Heterosis analysis of recessive genetic all sterile line in *Brassica napus* L.

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Abstract

It is the advantage that the recessive epistasis GMS may gain all sterile line(ASL) through crossing homozygous two-type line(HTL)with temporary maintainer. Triple-cross hybrids (TCH) and single-cross hybrids (SCH) were obtained by crossing ASL and HTL with restoring line respectively, and their heterosis was compared. The result showed that majority of characters of TCH, such as plant height, location of effective branches, pods of main inflorescence and seeds of pod, were superior to the SCH, and TCH was superior to SCH in resistance to *Sclerotinia sclerotiorum* and yield, too. At the same time, these characters of the heterogeneous TCH were better than those of homologous TCH. ASL was more excellent than HTL and CMS in the yield of hybrid reproduction and spontaneous pollination of sterile line, as the result, the cost of hybrids reproduction reduced greatly. So hybrid reproduction of the TCH of recessive genetic ASL was convenient and it's cost also was lower, thus the TCH has vast application prospect.

Key words: *B.napus* L, all sterile line, temporary maintainer line, Triple-cross hybrid.

Introduction

At present, the hybrids in *Brassica napus* in China were mainly produced through CMS, but their yield was lower. In addition, double-recessive GMS was also used in hybrid production,but about 50% normal fertile plants must be removed from female parent rows, it results in labor-intensive, instable seed purity, lower yield of hybrids and higher cost. However, the recessive interaction epistasis GMS has no above negative effects, and can produce three-line hybrids by all recessive sterile line. Compared with CMS three-line hybrid production, it must use temporary-maintainer line, so the hybrid is triple-cross hybrid. In different crops, compared single-cross hybrid, triple-cross hybrid heterosis is different. The reports about the heterosis comparison between triple-cross hybrids and single-cross one with all recessive GMS line in *Brassica napus* is less, some primary studies on this aspect were done in this paper.

1 Materials and methods

Five homozygous all sterile line(such as T12A/ TML12 etc) were obtained by homozygous two–type line of the recessive epistasis GMS (T12AB,T13AB,T16AB,T17AB, T25AB), which were bred by ourselves, crossing with its homologous temporary maintainer line(TML12, TML13,TML16,TML17,TML25). Two heterogeneous all sterile line(T17A/ TML 52, T25A/ TML 57) were also gotten by crossing homozygous two-type line with its heterogeneous temporary maintainer line. Using homozygous two-type line, homologous all sterile line, heterogeneous all sterile line as female parent, respectively, 5 restoring lines as male parent, 12 combinations were gained (5 single-cross hybrids, 5 homozygous triple-cross hybrids, 2 heterogeneous triple-cross hybrids, table 1).

The experiment was arranged using random block design with 3 repetitions and 180 thousand plants per hectare, planting on September 18, 2005. Ten individual plants were sampled from each block to measure their characters before harvest.

In addition, the hybrid production test was carried out in the same isolation net, using homozygous two-type line T12AB,all sterile line T12/TAM12 and CMS shaan-3A as female parents, respectively, restorer line R510 as male parent, at the same time, 3 different sterile lines were planted in field to identify their seed setting ability in nature condition. Every ten individual plants were sampled from field and isolation net to measure their characters before harvest. (table 2).

2 Results and analysis

2.1 Heterosis of hybrids of all sterile line

7 triple-cross hybrids were produced by all sterile lines(5 homozygous all sterile lines, 2 heterogenous all sterile lines), and 5 single-cross hybrids were produced by homozygous two-type lines for measuring their main agronomic characters and resistance to *S.sclerotiorum* (table 1). The results showed that plant height of triple-cross hybrids was shorter than that of corresponding single-cross hybrids except for H11, it was good for hybrids resistance to lodging. The pods of all branches in single-cross hybrids were more than corresponding triple-cross hybrids except for H31, while pods of main inflorescence in triple-cross hybrids were more than corresponding single-cross hybrids, which suggested that single-cross hybrids in ability of setting pods of branches was better than triple-cross hybrids, but triple-cross hybrids had better ability of setting pods in main inflorescence. The pods per plant had obvious variation. The triple-cross hybrids, H32, H33, H42 and H43, had significant heterosis in pods per plant; the triple-cross hybrids, except for H21, had less seeds per pod compared with corresponding single-cross hybrids. Other triple-cross hybrids than H22 and H42 were better than corresponding single-cross hybrids in

resistance to *S. sclerotiorum*, and heterogeneous triple-cross hybrids were better than homozygous triple-cross hybrids. The ability resistance to *S. sclerotiorum* was controlled by multi-gene, and triple-cross hybrids combined a temporary maintainer line, and heterogeneous triple-cross hybrids unlike homozygous TML included a heterogeneous TML, so it is possible that the heterogeneous TML will introduce more genes of resistance to *S. sclerotiorum* into the triple-cross hybrids to strengthen their ability of resistance to *S. sclerotiorum*. The triple-cross hybrid had no significant difference in yield per plant with corresponding single-cross hybrids, but the probability (71.4%) of higher yield combinations among triple-cross hybrids (their yield was higher than average yield among 12 triple-cross hybrid) was higher than among single-cross hybrids(28.9%). However, high yield combinations are also related to genotype.

2.2 Comparison of seed setting in different all sterile lines

A significant characteristic for all sterile line is its convenience and higher yield in reproduction. From table 2, CMS Shaan3A had significant superiority in length of pod and seeds per pod; the homozygous two-type line was preponderant in pods and yield per plant; recessive all sterile line had the highest yield of reproduction not only in isolation net but also in field, which reproduction yield in isolation net was high 42.5% and 40.2% than CMS Shaan3A and homozygous two-type line, respectively, and the yield in field was also high 24.3% and 10.6% than both, respectively. Therefore, it is safe and convenient and high yield to reproduce hybrids seeds using all sterile line, and production cost for hybrids also is reduced greatly.

Table 1 Comparison of main agronomic characters and disease resistance between triple-cross hybrids and single-cross hybrids of GMS

No.of hybrid	Combination	Type of GMS	Type of hybrids	Plant Height (cm)	Pods of all branches	Pods of main inflorescence	Pods /plant	Seeds /pod	Yield /plant (g)	Average yield (kg/hm^2)	Disease index of S. sclerotiorum (%)
H01	T12AB/R507	two-type Line	SCH	153.2	217.3	57.4	278.4	24.5	19.8	3350.8	30.7
H02	T12A/ TML 12//R507	Homozygous ASL	TCH	146.3	213.6	58.6	272.2	24.4	17.7	3667.2	29.1
H11	T13AB/R106	two-type line	SCH	140.7	251.7	62.8	313.8	25	21	3874.1	27
H12	T13A/ TML 13//R106	Homozygous ASL	TCH	150.1	251.7	68.2	319.2	24.9	22.3	3498.2	26.8
H21	T16AB/R97	two-type line	SCH	160.8	292.4	61.8	302	25.1	25.2	3956.3	21.4
H22	T16A/ TML 16//R97	Homozygous ASL	TCH	155.6	258.6	66.4	321.5	20.1	19.2	4156.7	23.7
H31	T17AB/R511	Two-type line	SCH	142.4	261	60.4	322.4	17.6	15.4	4153.9	30.8
H32	T17A/ TML 17//R511	Homozygous ASL	TCH	141.2	315.2	67.2	382.6	21.4	25.2	4300.4	27.6
H33	T17A/TAM52 //R511	Heterogeneous ASL	TCH	148.4	327.7	61.1	388.5	24.3	26.8	4331.1	25.4
H41	T25AB/R519	two-type line	SCH	141.6	309.1	62.4	316.1	23.7	19.2	3665.7	31.7
H42	T25AB/ TML 25//R519	Homozygous ASL	TCH	138.2	281.6	65.1	346.6	22.8	17.4	3588.6	32.2
H43	T25AB/ TML 57//R519	Heterogeneous ASL	TCH	142.8	263.7	71.8	335.6	20.9	19.5	4048.5	29.3

Note: ASL is all sterile line; SCH is single-cross hybrid; TCH is triple-cross hybrid

Note: 1. 50% fertile plants were removed in the homozygous two-type line(T12AB) in flowering stage;

2. Male parent: female parent was 1:2 in isolation net.

Table 2 Comparison of seed setting in net and in field for all sterile line, homozygous two-type line and CMS

Combinations and sterile line	Type of sterile lines	Pollinating ways	Pod length (cm)	Pods /plant	Seeds /pod	1000-seed weight (g)	Yield /plant (g)	Average yield (kg/hm^2)		Percentage of increment (±%)
T12AB×R510	two-type line	in net	4.1	261.6	13.2	3.4	13.4	1417.4	1.60	/
T12A/TML12 ×R510	All sterile line	in net	5.4	181.7	12.9	3.3	12.1	1987.7	42.5	40.2
Shaan3A ×R510	CMS	in net	5.8	160.8	17.7	3.7	7.3	1395.1	/	-1.6
T12AB	two-type line	in field	5.23	218.5	17.6	2.9	8.4	1103.3	12.4	/
T12A/TML 12	All sterile line	in field	5.19	249.3	21.6	3.1	7.3	1219.7	24.3	10.6
Shaan3A	CMS	in field	6.94	177.4	20.1	2.9	6.5	981.5	/	-11.0

3 Disscussion

In the study, the probability that good combinations appear in triple-cross hybrids produced by recessive genetic all sterile line was higher than that of in single-cross hybrids, and reproduction of triple-cross hybrid was convenient, safe with higher yield, and competitive ability in market was strong with low seeds cost. Triple-cross hybrids had rather dominance in resistant-lodge, resistant-disease, yielding ability and reproduction yield. Therefore it is inevitable and necessary to substitute all sterile line for recessive homozygous two-type line, and which has expansive utilization foreground. The higher yield combinations

can be selected by test cross with a great of different genotypes. Because of less utilization, genetics and breeding and characters of hybrids relative to recessive all sterile line need studying further.

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