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# COMBINING ABILITY STUDIES IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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## ABSTRACT

**In the present study, 4 CMS lines and 12 testers were crossed in line x tester fashion. The 48 $F_1$ hybrids along with 16 parents and 2 standard checks (APSH-11 and MSFH-8) were grown to estimate gca and sca for eight characters. The CMS 7-1A, EC 68415 Bulk and EC 68415 were good combiners for seed yield, while CMS 234A, CMS 207A among lines and EC 68415 among testers showed good gca effects for earliness. Among hybrids, the best performance for seed yield (56.9 g/plant) and sca effects were noticed for CMS 7-1A x EC 68415 $S_2$ which outyielded the standard check APSH-11 by 47.6 per cent. The highest oil content coupled with high yield/plant was recorded in the hybrids CMS 300A x EC 68415 $S_4$, CMS 300A x Morden $S_3$ and CMS 7-1A x Morden $S_3$.**

**Key words:** Sunflower, *Helianthus annuus*, heterosis, specific combining ability.

In sunflower, a cross pollinated crop, combining ability analysis is of special significance to identify potential lines to be used to develop good hybrids/synthetics/composites. Earlier studies [1–3] led to the selection of inbrids with high gca, predominance of nonadditive gene action for major yield components and oil content. The present investigation aims at identification of superior parents (lines and testers) and cross combinations for seed yield, oil content as well as their component characters.

## MATERIALS AND METHODS

In the present study, four male sterile lines were crossed with 12 testers in line x tester pattern. The 48 $F_1$ along with 16 parents and two check hybrids, APSH-11 and MSFH-8, were grown in randomised block design with three replications. In each replication, the parents and hybrids were sown separately in continuous block allocating two rows of 3 m length spaced at 60 cm between and 30 cm within the rows. The observations were recorded on five randomly selected competitive plants of each genotype per replication for eight

characters. The individual plant data for plant height, days to 50% flowering, days to maturity, head diameter, seed filling, 100-seed weight, seed yield, and oil content were subjected to statistical analysis to perform analysis of variance [2]. Since the male parents used in this study were randomly selected and female parents were deliberately selected, fixed effects model was followed to draw conclusions [4].

## RESULTS AND DISCUSSION

### GENERAL COMBINING ABILITY EFFECTS

Analysis of variance for gca (Table 1) revealed that the mean sum of squares (MSS) due to males were significant for all the traits under study. MSS due to females were also significant for all, except days to 50% flowering and seed filling. MSS due to sca (female vs. male) were also highly significant for all the traits.

Estimates of gca effects for different characters in sunflower (Table 2) indicated that CMS 234A was the best general combiner (– 15.4) for short stature, and CMS 300A (– 5.1) and CMS 207A (16.9) for tall height. CMS 207A (– 1.1) was the best general combiner for earliness, followed by CMS 234A (– 0.1). Among the male parents, EC 68415 bulk (– 2.9) exhibited best gca effect for earliness, followed by EC 68415 $S_1$ (– 1.8). Morden $S_5$ was the poorest general combiner. As regards days to maturity, CMS 234A was the best early maturing general combiner (– 1.4) and CMS 7-1A (2.1) late maturing. Among the male parents, EC 68415 bulk (– 4.8), EC 68415 $S_3$ (– 2.1) and EC 68415 $S_1$ (– 1.2) showed good gca effects for early maturity.

CMS 7-1A was the best general combiner (2.8) and CMS 207A (– 1.8), CMS 234A (– 0.9) were poor combiners for head diameter. The testers Morden $S_3$ (2.1), EC 68415 $S_4$ (1.6) and Morden $S_5$ (0.7) showed positive and significant gca effects. CMS 207A had the lowest (– 4.5) and CMS 7-1A the highest gca value (3.6) for seed filling. Among the male parents, Morden $S_3$ (11.5) was best with positive gca effects. For 100-seed weight, CMS 7-1A was the best (0.7) general combiner. CMS 207A showed significant negative gca effect.

**Table 1. Analysis of variance (M.S.S.) for general combining ability in sunflower**

| Character | Females (3) | Males (11) | Males x females (33) | Error (126) |
|---|---|---|---|---|
| Days to 50% flowering | 21.4 | 49.7** | 15.6** | 3.2 |
| Days to maturity | 96.4** | 90.8** | 14.8** | 2.1 |
| Plant height | 6743.8** | 520.9* | 287.4** | 8.3 |
| Head diameter | 145.5** | 16.0** | 15.1** | 1.1 |
| Seed filling | 429.9 | 385.8** | 201.1** | 4.7 |
| 100-seed weight | 14.7** | 4.7** | 0.9** | 0.0 |
| Seed yield/plant | 1848.5** | 459.7** | 257.6** | 2.1 |
| Oil content | 33.2 | 45.2** | 27.5** | 1.4 |

*,**Significant at P = 0.05 and 0.01 levels, respectively.

Figures in parentheses indicate d.f.

**Table 2. Estimates of general combining ability effects in sunflower**

| Parent | Days to flowering | Days to maturity | Plant height | Head diameter | Seed filling | 100-seed weight | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|
| **Lines:** | | | | | | | | |
| CMS 234A | -0.0* | -1.4** | -15.4** | -0.9** | 0.5 | 0.1** | -1.6** | -0.3 |
| CMS 300A | 0.5 | -0.6* | -5.1** | -0.0 | 1.5** | 0.0* | -0.1 | -0.5** |
| CMS 7-1A | 0.6* | 2.1** | 3.6** | 2.8** | 3.6** | 0.7** | 9.5** | 1.4** |
| CMS 207A | -1.1** | -1.2** | 16.9** | -1.8** | -4.5** | -0.8** | -7.8** | -0.6** |
| **Testers:** | | | | | | | | |
| EC 68415 Bulk | -2.9** | -4.8** | -7.5** | 0.2 | 0.9 | 1.4** | 4.1** | 2.2** |
| EC 68415 $S_1$ | -1.8** | -1.2** | -9.5** | -0.6 | 0.5 | 0.1** | -0.4 | 0.2 |
| EC 68415 $S_2$ | -0.8 | -0.3 | 2.9** | -0.6** | -3.4** | -0.4** | -1.1** | -1.2** |
| EC 68415 $S_3$ | -1.1* | -2.1** | -5.5** | -1.9** | -4.7** | -0.0** | -6.3** | -1.1** |
| EC 68415 $S_4$ | 2.1** | 1.4** | 4.6** | 1.6** | 3.8** | 0.4** | 7.2** | 0.2 |
| EC 68415 $S_5$ | 0.9 | 3.3** | 0.2 | -1.1** | -1.5 | 0.8** | -5.8** | -2.1** |
| Morden Bulk | -1.8 | -1.4** | -8.7** | -0.8** | 4.8** | 0.3** | 4.3** | 0.7* |
| Morden $S_1$ | 0.3 | 1.9** | -2.1* | -0.3 | 5.6** | 0.6** | 3.6** | 3.0** |
| Morden $S_2$ | -0.4 | -0.6 | 2.4** | -0.9** | -3.5** | -0.6** | -0.6** | 3.4** |
| Morden $S_3$ | -0.9 | -0.0 | 6.6** | 2.1** | 11.5** | 0.2** | 11.7** | 2.8** |
| Morden $S_4$ | 2.6** | 1.9** | 7.5** | -0.1 | -5.8** | -0.5** | -7.1** | -2.0** |
| Morden $S_5$ | 3.9** | 5.6** | 9.1** | 0.7** | 8.3** | -0.5** | -6.8** | -2.7** |
| S.E. $g_i$ | 0.3 | 0.2 | 0.5 | 0.3 | 0.3 | 0.0 | 0.3 | 0.2 |
| S.E. $g_j$ | 0.5 | 0.4 | 0.8 | 0.4 | 0.6 | 0.0 | 0.5 | 0.3 |

CMS 7-1A was the best (9.5) general combiner while CMS 234A and CMS 207A showed significant negative gca effects for seed yield/plant. Among the parents, Morden $S_3$ was the best (11.7) and Morden $S_4$ the poorest (– 7.1) general combiner. For oil content, CMS 7-1A exhibited good (1.4) gca effects and CMS 207A showed significant negative effect (– 0.6). Morden $S_1$ (3.0) and Morden $S_3$ (– 2.7) among parents were the best and poorest general combiners, respectively.

The female parent CMS 7-1A recorded high gca for head diameter, seed filling, 100-seed weight, and seed yield/plant. It also registered high gca for oil content but lowest gca effects for days to 50% flowering, days to maturity and plant height.

CMS 207A and CMS 234A were good general combiners for early flowering and maturity. In addition CMS 234A was also a good general combiner for plant height and 100-seed weight. Another female line, CMS 300A had good gca for plant height, seed filling, and 100-seed weight but was a poor general combiner for the remaining traits.

Among the male parents/testers, good gca was recorded for almost all the traits studied. EC 68415 $S_4$ was a good combiner for plant height but poor for seed yield/plant and head diameter. This genotype was a good combiner for early flowering and maturity, whereas EC 68415 $S_2$, EC 68415 $S_3$ and EC 68415 $S_5$ were poor combiners for seed yield/plant and oil content. EC 68415 $S_4$ was a poor general combiner for earliness but very good for seed yield/plant. Gca effects in Morden $S_3$ were significantly higher for all the traits except plant height. This genotype may be extensively used in breeding programmes to develop new inbred lines.

Morden Bulk and Morden $S_2$ were good combiners for earliness but poor for seed yield/plant. Morden $S_5$ showed poor general combining ability for all traits except seed filling. Similar results were reported from previous studies [5–7].

ESTIMATES OF SPECIFIC COMBINING ABILITY

Significant sca effects were recorded in 15 out of 48 hybrids with tendency towards dwarfness (Table 3). CMS 207A was the best cross for plant height. For days to 50% flowering, sca effects were significant in 4 hybrids of which 300A x EC 68415 $S_1$ (– 4.6), CMS 300A x Morden $S_1$ and CMS 7-1A x EC 68415 $S_5$ gave 4.5 and 4.1 sca values, respectively. Early maturity was observed in the crosses CMS 207A x Morden $S_2$ (– 3.6), CMS 7-1A x EC 68415 $S_3$ (– 3.1) and CMS 300A x EC 68415 $S_4$ (– 2.8). CMS 300A x Morden $S_1$ (5.2) recorded lowest sca effects for earliness.

Head diameter differed significantly between parents and their crosses. The highest and lowest values for this trait were recorded in CMS 7-1A and CMS 300A. Twelve $F_1$ hybrids recorded significant positive and eleven $F_1$ hybrids significant negative sca effects. The crosses CMS 234A x EC 68415 $S_4$, CMS 7-1A x EC 68415 $S_2$ and CMS 7-1A x EC 68415 $S_3$ had sca estimates 3.7, 3.1 and 3.0, respectively (Table 3).

Hybrids CMS 7-1A x EC 68415 $S_2$ (12.5), CMS 7-1A x Morden $S_2$ (14.2) and CMS 7-1A x EC 68415 $S_3$ (10.2) showed significant sca effects for seed filling. Fifteen hybrids showed significant negative sca effects.

Combining abilities showed large variations in the parents and their crosses for 100-seed weight. CMS 7-1A x EC 68415 $S_2$ was the best (1.1) cross, followed by CMS 234A x Morden

**Table 3. Estimates of specific combining ability in promising sunflower hybrids**

| Cross | Days to flowering | Days to maturity | Plant height | Head diameter | Seed filling | 100-seed weight | Seed yield per plant | Oil content |
|---|---|---|---|---|---|---|---|---|
| CMS 234A x EC 68415 $S_2$ | 0.1 | 2.2** | 9.0** | 0.1 | 2.4 | 4.8** | 4.8** | 2.0** |
| CMS 234A x EC 68415 $S_4$ | -1.3 | 0.7 | 6.2** | 3.7** | -2.6* | -0.1* | -0.8 | -0.1 |
| CMS 234A x EC 68415 $S_1$ | -4.6** | -1.1 | 1.5 | 0.1 | 4.** | -0.2** | 3.3** | 0.4 |
| CMS 2300A x EC 68415 $S_3$ | -1.7 | -0.2 | -1.0 | -3.5** | -3.4** | -0.5** | -9.6** | -0.6 |
| CMS 300A x EC 68415 $S_4$ | -0.5 | -2.8** | 5.8** | 0.8 | 7.4** | 0.3** | 12.8** | -6.9** |
| CMS 300A x Morden $S_1$ | 4.5** | 5.2** | 1.7 | -0.2 | -6.1** | -0.1** | -6.6** | -1.1 |
| CMS 300A x Morden $S_2$ | 2.3 | 1.6 | -12.3** | -2.7** | -14.6** | -1.1** | -14.7** | -5.2** |
| CHS 7-1A x EC 68415 $S_2$ | -0.8 | 1.1 | 8.5 | 3.1** | 12.6** | 1.1** | 17.6** | -3.0** |
| CHS 7-1A x EC 68415 $S_3$ | -1.6 | -3.1** | 4.5** | 3.0** | 10.2** | 0.1** | 13.1** | -0.8 |
| CHS 7-1A x Morden $S_2$ | -0.9 | -2.2 | -4.7** | -0.2* | 14.2** | -0.2** | 8.0** | 1.9** |
| CHS 7-1A x Morden $S_5$ | -0.6 | 1.2 | -14.1** | -2.1** | -12.6** | -0.5** | -13.7 | 0.9 |
| CMS 207A x EC 68415 $S_1$ | 1.6 | 0.6 | 14.00** | 0.4 | 4.7** | -0.0 | 5.4** | -4.6** |
| CMS 207A x EC 68415 $S_3$ | 2.8** | 2.2** | 5.8** | 0.3 | -5.1** | 0.2** | -0.6 | -3.0** |
| CMS 207A x EC 68415 $S_4$ | -0.0** | 2.0** | -12.8** | -2.7** | -6.6** | -0.1** | -10.1** | -1.3 |
| CMS 207A x Morden $S_1$ | -2.6* | -0.7 | -19.4** | -1.1 | -1.4 | -0.5** | -0.9 | -0.7 |
| CMS 207A x Morden $S_2$ | -1.5 | -3.6** | 8.4** | 2.8** | -2.0 | 0.3** | 1.9** | 1.3* |

*,** Significant at P = 0.05 and 0.01, respectively.

$S_2$ (1.1). Lowest sca effects were recorded in CMS 300A x Morden $S_2$ and CMS 7-1A x EC 68415 $S_5$ (Table 3). These results indicate that genes with additive effects were more important in the expression of this character as also observed earlier [8].

For seed yield/plant, two crosses, i.e. CMS 7-1A x EC 68415 $S_2$ (17.6 g) and CMS 7-1A x EC 68415 $S_3$ (13.1 g) gave best performance in $F_1$. These two hybrids also recorded highest and significant sca effects for head diameter and seed filling (Table 3). Nineteen $F_1$ hybrids had significant negative sca values for this character. The cross CMS 7-1A x Morden $S_5$ (– 13.7) had the lowest value.

The cross CMS 300A x EC 68415 $S_4$ had highest (6.6) and CMS 300A x Morden $S_2$ the lowest (– 5.2) sca values for oil content.

**Table 4. Performance of promising parents and hybrids of sunflower**

| Parent/hybrid | Character mean of | | Combining ability effects | | | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | gca | | sca | | |
| | seed yield (g) | oil content (%) | yield | oil content | yield | oil content | |
| CMS 300A | 35.1 | 34.3 | - 0.1 | - 0.5 | — | — | High seed yield and oil content |
| CMS 7-1A | 23.1 | 34.5 | 9.5 | 1.4 | — | — | —Do— |
| EC 68415 $S_2$ | 17.3 | 33.3 | - 1.1 | - 1.2 | — | — | |
| EC 68415 $S_4$ | 18.1 | 35.2 | 7.2 | 0.2 | — | — | High gca for seed yield |
| Morden Bulk | 22.4 | 32.3 | 4.3 | 0.7 | — | — | —Do— |
| Morden $S_3$ | 18.7 | 35.4 | 3.6 | 2.0 | — | — | High sca for seed yield and oil content |
| CMS 7-1A x EC 68415 $S_2$ | 56.9 | 31.8 | — | — | 17.6 | - 3.0 | Best combiner for seed yield |
| CMS 7-1A x Morden Bulk | 55.8 | 36.7 | — | — | 11.0 | - 0.0 | High sca effects for seed yield and oil content |
| CMS 300A x EC 68415 $S_4$ | 50.9 | 40.8 | — | — | 12.8 | 6.9 | Good sca effects for seed yield and oil content |
| CMS 300A x Morden $S_3$ | 45.9 | 39.9 | — | — | 3.3 | 3.0 | —Do— |

Combining ability analysis data indicated predominant role of both gca and sca for yield components and higher magnitude of additive than nonadditive component for oil/content showing that genes with additive effect have greater significance in genetic amelioration of this character [9, 10]. Hybrids CMS 207A x Morden $S_2$ was the best specific combination for days to maturity. Two crosses, i.e. CMS 7-1A x EC 68415 $S_2$ and CMS 7-1A x Morden $S_3$, showed high sca effects for head diameter, seed filling, and seed yield/plant; and CMS 300A x EC 68415 $S_4$ for oil content.

The performance of hybrids vis a vis their parents (Table 4) depicted that hybrid CMS 7-1A x EC 68415 $S_2$ was best for seed yield per plant which outyielded the standard check APSH-11 by 47.6%. Three hybrids, CMS 300A x EC 68415 $S_4$, CMS 300A x Morden $S_3$ and CMS 7-1A x Morden $S_3$, were specifically good combiners for oil content and seed yield per plant.

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