Seed yield of self-incompatibility hybrids (*Brassica napus*) in China and Sweden

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Abstract Fifteen hybrids were developed from one common Chinese weak-winter self-incompatible (SI) mother line and eight Chinese weak-winter and seven Swedish spring lines. The seed yield was measured in China and Sweden in a randomised complete-block design. Hybrids usually produced much higher seed yield than their father lines and hybrids from spring fathers yielded more than hybrids from Chinese weak-winter fathers. The three top yielding hybrids in China were "SI1300×Maskot", "SI1300×Estrade" and "SI1300×Senator". Hybrids had better adaptation to different environments than their parents. The problem of adaptation might exist also in other geographic areas, so it is suggested that research trials for the genetic basis of heterosis and development of DNA markers to predict heterosis, should be made in areas where the parental lines are normally grown.

Key words: Yield – self-incompatibility – hybrid – *Brassica napus*

Introduction

Previous studies have shown that hybrids have high seed yield heterosis and that hybrids between parents of disparate origin exhibit greater levels of heterosis than hybrids between more genetically similar lines (Grant and Beversdorf 1985, Lefort-Buson et al. 1987, Srivastava and Rai 1993). Spring *B.napus* is distinguished genetically from Chinese weak-winter *B. napus* (Meng et al. 1996; Ma et al. 2000; Ma et al. 2003), but there is no report on the seed yield of hybrids between weak-winter and spring accessions.

Table 1 Yield (kg/ha) of hybrids and their fathers

Combination	Svalöv, Sweden			Gansu, China		
	Hybrid	Father	Difference	Hybrid	Father	Difference
SI-1300×Maskot	2955(1.12±)	2892(1.10)	63	3836(1.26)	2421(0.79)	1415
SI-1300×Senator	2914(1.11)	2982(1.13)	-68	3605(1.18)	3142(1.03)	463
SI-1300×Estrade	3278(1.25)	3000(1.14)	278	3638(1.19)	2275(0.74)	1362
SI-1300×Canyon	2995(1.14)	2591(0.98)	404	3505(1.15)	2513(0.82)	992
SI-1300×Puma	2892(1.10)	2609(0.99)	283	3538(1.16)	2460(0.81)	1078
SI-1300×SW9522170	2789(1.06)	2775(1.05)	13	3439(1.13)	2632(0.86)	807
SI-1300×SW9623628	2816(1.07)	2870(1.09)	-54	3175(1.04)	2434(0.80)	741
Average	2948.5(1.12)	2817(1.07)	132	3534(1.16)	2554(0.84)	980
SI-1300×Shanghai 9715	1936(0.74)	2174(0.83)	-238	3545(1.16)	2646(0.87)	899
SI-1300×Huyou12	2605(0.99)	2326(0.88)	278	3492(1.14)	3042(1.00)	450
SI-1300×Huyou14	2425(0.92)	2726(1.04)	-301	3373(1.10)	2487(0.81)	886
SI-1300×Xiangyou15	2641(1.00)	1729(0.66)	912	3373(1.10)	2579(0.84)	794
SI-1300×Bao81	3139(1.19)	2685(1.02)	454	3307(1.08)	2646(0.87)	661
SI-1300×Zhou668	2205(0.84)	2030(0.77)	175	2976(0.97)	2751(0.90)	225
SI-1300×89008	3382(1.28)	2250(0.85)	1132	3439(1.13)	3108(1.02)	331
SI-1300×Huashuang 3	2497(0.95)	1868(0.71)	629	3241(1.06)	3042(1.00)	198
Average	2603(0.99)	2224(0.84)	380	3343(1.09)	2788(0.91)	556

± Relative seed yield calculated from the average seed yield of the location

The self-incompatibility (SI) system is one available way to produce hybrids in *B. napus*. Compared to a CMS system, which is commonly used, a SI system has some advantages, such as no possible cytoplasmic side effect. More restorers are available and it is therefore easy to get promising combinations. Fu et al (1981) have bred SI line "271" with high erucic acid and high glucosinolate content. By improving the seed quality, Ma et al. (1998) have developed double zero SI line "SI1300". In this report, we used "SI1300" as the mother and made crosses with father lines from both weak-winter accessions from China and spring accessions from Sweden to study the seed yield of these hybrids and their adaptability to different environments.

Materials and Methods

The SI line, as the common mother line, was crossed with eight Chinese weak-winter and seven Swedish spring lines in the greenhouse. Fifteen F_1 hybrids were produced for field trials.

Seeds of parents and hybrids were sown in spring and harvested in autumn 2001 in Gansu, China and Svalöv, Sweden. Plots were arranged in a randomised complete-block design with two replications at each location. Area of each plot was 11.5m^2 at Svalöv and 3.78m^2 in Gansu. Plot seed yield was measured at both locations.

Results

Seed yield of hybrids and fatherlines

The analysis of variance indicated that there were significant differences ($P < 0.01$) between entries for seed yield within and between locations. Seed yield was higher in Gansu, China (Table 1). It ranged from 2275 kg ha^{-1} to 3142 kg ha^{-1} for father lines and 2976 kg ha^{-1} to 3836 kg ha^{-1} for hybrids, average for all entries was 3055 kg ha^{-1}. The seed yield in Svalöv, Sweden ranged from 1729 kg ha^{-1} to 3000 kg ha^{-1} for father lines and 1936 kg ha^{-1} to 3382 kg ha^{-1} for hybrids. Average for all entries was 2632 kg ha^{-1}. The three highest relative seed yield hybrids were "SI1300×89008" (1.28), "SI1300×Mascot" (1.26), and "SI1300×Estrade" (1.23).

Hybrids usually produced much higher seed yield than their father lines. The result of "t test" (paired sample for means) showed that seed yield of 15 hybrids were significantly higher than seed yields of their 15 father lines at Svalöv ($P < 0.05$) and at Gansu ($P < 0.01$). Most of the 15 hybrids have higher seed yield than their respective father lines. Average relative seed yield of seven hybrids from spring fathers in Svalöv is 1.12, significantly (at 0.01 level) higher than that of eight hybrids from weak-winter fathers. The result in Gansu is similar, although the difference is not significant. Top yielding hybrids are often from crosses with Swedish spring father lines. These observations indicate that breeding for hybrids is a way to improve seed yield in *B. napus* and that hybrids combining more distantly related father- and mother lines have higher seed yield.

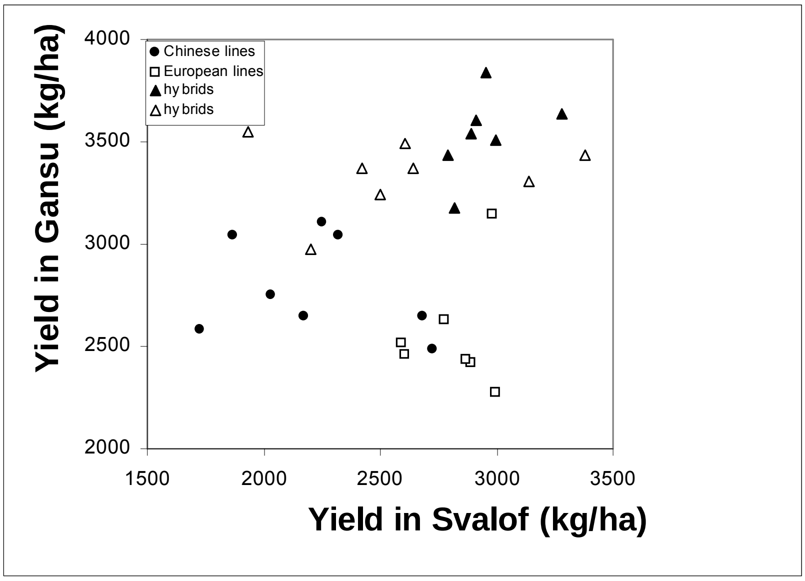

Fig.1 Seed yield of Chinese parents (solid circles), Swedish parents (open squares), hybrids from Swedish fathers (solid triangles) and hybrids from Chinese fathers (open triangles) tested at Gansu, China and Svalöv, Sweden.

Seed yield in different locations

Both hybrids and father lines are affected by environment, but hybrids are less affected as shown in Fig 1. Simple regression analysis indicated that seed yield of 15 hybrids in Gansu is related to the yield in Svalöv (r=0.3643, not significant). However, the correlation coefficient of 15 fathers at these two locations is negative (r=−0.3861). Compared with Chinese weak-winter fathers, Swedish spring father lines have much higher seed yield in Svalöv (P <0.01), and were significantly lower in China (P <0.10). Hybrids from spring father lines produced more seed than hybrids from Chinese weak-winter fathers in Svalöv, Sweden and Gansu, China, but the differences were less than those between spring father lines and weak-winter father lines. These results indicate that Chinese father lines are less adapted to European environment than Swedish spring lines to Chinese environment, and hybrids are better adapted than their father lines.

Father lines had different contribution to their hybrids depending on location. All hybrids had a common mother ("SI1300"), so correlation coefficient between seed yield of father lines and hybrids was evaluated by simple regression analysis to detect the influence from father lines on hybrids (data not shown). Positive correlations were significant at Svalöv (P < 0.1), but negative correlation was observed in China, although it was not significant.

Discussion

Elite hybrids in many crops cultivated in China are from two parents with large genetic difference (Wu, 2000). Hybrids with one parent from Sweden had higher seed yield than hybrids with both parents from China, even in Gansu where Chinese semi-winter lines are adapted for cultivation. Top performing hybrids with more than 3500 kg ha^{-1} were developed from crosses between the Chinese mother line "SI1300" and Swedish spring lines "Maskot", "Estrade", "Senator" "Canyon" and "Puma" This is in agreement with other reports which show that hybrids from two parents with unrelated genetic background had higher seed yield (Grant and Beversdorf 1985, Lefort-Buson et al 1987, Srivastava and Rai 1993).

Quantitative traits like seed yield are usually affected by environment and this makes research on the genetics more difficult. Svalöv in Sweden and Gansu in China are environmentally different although they both are spring-sowing areas. Seed yield of 15 hybrids and their parents is highest at Gansu, China and so Gansu is a suitable area to grow these lines. However, Chinese weak-winter father lines were less yielding in Svalöv, Sweden. Chinese weak-winter lines in this study were not fit to grow at Svalöv.

Hybrids had better adaptation to different environments than their parent lines. Improved adaptation of hybrids compared to their parents would affect the seed yield heterosis. Although hybrids from Chinese weak-winter father lines were less yielding than hybrids from Swedish spring father lines, they had higher mid-parent heterosis and father heterosis than hybrids from Swedish spring fathers in Svalöv, Sweden (Ma, unpublished). The problem of adaptation exist more or less also in other areas, even if not as seriously as of the two locations in this report, so it is suggested that research trials for the genetic basis of heterosis and development of DNA markers to predict heterosis, should be made in areas where the parental lines are normally grown.

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