The Bioscan 10(4): 1991-1996, 2015 (Supplement on Genetics and Plant Breeding) www.thebioscan.in
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES

# ESTIMATION OF HETEROSIS FOR YIELD AND YIELD CONTRUBUTING CHARACTERS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

**S. V. YAMGAR*, M. K, GHODAKE[1] AND R. D. MALI[2]**
[1]Department of Agricultural Botany, College Of Agriculture, Latur - 413 512, INDIA
[2]Oilseed Research Station,
Latur. Vasantrao Naik Marathwada Agricultural University, Parbhani - 431 402 (M.S.), INDIA
e-mail: Yamgarsv@Gmail.Com

**KEYWORDS**
Sunflower
Heterosis
yield components
Line x tester analysis

**Received on :**
21.07.2015

**Accepted on :**
09.10.2015

***Corresponding author**

**ABSTRACT**

The experiment consisting of four cytoplasmic male sterile lines and seven restorers were crossed in line x tester fashion to estimate the heterosis for seed yield and yield contributing trait in sunflower resulting their 28 crosses were evaluated in two replication of randomized block design over two commercial checks LSFH-171 and LSFH-35. The morphological observations on 10 quantitative characters were recorded. The extend of heterosis in 28 hybrids over mid parent (MP) ranging from 33.33 to 148.00 better parents (BP) ranged from 3.13 to 121.43 and standard heterosis over on check LSFH-35 ranged from -8.33 to 61.11 other check LSFH-171 showed heterosis ranged from-17.50 to 55.00 for seed yield while extend of heterosis for oil content in hybrids over mid parent (MP) ranging from -11.49 to 16.67.00 better parents (BP) ranged from -18.52 to 15.62 and standard heterosis estimated over one check LSFH-35 ranged from -16.98 to 2.12 and other check LSFH-171 ranged from -10.72 to 11.59 , The best crosses based on heterosis and sca effect per se performance were LSFH-221,LSFH-273,LSFH-1218,LSFH-2421 and LSFH-2073 were identified as the best crosses combination for seed yield, oil content, yield characters. These better performing hybrids can be used for exploiting hybrid vigour and need to be evaluating stability parameter.

## INTRODUCTION

Sunflower (*Helianthus annuus* L) is a member of composite family is significant edible oilseed crop. The oilseed revolution was mainly attributed to attaining self- sufficiency in edible oil as well as to "yellow revolution" in the country is noteworthy (Mangala Rai, 2002). Due to its cross pollinated nature, it offers considerable scope for commercial exploitation of heterosis utilizing cyto-restorer system (Madrap and Makne, 1993; Gangappa *et al*., 1997). A new era opened in sunflower breeding with the discovery of cytoplasmic male sterility by Leclercq (1969) in France and fertility restoration by Kinman (1970) in USA, which provided the required breakthrough heterosis breeding. With the increase in demand for edible oils, there is a need to develop new sunflower hybrids suited to different agro-climatic zones of India with improved seed yield and oil content. Hybrids are preferred over varietal populations because of their high productivity uniform growth and also respond to higher level of fertilizer application and irrigation resulting in terms of seed and oil yield. In view of these advantages, the coverage of area is more under hybrids and it is around 95 percent In India, first ever sunflower hybrid BSH-1 developed by Seetharam (1980), as turning point in sunflower cultivation. a biometrical techniques have been developed to generate information on gene action and mode of inheritance of various characters, among which line × tester analysis (Kempthorne, 1957) has been widely used for genetic analysis in large number of crop plants. The present attempt has been taken to evaluate the magnitude of heterosis in form of heterobeltiosis and standard heterosis for seed yield and yield contributing trait in sunflower.

## MATERIALS AND METHODS

The experimental material consists of four female lines *viz,*CMS-2A, CMS-249A, CMS-127A,CMS-2023A and seven restorers *viz,* EC-601963, EC-601800, EC-623021, EC-512673, EC-512681, EC-512682,EC-623018 were crossed in Line X Tester design (Kempthorne, 1957) and produced 28 hybrids in *kharif*, 2013 seeds were harvested separately to study heterosis in next season. The resulting 28 hybrids, 11 parents and two checks were sown in randomized block design with two replications during *rabi*-2013-14 at Oilseeds Research Station, Latur. Each plot consisted of three rows of 3.0 meter length with spacing of 60 cm between rows and 30 cm within row. The recommended dose of fertilizer was applied 60:30:30 kg NPK/ha. The recommended cultural practices including plant protection measures were followed. The morphological observations on 10 quantitative characters were recorded by selecting randomly 5 competitive plants in each plot.viz., days to 50% flowering, days to maturity, plant height(cm), Head diameter (cm), seed filling percent, seed yield per plant(g), 100 seed weight(g), Volume weight(g), hull per cent, Oil content(%). The analysis was carried out in computer using software INDOSTAT as per standard procedure of heterobeltiosis, pooled values and standard heterosis at oilseed research station, Latur.

## RESULTS AND DISCUSSION

The analyses of variances for various economic traits are revealed that seed yield and its components indicate significant differences among parents for all ten traits studied. This revealed the presence of significant variability in the experimental material presented in Table.1 Resulting performance of 28 hybrids over standard heterosis and heterobeltiosis for ten character is presented in table *per se* performance for seed yield per plant with standard heterosis of best five crosses there GCA , SCA status of high yielding hybrids and their parent are presented in Table.3 and table.4 respectively. The traits days to 50% flowering and early maturity are desirable attributes in sunflower crop under rainfed cultivation or protected irrigation supply therefore negative heterosis was considered as desirable for those characters. Five hybrid and 14 hybrids had negative heterosic effect for early flowering and early maturity over best check LSFH-171, Similarly two hybrids LSFH-2073 (8.25, 3.96) and LSFH-2481 (8.25, 3.96) had negative heterosic effect for early maturity over both standard checks LSFH-35 and LSFH-171 Negative heterosis for early flowering, and early maturity was reported by Govindraju (1986) Chidambaram and sundarsan (1990), Bandiwad (1996) and Bhattacharjee (1996) in sunflower.

**Table 1: Analysis of variance for different characters in sunflower**

| Sr.No. | Characters | Source of variation Replications MSS1 (d.f) | Treatments MSS40 (d.f) | Error MSS40 (d.f) |
|---|---|---|---|---|
| 1 | Days to 50 % flowering | 0.20513 | 31.56545** | 2.73144 |
| 2 | Days to maturity | 1.84615 | 46.00000** | 2.37247 |
| 3 | Plant height (cm) | 49.28205 | 1958.98785** | 20.33468 |
| 4 | Head diameter (cm) | 0.38782 | 5.68775** | 0.40782 |
| 5 | Seed yield / plant (gm) | 20.51282 | 275.10931** | 15.56545 |
| 6 | Seed filling (%) | 3.28205 | 75.44399** | 6.65047 |
| 7 | 100-seed weight (gm) | 0.12480 | 1.59089** | 0.13875 |
| 8 | Volume weight (gm/100ml) | 0.82051 | 41.14440** | 7.97841 |
| 9 | Hull content (%) | 14.82051 | 24.43995** | 5.76788 |
| 10 | Oil content (%) | 0.68321 | 7.47378* | 1.94110 |

** and * indicates significant at 1% and 5%, respectively

**Table 2: Estimation of standard heterosis for ten characters in sunflower.**

| Sr. No. | Hybrids | Days to 50 % flowering Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 | Days to maturity Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | LSFH-2018 | 0.74 | -1.45 | -2.86 | -4.23 | 2.15 | -2.06 | -2.06 | -5.94** |
| 2 | LSFH-2021 | -1.43 | -6.76** | -1.43 | -2.82 | 3.16* | -2.97 | 1.03 | -2.97 |
| 3 | LSFH-2063 | -5.43 | -7.58** | -12.86 | -14.08** | -4.92** | -7.45** | -10.31** | -13.86** |
| 4 | LSFH-2000 | 7.81** | 4.55 | -1.43 | -2.82 | 9.09** | 7.87** | -1.03 | -4.95** |
| 5 | LSFH-2073 | 1.43 | -4.05 | 1.43 | 0.00 | 8.25** | 0.00 | 8.25** | 3.96* |
| 6 | LSFH-2081 | -8.96** | -10.29** | -12.86 | -14.08** | -6.38** | -11.11** | -9.28** | -12.87** |
| 7 | LSFH-2082 | 2.82 | -3.95 | 4.29 | 2.82 | -1.54 | -9.43** | -1.03 | -4.95 |
| 8 | LSFH-218 | 5.19* | 2.90 | 1.43 | 0.00 | 4.21** | 2.06 | 2.06 | -1.98 |
| 9 | LSFH-221 | -2.86 | -8.11** | -2.86 | -4.23 | -1.03 | -4.95** | -1.03 | -4.95** |
| 10 | LSFH-263 | 0.78 | -1.52 | -7.14** | -8.45 | 0.53 | 0.00 | -3.09 | -6.93** |
| 11 | LSFH-200 | 4.69* | 1.52 | -4.29 | -5.63* | 7.78** | 4.30 | 0.00 | -3.96* |
| 12 | LSFH-273 | -1.43 | -6.76** | -1.43 | -2.82 | -4.04** | -9.52** | -2.06 | -5.94** |
| 13 | LSFH-281 | 2.99 | 1.47 | -1.43 | -2.82 | 0.00 | -3.03 | -1.03 | -4.95 |
| 14 | LSFH-282 | 7.04* | 0.00 | 8.57** | 7.04** | 2.51 | -3.77* | 5.15** | 0.99 |
| 15 | LSFH-2418 | -0.72 | -1.43 | -1.43 | -2.82 | 1.54 | 1.02 | 2.06 | -1.98 |
| 16 | LSFH-2421 | 0.00 | -2.70 | 2.86 | 1.41 | -0.50 | -1.98 | 2.06 | -1.98 |
| 17 | LSFH-2463 | 5.26* | 0.00 | 0.00 | -1.41 | -3.13* | -5.10** | -4.12 | -7.92 |
| 18 | LSFH-2400 | 9.09** | 2.86 | 2.86 | 1.41 | 4.86** | -1.02 | 0.00 | -3.96 |
| 19 | LSFH-2473 | 1.39 | -1.35 | 4.29 | 2.82 | -0.49 | -3.81* | 4.12* | 0.00 |
| 20 | LSFH-2481 | 8.70** | 7.14** | 7.14** | 5.63* | 6.60** | 6.06** | 8.25** | 3.96* |
| 21 | LSFH-2482 | 2.74 | -1.32 | 7.14** | 5.63* | 0.98 | -2.83 | 6.19** | 1.98 |
| 22 | LSFH-1218 | -2.90 | -2.90 | -4.29 | -5.63* | 2.11 | 0.00 | 0.00 | -3.96* |
| 23 | LSFH-1221 | -2.10 | -5.41* | 0.00 | -1.41 | -2.06 | -5.94** | -2.06 | -5.94** |
| 24 | LSFH-1263 | 3.03 | -1.45 | -2.86 | -4.23 | 0.53 | 0.00 | -3.09 | -6.93** |
| 25 | LSFH-1200 | 2.29 | -2.90 | -4.29 | -5.63* | 7.78** | 4.30* | 0.00 | -3.96* |
| 26 | LSFH-1273 | 6.29** | 2.70 | 8.57** | 7.04** | 5.05** | -0.95 | 7.22** | 2.97 |
| 27 | LSFH-1281 | 2.19 | 1.45 | 0.00 | -1.41 | 2.08 | -1.01 | 1.03 | -2.97 |
| 28 | LSFH-1282 | 0.69 | -3.95 | 4.29 | 2.82 | -4.52** | -10.38** | -2.06 | -5.94** |

**Table 2: Continued....**

| Sr. No. | Hybrids | Plant height (cm) Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 | Head diameter (cm) Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | LSFH-2018 | 70.64** | 61.74** | -2.11 | -7.46** | 5.88 | 3.85 | -7.35 | -10.85** |
| 2 | LSFH-2021 | 30.86** | 6.02* | -7.37** | -12.44** | -2.94 | -5.47 | -11.03 | -14.39** |
| 3 | LSFH-2063 | 23.32** | 4.00 | -17.89** | -22.39** | 7.65* | 6.32 | -5.15 | -8.73** |
| 4 | LSFH-2000 | 13.97** | -8.28** | -18.42** | -22.89** | 23.90** | 17.49** | 16.91** | 12.50** |
| 5 | LSFH-2073 | 45.31** | 25.35** | -6.32* | -11.44** | 23.33** | 22.49** | 10.78** | 6.60* |
| 6 | LSFH-2081 | 55.26** | 41.60** | -6.84** | -11.94** | -2.78 | -6.14 | -10.05** | -13.44** |
| 7 | LSFH-2082 | 44.30** | 27.61** | -10.00** | -14.93** | -2.53 | -5.43 | -10.29** | -13.68** |
| 8 | LSFH-218 | 63.30** | 43.42** | 14.74** | 8.46** | 9.59** | 5.26 | -1.96 | -5.66 |
| 9 | LSFH-221 | 23.90** | 18.67** | 3.68 | -1.99 | 18.32** | 17.71** | 10.78** | 6.60* |
| 10 | LSFH-263 | 31.13** | 30.26** | 4.21 | -1.49 | 2.86 | -0.53 | -7.35* | -10.85** |
| 11 | LSFH-200 | 21.50** | 15.38** | 2.63 | -2.99 | 1.27 | -1.97 | -2.45 | -6.13 |
| 12 | LSFH-273 | 33.33** | 28.95** | 3.16 | -2.49 | 11.08** | 9.47** | 1.96 | -1.89 |
| 13 | LSFH-281 | 38.63** | 26.32** | 1.05 | -4.48 | -0.91 | -2.30 | -6.37 | -9.91** |
| 14 | LSFH-282 | 46.85** | 38.16** | 10.53** | 4.48 | 15.25** | 14.21** | 8.33* | 4.25 |
| 15 | LSFH-2418 | 65.00** | 40.00** | 21.58** | 14.93** | 9.55** | 2.23 | 1.23 | -2.59 |
| 16 | LSFH-2421 | 32.93** | 32.53** | 15.79** | 9.45** | 4.31 | 1.73 | 0.74 | -3.07 |
| 17 | LSFH-2463 | 35.87** | 29.70** | 12.63** | 6.47** | 4.08 | -2.23 | -3.19 | -6.84* |
| 18 | LSFH-2400 | 29.94** | 28.40** | 14.21** | 7.96** | 11.11** | 10.84** | 10.29** | 6.13 |
| 19 | LSFH-2473 | 38.76** | 29.09** | 12.11** | 5.97* | -0.39 | -4.70 | -5.64 | -9.20** |
| 20 | LSFH-2481 | 43.45** | 26.06** | 9.47** | 3.48 | 12.96** | 11.14** | 10.05** | 5.90 |
| 21 | LSFH-2482 | 43.81** | 30.30** | 13.16** | 6.97** | 8.22** | 5.94 | 4.90 | 0.94 |
| 22 | LSFH-1218 | 63.08** | 46.21** | 11.58** | 5.47* | 5.85 | 5.70 | -9.07** | -12.50** |
| 23 | LSFH-1221 | 26.69** | 18.67** | 3.68 | -1.99 | -7.48* | -11.46** | -16.67** | -19.81** |
| 24 | LSFH-1263 | 31.53** | 29.33** | 2.11 | -3.48 | -3.40 | -3.94 | -16.42** | -19.58** |
| 25 | LSFH-1200 | 24.20** | 15.38** | 2.63 | -2.99 | 8.32** | 0.99 | 0.49 | -3.30 |
| 26 | LSFH-1273 | 40.07** | 38.62** | 5.79* | 0.00 | 16.67** | 13.82** | 2.94 | -0.94 |
| 27 | LSFH-1281 | 34.81** | 25.52** | -4.21 | -9.45* | 0.81 | -4.35 | -8.33* | -11.79** |
| 28 | LSFH-1282 | 37.63** | 32.41** | 1.05 | -4.48 | 0.54 | -4.13 | -9.07** | -12.50** |

**Table 2: Continued....**

| Sr. No. | Hybrids | Seed filling (%) Mid Parent | Better Parent | 100 seed weight (g) LSFH-35 SC-1 | LSFH-171 SC-2 | Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | LSFH-2018 | 10.06** | 9.41** | 8.14* | 1.09 | 86.86** | 72.97** | 6.67 | 1.59 |
| 2 | LSFH-2021 | 1.86 | -2.38 | -4.65 | -10.87** | 11.11 | -11.49 | -21.67** | -25.40** |
| 3 | LSFH-2063 | 14.63** | 11.90** | 9.30** | 2.17 | 46.67 | 26.44** | -8.33 | -12.70* |
| 4 | LSFH-2000 | 12.57** | 11.90** | 9.30** | 2.17 | 68.55** | 39.58** | 11.67 | 6.35 |
| 5 | LSFH-2073 | 8.24** | 6.98* | 6.98* | 0.00 | 21.21** | -11.11 | 0.00 | -4.76 |
| 6 | LSFH-2081 | 16.87** | 15.48** | 12.79** | 5.43 | 80.45** | 71.43** | 0.00 | -4.76 |
| 7 | LSFH-2082 | 4.76 | 4.76 | 2.33 | -4.35 | 58.87** | 43.59** | -6.67 | -11.11 |
| 8 | LSFH-218 | 10.71** | 9.41** | 8.14* | 1.09 | 3.18 | -2.41 | -32.50** | -35.71** |
| 9 | LSFH-221 | 3.75 | 0.00 | -3.49 | -9.78** | 15.22* | 2.64 | -9.17 | -13.49* |
| 10 | LSFH-263 | 19.02** | 16.87** | 12.79** | 5.43 | 9.411 | 6.90 | -22.50** | -26.19* |
| 11 | LSFH-200 | 9.64** | 9.64** | 5.81 | -1.09 | 16.20* | 8.33 | -13.33* | -17.46** |
| 12 | LSFH-273 | 11.24** | 9.30** | 9.30** | 2.17 | 4.59 | -15.56** | -5.00 | -9.52 |
| 13 | LSFH-281 | 11.52** | 10.84** | 6.98* | 0.00 | 41.18** | 30.12** | -10.00 | -14.29* |
| 14 | LSFH-282 | -0.60 | -1.19 | -3.49 | -9.78** | -3.11 | -6.02 | -35.00** | -38.10** |
| 15 | LSFH-2418 | 5.81* | 4.60 | 5.81 | -1.09 | -12.64 | -24.00** | -36.67** | -39.68** |
| 16 | LSFH-2421 | 17.07** | 10.34** | 11.63** | 4.35 | 1.84 | -1.13 | -12.50 | -16.67** |
| 17 | LSFH-2463 | 11.38** | 6.90* | 8.14* | 1.09 | 4.81 | -2.00 | -18.33 | -22.22** |
| 18 | LSFH-2400 | 1.38 | -1.15 | 0.00 | -6.52* | 39.80** | 37.00 | 14.17* | 8.73 |
| 19 | LSFH-2473 | 6.36* | 5.75 | 6.98* | 0.00 | -13.19* | -24.44** | -15.00* | -19.05** |
| 20 | LSFH-2481 | 4.14 | 1.15 | 2.33 | -4.35 | 9.41 | -7.00 | -22.50** | -26.19** |
| 21 | LSFH-2482 | -19.30** | -20.69** | -19.77** | -25.00** | 1.12 | -10.00 | -25.00** | -28.57** |
| 22 | LSFH-1218 | 10.71** | 9.41** | 8.14* | 1.09 | 18.79* | 7.69 | -18.33** | -22.22** |
| 23 | LSFH-1221 | 13.75** | 9.64** | 5.81 | -1.09 | -4.67 | -11.49 | -21.67** | -25.40** |
| 24 | LSFH-1263 | 19.02** | 16.87** | 12.79** | 5.43 | 13.48 | 10.99 | -15.83* | -19.84** |
| 25 | LSFH-1200 | 13.25 | 13.25** | 9.30** | 2.17 | 19.79** | 16.67* | -6.67 | -11.11 |
| 26 | LSFH-1273 | 5.33 | 3.49 | 3.49 | -3.26 | -17.70** | -31.11** | -22.50** | -26.19** |
| 27 | LSFH-1281 | 11.52** | 10.84** | 6.98* | 0.00 | 41.61** | 25.27** | -5.00 | -9.52 |
| 28 | LSFH-1282 | 7.78** | 7.14* | 4.65 | -2.17 | 23.08** | 14.29 | -13.33* | -17.46** |

**Table 2: Continued......**

| Sr. No. | Hybrids | Volume weight (gm/100ml) | | | | Seed yield / plant (g) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 | Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 |
| 1 | LSFH-2018 | 30.56** | 17.50* | -6.00 | -9.62 | 90.24** | 69.57** | 8.33 | -2.50 |
| 2 | LSFH-2021 | 23.68** | 6.82 | -6.00 | -9.62 | 33.33* | 21.43 | -5.56 | -15.00 |
| 3 | LSFH-2063 | 35.90** | 12.22* | 6.00 | 1.92 | 51.02** | 42.31** | 2.78 | -7.50 |
| 4 | LSFH-2000 | 13.92* | -4.26 | -10.00 | -13.46* | 20.00 | 3.13 | -8.33 | -17.50 |
| 5 | LSFH-2073 | 12.20 | -8.00 | -8.00 | -11.54* | 103.85** | 82.76** | 47.22** | 32..50** |
| 6 | LSFH-2081 | 50.00** | 35.00** | 8.00 | 3.85 | 100.00** | 86.96** | 19.44 | 7.50 |
| 7 | LSFH-2082 | 18.31* | 7.69 | -16.00** | -19.23** | 37.50* | 32.00 | -8.33 | -17.50 |
| 8 | LSFH-218 | 20.99** | 19.51** | -2.00 | -5.77 | 125.00** | 104.55** | 25.00* | 12.50 |
| 9 | LSFH-221 | 8.24 | 4.55 | -8.00 | -11.54* | 148.00** | 121.43** | 72.22** | 55.00** |
| 10 | LSFH-263 | 12.64* | 6.52 | -2.00 | -5.77 | 116.67** | 100.00** | 44.44** | 30.00** |
| 11 | LSFH-200 | 15.91** | 8.51 | 2.00 | -1.92 | 37.07** | 15.63 | 2.78 | -7.50 |
| 12 | LSFH-273 | -7.69 | -16.00** | -16.00 | -19.23** | 127.45** | 100.00** | 61.11** | 45.00** |
| 13 | LSFH-281 | 16.05* | 14.63* | -6.00 | -9.62 | 95.24** | 86.36** | 13.89 | 2.50 |
| 14 | LSFH-282 | 2.50 | 0.00 | -18.00** | -21.15** | 61.70** | 52.00** | 5.56 | -5.00 |
| 15 | LSFH-2418 | 1.12 | -8.16 | -10.00 | -13.46* | 62.79** | 40.00* | -2.78 | -12.50 |
| 16 | LSFH-2421 | -5.38 | -10.20 | -12.00* | -15.38** | 115.09** | 103.57** | 58.33** | 42.50** |
| 17 | LSFH-2463 | -5.26 | -8.16 | -10.00 | -13.46* | 60.78** | 57.69** | 13.89 | 2.50 |
| 18 | LSFH-2400 | 2.08 | 0.00 | -2.00 | -5.77 | 40.35** | 25.00 | 11.11 | 0.00 |
| 19 | LSFH-2473 | -7.07 | -8.00 | -8.00 | -11.54* | 100.00** | 86.21** | 50.00** | 35.00** |
| 20 | LSFH-2481 | -7.87 | -16.33** | -18.00** | -21.15** | 131.11** | 108.00** | 44.44** | 30.00** |
| 21 | LSFH-2482 | 11.36 | 0.00 | -2.00 | -5.77 | 96.00** | 96.00** | 36.11** | 22.50* |
| 22 | LSFH-1218 | 5.49 | -5.88 | -4.00 | -7.69 | 205.26** | 190.00** | 61.11** | 45.00** |
| 23 | LSFH-1221 | -5.26 | -11.76* | -10.00 | -13.46* | 37.50* | 17.86 | -8.33 | -17.50 |
| 24 | LSFH-1263 | 9.28 | 3.92 | 6.00 | 1.92 | 65.22** | 46.15** | 5.56 | -5.00 |
| 25 | LSFH-1200 | 4.08 | 0.00 | 2.00 | -1.92 | 73.08** | 40.63** | 25.00* | 12.50 |
| 26 | LSFH-1273 | -20.79** | -21.57** | -20.00** | -23.08** | 38.78** | 17.24 | -5.56 | -15.00 |
| 27 | LSFH-1281 | 5.49 | -5.88 | -4.00 | -7.69 | 95.00** | 95.00** | 8.33 | -2.50 |
| 28 | LSFH-1282 | 0.00 | -11.76* | -10.00 | -13.46* | 77.78** | 60.00** | 11.11 | 0.00 |

**Table 2: Continued....**

| Sr. No. | Hybrids | Oil content (%) | | | | Hull content | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 | Mid Parent | Better Parent | LSFH-35 SC-1 | LSFH-171 SC-2 |
| 1 | LSFH-2018 | 9.18* | 5.41 | -6.90 | 1.74 | -26.58** | -27.50** | -9.38 | 11.54 |
| 2 | LSFH-2021 | 4.93 | 3.45 | -12.47** | -4.35 | 4.11 | -2.56 | 18.75* | 46.15** |
| 3 | LSFH-2063 | 15.91** | 13.84** | -2.92 | 6.09 | -13.04* | -23.08** | -6.25 | 15.38 |
| 4 | LSFH-2000 | 0.97 | 0.97 | -16.98** | -9.28* | -17.33 | -20.51** | -3.13 | 19.23* |
| 5 | LSFH-2073 | -1.52 | -7.14 | -13.79** | -5.80 | -17.81 | -23.08** | -6.25 | 15.38 |
| 6 | LSFH-2081 | 6..98 | 5.31 | -10.61** | -2.32 | -27.50 | -29.27** | -9.38 | 11.54 |
| 7 | LSFH-2082 | 0.64 | -0.63 | -16.18** | -8.41* | -17.81** | -23.08** | -6.25 | 15.38 |
| 8 | LSFH-218 | -5.69 | -5.97 | -16.45** | -8.70* | -20.51** | -22.50** | -3.13 | 19.23* |
| 9 | LSFH-221 | -1.53 | -3.88 | -14.59** | -6.67 | 5.56 | 0.00 | 18.75* | 46.15** |
| 10 | LSFH-263 | -0.99 | -2.99 | -13.79** | -5.80 | 5.88 | -5.26 | 12.50 | 38.46** |
| 11 | LSFH-200 | -2.33 | -5.97 | -16.45** | -8.70* | -24.32** | -26.32** | -12.50 | 7.69 |
| 12 | LSFH-273 | -4.53 | -6.57 | -13.26** | -5.22 | -13.89* | -18.42** | -3.13 | 19.23* |
| 13 | LSFH-281 | 2.29 | 0.00 | -11.14** | -2.90 | -18.99 | -21.95** | 0.00 | 23.08* |
| 14 | LSFH-282 | -4.13 | -6.57 | -16.98** | -9.28* | 2.78 | -2.63 | 15.63* | 42.31** |
| 15 | LSFH-2418 | -9.70** | -15.08** | -14.85** | -6.96 | -9.33 | -15.00* | 6.25 | 30.77** |
| 16 | LSFH-2421 | 0.43 | -7.41 | -7.16 | 1.45 | -10.14 | -11.43 | -3.13 | 19.23* |
| 17 | LSFH-2463 | -7.36* | -14.29** | -14.06** | -6.09 | 4.62 | -2.86 | 6.25 | 30.77** |
| 18 | LSFH-2400 | -4.65 | -13.23** | -13.00** | -4.93 | 1.41 | 0.00 | 12.50 | 38.46** |
| 19 | LSFH-2473 | 1.65 | -2.12 | -1.86 | 7.25 | -7.25 | -8.57 | 0.00 | 23.08* |
| 20 | LSFH-2481 | -4.30 | -11.64** | -11.41** | -3.19 | -23.68** | -29.27** | -9.38 | 11.54 |
| 21 | LSFH-2482 | -11.49** | -18.52** | -18.30** | -10.72* | 1.45 | 0.00 | 9.38 | 34.62** |
| 22 | LSFH-1218 | 16.67** | 15.62 | 2.12 | 11.59** | -23.68** | -27.50** | -9.38 | 11.54 |
| 23 | LSFH-1221 | 2.17 | 0.92 | -12.47** | -4.35 | -11.43 | -13.89* | -3.13 | 19.23* |
| 24 | LSFH-1263 | 8.25* | 7.34 | -6.90 | 1.74 | -3.03 | -11.11 | 0.00 | 23.08* |
| 25 | LSFH-1200 | 10.52** | 7.65 | -6.63 | 2.03 | -13.89* | -13.89* | -3.13 | 19.23* |
| 26 | LSFH-1273 | -4.87 | -8.00 | -14.59** | -6.67 | -11.43 | -13.89* | -3.13 | 19.23* |
| 27 | LSFH-1281 | 8.50* | 7.34 | -6.90 | 1.74 | -24.68** | -29.27** | -9.38 | 11.54 |
| 28 | LSFH-1282 | 7.91* | 6.42 | -7.69* | 0.87 | -11.43 | -13.89* | -3.13 | 19.23* |

** and * indicates significant at 1% and 5%, respectively

**Table 3: per se performance for seed yield per plant with standard heterosis of best five crosses**

| Crosses | Seed yield/ plant(gm) | Heterosis over standard check Mid parent | Better parent | LSFH-35 | LSFH-171 | Significant heterosis for other characters |
|---|---|---|---|---|---|---|
| LSFH-221 | 62.00 | 148.00 | 121.00 | 72.22 | 55.00 | Head diameter(10.78),(6.60) significant heterosis over both checks |
| LSFH-273 | 58.00 | 127.45 | 100.00 | 61.11 | 45.00 | Early maturity(-5.94) over check LSFH-171 seed filling (9.30) over check LSFH-35, |
| LSFH-1218 | 58.00 | 205.26 | 190.00 | 61.11 | 45.00 | Early flowering.(-5.63), early maturity(-3.96) and oil content(11.59) over check LSFH-171 |
| LSFH-2421 | 57.00 | 115.09 | 103.57 | 58.33 | 42.50 | Seed filling(11.63) over check LSFH-35 |
| LSFH-2073 | 53.00 | 103.85 | 82.76 | 47.22 | 32.50 | Dwarf plant height(-6.32),(-11.44), head diameter(10.78),(6.60). over both standard checks LSFH-35 and LSFH-171. |

**Table 4: GCA and SCA status of high yielding hybrids and their parent.**

| Crosses | GCA effect Parent-I | Parent-II | SCA effect | Significance t SCA for other character |
|---|---|---|---|---|
| LSFH-221 | 4.000 | 2.929 | 11.500 | Head diameter(2.568) and test weight(0.736) |
| LSFH-273 | 4.000 | -4.821 | 4.250 | Early flowering(-2.750), early Maturity(-6.071) and test weight(0.648). |
| LSFH-1218 | -2.571 | 0.679 | 16.321** | Test weight(0.988), |
| LSFH-2421 | 3.286 | 2.929 | 7.214* | Seed filling(10.643), low hull content(-4.536). |
| LSFH-2073 | -4.714 | 6.179 | 7.964* | Head diameter(1.788) |

Prof sambhaji Vishnu yamgar; Mb-9960111660

In sunflower dwarf to medium tall plant is required because tall plant are prone to lodging therefore negative heterosis in this is case also desirable. Six hybrids out of 28 the hybrids exhibited significant negative heterosis over both checks, LSFH-35 and LSFH-171. The best three heterotic hybrids were LSFH-2000 (-18.42, -22.89), LSFH-2063 (-17.89, -22.39) and LSFH-2082 (-10.00, -14.93) Negative heterosis for plant height was also reported by Chidambaran and Sudarshan (1990) and Phad *et al.* (2002). The role played by restorer EC-512681 in transferring dwarfness in the hybrids is again witnessed through *per se* performance and high gca effect

Head diameter is the most important character related to yield. Large heads accommodate more seeds which help to increase the production. Out of 28 hybrids 3 hybrids viz., LSFH-2000(16.91, 12.50), LSFH-2073 (10.78, 6.60) and LSFH-221(10.78, 6.60) showed highest significant positive heterosis over both checks LSFH-35 and LSFH-171. The significant contribution for head diameter in above hybrids involves CMS -249A, such high heterosis for head diameter in sunflower was also reported by Naresh *et al*. (1996) and Gill and Punia (1996). Increased seed yield per plant is the ultimate objective in crop breeding hence high heterosis for seed yield is always looked for. Out of 28 hybrids nine hybrids exhibited significant positive heterosis overall both checks. LSFH-35 and LSFH-171. The five best heterotic hybrids are LSFH-221 (72.22, 55.000) LSFH-273 (61.11, 45.00), LSFH-1218 (61.11, 45.00), LSFH-2421 (58.33, 42.50) and LSFH-2473 (50.00, 35.00), Female parent ARM-249A play important role in transfer of seed yield in resultant hybrids. High heterosis for seed yield was also reported by Jeena and Sheikh (2004), Latha *et al.,* (2005) and Thombare *et al.* (2007). Percent filled seeds in sunflower were positively correlated with seed yield. Out of 28 hybrids 16 hybrids recorded significant positive heterosis over best standard check LSFH-35. These significant heterotic three best hybrids were, LSFH-2081 (12.79),LSFH-263 (12.79), LSFH-1263 (12.79), Desirable positive heterosis were al so reported by Limbore *et al.* (1998) and Jeena and sheikh (2004)

High test weight is related to seed yield. In the present study only one hybrid LSFH-2400 (14.17) exhibited significant positive heterosis over standard check LSFH-35 while 14 hybrids out of 28 hybrids showed the highest significant negative heterosis over both standard checks LSFH-35 and LSFH-171 highest test weight recorded hybrids are LSFH-2418 (-36.67, -39.68), LSFH-282 (-35.00, -38.10), LSFH-218 (-32.50, -35.71) Similar high heterosis test weight was reported by Giriraj *et al.* (1986) and Govindaraju *et al. (*1986). High volume weight is having direct relation to increase the weight of seed. Among 28 hybrids none of the hybrids exhibited positive significant heterosis over two standard checks. The low and negative heterosis was also reported by Bhattacharjee *et al.* (1996).

Low hull content in seed is having direct relation to increase the oil content percent. Among 28 hybrids studied, the desirsble negative heterosis was manifested by 5 hybrids. The high heterotic hybrids were viz., LSFH-200 (-12.50), LSFH-1282 (-9.38), LSFH-2481 (-9.38) LSFH-2082 (-9.38) and LSFH-2018 (-9.38) over check LSFH-35. Such desirable negative significant heterosis was also reported by Singh *et al.* (1964) and Thombare *et al*. (2007). Oil yield per hectare is the important criteria in sunflower which depends on the genotype. Out of 28 hybrids only one hybrid LSFH-1218 (11.59) recorded significant high heterosis over standard check LSFH-171.Such type of high heterosis for oil content was also reported by Naresh *et al*., (1996) and Limbore *et al*., (1997).

Based on the *per se* performance, significant sca effects and extends of heterosis, five best hybrids viz., LSFH-221, LSFH-273, LSFH-1218, LSFH-2421 and LSFH-2073 possesses good head diameter, test weight, seed filling percentage, early maturity, plant height, low hull content and oil content respectively over commercial checks LSFH-35,LSFH-171 and can be exploited through heterosis breeding programme (Table

3) All cross combinations with significant sca effects for seed yield did not passes significant and desirable sca effects all the components traits which suggested that at least three significant desirable sca effects were sufficient for seed yield.

## REFERENCES


**Bhandiwad, S. 1996.** Heterosis and combining ability of branching and non-branching restorers in sunflower *M. Sc (Agri.) Thesis*, *Univ. Agric. Sci. Dharwad* (India).

**Bhattacharjee, R. 1996.** Heterosis and combining ability of converted female and restorer lines of sunflower. *M. Sc (Agri.) Thesis*, *Univ. Agric. Sci. Dharwad* (India).

**Bhosle, S. M., Chavhan, R. L., Hinge, V. R. and Ghodke, M. K. 2015.** Molecular Fingerprinting and assessment Of Genetic Purity Of Sunflower (Helianthus annuus L.) hybrids by using Rapd and SSR Markers. *The Bioscan.* **10(2):** 773-779.

**Chandra, B. S., Ranganatha, A. R. G. and Kumar, S. 2013.** Heterosis studies for yield and it's components in sunflower hybrids over locations *Madras Agric. J.* **100(1-3):** 23-29.

**Chidambamram, S. and Sudarshan, N. 1990.** Correlation between yield and yield components in sunflower. *Madras Agric. J.* **77:** 406-407.

**Deengra, S., Kumar, V., Dhaka, R. P. S. 2012.** Combining ability studies in sunflower (*Helianthus annuus*). *Prog. Agric. J.* **12(1):** 154-157.

**Gangappa, E., Channakrishniah, K. M., Ramesh, S. and Harini A. S. 1997.** Studies on combining ability in sunflower. *Helia*. **27:** 73-84.

**Gill, H. S. and Punia, M. S. 1996.** Expression of heterosis in single, double and three way cross hybrids of sunflower (*Helianthus annuus* L.). *Helia.* **19:** 111-118.

**Giriraj, K., Shivaraju, N. and Shanta, R. H. 1986.** Studies on heterosis and inbreeding depression in selected cross combinations of sunflower. *J. Oilseeds Res***. 3:** 67-72.

**Goksoy, A. T., Turkec, A. and Turan, Z. M. 2000.** Heterosis and combining ability in sunflower (*Helianthus annuus* L.). *Ind. J. Agric. Sci.* **70(8):** 525-529.

**Govindaraju, T. A. 1986.** Evaluation of sunflower (*Heliatnhus annuus* L.) inbreeds by top cross analysis. *M. Sc. (Agri.) Thesis*, *Univ. Agric. Sci.* Bangalore (India).

**Govindaraju, T. A., Sindagi, S. S., Virupaxappa, K. and Ranganath, A. R. G. 1992.** Combining ability for achene yield and its attributes in sunflower (*Helianthus annuus* L.). *J. Oilseeds Res*. **9:** 314-319.

**Jeena, A. S. and Sheikh, F. A. 2004.** Standard heterosis in sunflower (*Helianthus annuus* L.*) J. Maharastra Agric. Univ***. 29(3):** 261-263.

**Kadkol, G. P., Anand, I. J. and Sharma, R. P. 1984.** Combining ability and heterosis in sunflower. *Ind. J. Genet. and Plant Breeding.* **44:** 447-451.

**Kempthorne, O.1957**. *An introduction to Genetic Statistics* the Iowa University Press, pp. 18-23.

**Kinman, M. L. 1970.** New developments in the USDA and state experiment station sunflower breeding programme. *In Proceedings of fourth InternationalSunflower Conference, Memphis,* Tennessee, pp. 181-183.

**Latha, K. M., Vishnuvardhan Reddy, A. and Devasenamma V. 2005.** Hybrid vigour and combiing ability in sunflower, *(Helianthus annuus* L.) hybrids involving CMS lines *J. Oilseed Res.* **23(2):** 154-156.

**Leclercq, P. 1969.** Line sterile cytoplasmique chezk tournesol. *Ann. Amelior Planta.* **19:** 99-106.

**Limbore, A. R., Weginwar, D. G., Gite, B. D. and Ghorade, R. B. 1997.** Combining ability in sunflower (*Helianthus annuus* L.), *Helia.* **20:** 79-88.

**Madrap, I. A. and Makne, V. G. 1993.** Heterosis in relation to combining ability effect and phenotypic stability in sunflower. *Ind. J. Agric. Sci.* **63(8):** 484-488.

**Mangala Rai 2002.** Oilseeds in India. *Andhra Pradesh Agric. Reg. Res. J.* pp. 13-15.

**Naresh, R., Channakrishnaiah, K. M. and Gangappa, E. 1996.** Heterosis in single cross and three way cross hybrids of sunflower. *Mysore J. Agric. Sci.* **30:** 197-203.

**Parmeshwarppa, K. G., Jalandhar, R. and Lingaraju, B. S. 2008.** Heterosis and combining ability for seed yield, oil content other agronomic traits involving mutant restorer lines in sunflower (*Helianthus annuus* L.) *J. Oilseeds Res.* **25(1):** 8-12.

**Phad, D. S., Joshi, B. M., Ghodke, M. K., Kamble, K. R. and Gole, J. P. 2002**. Heterosis and combining ability analysis of sunflower (*Helianthus annuus* L.). *J. Maharashtra Agric. Univ.* **27(1):** 115-117.

**Seetharam, A., Kusumakumari, P., Patil, N. M. and Singagi, S. S. 1977.** Performance of hybrids of sunflower produced by means of cytoplasmic male sterility. *SABRAO J.* **9:** 51-55.