Estimation of economic heterosis for seed and oil yield in sunflower (Helianthus annuus L.) hybrids for coastal saline belt

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Abstract
Present investigation was carried out to identify the best hybrid combinations giving high degree of useful heterosis for economic traits like seed and oil yield in sunflower under high saline soil in coastal saline belts of West Bengal. The standard heterosis for seed yield ranged from -12.7 to 17.9, -3.4 to 30.5 and -10.5 to 20.8 per cent over LFSH-171, DRSH-1 and KBSH-44, respectively. The maximum hybrid vigor for seed yield was reported in the CMS-234A x EC-273009, followed by CMS-853A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725 and CMS-852A x EC-601751. The range of economic heterosis for oil yield varied from 0.3 to 27.2 per cent over LSFH-171, from -10.2 to 13.9 per cent over DRSH-1 and from 5.2 to 33.4 per cent over KBSH-44. The maximum hybrid vigor for oil yield was reported in the CMS-234 A x EC-273009, followed by CMS-853 A x EC 623023, CMS-103 A x EC-601978, CMS-850 A x EC-601978, CMS-852 A x EC-601725, CMS-207 A x CSFI-99, CMS-234A X RHA-1-1 and PET-2-7-1 A x R-138-2. The study revealed that out of 32 new sunflower hybrids, only hybrids viz., CMS-234 A x EC-273009, CMS-853 A x EC-601978 and CMS-850 A x EC-601978 manifested significant economic heterosis for seed and oil yield over national checks LSFH-171, DRSH-1 and KBSH-44. From the study it may be concluded that the sunflower hybrids viz. CMS-234 A x EC-273009, CMS-853 A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725 and CMS-207 A x CSFI-99 might be promoted for further evaluation and commercialization.

Key word
Economic heterosis, Sunflower, Seed Yield, Oil Yield.

INTRODUCTION
Sunflower (Helianthus annuus L.) is the fourth important oilseed crop in the world. It belongs to the genus Helianthus, family Asteraceae. Sunflower seeds contain 38 to 42 per cent edible oil which is used for culinary purposes. Sunflower oil is considered as premium Oil as compared to other vegetable oils because of its light yellow colour, flavour, high smoke point and high level of linoleic acid (55 – 60 %).

In India, sunflower is cultivated over an area of 5.2 lakh hectares with a production and productivity of 3.35 lakh tonnes and 0.64 t/ha, respectively (Anonymous, 2016). Sunflower is being grown over 70 per cent of area across Karnataka, Maharashtra and Andhra Pradesh. It occupies an area of about 3.6 lakh hectares with a production of 2.1 lakh tonnes and productivity of 0.57 t/ha in Karnataka (Anonymous, 2018). Exploitation of heterosis on commercial for a particular locally requires isolation of suitable inbred and development of hybrids. To accomplish this task, one has to know the genetic diversity of the available germplasm and the combining ability of the parents. For improving the yield potential of

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varieties and hybrids, the decision should be made on the choice of the right parent for hybridization.

Increasing seed and oil yields is the top priority of most sunflower breeding programs. Exploitation of heterosis is the main purpose in sunflower hybrid breeding programme (Putt, 1966; Fick, 1978, Miller and Hammond, 1991; Limbore et al., 1997). The main objective of sunflower breeding program is the development of productive F₁ hybrids with high seed and oil yield. Sunflower oil yield is determined as the product of seed yield per unit area and the oil percentage in seeds (Fick, 1976). Therefore, consideration of both the factors is important when breeding for a high oil yield. National sunflower hybrid breeding programme is a continuous programme which started in our country early 1980s. Sunflower hybrid breeding was started economically in discovering CMS by Leclercq (1969) and restorer genes by Kinman (1970). Economic/Standard heterosis is the measure of heterosis in terms of superiority over the standard check(s)/ hybrid(s). The presence of high heterosis in certain crosses and low in others suggested that the nature of gene action varied with genetic architecture of the parents (Reddy and Madhavilatha, 2005; Vishwanath and Goud, 2006).

Present research programme was carried out with the objectives of (i) to evaluate the performance of the sunflower hybrids for yield and yield component under high saline soil and (ii) to identify the Economic/standard heterotic cross combinations/sunflower hybrids suitable for growing in the rabi-summer season in in coastal saline belts.

MATERIALS AND METHODS

Thirty-two promising sunflower hybrids along with three National checks (LSFH-171, KBSH-44 and DRSH-1) were evaluated at AICRP-Sunflower, Nimpith Centre, West Bengal during Rabi, 2017-18 and 2018-19 in Randomized Complete Bock Design with three replications under medium to high spoil salinity (EC 2.0-3.0dS/m) throughout the crop growth period. Each hybrids were sown in three rows of three meter length with a spacing of 60 x 30 cm.

Observations were recorded on ten randomly selected plants from each plot of all replications on the characters viz., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), seed yield/ head (g), 100-seed weight (g), hull content (%), volume weight (g/100cc). The seed yield (kg/ha), and oil yield (kg/ha) were estimated on plot basis. The mean values were subjected to statistical analysis. Heterosis, heterobeltiosis and economic heterosis was estimated as per the methods suggested by Fonesca and Patterson (1968) and Meredith and Bridge (1972) for individual as well as over the environments.

RESULTS AND DISCUSSION

Pooled analysis of data for seed yield and oil yield indicated that F₁'s from the crosses CMS-234 A x EC-273009 (1276), CMS-853 A x EC 623023(1240), CMS-234A X RHA-1-1(1208), CMS-234 X RHA-1-1(1178), CMS-852 A x EC-601725(1176), CMS-852 A x EC-601751(1175), CMS-850A x EC-601751(1162) and CMS-853A x EC623021(1136) exhibited the higher seed yield/ plant over the national check hybrids, LSFH-171(NC-1), DRSH-1(NC-2), KBSH-53(NC-3) which recorded 1082 kg/ ha, 978 kg/ha and 1058 kg/ha of seed yield, respectively (Table 1 & 2).

The sunflower hybrids were evaluated on the basis of economic/standard heterosis for seed yield and yield contributing traits. The standard heterosis or seed yield varied from -12.7 to 17.9 per cent over LSFH-171, from -3.4 to 30.5 per cent over DRSH-1 and from -10.5 to 20.8 per cent over KBSH-44. Hybrid vigor for seed yield was the highest in case of CMS-234 A x EC-273009, followed by CMS-853 A x EC 623023, CMS-234A X RHA-1-1, CMS-852 A x EC-601725 and CMS-852A x EC-601751 (Table 3). The range of economic heterosis for oil yield varied from 0.3 to 27.2 per cent over LSFH-171, -10.2 to 13.9 per cent over DRSH-1 and 5.2 to 33.4 per cent over KBSH-4. The maximum hybrid vigor for oil yield was reported in CMS-234 A x EC-273009, followed by CMS-853 A x EC 623023, CMS-103 A x EC-601978, CMS-850 A x EC-601978, CMS-852 A x EC-601725, CMS-207 A X CSFI-99, CMS-234A X RHA-1-1 and PET-2-7-1A x R-138-2 (Table 3).

Parameshwarappa et al. (2008) and Mohanasundaram et al. (2010) noticed standard heterosis for seed yield and for oil content. Significant standard heterosis for seed yield was also reported by Manivannan et al. (2015) and Thakare et al. (2015). High value of standard heterosis for seed yield in the experimental hybrids using CMS lines/tester lines had also been reported by Lakshman et al. (2019) in combining ability study; Meena et al. (2013), Chandra et al. (2015) Supriya et al. (2017) and Nandini et al. (2017). Existence of significant standard heterosis for seed yield had also been reported by Sahane et al. (2017).

The study revealed that for standard/ economic heterosis for seed yield, sunflower hybrid CMS-234 A x EC-273009 (1276 kg/ha) recorded 17.9, 30.5 and 20.8 per cent higher over that of three national checks i.e. LFSH-171, DRSH-1 and KBSH-44, respectively. Economic/standard heterosis for seed yield was also significant in experimental sunflower hybrid CMS-853 A x EC-623023, (1240kg/ha) which recorded 14.6 per cent higher than LSFH-171, 26.8 per cent higher than DRSH-1 and 17.4 per cent higher than that of KBSH-44. Seed yield of CMS-234 A x R-1-1 (1208 kg/ha) recorded 11.6, 23.5 and 14.4 higher than that of LSFH-171, DRSH-1 and KBSH-44, respectively. The hybrid CMS-852 A x EC-601725 (1175kg/ha) was recorded 8.7 per cent higher than LSFH-171, 20.2 per cent higher than DRSH-1 and KBSH-44, respectively (Table 4).
Table 1. Performance *per se* of the sunflower hybrids for yield contributing traits

| Hybrid combination | Seed yield (kg/ha) | Seed yield (kg/ha) | Oil yield (kg/ha) | Oil yield (kg/ha) |
|--------------------|--------------------|--------------------|-------------------|-------------------|
|                    | 2017-18             | 2018-19             | 2017-18           | 2018-19           |
| CMS-234 A x EC-273009 | 1346               | 1206               | 428               | 394               |
| CMS-853 A x EC 623023 | 1308               | 1172               | 425               | 389               |
| CMS-234A X RHA-1-1    | 1274               | 1142               | 411               | 375               |
| CMS-103 A x EC-601978 | 1220               | 1092               | 418               | 382               |
| CMS-207 A X CSFI-99   | 1194               | 1070               | 411               | 375               |
| CMS-852 A x EC-601725 | 1241               | 1111               | 412               | 376               |
| PET-89-1A x EC-601978 | 1102               | 988                | 381               | 349               |
| CMS-850 A x EC-601978 | 1190               | 1066               | 416               | 380               |
| PET-2-7-1A x R-138-2  | 1187               | 1063               | 410               | 374               |
| P-2-7-1A x EC-601978  | 1225               | 1097               | 404               | 370               |
| CMS-234 X RHA-1-1     | 1243               | 1113               | 394               | 360               |
| CMS-853A x EC623021   | 1198               | 1074               | 400               | 366               |
| CMS-852A x EC-601751  | 1240               | 1110               | 402               | 368               |
| CMS-850A x EC-601751  | 1226               | 1098               | 402               | 368               |
| CMS-10A x EC-601725   | 1167               | 1045               | 391               | 357               |
| CMS-207A x SCG-2R     | 1194               | 1070               | 381               | 349               |
| PET-89-1A x EC-601751 | 1169               | 1047               | 388               | 354               |
| PET-2-7-1A x EC-601751| 1124               | 1006               | 376               | 344               |
| CMS-853A x EC-601725  | 1215               | 1089               | 381               | 349               |
| CMS-10 A x EC-601978  | 1102               | 988                | 375               | 343               |
| CMS-207A x R-272      | 1142               | 1022               | 382               | 350               |
| CMS-103A x EC-623023  | 1146               | 1026               | 380               | 348               |
| CMS-10A x EC-623023   | 1139               | 1021               | 370               | 338               |
| PET-2-7-1A x EC-623016| 1004               | 900                | 339               | 309               |
| P-2-7-1A x EC-601751  | 1134               | 1016               | 356               | 326               |
| CMS -207A x EC-623023 | 1072               | 960                | 348               | 318               |
| CMS-207A x EC-623016  | 997                | 893                | 343               | 313               |
| CMS -10A x EC-623021  | 1074               | 962                | 350               | 320               |
| CMS-207A x EC-601725  | 1142               | 1022               | 374               | 342               |
| CMS-207A x EC-623021  | 1085               | 971                | 363               | 331               |
| CMS-207A x EC-623027  | 1047               | 937                | 364               | 332               |
| CMS-10 A x EC-623023  | 1114               | 998                | 382               | 350               |
| LSFH-171 (NC-1)       | 1142               | 1022               | 338               | 308               |
| DRSH-1 (NC-2)         | 1021               | 915                | 377               | 345               |
| KBSH-44 (NC-3)        | 1116               | 1000               | 322               | 294               |
| **G. Mean**           | **1159.5**         | **1038.6**         | **384.5**         | **351.5**         |
| **S. E m(±)**         | **33.1**           | **28.6**           | **11.6**          | **8.2**           |
| **C.D.(P=0.005)**     | **97.2**           | **85.8**           | **35.2**          | **25.6**          |
| **C.V. (%)**          | **9.6**            | **9.2**            | **9.1**           | **8.8**           |
Table 2. Mean Seed yield and yield contributing traits of sunflower hybrids under high saline soil (EC 3.0 to 4.0 dS/m) (2017-18 & 2018-19 Pooled)

| Hybrid combination         | Plant height (cm) | Head diameter (cm) | Days to 50% flowering | Seed yield (kg/ha) | 100-seed weight (g) | Oil content (%) | Oil yield (kg/ha) |
|----------------------------|-------------------|--------------------|------------------------|--------------------|---------------------|-----------------|-----------------|
| CMS-234 A x EC-273009      | 132               | 11.5               | 65.5                   | 1276               | 5.6                 | 32.2            | 411             |
| CMS-853 A x EC-623023      | 128               | 11.0               | 65.5                   | 1240               | 4.5                 | 32.8            | 407             |
| CMS-234 A x RHA-1-1        | 120               | 12.0               | 66.5                   | 1208               | 4.1                 | 32.5            | 393             |
| CMS-103 A x EC-601978      | 116               | 11.2               | 63.8                   | 1156               | 5.3                 | 34.6            | 400             |
| CMS-207 A x CSFI-99        | 116               | 10.6               | 68.2                   | 1132               | 4.8                 | 34.7            | 393             |
| CMS-852 A x EC-601725      | 117               | 11.7               | 62.0                   | 1176               | 5.0                 | 33.5            | 394             |
| PET-89-1A x EC-601978      | 110               | 10.2               | 66.3                   | 1045               | 4.5                 | 34.9            | 365             |
| CMS-850 A x EC-601978      | 98                | 9.6                | 63.3                   | 1128               | 4.5                 | 35.3            | 398             |
| PET-2-7-1A x R-138-2       | 112               | 9.8                | 65.8                   | 1125               | 4.1                 | 34.8            | 392             |
| P-2-7-1A x EC-601978       | 127               | 11.5               | 68.5                   | 1161               | 4.7                 | 33.3            | 387             |
| CMS-234 X RHA-1-1          | 135               | 11.2               | 66.5                   | 1178               | 5.4                 | 32.0            | 377             |
| CMS-853A x EC623021        | 121               | 10.9               | 64.0                   | 1136               | 5.0                 | 33.7            | 383             |
| CMS-852A x EC-601751       | 119               | 11.1               | 65.5                   | 1175               | 4.3                 | 32.8            | 385             |
| CMS-850A x EC-601751       | 93                | 10.6               | 62.5                   | 1162               | 4.6                 | 33.1            | 385             |
| CMS-10A x EC-601725        | 120               | 12.2               | 66.5                   | 1106               | 4.7                 | 33.8            | 374             |
| CMS-207A x SCG-2R          | 131               | 10.8               | 67.5                   | 1132               | 4.5                 | 32.2            | 365             |
| PET-89-1A x EC-601751      | 108               | 11.3               | 68.8                   | 1108               | 4.7                 | 33.5            | 371             |
| PET-2-7-1A x EC-601751     | 114               | 11.0               | 66.0                   | 1065               | 5.0                 | 33.8            | 360             |
| CMS-853A x EC-601725       | 135               | 12.8               | 66.5                   | 1152               | 4.3                 | 31.7            | 365             |
| CMS-10 A x EC-601978       | 124               | 10.8               | 63.8                   | 1045               | 4.5                 | 34.4            | 359             |
| CMS-207A x R-272           | 112               | 10.1               | 66.1                   | 1082               | 4.6                 | 33.8            | 366             |
| CMS-103A x EC-623023       | 122               | 10.4               | 63.1                   | 1086               | 4.3                 | 33.5            | 364             |
| CMS-10A x EC-623023        | 125               | 11.8               | 65.0                   | 1080               | 4.0                 | 32.8            | 354             |
| PET-2-7-1A x EC-623016     | 109               | 10.4               | 67.7                   | 952                | 6.2                 | 34.0            | 324             |
| P-2-7-1A x EC-601751       | 124               | 11.1               | 68.5                   | 1075               | 5.0                 | 31.7            | 341             |
| CMS -207A x EC-623023      | 132               | 10.3               | 66.5                   | 1016               | 4.0                 | 32.8            | 333             |
| CMS-207A x EC-623016       | 112               | 9.8                | 64.9                   | 945                | 3.9                 | 34.7            | 328             |
| CMS-10A x EC-623021        | 128               | 10.4               | 68.0                   | 1018               | 5.0                 | 32.9            | 335             |
| CMS-207A x EC-601725       | 121               | 10.1               | 68.0                   | 1082               | 4.3                 | 33.1            | 358             |
| CMS-207A x EC-623021       | 128               | 10.4               | 67.0                   | 1028               | 4.5                 | 33.8            | 347             |
| CMS-207A x EC-623027       | 122               | 9.5                | 66.1                   | 992                | 4.2                 | 35.1            | 348             |
| CMS-10 A x EC-623023       | 132               | 10.3               | 65.5                   | 1056               | 4.3                 | 34.7            | 366             |
| LSFH-171 (NC-1)            | 127               | 11.0               | 70.5                   | 1082               | 4.6                 | 29.9            | 323             |
| DRSH-1 (NC-2)              | 123               | 10.6               | 68.5                   | 968                | 5.0                 | 37.0            | 361             |
| KBSH-44 (NC-3)             | 130               | 10.9               | 70.5                   | 1058               | 4.6                 | 29.2            | 308             |
| **G. Mean**                | **120.1**         | **10.7**           | **66.2**               | **1098.2**         | **4.6**             | **33.2**        | **366.2**       |
| **S. E m(±)**              | 2.3               | 0.34               | 1.1                    | 30.1               | 0.2                 | 0.7             | **10.2**        |
| **C.D.(P=0.005)**          | 6.8               | 1.0                | 3.1                    | 90.2               | 0.6                 | 2.1             | 31.6            |
| **C.V. (%)**               | 9.2               | 5.1                | 6.8                    | 9.6                | 5.8                 | 8.2             | 9.4             |

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Table 3. Economic Heterosis for seed and oil yield in sunflower hybrids

| Hybrid combination          | 2017-18 & 2018-19 (Pooled) |
|-----------------------------|-----------------------------|
|                             | Seed yield (kg/ha) | h2 (%) for seed yield over N.Ch-1 | h2 (%) for seed yield over N.Ch-2 | h2 (%) for seed yield over N.Ch-3 | Oil yield (kg/ha) | h2 (%) for oil yield over N.Ch-1 | h2 (%) for oil yield over N.Ch-2 | h2 (%) for oil yield over N.Ch-3 |
| CMS-234 A x EC-273009      | 1276              | 17.9                           | 30.5                           | 20.8                           | 411              | 27.2                            | 13.9                            | 33.4                             |
| CMS-853 A x EC-623023      | 1240              | 14.6                           | 26.8                           | 17.4                           | 407              | 26.0                            | 12.7                            | 32.1                             |
| CMS-234 A x RHA-1-1        | 1208              | 11.6                           | 23.5                           | 14.4                           | 393              | 21.7                            | 8.9                             | 27.6                             |
| CMS-103 A x EC-601978      | 1156              | 6.8                            | 18.2                           | 9.5                            | 400              | 23.8                            | 10.8                            | 29.9                             |
| CMS-207 A x CSFI-99        | 1132              | 4.6                            | 15.7                           | 7.2                            | 393              | 21.7                            | 8.9                             | 27.6                             |
| CMS-852 A x EC-601725      | 1176              | 8.7                            | 20.2                           | 11.4                           | 394              | 22.0                            | 9.1                             | 27.9                             |
| PET-89-1A x EC-601978      | 1045              | -3.4                           | 6.9                            | -1.0                           | 365              | 13.0                            | 1.1                             | 18.5                             |
| CMS-850 A x EC-601978      | 1128              | 4.3                            | 15.3                           | 6.8                            | 398              | 23.2                            | 10.2                            | 29.2                             |
| PET-2-7-1A x R-138-2       | 1125              | 4.0                            | 15.0                           | 6.5                            | 392              | 21.4                            | 8.6                             | 27.3                             |
| P-2-7-1A x EC-601978       | 1161              | 7.3                            | 18.7                           | 9.9                            | 387              | 19.8                            | 7.2                             | 25.6                             |
| CMS-853A x EC623021        | 1136              | 5.0                            | 16.2                           | 7.6                            | 383              | 18.6                            | 6.1                             | 24.4                             |
| CMS-852A x EC-601751       | 1175              | 8.6                            | 20.1                           | 11.3                           | 385              | 19.2                            | 6.6                             | 25.0                             |
| CMS-850A x EC-601751       | 1162              | 7.4                            | 18.8                           | 10.0                           | 385              | 19.2                            | 6.6                             | 25.0                             |
| CMS-10A x EC-601725        | 1106              | 2.2                            | 13.1                           | 4.7                            | 374              | 15.8                            | 3.6                             | 21.4                             |
| CMS-207A x SCG-2R          | 1132              | 4.6                            | 15.7                           | 7.2                            | 365              | 13.0                            | 1.1                             | 18.5                             |
| PET-89-1A x EC-601751      | 1108              | 2.4                            | 13.3                           | 4.9                            | 371              | 14.9                            | 2.8                             | 20.5                             |
| PET-2-7-1A x EC-601751     | 1065              | -1.6                           | 8.9                            | 0.9                            | 360              | 11.5                            | -0.3                            | 16.9                             |
| CMS-853A x EC-601751       | 1152              | 6.5                            | 17.8                           | 9.1                            | 365              | 13.0                            | 1.1                             | 18.5                             |
| CMS-10 A x EC-601978       | 1045              | -3.4                           | 6.9                            | -1.0                           | 359              | 11.1                            | -0.6                            | 16.6                             |
| CMS-207A x R-272           | 1082              | 0.0                            | 10.6                           | 2.5                            | 366              | 13.3                            | 1.4                             | 18.8                             |
| CMS-103A x EC-623023       | 1086              | 0.4                            | 11.0                           | 2.8                            | 364              | 12.7                            | 0.8                             | 18.2                             |
| CMS-10A x EC-623023        | 1080              | -0.2                           | 10.4                           | 2.3                            | 354              | 9.6                             | -1.9                            | 14.9                             |
| PET-2-7-1A x EC-623016     | 952               | -12.0                          | -2.7                           | -9.8                           | 324              | 0.3                             | -10.2                           | 5.2                              |
| P-2-7-1A x EC-601751       | 1075              | -0.6                           | 9.9                            | 1.8                            | 341              | 5.6                             | -5.5                            | 10.7                             |
| CMS -207A x EC-623023      | 1016              | -6.1                           | 3.9                            | -3.8                           | 333              | 3.1                             | -7.8                            | 8.1                              |
| CMS -207A x EC-623016      | 945               | -12.7                          | -3.4                           | -10.5                          | 328              | 1.5                             | -9.1                            | 6.5                              |
| CMS -10A x EC-601725       | 1018              | -5.9                           | 4.1                            | -3.6                           | 335              | 3.7                             | -7.2                            | 8.8                              |
| CMS -207A x EC-601725      | 1082              | 0.0                            | 10.6                           | 2.5                            | 358              | 10.8                            | -0.8                            | 16.2                             |
| CMS -207A x EC-623021      | 1028              | -5.0                           | 5.1                            | -2.7                           | 347              | 7.4                             | -3.9                            | 12.7                             |
| CMS -207A x EC-623027      | 992               | -8.3                           | 1.4                            | -6.1                           | 348              | 7.7                             | -3.6                            | 13.0                             |
| CMS -10 A x EC-623023      | 1056              | -2.4                           | 8.0                            | 0.0                            | 366              | 13.3                            | 1.4                             | 18.8                             |
| LSFH-171 (N.Ch-1)          | 1032              | -                              | -                              | -                              | 338              | -                               | -                               | -                                |
| DRSH-1 (N.Ch-2)            | 978               | -                              | -                              | -                              | 361              | -                               | -                               | -                                |
| KBSH-44 (N.Ch - 3)         | 1058              | -                              | -                              | -                              | 316              | -                               | -                               | -                                |
| G. Mean                    | 1097.5            | -                              | -                              | -                              | 412.2            | -                               | -                               | -                                |
| S. E m(±)                  | 30.1              | -                              | -                              | -                              | 23.2             | -                               | -                               | -                                |
| C.D.(P=0.005)              | 90.2              | -                              | -                              | -                              | 68.6             | -                               | -                               | -                                |
| C.V. (%)                   | 9.6               | -                              | -                              | -                              | 9.4              | -                               | -                               | -                                |

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Table 4. Economic Heterosis for seed and oil yield of Superior sunflower hybrids

| Hybrid combination                  | 2017-18 & 2018-19 (Pooled) |
|-------------------------------------|----------------------------|
|                                     | Seed yield (kg/ha) | h2 (%) for seed yield over N.Ch-1 | h2 (%) for seed yield over N.Ch-2 | Oil yield (kg/ha) | h2 (%) for oil yield over N.Ch-1 | h2 (%) for oil yield over N.Ch-2 | h2(%) for seed yield over n.ch-3 |
| CMS-234 A x EC-273009               | 1276              | 17.9  | 30.5  | 20.8  | 411              | 27.2  | 13.9  | 33.4  |
| CMS-853 A x EC 623023              | 1240              | 14.6  | 26.8  | 17.4  | 407              | 26.0  | 12.7  | 32.1  |
| CMS-234A X RHA-1-1                 | 1208              | 11.6  | 23.5  | 14.4  | 393              | 21.7  | 8.9   | 27.6  |
| CMS-852 A x EC-601725              | 1176              | 8.7   | 20.2  | 11.4  | 394              | 22.0  | 9.1   | 27.9  |
| CMS-103 A x EC-601978              | 1156              | 6.8   | 18.2  | 9.5   | 400              | 23.8  | 10.8  | 29.9  |
| CMS-207 A X CSFI-99                | 1132              | 4.6   | 15.7  | 7.2   | 393              | 21.7  | 8.9   | 27.6  |
| CMS-850 A x EC-601978              | 1128              | 4.3   | 15.3  | 6.8   | 398              | 23.2  | 10.2  | 29.2  |
| PET-2-7-1A x R-138-2               | 1125              | 4.0   | 15.0  | 6.5   | 392              | 21.4  | 8.6   | 27.3  |
| LSFH-171 (N.Ch-1)                  | 1032              | -     | -     | -     | 309              | -     | -     | -     |
| DRSH-1 (N.Ch-2)                    | 928               | -     | -     | -     | 346              | -     | -     | -     |
| KBSH-44 (N.Ch - 3)                 | 972               | -     | -     | -     | 276              | -     | -     | -     |

Analysis on pooled data for oil yield revealed that standard heterosis for oil yield the sunflower hybrid, CMS-234 A x EC-273009 (411kg/ha) was the highest and manifested 27.2, 13.9 and 33.4 per cent increased standard heterosis over that of LSFH-171, DRSH-1 and KBSH-44, respectively. Higher standard heterosis for seed yield and most of the yield contributing traits in the experimental hybrids with the use of diverse CMS lines were also reported by Manivannan et al. (2015). Standard heterosis over best check i.e. DRSH-1 for seed yield and oil content was also recorded by Rathi et al. (2016) The magnitude and direction of standard heterosis of diverse CMS based hybrids were different for all the traits under study. The result was further attested by Tyagi et al. (2013) and Lakshman et al. (2018).

The significant economic heterosis for oil yield were also observed in experimental sunflower hybrids viz., CMS-853 A x EC-623023(407), which recorded 26.0 per cent over LSFH-171, 12.8 per cent over DRSH-1 and 32.1 per cent over KBSH-44. Oil yield of CMS-103A x EC-601978 (400kg ha) showed 23.8, 10.85 and 29.9 per cent economic heterosis over LSFH-171, DRSH-1 and KBSH-44, respectively, CMS-850 A x EC-601978 (398) was recorded 23.2 per cent economic heterosis over LSFH-171, 10.2 per cent over DRSH-1 and 29.2 per cent over KBSH-44 with respect to oil yield. CMS-852 A x EC-601725(394 kg/ha), CMS-207 A X CSFI-99(393), CMS-234A X RHA-1-1(393 kg/ha) and PET-2-7-1A x R-138-2 (393 kg/ha) rerecorded 22.0, 9.0 and 27.2 per cent increased standard heterosis over LSFH-171, DRSH-1 and KBSH-44, respectively.

The study revealed that out of 32 sunflower hybrids evaluated, hybrids viz., CMS-234 A x EC-273009, CMS-234 X RHA-1-1, CMS-853 A x EC 623023, CMS-103 A x EC-601978, CMS-852 A x EC-601725, CMS-207 A X CSFI-99 and CMS-850 A x EC-601978 manifested significantly a higher seed and oil yield over national checks LSFH-171, DRSH-1 and KBSH-44. These hybrids could be exploited further and commercialized.

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