, Guizhou, Sichuan, Shaanxi and Chongqing in the upper reach, Hunan, Hubei and Jiangxi in the middle reach, Anhui, Jiangsu, Shanghai and Zejiang in the lower reach of Yangzi river valley. In the trials of 2003-2004, Zhongyouza 11 over yielded the respective controls at all 21 locations of the trials in the upper and middle reaches, whereas in the lower reach trial, seven out of eight locations over yielded. The highest yield reached 4452.3 kg/hm2 at the experimental location in Hefei, Anhui province in the lower reach of Yangzi river valley in 2003-2004. Due to the climate and soil condition difference, the average yield in the three regions was different, with the highest yield obtained in the lower reach region, and the lowest yield in the upper reach region. The yield increase also varied among regions as well as between years. The highest yield increase rate occurred in the middle reach trial in 2003-2004, which was 25.17% compared to the control (Table 1). However, the average yield increase among the regions did not show big difference, ranged only from 11.52%-14.92%. Overall, the average yield of Zhongyouza 11 were 2405.7 kg/hm^2, 2697.3 kg/ hm^2 and 2770.2 kg/ hm^2 in the upper, middle and lower reaches, over yielding the respective control varieties by 11.52%, 12.9% and 14.92% over the two experimental seasons.

Table 1 Yield performance of Zhongyouza 11 in national regional variety trials

Trial	Year	Zhongyouza 11	Control	Yield increase (%)
Upper reach	2003-2004	2517.5	2091.9	+20.35
	2004-2005	2293.9	2222.4	+3.22
	Average	2405.7	2157.2	+11.52
Middle reach	2003-2004	2964.0	2357.9	+25.71
	2004-2005	2430.5	2420.1	+0.43
	Average	2697.3	2389.0	+12.90
Lower reach	2003-2004	2840.4	2536.8	+11.97
	2004-2005	2699.9	2285.9	+18.11
	Average	2770.2	2411.3	+14.92

Note:The control variety in the Upper reaches isYouyan 7, the controls in the Middle reaches are Zhongyou 821 and Zhongyouza 2 in the year 2003-04 and 2004-05 respectively, and the control variety in the Lower reaches is Wanyou 14. The same in following tables.

2.2 Oil content and oil yield

Oil content determination of mixed seed samples from the three regional variety trials of two seasons showed that all seed samples of Zhongyouza 11 contained over 43% oil. Under optimum conditions, the oil content can be stabilized at around 45%. For example, in 2004-2005, the oil content of the seed samples from all three regions ranged from 44.84%-46.68% (Table 2). Combined with the high grain yield, the theoretical oil yield of Zhongyouza 11 in the national regional trials was 1083.3 kg/hm^2, 1210.2 kg/hm^2, 1224.8 kg/hm^2, over yielding the controls by 29.42%, 27.65% and 20.98%, respectively, in the upper, middle and lower reaches of Yangzi River Valley. The highest oil yield reached 1369.65 kg/hm^2 (in the middle reach of Yangzi River Valley, 2003-2004), increased by 46.21% compared to the control. The highest oil yield increase of Zhongyouza 11 occurred in the upper reach trial in 2003-2004, where 379.95 kg/hm^2 more oil could be produced by growing Zhongyouza 11 than growing the control variety, Youyan 7, with an over yielding rate of 47.76%. Even the minimum rate of oil yield increase of Zhongyouza 11 over the control was still as high as 10.33%, which means that at least 100 kg more oil can be produced by growing Zhongyouza 11 instead of other varieties. There was also a slight difference on oil content among the three regions, with an opposite tendency to the grain yield, which was the upper reach produced seeds with the highest oil content and the lower reach produced seeds with the lowest oil content. The oil yield of Zhongyouza 11 ranked the first among all the lines involved in the national regional variety trials all over the six location/years.

Table 2 Oil content and oil yield of Zhongyouza 11 in national regional trials

Trial	Year	Zhongyouza 11		Control		Yield increase (%)	
		Oil content(%)	Oil yield(kg/hm^2)	Oil content(%)	Oil yield(kg/hm^2)	Oil content(%)	Oil yield(kg/hm^2)
Upper reach	2003-2004	46.68	1175.2	38.02	795.3	22.78	47.76
	2004-2005	43.21	991.2	39.54	878.7	9.28	12.80
	Average	44.95	1083.3	38.78	836.5	15.90	29.42
Middle reach	2003-2004	46.21	1369.7	39.73	936.8	16.31	46.21
	2004-2005	43.55	1058.5	39.64	959.3	9.86	10.33
	Average	44.88	1210.2	39.69	948.1	13.09	27.65
Lower reach	2003-2004	44.84	1273.7	42.06	1067.0	6.61	19.37
	2004-2005	43.55	1175.8	41.93	958.5	3.86	22.67
	Average	44.20	1224.8	42.00	1012.6	5.24	20.98

2.3 Yield stability and seed quality

In all the national trials, including both the regional variety trials carried out as described above and production tests using 66 m2 plot for yield evaluation throughout the Yangzi river valley. In total, grain yield of Zhongyouza 11 was determined at 89 locations, the average yield increase over controls was 12.93%, ranging from –35.47% to 67.76%. Among these, the yield increased at 77 locations, and decreased at 12 locations (Fig. 1). Even though most of the yield decrease occurred in the upper reach of the Yangzi river valley, for example, at Zunyi, Guizou province, at the majority of locations, Zhongyouza 11 obtained significant yield increase. The highest yield increase was also occurred in the upper reach region, which was in Sanxia, Chongqing municipal. Determination of erucic acid and glucosinolate content of Zhongyouza 11 using mixed seeds taking from various national regional trials showed the eruci acid content ranged from 0.18%-0.35% with an average of 0.26% and glucosinolate content ranged from 16.24-20.61 μmol/g meal with an average of 18.79 μmol/g.

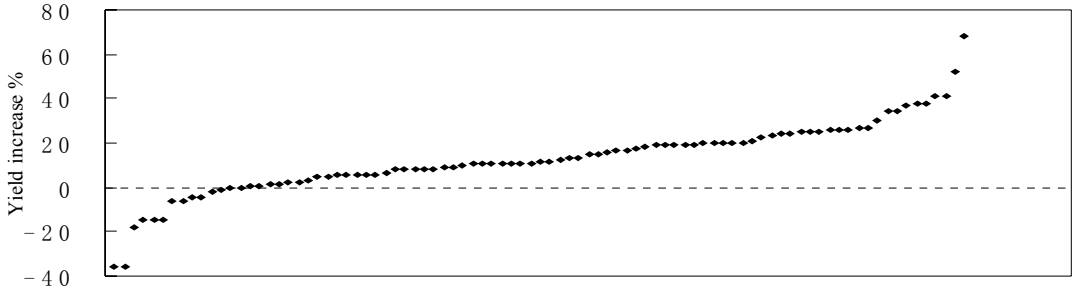

Fig.1 Yield increase of Zhongyouza 11 over the controls in national trials

3. Conclusion

Zhongyou hybrid 11 is a new hybrid canola variety with superior oil yield and wide adaptability, which making use of Shaan 2A sterile cytoplasm as a donor for male sterile cytoplasm. After passing the national regional trials in 2005, it was released for growing in the main production area along the Yangzi river valley. Due to its significant superiority of yield and oil content, the theoretical oil yield of Zhongyou hybrid 11 reached more than 1000 kg/hm2, increased by over 100 kg/hm2 compared to the control varieties, becoming the highest oil yielding and widest adaptability rapeseed variety suitable for planting in Yangzi River valley. The extension of the variety gained much interests from both each provincial government extension bureau and farms. Since there is over 400 thousand hectare sowing to oilseed rape, the high competitive Zhongyouza 11 may finally account for around 5-8% in the region, which means 20-35 thousand hectare planting area each year, resulting over 2-4 million kg oil increase. This will greatly enhance the production efficiency of oilseed rape, and facilitate the changeover process from conventional rapeseed to canola production.

4. Literature

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