Short Communications

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# Inter-relationship between combining ability effects for oil and yield traits in sunflower (*Helianthus annuus*)*

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Sunflower (*Helianthus annuus* L.) is one of the most economically important oilseed crops in the world next to soyabean and groundnut. It is cultivated in an area of 21 million ha with a production of 1.25 million tonnes and accounts for 78% of the world vegetable oil. Genetic improvement in sunflower emphasizes the urgency of generating a heterotic hybrid that can be achieved by tapping the excellent combining ability and heterotic vigour available in the genetically diverse parental lines. To make a yellow revolution, the choice of the parents is an important key which has become an important breeding objective in sunflower. The GCA and SCA variances provide estimation for additive and non-additive gene actions. Both additive and non-additive genetic variances determine yield and other agronomic traits in sunflower (Mijic *et al.* 2008, Wani *et al*. 2010). For understanding the nature of additive and non-additive gene action for exploitation of heterosis in sunflower, the present investigation was undertaken to choose appropriate parents for hybridization based on combining ability and to study the inter-relationship between *gca* and *sca* of hybrids.

The study was undertaken with 13 genotypes including 3 CMS lines and 10 inbreds in sunflower, viz. 17A, 234A and 851A and ten testers, viz. CSFI 5014, CSFI 5118, CSFI 5169, CSFI 5274, CSFI 5325, CSFI 5414, CSFI 5418, CSFI 5434, CSFI 5435 and CSFI 5436. All the three CMS lines and 10 testers were raised in a crossing block during *kharif* '2005 and the second crossing block during *rabi/ summer'2005*–2006. Crossing was done in a line × tester fashion. A total of 30 hybrids obtained were raised along with their 13 parents and check hybrids KBSH 44, TCSH 1 and Sunbred 275 during *rabi*/*summer* 2005–2006 and *kharif* 2006 for studying the combining ability of hybrids. The experiment was laid out in a randomized block design with two replications. Each entry was raised in one row of 3 m length adopting a spacing of 60 cm between rows and 30 cm between plants. Observations were recorded on five randomly selected plants from each hybrid combination per replication for eight traits, viz. days to fifty per cent flowering, plant height, head diameter, volume weight, hundred seed weight, seed yield, oil content and oil yield. To understand the real picture of genetic architecture of the hybrids and their parents, the data of both seasons were subjected to pooled analysis

The analysis of variances for line × tester revealed significant differences among the parents for all the character, viz. days to fifty per cent flowering, plant height, head diameter, volume weight, seed yield, oil content and oil yield. In pooled analysis substantial variability among the testers and seasons was noticed except for days to fifty per cent flowering and oil content. The interaction of line × seasons and tester × seasons, line × testers × seasons were significant for all the traits except days to fifty percent flowering, plant height and oil content suggesting that lines and testers interacted in different ways over the environment (Table 1). The relative estimate of variances due to additive and dominance components revealed the preponderance of dominant component for all the characters studied for individual seasons as well as pooled over seasons (Marinkovic *et al*. 2000, Khan *et al*. 2008). This indicates that the traits may be improved by heterosis breeding and commercial exploitation of hybrids is also possible with the present set of materials. The relative contribution of line × tester interaction was higher than lines and testers for hundred seed weight, seed yield, oil content and oil yield in both the seasons indicating the preponderance of dominance gene action.

The *gca* is generally attributed to the additive effects of genes and is fixable. Hence selection of parents based on *gca* effects is of great importance in breeding programme. The CMS line 234 A was found to be as good general combiner

*Short note

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for seed yield, oil content, oil yield, head diameter and volume weight, while 851 A had high *gca* effect for head diameter, hundred seed weight with desirable *gca* for plant height. Hence 234 A and 851 A are considered to be as suitable parents for production of good combinations (Table 2). The testers, CSFI 5014 and CSFI 5414 were good general combiner for seed yield, oil yield, oil content along with early flowering. Significant positive *gca* effects for seed yield and the yield attributes such as head diameter, hundred seed weight, volume weight, oil content and oil yield are desirable, while significant negative *gca* effects for days to 50% flowering bringing in earliness in duration and plant

Table 1 Analysis of variance for combining ability in sunflower

| Source | Degrees of freedom | Mean square | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Days to fifty per cent flowering (cm) | Plant height (cm) | Head diameter (g) | Volume weight (g) | Hundred seed weight (g) | Seed yield (g) | Oil content (%) | Oil yield (g) |
| Seasons | 1 | 0.13 | 5827.73 ** | 164.01 ** | 7.83 ** | 0.43 | 292.93 ** | 1.38 | 35.31 ** |
| Lines | 2 | 4.43 ** | 3060.10 ** | 62.26 ** | 143.69 ** | 4.29 * | 170.59 ** | 94.91 ** | 216.43 ** |
| Testers | 9 | 177.62 ** | 1391.27 ** | 15.42 ** | 43.08 ** | 1.46 | 369.29 ** | 39.63 ** | 51.63 ** |
| Line × Tester | 18 | 86.03 ** | 720.93 ** | 8.74 ** | 18.69 ** | 5.51 ** | 348.08 ** | 21.47 ** | 45.62 ** |
| Season × Lines | 2 | 0.23 | 680.93 ** | 11.15 ** | 13.6 ** | 0.14 | 235.21** | 0.51 | 18.44 ** |
| Season × Testers | 9 | 0.17 | 1091.19 ** | 8.93 ** | 17.28 ** | 0.15 | 204.41 ** | 0.21 | 17.42 ** |
| Seasons × Lines × Testers | 18 | 0.21 | 473.50 ** | 4.32 ** | 7.09 ** | 0.26 | 87.94 ** | 0.31 | 8.16 ** |
| Error | 58 | 0.25 | 24.29 | 1.38 | 4.22 | 0.11 | 57.01 | 0.11 | 5.85 |
| Additive variance (F = 0) | | 0.73 | 167.95 | 3.75 | 10.21 | -0.39 | 60.00 | 7.04 | 12.14 |
| Dominance variance (F = 0) | | 86.05 | 696.63 | 7.36 | 14.47 | 5.40 | 291.07 | 20.37 | 39.47 |

* Significance of *P* at 5% level; ** significance of *P* at 1% level

Table 2 Pooled general and specific combining ability effects of parents and hybrids for different characters in sunflower

| Parents/Hybrids | Days to fifty per cent flowering (cm) | Plant Plant (cm) | Head diameter (g) | Volume weight (g) | Hundred seed weight (g) | Seed yield (g) | Oil content (%) | Oil yield (g) |
|---|---|---|---|---|---|---|---|---|
| *Parents (Lines)* | | | | | | | | |
| 234 A | 0.08 | 9.93 | 1.28 * | 2.13 * | -0.16 | 6.21 * | 1.62 * | 2.65 * |
| 851 A | 0.28 | -6.54 | -0.07 | -1.51 | 0.38 * | -5.41 | -0.16 | -1.71 |
| SE (lines) | 0.05 | 0.53 | 0.13 | 0.22 | 0.04 | 0.81 | 0.11 | 0.26 |
| *Parents (Testers)* | | | | | | | | |
| CSFI 5014 | -3.1 | -7.95 | -0.27 | -1.65 | 0.70 * | 5.46 * | 1.40 * | 2.57 * |
| CSFI 5414 | -4.68 | 14.45 | 1.58 | -1.93 | 0.02 | 10.49 * | 2.24 * | 4.24 * |
| CSFI 5418 | 0.82 | -4.67 | -0.10 | -3.50 | -0.06 | -1.17 | 2.34 * | 0.57 |
| CSFI 5434 | 6.07 | 3.24 | -0.39 | 0.65 | 0.44 | 6.41 * | -1.72 | 0.91 |
| SE (testers) | 0.11 | 1.13 | 0.27 | 0.47 | 0.08 | 1.73 | 0.24 | 0.55 |
| *Hybrids* | | | | | | | | |
| CSFH 6008 (234A × CSFI 5014) | 1.75 | 1.52 | 1.59 | 0.83 | 0.18 | 8.34 | 2.25 | 3.87 |
| CSFH 6009 (234A × CSFI 5418) | -4.92 | 1.32 | 2.14 | 2.96 | 1.79 | 15.94 | -27.00 | 5.27 |
| CSFH 6025 (851A × CSFI 5414) | -2.87 | 0.68 | 0.01 | 1.13 | 1.35 | 11.84 | 2.90 | 5.28 |
| CSFH 6021 (851A × CSFI 5434) | 1.38 | -3.81 | -0.59 | 3.56 | -0.43 | 8.96 | 0.33 | 2.94 |
| SE | 0.16 | 1.59 | 0.38 | 0.66 | 0.11 | 2.44 | 0.34 | 0.78 |

height bringing in dwarf nature coupled with positive effect for seed yield are economically useful. Considering all the factors, the parents 234 A, 851 A, CSFI 5414, CSFI 5014 and CSFI 5434 were good combiners for yield and yield attributing traits over seasons.

Incase of specific combining ability of 30 hybrid combinations, the cross combinations CSFH 6009 (234 A × CSFI 5418) (Table 2) was found to be as best specific combiner for seed yield, oil yield, hundred seed weight, volume weight, head diameter and earliness to days to fifty flowering. The hybrid CSFH 6025 (851 A × CSFI 5414) was found to register significant positive *sca* effects for seed yield, oil content, oil yield, hundred seed weight with negative significant *sca* effect for days to fifty per cent flowering indicating that the hybrid CSFH 6025 (851 A × CSFI 5414) may be specifically suitable for exploitation for increased seed yield, oil content and oil yield. The results are in accordance with Halaswamy *et al*. (2004).

Positive and significant *sca* effect for oil content, oil yield, hundred seed weight, volume weight and head diameter with earliness to flowering was observed in hybrid CSFH 6008 (234 A × CSFI 5014) but it failed to possess significant *sca* effect for seed yield. Similarly the hybrid CSFH 6021 recorded positive significant *sca* effect for seed yield, oil yield, volume weight with desirable plant height. Hence the hybrids CSFH 6009 (234 A × CSFI 5418), CSFH 6008 (234 A × CSFI 5014) and CSFH 6021 (851 A × CSFI 5434) will be useful for enhanced seed yield.

In the present study, a positive relationship between *sca* effects for seed yield with other component characters was observed in most of the cross combinations. Though this result confirmed the report of Machikowa *et al*. (2011) a detailed examination of *gca* effects of parents and *sca* effects of the resultant hybrids revealed that it may not be possible to find an uniform trend for all the characters in all the hybrid combinations. Significant positive *gca* effect in any one of the parents and negative or non-significant effect on the other parents leading to significant *sca* effect in hybrids could be observed for seed yield in hybrid CSFH 6021(851 A × CSFI 5434) and CSFH 6011(17 A × CSFI 5434). Both GCA and SCA were significant for yield, oil content and oil yield, and estimates of GCA were greater than SCA in magnitude**.** This indicates the presence of additive × dominance type of gene action as reported by Mijic *et al.* (2008).

Positive *gca* effects of both the parents and negative *sca* effect of the resultant hybrid was observed for seed yield and plant height in hybrid CSFH 6005 (234 A × CSFI 5414). Few instances were found in which both the parents have significant negative *gca* effect, while the hybrid had significant positive *sca* effect as could be seen for days to flowering in hybrids CSFH 6017(17 A × CSFI 5118) and CSFH 6019(17 A × CSFI 5418). This may be due to the presence of dominance × dominance type of gene action. The crosses derived from parents having high gca resulted in high sca effects for hundred seed weight in hybrid CSFH 6028 (851A × CSFI 5014); CSFH 6008 (234A × CSFI 5014) for oil yield suggests the presence of additive × additive type of gene action.

## SUMMARY

The investigation clearly indicated that the parental lines 234 A, 851 A and the testers CSFI 5014 and CSFI 5414 could be used as potential donors for improving seed and oil yield along with oil content. The hybrids, viz. CSFH 6009 (234 A × CSFI 5418), CSFH 6008 (234 A × CSFI 5014) CSFH 6021 (851 A × CSFI 5434) and CSFH 6025 (851 A × CSFI 5414) were found to be desirable based on *sca* effects for yield and yield contributing traits. The present investigation on inter-relationship of *gca* with *sca* revealed the predominance of non-additive gene action, viz. additive × dominance and dominance × dominance type gene interaction for most of the hybrid combinations which could be exploited for heterosis breeding programme in sunflower.

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