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# STUDY OF HETEROSIS FOR YIELD AND YIELD ATTRIBUTES CHARACTERS IN FORAGE SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH]

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## SUMMARY

Heterosis analysis was carried out in 28 $F_1$ hybrids and their 8 diverse parents for fodder yield, its quality and other yield related traits during *Kharif* 2016-17 at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa. Analysis of variance revealed significant differences among the genotypes, parents and hybrids for all the traits. Several crosses exhibited significantly desirable heterobeltiosis and economic heterosis for green fodder yield plant$^{-1}$ and other characters. On the basis of *per se* performance and estimates of heterosis, the crosses DSF 127 X CSV 15, CSV 21 F X MP Chari, DSF 117 X DSF 123, CSV 15 X GFS 4, DSF 123 X GFS 4 and CSV 21 F X GFS 4 were found most promising for green fodder yield per plant.

**Key words :** Heterosis, Forage sorghum, Fodder yield

India is contemplating for white revolution which is possible only with adequate supply of nutritious feeds and fodder. There is a deficit of fodder in the country amounting to over 16 per cent of the stover and 64 per cent of the green fodder requirement (Appaji *et al.*, 2003). Concentrated efforts are to be made for reducing the large gap between demand and supply of the fodder in the country. To meet the current level of livestock production and its annual growth in the population, the deficit has to be met from either increasing productivity, increasing land area under fodder cultivation or through import. In animal feed supply, cereals have major role. Cereals like maize, sorghum, oat and pearl millet account for 44 per cent of total cereal fodder production. At present, the country faces net deficit of 63.5 per cent green fodder and 21.9 per cent dry fodder and 64 per cent feeds (Kumar *et al.*, 2012). The cultivated area under different forage crops is 4.4 per cent of the total area under cultivation of which about 2.3 m.ha. is under fodder sorghum. In order to make forage sorghum as more enterprising and remunerative crop, there is an urgent need to develop fast growing varieties and hybrids, early to medium maturity and higher fodder yield with good fodder quality. To develop such fodder varieties/hybrids, knowledge and information of the genetic architecture are necessary. The aim of estimation of heterosis in the present study was to find out the superior combinations of parents giving the high degree of useful heterosis for yield and its contributing characters and for its future use in breeding programme.

## MATERIALS AND METHODS

The present investigation entitled "Study of heterosis for yield and yield attributes characters in forage sorghum" was carried out to elicit information on magnitude of heterosis, heterobeltiosis and standard heterosis, for fodder yield and its contributing characters. The crossing program was carried out during *Kharif* 2016 and summer 2017. The experimental materials consisted of 28 $F_1$ hybrids and their eight diverse parents *viz.*, DSF 117, DSF 123, DSF 127, DSF 136, CSV 21F, CSV 15, MP Chari and GFS 4. The $F_1$ hybrids along with eight parents were evaluated in a Randomized Block Design with three replications during *Kharif* 2016-17 at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa. Each genotype was planted in a single row consisted of 20 plants. The plant to plant and between two rows distance were 10 cm and 30 cm, respectively. All the recommended agronomical practices and plant protection measure were followed as per recommendation. Data were recorded on five competitive plants selected randomly for plant height (cm), number of leaves per plant (No.), stem girth (cm), leaf length (cm), leaf width (cm), leaf area ($cm^2$), leaf : stem ratio, green fodder yield per plant (g), Brix (%), dry fodder yield per plant (g) and protein content (%). Formula used for estimation of heterosis over mid-parent, over better parent and heterosis over standard check. The data were analyzed statistically using the software WINDOSTAT version 8.1 developed by Indostat Services Ltd., Hyderabad, India.

$$\text{Relative heterosis (\%)} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{Hetrobeltiosis (\%)} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Standard heterosis (\%)} = \frac{F_1 - SP}{SC} \times 100$$

## RESULTS AND DISCUSSION

The results revealed that the mean squares due to genotypes were highly significant for all the characters (Table 1). This indicated that sufficient amount of genetic variability was present in the experimental material for all the characters under study. The mean squares due to genotypes were further partitioned into parents, hybrids and parents *vs.* hybrids. The mean square due to parents was highly significant for all the characters indicated sufficient amount of genetic variability among the parents. Mean squares due to parents vs. hybrids were also significant for all the characters except leaf : stem ratio. This indicated that average performance of hybrids significantly differed from that of the parents as a group, suggesting the presence of sufficient amount of variability for all these characters. The magnitude of heterosis was measured as per cent increase or decrease of $F_1$ value over mid-parent (relative heterosis), over better parent (heterobeltiosis), and over standard check, GFS 5 (standard heterosis) for all 11 characters. The measures of heterosis over mid parent have relative less importance than better parent and standard check. Therefore, it is better to measure heterosis in terms of superiority of $F_1$ over better parent and standard check. Considerably high heterosis in certain crosses and low in other crosses suggested the nature of gene actions varied with the genetic architecture of the parent. The degree of heterosis varied from cross to cross for all the eleven traits. Negative heterosis is considered as desirable for days to flowering, while for other traits significant positive heterosis was considered as desirable. The results in this pursuit are discussed in following ways. A vary wide range of heterosis was found for all traits under study (Table 2). Heterosis for green fodder yield

TABLE 1
Analysis of variance for various characters in sorghum

| Source of variation | d. f. | 1 | Plant height (cm) | No. of Leaves/ plant | Leaf width (cm) | Leaf length (cm) | Leaf area ($cm^2$) |
|---|---|---|---|---|---|---|---|
| Replications | 2 | 5.454 | 927.858* | 1.164 | 0.254 | 31.512 | 17057.760 |
| Genotypes (G) | 35 | 276.085** | 5997.765** | 3.696** | 9.495** | 131.702** | 728416.600** |
| Parents (P) | 7 | 336.518** | 10404.890** | 4.698** | 9.068** | 150.288** | 201286.700** |
| HybridS (H) | 27 | 269.573** | 2072.108** | 3.380** | 9.335** | 98.080** | 744049.800** |
| Parents vs. Hybrids | 1 | 28.890** | 81140.630** | 5.192** | 16.804** | 909.385** | 3996229.000** |

| Source of variation | d. f. | Stem girth | leaf : stem ratio | Brix % | Green fodder yield/plant (gm) | Dry fodder yield/plant (gm) | Protein % |
|---|---|---|---|---|---|---|---|
| Replications | 2 | 0.108 | 0.001 | 0.254 | 360.218 | 14.606 | 0.11 |
| Genotypes (G) | 35 | 2.894** | 0.005** | 9.495** | 20873.120** | 2338.207** | 4.180** |
| Parents (P) | 7 | 0.883** | 0.008** | 9.068** | 23329.030** | 2167.885** | 10.535** |
| Hybrids (H) | 27 | 2.882** | 0.005** | 9.335** | 20749.840** | 2335.478** | 2.421** |
| Parents vs. Hybrids | 1 | 17.316** | 0.002 | 16.804** | 7010.305** | 3604.153** | 7.192** |
| Error | 70 | 0.039 | 0.001 | 0.667 | 442.031 | 132.751 | 0.11 |

*,**Indicate level of significance at 5% and 1%, respectively.

indicated that out of 28 hybrids, 11 hybrids showed positive and significant relative heterosis. The significant and positive heterosis varied from -35.93 per cent to 101.29 per cent. The heterobeltiosis and standard heterosis ranged from -38.07 per cent to 73.87 per cent and -12.14 per cent to 120.56 per cent respectively. The similar finding was reported by Agrawal and Shrotria (2005) and Chikuta *et al*. (2017) for heterobeltiosis and standard heterosis; Jayamani and Dorairaj (1994) and Patel and Patel (2011) for heterobeltiosis and standard heterosis and Mistry and Patil (1994), Grewal *et al*., (2003) and Prakash *et al*., (2010) for standard heterosis. Among 28 hybrids, DSF 127 X CSV 15, DSF 117 X DSF 123, CSV21 F X MP Chari, CSV 15 X GFS 4 and DSF 127 X DSF 136 (Table 3) had higher mean with desire heterosis for greed fodder yield as well as for other yield attribute characters, so it may be useful for hybrid exploitation in further study. For days to 50 per cent flowering, out of 28 hybrids, 12 hybrids depicted significant and negative relative heterosis, which is desired for earliness. Range of heterosis from -39.91 per cent to 23.97 per cent for mid parent, -35.91 per cent to 58.45 per cent for heterobeltiosis and -13.21 per cent to 55.35 per cent for standard heterosis. The results are in agreement with the findings of Jahagirdar and Borikar (2004), Chaudhary and Narkhede (2004), Wadikar *et al*., (2007) and Akabari *et al*., (2012). The heterosis over mid parent for plant height ranged from -1.05 to 63.84. Out of 28 hybrids, 26 hybrids depicted significant and positive relative heterosis for plant height. The range of heterobeltiosis was from -11.74 per cent to 59.46 per cent for plant height. Seventeen hybrids exhibited significant positive heterosis over better parent and standard heterosis varied from -11.99 per cent to 23.48 per cent. Among 28 hybrids, fourteen hybrids expressed significant positive heterosis over standard check. That was also reported by Desai *et al*. (2000), Agrawal and Shrotria (2005) and El-Dardeer *et al*. (2011). While for number of leaves its ranged in per cent from -16.86 to 31.08, -18.29 to 15.43 and 19.41 to 70.46 for mid parent, better parent and standard heterosis respectively. Similar result was obtained by Lakshyadeep and Chaudhary (2006). For stem girth, out of 28 hybrids, 26 showed positive significant standard heterosis with range 11.11 per cent to 290 per cent and its agreement with Prakash *et al*., (2010). Among eleven characters studied, leaf length, leaf width, leaf area and leaf : stem ratio showed very wide range of heterosis for mid parent, better parent as well as for standard heterosis (Table 3). One, nine eighteen and one cross showed significant desire standard heterosis and the results are substantiates by findings of Jail and Patel (2016), Prakash *et al*. (2010), Agrawal and Shrotria (2005) and Chikuta *et al*. (2017). A perusal data indicated that out of 28 hybrids, eleven, five and fourteen hybrids showed useful significant heterosis for mid parent, better parent and for standard heterosis with the range -35.93 per cent to 101.29 per cent, -38.07 per cent to 73.87 per cent and -12.14 per cent to 120.56 per cent respectively. For green fodder yield per plant, the results observed in present investigation was also reported by Agrawal and Shrotria (2005), Chikuta *et al*., (2017) and Patel and Patel (2011). In this investigation, quality characters like brix and protein content varied from -33.08 per cent to 34.07 per cent and -30.39 per cent to 9.82 per cent respectively for standard heterosis.

TABLE 2

Number of hybrids having significant heterotic effect

| Characters | Over mid parent | | | | Over better parent | | | | Over standard check | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | +ve | -ve | Total | Range | +ve | -ve | Total | Range | +ve | -ve | Total | Range |
| Days to flowering | 9 | 13 | 22 | -39.9 to 23.97 | 11 | 6 | 17 | -11.30 to 58.45 | 24 | 3 | 27 | -13.21 to 55.35 |
| Plant height | 25 | 0 | 25 | -1.05 to 63.84 | 18 | 1 | 17 | -11.74 to 52.31 | 14 | 2 | 16 | -11.19 to 23.48 |
| Number of leaves/plant | 8 | 2 | 10 | -16.86 to 31.08 | 3 | 2 | 5 | -18.29 to 15.43 | 28 | 0 | 28 | 19.41 to 70.46 |
| Stem girth | 21 | 2 | 23 | -40.70 to 213.53 | 23 | 1 | 24 | -30.80 to 482.16 | 26 | 0 | 26 | 11.11 to 290.0 |
| Leaf length | 11 | 0 | 11 | -7.14 to 35.60 | 4 | 0 | 4 | -8.82 to 21.12 | 1 | 3 | 4 | -16.12 to 10.88 |
| Leaf width | 14 | 3 | 17 | -24.18 to 68.13 | 7 | 5 | 12 | -33.68 to 43.45 | 9 | 5 | 14 | -33.08 to 34.07 |
| Leaf area | 12 | 0 | 12 | -19.02 to 125.66 | 9 | 1 | 10 | -26.64 to 119.33 | 18 | 0 | 18 | -10.82 to 119.54 |
| Leaf : Stem ratio | 3 | 8 | 11 | -30.65 to 29.13 | 3 | 11 | 14 | -39.36 to 18.84 | 1 | 17 | 18 | -35.23 to 25.00 |
| Green fodder yield/plant | 11 | 10 | 21 | -35.93 to 101.29 | 5 | 12 | 17 | -38.07 to 73.87 | 14 | 0 | 14 | -12.14 to 120.56 |
| Brix | 14 | 3 | 17 | -24.18 to 46.42 | 7 | 6 | 13 | -32.65 to 43.45 | 9 | 5 | 14 | -33.08 to 34.07 |
| Dry fodder yield/plant | 12 | 4 | 16 | -37.50 to 100.35 | 7 | 10 | 17 | -44.12 to 68.57 | 10 | 3 | 13 | -25.75 to 104.70 |
| Protein content | 14 | 5 | 19 | -36.53 to 34.52 | 2 | 19 | 21 | -43.08 to 25.12 | 1 | 15 | 16 | -30.39 to 9.82 |

TABLE 3
Top five hybrids on the basis of their mean, heterosis for better parent and standard heterosis

| S. No. | Hybrids | Mean green fodder yield/ plant (gm) | Heterosis (%) over | | Significant standard heterosis for component traits in desired direction |
|---|---|---|---|---|---|
| | | | BP | SC | |
| 1. | DSF 127 X CSV 15 | 625.61 | 73.87 ** | 120.56 ** | DF,LA,SG,BR,DFY |
| 2. | DSF 117 X DSF 123 | 478.38 | 41.98 ** | 68.65 ** | PH,NOL,LA,SG,BR,DFY |
| 3. | CSV21 F X MP Chari | 460.68 | 21.09 ** | 62.41 ** | LL,SG,DFY |
| 4. | CSV 15 X GFS 4 | 395.86 | 51.21 ** | 39.56 ** | SG,DFY |
| 5. | DSF 127 X DSF 136 | 384.24 | -37.17 ** | 120.56 ** | PH,NOL,LA,LST,BR,P |

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