General combining ability analysis in sunflower maintainer lines using line x tester crosses

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ABSTRACT

A line×tester analysis including 15 B-lines and two testers of sunflower was conducted to estimate the general combining abilities of B-lines to be converted into CMS lines and, ultimately used in a hybrid production program. Significant differences in mean values for all of the studied traits (length of growing period, plant height, seed yield, thousand kernel weight and oil content) were noticed between genotypes. High heterosis expression for all traits was observed due to a highly significant contrast variance of parents versus crosses. The main role in the inheritance of most of the studied traits was played by an additive component of genetic variance, which was documented by significant differences between lines and between testers means. Among the lines, the best general combiner was the line B-F80-407, which expressed a significant positive effect of GCA on almost all the traits studied. Moreover, there were other lines with good general combining abilities with respect to individual traits. It could be concluded that the choice of B-F80-407 as a B-line to be used for the production of a CMS sister line would be promising for a successive hybrid production system.

Key words: B-line – combining ability – line×tester – sunflower

INTRODUCTION

Combining ability of parental lines is one of the basic parameters which determine the heterosis of hybrid progenies in genetically controlled traits. Sprague and Tatum (1942) introduced general and specific combining abilities, the former determined by additive gene effects, and the latter by dominance and epistatic effects. Other authors (Griffing, 1956; Falconer, 1967) had the same point of view. Since the combining abilities can be tested only in crosses, various methods are used, one of which is the line×tester analysis first developed by Kempthorne (1957).

Choosing suitable lines for breeding as a parental component of a hybrid variety is of great importance. It is clear that the use of good general combiner B-lines (maintainers) for backcross transferring of CMS trait will improve the performance of the resulting future hybrids.

The objective of this investigation was to assess the general combining abilities for length of growing period, plant height, seed yield, thousand kernel weight and oil content in sunflower inbred B-lines to choose them for CMS sister-line production through backcross breeding and subsequent F_1 hybrid production.

MATERIALS AND METHODS

Fifteen inbred sunflower B-lines (S_8) developed at the Seed and Plant Improvement Institute (SPII) of Iran in Karaj were crossed with two testers in 2004. Two CMS lines with good combining abilities were used as testers. Lines, testers and their F_1 hybrids were planted at the experimental farm of SPII in a randomized complete block design with two replications and examined during 2005 crop season. Each plot consisted of 4 rows with 22 plants per row. As the testers and resulting F_1 hybrids were sterile, alternating rows of an open-pollinated variety were used to provide a sufficient pollen load for seed setting. Distance between the rows was 60 cm and between plants 25 cm.

Forty plants in each plot were chosen for observations on length of growing period (days), plant height (cm), seed yield (t/ha), thousand kernel weight (TKW) (g), oil content (%), and oil yield (t/ha). The combining ability analyses were done according to the procedures described by Singh and Chaudhary (1976).

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences between genotypes for all the characters at 1% probability level. Parents mean squares also differed significantly for growing period, plant height, head diameter, TKW and oil percent indicating a great deal of diversity between them. High heterosis expression for all traits was observed due to highly significant variance components of parents versus crosses. The variance due to a general combining ability of the males (lines) was significant for growing period, plant height and TKW, while that of the females (testers) was significant for all characters under study except seed yield. The line×tester component of variance for all traits was not significant except in the case of plant height (Table 1). This indicates that there is a predominant role of the additive rather than non-additive (epistasis and dominance) component for all characters under study.

Table 1. Analysis of variance for general and specific combining abilities of growing period, plant height, seed yield, TKW, oil percent and oil yield in a line×tester crossing scheme.

Source of variation		df	Mean Squares				
			Growing period	Plant height	Seed yield	TKW	Oil percent
Replication		1	80.929 **	75.781 ns	0.058 ns	182.564 *	1.89 ns
Genotypes		46	40.3259 **	1225.813 **	1.612 **	178.977 **	48.997 **
Parents		17	44.7706 **	604.248 **	0.523 ns	114.854 **	27.552 *
Parents vs. Crosses		1	700.55 **	40070.98 **	51.19 **	3163.63 **	1381.22 **
Crosses	Line	14	16.004 *	278.98 **	0.579 ns	82.055 *	9.11 ns
	Tester	1	30.33 *	423.79 **	0.289 ns	1336.704 **	98.74 **
	Line×Tester	14	9.926 ns	122.48 *	0.406 ns	45.094 ns	12.713 ns
Error		46	6.497	51.897	0.318	38.333	13.28

ns, *, **: non-significant, significant at 5% and 1% probability levels, respectively

The predominant role of the additive component in the study of inheritance of some traits in sunflower has been described by some other researchers for plant height (Rao and Singh, 1977), 1000 seed weight (Putt, 1965; Kovacik et al., 1972), oil content in seed (Putt, 1965; Fick, 1975; Sindagi et al., 1979), kernel content in seed (Marinković, 1985) and seed yield (Putt, 1965). However, other studies (Putt, 1965; Velkov, 1980; Kovacik et al., 1972; Rao and Singh, 1977; Sindagi et al., 1980) pointed out that the predominant role in inheritance of some of the studied traits is played by non-additive component.

Considering the growing period, the lines B-F80-407 and B-F80-411/1 had significant positive effects and the line B-F80-421/2 showed significant negative effects of general combining ability (GCA). Other lines had no significant positive or negative effects on general combining ability (Table 2).

With respect to plant height, the lines B-F80-438/1, B-F80-421/1, B-F80-407 and B-F80-421/2 had significant positive effects and the lines B-F80-409/2, B-F80-409/1 and B-F80-418/2 demonstrated significant negative general combining ability (GCA) effects (Table 2).

For seed yield, none of the lines had significant positive or negative effects of general combining ability (GCA), but the greatest positive value of GCA effects was attributable to the line B-F80-407 (Table 2).

Line B-F80-407 had significant positive effects of GCA on the TKW, while B-F80-428/2 and B-F80-408 had significant negative GCA effects on it. For oil percent, none of the lines had significant positive or negative effects of general combining ability (GCA), but the positive value of GCA effects was accounted by B-F80-438/2, B-F80-409/2, B-F80-407 and B-F80-428/2. On the contrary, the lines B-F80-418/1, B-F80-421/1, B-F80-408 and B-F80-421/2 showed negative but non-significant GCA effects (Table 2).

Table 2. General combining abilities of B-lines according to growing period, plant height, seed yield, TKW and oil percent

Lines	GCA				
	Growing period	Plant height	Seed yield	TKW	Oil percent
B-F80-407	4.262**	8.689*	0.560	10.861**	1.271
B-F80-408	0.399	-6.064	-0.575	-6.664*	-1.880
B-F80-409/1	0.782	-12.456**	0.227	-2.564	0.276
B-F80-409/2	-1.606	-13.039**	-0.565	-1.802	1.528
B-F80-410	0.267	-7.674	0.352	2.598	-0.597
B-F80-411/1	3.454*	4.371	0.144	3.761	0.901
B-F80-411/2	-0.051	0.224	-0.599	-1.114	-0.439
B-F80-418/1	0.797	0.244	-0.200	1.861	-2.632
B-F80-418/2	-1.566	-8.259*	0.113	2.798	0.088
B-F80-421/1	0.722	9.139*	0.133	-0.952	-1.962
B-F80-421/2	-3.416*	8.306*	-0.200	0.511	-0.994
B-F80-428/1	0.449	-0.531	0.456	1.623	-0.039
B-F80-428/2	-1.121	-1.689	-0.294	-8.239*	0.993
B-F80-438/1	-1.876	14.914**	0.269	0.436	0.308
B-F80-438/2	-1.498	3.824	0.178	-3.114	3.181
SE	**1.274**	**3.602**	**0.282**	**3.096**	**1.822**

Strictly speaking, the best general combiner on the whole was the line B-F80-407 which expressed a significant positive effect of GCA on growing period, plant height and TKW, and non-significant positive GCA effects on seed yield and oil percent (Table 2). It would be useful to include this line in backcrossing programs for CMS A-line production to be used in the development of highly productive hybrid cultivars.

There were different contribution of lines, testers and their interaction in expression of the studied traits (Table 3). Contribution of lines in the expression of growing period, plant height and seed yield was the greatest. More pronounced was the contribution of lines in expression of plant height (64.6%). Contribution of testers in expression of TKW was the greatest, while it had the minimum contribution in the expression of growing period, plant height and seed yield and moderate contribution with respect to oil content. Interaction between lines and testers expressed high contribution in oil content and moderate contribution in other traits.

Table 3. Component's contribution (%) to the total variance of growing period, plant height, seed yield, TKW and oil percent

Components	Traits				
	Growing period	Plant height	Seed yield	TKW	Oil percent
Lines	56.960	64.619	57.583	36.858	31.552
Testers	7.711	7.012	2.049	42.887	24.423
Line×Tester	35.329	28.369	40.368	20.255	44.025

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