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SUMMARY

Heterosis and combining ability in sunflower through line x tester analysis.

The present investigation was carried out during three successive summer seasons, 2005, 2006 and 2007 to study performance, heterotic response, combining ability and proportional contribution (%) of lines, testers and line x tester interaction in sunflower hybrids for studied traits.

Twenty four crosses produced by crossing between six introduced cytoplasmic male sterile lines (CMS-lines) with four restorer lines (RF-lines) using line x tester mating design at Shandaweel Agric. Res. Station, Sohag, in 2005 season. Twenty four crosses, four restorers, six fertile lines (B-lines) along with two check varieties (Sakha53 and Giza102) were evaluated at Shandaweel Agric. Res. Station, Sohag, in 2006 and 2007 seasons. The experiment was conducted in a randomized complete block design of three replication in the two seasons. Data were recorded on days to 50% flowering, days to maturity, plant height, stalk diameter, head diameter, 100-achene weight, achene yield/plant, achene yield/plot and achene oil percentage. Separate and combined analysis of variance, line x tester analysis, heterosis over the better parent, combining ability analysis and proportional contribution of lines, testers and line x tester interaction for studied traits were completed. The obtained results were summarized as follow:

A. Mean performance:

The combined analysis of variance over the two years, showed highly significant differences between years for all studied traits except stalk diameter and 100-achene weight. Differences among genotypes were highly significant for all studied traits. The interaction among genotypes and years was highly significant for all studied traits.

Also, highly significant differences were detected among parents, crosses, their partitions; lines (females), testers (males) and lines x testers and parent vs. crosses for all studied traits.

1. Average days to 50% flowering over the two years indicated that, seventeen crosses were earlier than their respective parent. All crosses were significantly earlier compared to the check variety Sakha53 while only three crosses were significantly earlier than Giza102. All genotypes (crosses and parents) were earlier in the second season compared to the first season. The earliest cross over the two seasons (L5 x Rf10). Some genotypes varied in flowering from year to another, indicating significant of variance interaction between the genotypes x years.
2. Average days to maturity over the two years, reflects the position towards earliness for some crosses. Eight crosses were earlier than their earlier parent. Most of materials (crosses and their parents) were earlier in the second season compared to the first season. Most of genotypes were changed in days to maturity from year to another. This reflects the significant genotype x year interaction. Moreover, in the combined level over the two years the cross (L5 x Rf1) was the earliest (79.00days) compared to 87.17 and 82.00days for the check variety. All crosses at the first season were significantly earlier compared to the check variety Sakha53 while nine crosses were significantly earlier than Giza102.
3. The combined mean over the two years indicated that the lines were taller than the tester. On the other side, the crosses were affected by the female lines height than the fertile line one. Average plant height over the two years indicated that twenty two crosses were taller than the respective tall parent. The results established the highly significant contrast obtained among crosses and their parents. All crosses were shorter than the check variety Sakha53 while compared to the check variety Giza102 the crosses were taller than it in all cases.
4. The crosses displayed a wide variability in stalk diameter. The combined mean over the two years indicated significant towards thicker (fertile lines-females) in only two crosses. While, the remaining majority of crosses exhibited equal to or less than the best parent. Over the two years the crosses (L19 x Rf4) 2.39cm followed (L7 x Rf1) 2.15cm had the thickest stem.

5. Average head diameter over the two years indicated that fourteen crosses showed significantly broadest head diameter than the best parent. The cross (L19 x Rf4) had the broadest head in both seasons and at the combined level over the two years. All crosses were broadest head diameter than the check variety Giza102. While it gave narrow head diameter compared to the check variety Sakha53.
6. Average 100-achene weight over the two years indicating maximum 100-seed weight for some crosses. Nine crosses displayed significantly exceed the best parent in this trait, and the remaining crosses showed insignificant. In general, the average 100-achene weight of the crosses was large (7.76g.) compared to that of the better parents (females) 7.37g. and check variety Giza102 (7.30g.).
7. Mean performance for achene yield/plant over the two years reflected that seventeen crosses out of twenty four F1 single crosses were exhibited significantly seed yield/plant. The remaining crosses were less than the better parent. Generally, in the first, second seasons and in the combined level over the two years all crosses were significantly outyielded compared to the check variety Giza102, while twenty one were significantly better than Sakha53.
8. The combined mean over the two years for achene yield/plot reflected that twenty crosses showed significantly exceeds the better parent. Twenty three crosses were significantly outyielded compared to the check variety Giza102. While only one cross significantly outyielded Sakha53 in the combined level over the two years.
9. Achene oil percentage over the two years expressed that only seven crosses out of twenty two crosses showed significantly surpassed the best parent. The remaining crosses showed not significant and less than the best parent.

B.1. Combining ability variance:

Separate and combined analysis indicated that the magnitude of δ^2_{sca} (variance of S.C.A) was higher than the obtained for δ^2_{gca} (variance of G.C.A) for all studied traits. The ratios of $\delta^2_{gca}/\delta^2_{sca}$ were less than unity for all studied traits. Indicating that the dominance gene action (non-additive effects) an important role in inheritance of these trait.

B.2. contribution of lines, testers and their interaction to total variance:

Proportional contribution (%) of lines, testers and their interaction for the studied traits in the first, second seasons and the combined level over the two years showed that both additive and non-additive gene effects controlled days to 50% flowering, stalk diameter, 100-achene weight and achene yield/plant traits. While, days to maturity trait was predominance of additive gene action in inheritance. However, the non-additive components were predominant for plant height, head diameter, achene yield/plot and oil percentage characters.

B.3. Combining ability effects:

1. For days to 50% flowering, the fertility restorer lines Rf1, Rf4, Rf5 and Rf10 showed significant or highly significant in the combined level over the two years. While, GCA effects of L5 recorded the highest significantly negative in the first, second seasons and at combined level. The data clearly showed that three, one and three crosses had negative and significant or highly significant SCA values in the first, second seasons and at combined level. That means these crosses were earlier compare with their parents.
2. For days to maturity, the highest negative effect was recorded by the restorer line Rf1 in the first season and the combined data over the two years, and Rf10 in the second season. The female lines L5 and L21 exhibited negative and significant or highly significant GCA effects in the first, second seasons and combined over two years. Three, four and five crosses exhibited negative and significant or highly significant SCA effects in the first, second seasons and their combined. These crosses could be considered as best combination for days to maturity.
3. For plant height, the female lines L1 was the highest negative and significant GCA effects in the first season. While, L21 recorded the highest negative and significant GCA effects in the combined level. Lines Rf1 and Rf5 were showed negative significant or highly significant in the second and at combined level. Three, three and four crosses recorded negative and significant or highly significant SCA effects in the first, second seasons and at combined level. These crosses were considered to be the best combinations for shortness.
4. For stalk diameter, the highest positive significant GCA effects was only registered by the restorer line Rf4 in the first and at combined level over the two

years. Female lines, L19 only showed the highest significant positive in both seasons and their combined. Only two crosses showed significant SCA values. These crosses were considered as a good combination for this trait.

5. Head diameter, the tester Rf4 had possessed positive and highly significant in the first, second seasons and over the two years. While, the lines L7 and L19 had positive and highly significant in the first and at combined level over two years. Indicating that these lines could be considered as good combiner for head diameter. Ten, nine and eleven crosses had positive and significant or highly significant SCA effects in both seasons and at the combined data over the two years. These crosses could be considered as the best combination of head diameter.
6. 100-achene weight, the two lines L7 and L19 had positive and highly significant GCA effects in the first and at combined data over the two years. Also, the restorer lines Rf4 was showed positive and highly significant in both seasons and at the combined level over the two years. Six, six and seven crosses registered positive and significant or highly significant in the first, second seasons and their combined level, respectively. These crosses were considered the best combinations for increasing the 100-achene weight.
7. Achene yield/plant, the restorer lines, Rf1 had positive and highly significant in at combined level over the two years, and Rf4 showed positive and highly significant in the second season and at combined level over the two years. While, the female lines L7 and L21 had positive and highly significant in the first, second seasons and at combined level over the two years, also L19 showed positive and highly significant in the first and at combined level over the two years. Five, eight and nine crosses were recorded positive and highly significant in both seasons and their combined. These crosses could be considered as the best combination of head diameter. Moreover, most the highest crosses in seed yield/plant resulted from crossing line having positive and significant GCA values. It may be concluded that GCA and SCA effects, were effective in prediciting hybrid performance in this trait.

8. Achene yield/plot, testers Rf4 and Rf10 had positive and highly significant GCA values in the first season and at combined level the two years. While, the line L7 had positive and highly significant in all cases. Eleven, six and nine crosses registered positive and significant or highly significant in all cases (in the first, second seasons and their combined level, respectively). These crosses were exerted the best combinations for this traits.
9. Achene oil percentage, two lines L1 and L7 had positive and significant or highly significant GCA effects in the first season and at combined level over two years. While, the Rf10 showed positive and highly significant in the second season and over the two years. The single crosses (L1 x Rf1) and (L21 x Rf10) were positive and significant or highly significant in all cases. These crosses may be considered as the best combinations for achene oil percentage.

C. Heterosis:

The heterotic values were estimated as a percentage of the better parent for all studied traits in all cases as follows:

1. Days to 50% flowering, showed (eighteen crosses, in the first season),(twenty one crosses, in the second season) and (seventeen crosses in their combined), negative significant or highly significant heterosis. These results indicating that most of the significant heterosis towards earliness was for crosses which gave negative SCA.
2. Days to maturity, most of the crosses registered negative significant or highly significant heterosis in the first season (sixteen crosses), also (sixteen crosses) in the second season and (nine crosses) in their combined. Generally, these crosses were earlier than earliest parents.
3. Plant height, all single crosses showed significant or highly significant positive heterotic effects in both seasons and their combined, except the cross (L3 x Rf5) in the second season and their combined level. In over the two years the minimum plant height (158.00cm) by the cross (L21 x Rf4). The maximum plant height (197.00, 192.33 and 194.46cm) was exhibited by the cross (L7 x Rf10) in both seasons and their combined level.

4. Stalk diameter, eleven, six and five hybrids showed positive significant or highly significant of heterosis in all cases. The heterotic values in most cases were not consistent and changed from year to year caused by the SCA values of the hybrids which were not significant and differed from year to year.
5. Head diameter, ten, twenty one and fourteen crosses showed positive and significant or highly significant heterosis in the first, second seasons and their combined level. Generally, maximum head diameter (21.90cm) was produced by single cross (L19 x Rf4) along with significant positive heterobeltiotic effects (28.32%) followed by crosses (L21 x Rf4), (L1 x Rf4), (L7 x Rf10) and (L7 x Rf1). Which exhibited largest head diameter.
6. 100-achene weight, the five crosses which high 100-seed weight over the two years were (L7 x Rf4), (L1 x Rf4), (L19 x Rf4), (L7 x Rf1) and (L3 x Rf4). Indicating that these had high 100-seed weight than the best parent.
7. Achene yield/plot, the five high yielding crosses in achene yield/plot over the two years were L7 x Rf10, L21 x Rf1, L1 x Rf4, L7 x Rf1 and L5 x Rf5. That means these crosses had higher seed yield/plot than the highest parent.
8. A wide range of heterosis and standard heterosis was for achene yield/plot. The five heaviest yielding crosses over the two years were L5 x Rf10, L7 x Rf1, L1 x Rf4, L3 x Rf10 and L5 x Rf4. That means these crosses had higher seed yield/plot than the highest parent.
9. Achene oil percentage, the best five crosses in achene oil percentage over years were L1 x Rf1, L21 x Rf10, L19 x Rf5, L7 x Rf4 and L5 x Rf5.