Research Note

Heterosis for fodder yield in sorghum (*Sorghum bicolor* L. Moench)

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Abstract :
A study was conducted to investigate the possibility of exploiting heterosis in breeding for improved fodder yield in sorghum. Seven cytoplasmic male sterile lines and five testers were crossed in a line × tester mating design. A total of thirty five F_1 hybrids along with twelve parents were evaluated for days to 50 % flowering, plant height, number of tillers, number of leaves, leaf length, leaf breadth, stem diameter, green fodder yield and dry fodder yield. Among the thirty five hybrid combinations, two hybrids namely, ICSA 547 × PKB 192 (L_1 × T_5) was high for five traits *viz*., plant height, number of tillers, leaf length, green fodder yield and dry fodder yield and ICSA 693 × PKB 291(L_4 × T_1) was high for four traits *viz*., plant height, leaf breadth, green fodder yield and dry fodder yield. These two hybrids recorded significant standard heterosis over both CO 27 and COFS 29 for more than one yield contributing characters in addition to that of green fodder yield.

Key words:
Sorghum, line × tester, fodder yield, heterosis

Sorghum (*Sorghum bicolor* L. Moench) is an important dry land cereal crop cultivated over 47 million ha in 68 countries in the world. It is the fifth major cereal crop in the world after wheat, rice, maize and barley. It is one of the most important food and feed crops of India. The demand for fodder sorghum is fast increasing. To meet out the demand the increase in the production should come from same or even less area in the present situation of shrinking agricultural land. The fodder yield is the primary trait targeted for improvement of fodder sorghum productivity through exploitation of heterosis. In crops like sorghum with the availability of a large number of diversified cytosteriles, exploitation of heterosis for high yield potential is very easy.

The experimental materials comprised seven cytoplasmic male sterile lines *viz.,* ICSA 547 (L_1), ICSA 403 (L_2), BJ 3A (L_3), ICSA 693 (L_4), ICSA 374 (L_5), ICSA 744 (L_6) and TNSPV 14094 (L_7) and five testers *viz.,* PKB 291 (T_1)**,** PKB 161 (T_2), CSV 15-217 (T_3), CSV 15-310 (T_4) and PKB 192 (T_5) and their resulting 35 hybrids obtained in a line × tester mating design. The parents as well as hybrids were raised in a randomized block design with three replications during *kharif* 2008 at the Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore. University, Coimbatore. Both parents and F_1 were raised each in one row of 4 m length with a spacing of 60 cm × 15 cm. The biometrical observations on fodder yield and other related components *viz.,* days to 50 per cent flowering, plant height, number of tillers, number of leaves, leaf length, leaf breadth, stem diameter, green fodder yield and dry fodder yield were recorded on five randomly selected plants. Relative heterosis, heterobeltiosis and standard heterosis were estimated and tested by working out the standard errors as suggested by Hays *et al.* (1955).

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Knowledge on the magnitude of heterosis for various characters is essential to locate better combinations to exploit them through heterosis breeding. Over dominance is attributed towards heterobeltiosis, while commercial superiority of the hybrid may be assessed by evaluating with a standard commercial check (Swaminathan *et al.,* 1972). Rather than mid parent heterosis and heterobeltiosis the standard, useful or economic heterosis reflecting the actual superiority over the best existing cultivar to be replaced appears to be more relevant and practical. With this point of views the hybrids generated in the present investigation were evaluated and selected on the basis of their standard heterosis. The checks CO 27 and COFS 29 were chosen for the present study.

The value of percentage heterosis of hybrids for all the nine characters over mid, better and standard parent are given in the Table 1, Table 2 and 3. Early flowering is a desirable feature of a genotype. Therefore, negative heterosis for days to 50% flowering was considered desirable. Heterosis for this trait ranged from -24.12 ($L_2 \times T_4$) to 15.23 ($L_3 \times T_5$) per cent and -26.26 ($L_4 \times T_2$) to 21.68 ($L_3 \times T_5$) per cent over mid and better parent respectively (Table 1). The standard heterosis over CO 27, ranged from -27.07 ($L_4 \times T_2$) to 2.76 ($L_2 \times T_5$) per cent and out of 35 hybrids, 20 hybrids recorded significantly negative standard heterosis. The range of standard heterosis over COFS 29, was from -16.98 ($L_4 \times T_2$) to 16.98 ($L_2 \times T_5$) per cent and among the 35 hybrids, five hybrids recorded significantly negative standard heterosis.

Heterosis for plant height ranged from -5.44 ($L_5 \times T_1$) to 61.09 ($L_7 \times T_1$) per cent and -17.22 ($L_6 \times T_5$) to 46.07 ($L_4 \times T_1$) per cent over mid and better parent respectively. For standard heterosis over CO 27, it was from -10.91($L_1 \times T_4$) to 74.40 ($L_1 \times T_5$) per cent and out of 35 hybrids, 27 hybrids recorded significantly positive standard heterosis. Standard heterosis over COFS 29, ranged from -37.64 ($L_1 \times T_4$) to 22.08 ($L_1 \times T_5$) per cent and three hybrids recorded significantly positive standard heterosis.

For number of tillers, the range of heterosis over mid and better parent was from-22.22 ($L_1 \times T_4$) to 66.67 ($L_2 \times T_2$) per cent and -25.00 ($L_4 \times T_1$) to 66.67 ($L_2 \times T_2$) and ($L_7 \times T_2$) per cent respectively. The range of standard heterosis over CO 27 was from -33.33 ($L_4 \times T_1$) to 33.33 ($L_1 \times T_5$), ($L_2 \times T_3$) and ($L_3 \times T_3$) per cent and six hybrids recorded significantly positive standard heterosis. Standard heterosis over COFS 29, ranged from -25.00 ($L_4 \times T_1$) to 50.00 ($L_1 \times T_5$), ($L_2 \times T_3$) and ($L_3 \times T_3$) per cent and 11 hybrids recorded significantly positive standard heterosis.

The range of heterosis for number of leaves over mid and better parent was from -15.25 ($L_2 \times T_2$) to 21.57 ($L_4 \times T_1$) per cent and -24.24 ($L_2 \times T_2$) to 19.23 ($L_4 \times T_1$) per cent respectively. The range for standard heterosis over CO 27 was from -7.41 ($L_2 \times T_2$) and ($L_3 \times T_1$) to 29.63 ($L_2 \times T_1$) per cent and ten hybrids recorded significantly positive standard heterosis. Standard heterosis over COFS 29, ranged from -13.79 ($L_2 \times T_2$) and ($L_3 \times T_1$) to 20.69 ($L_2 \times T_1$) per cent and three hybrids recorded significantly positive standard heterosis.

Heterosis for leaf length, ranged from -7.69 ($L_7 \times T_2$) to 24.46 ($L_1 \times T_5$) per cent and -9.90 ($L_7 \times T_2$) to 19.18 ($L_2 \times T_1$) per cent over mid and better parent respectively. The range for standard heterosis over CO 27 was from -23.59 ($L_1 \times T_1$) to 1.09 ($L_2 \times T_1$) per cent and none of the hybrids recorded significantly positive standard heterosis. Standard heterosis over COFS 29, ranged from -3.70 ($L_1 \times T_1$) to 27.40 ($L_2 \times T_1$) per cent and 23 hybrids recorded significantly positive standard heterosis.

Heterosis for leaf breadth, ranged from -18.37 ($L_5 \times T_5$) to 55.87 ($L_2 \times T_1$) per cent and -20.70 ($L_5 \times T_5$) to 38.12 ($L_2 \times T_1$) per cent over mid and better parent respectively. The range for standard heterosis over CO 27 was from -5.88 ($L_3 \times T_3$) to 49.20 ($L_2 \times T_1$) per cent and 29 hybrids recorded significantly positive standard heterosis over CO27. Standard heterosis over COFS 29, ranged from 4.14 ($L_3 \times T_3$) to 65.09 ($L_2 \times T_1$) per cent and 32 hybrids recorded significantly positive standard heterosis over COFS 29.

The range of heterosis for stem diameter over mid and better parent was from -37.01 ($L_3 \times T_2$) to 44.19 ($L_5 \times T_4$) per cent and -37.50 ($L_3 \times T_2$) to 44.19 ($L_5 \times T_4$) per cent respectively. The standard heterosis over CO 27, ranged from -23.08 ($L_1 \times T_1$) to 46.85 ($L_5 \times T_2$) per cent and 21 hybrids recorded significantly positive standard heterosis over CO27. Standard heterosis over COFS 29, ranged from 77.42 ($L_1 \times T_1$) to 238.71 ($L_5 \times T_2$) per cent and all the hybrids recorded significantly positive standard heterosis over COFS 29.

The magnitude of heterosis for green fodder yield, ranged from -30.30 ($L_5 \times T_5$) to 66.18 ($L_1 \times T_5$) per cent and -39.38 ($L_5 \times T_5$) to 48.43 ($L_2 \times T_3$) per cent over mid and better parent respectively. For standard heterosis over CO 27, it was from -21.30 ($L_5 \times T_5$) to 91.78 ($L_1 \times T_5$) per cent and 26 hybrids recorded significantly positive standard heterosis over CO27. Standard heterosis over COFS 29, ranged from -39.38($L_5 \times T_5$) to 47.71 ($L_1 \times T_5$) per cent and 12 hybrids recorded significantly positive standard heterosis over COFS 29.

Heterosis for dry fodder yield, ranged from -34.53 ($L_5 \times T_5$) to 62.95 ($L_4 \times T_1$) per cent and -43.46 ($L_5 \times T_5$) to 48.02 ($L_2 \times T_3$) per cent over mid and better parent range for standard heterosis over CO 27 was from -24.56 ($L_5 \times T_5$) to 84.02 ($L_1 \times T_5$) per cent and 27 hybrids recorded significantly positive standard heterosis over CO27. Standard heterosis over COFS 29, ranged from -43.46 ($L_5 \times T_5$) to 37.92($L_1 \times T_5$) per cent and 10 hybrids recorded significantly positive standard heterosis over COFS 29.

In general, it was observed that positive and high magnitude of heterosis for green fodder yield/plant was noticed and this may be due to the heterosis contributed by one or more yield contributing characters. Among the thirty five hybrid combinations, two hybrids namely, ICSA 547 × PKB 192 ($L_1 \times T_5$) was high for five traits *viz*., plant height, number of tillers, leaf length, green fodder yield and dry fodder yield and ICSA 693 × PKB 291(L_4 × T_1) was high for four traits *viz*., plant height, leaf breadth, green fodder yield and dry fodder yield. These two hybrids recorded significant standard heterosis over both CO 27 and COFS 29 for more than one yield contributing characters in addition to that of green fodder yield. Thus, heterosis for yield was reflected in the simultaneous heterosis of yield attributing traits. This can be exploited under development of fodder sorghum hybrids, after sufficient testing along with commercial hybrids/varieties. This was in close agreement with the findings of Nandanwankar and Chandan (1990), Mehndiratta *et al*. (1993), Reddy and Joshi (1993), ShouJun *et al*. (1999), Mohammed (2007) and Mohammed and Talib (2008).

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Crosses	Days to 50% flowering				Plant height				Number of tillers			
	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)
L1 × T1	6.59 **	5.33	-1.66	11.95 **	25.57 **	8.99 **	15.48 **	-19.17 **	20.00	0.01	0.01	12.50
L1 × T2	5.11 *	3.55	-3.31	10.06 **	27.37 **	6.91 *	22.82 **	-14.03 **	46.67 **	22.22 *	22.22 *	37.50 **
L1 × T3	0.57	4.73	-2.21	11.32 **	13.15 **	2.04	-0.99	-30.69 **	0.01	0.01	0.01	12.50
L1 × T4	4.87 *	8.28 **	1.10	15.09 **	0.11	-10.91 **	-10.91 **	-37.64 **	-22.22 *	-22.22 *	-22.22 *	-12.50
L1 × T5	0.61	-2.37	-8.84 **	3.77	57.95 **	22.08 **	74.40 **	22.08 **	33.33 **	33.33 **	33.33 **	50.00 **
L2 × T1	-3.95	-10.05 **	-6.08 *	6.92 *	60.86 **	33.15 **	41.07 **	-1.25	50.00 **	50.00 **	0.01	12.50
L2 × T2	-20.11 **	-25.40 **	-22.10 **	-11.32 **	45.53 **	16.75 **	34.13 **	-6.11 *	66.67 **	66.67 **	11.11	25.00 *
L2 × T3	-22.58 **	-23.81 **	-20.44 **	-9.43 **	58.76 **	36.20 **	32.14 **	-7.50 **	60.00 **	33.33 **	33.33 **	50.00 **
L2 × T4	-24.12 **	-25.93 **	-22.65 **	-11.95 **	17.10 **	-0.79	-0.79	-30.56 **	20.00	0.01	0.01	12.50
L2 × T5	6.90 **	-1.59	2.76	16.98 **	18.69 **	-11.81 **	25.99 **	-11.81 **	20.00	0.01	0.01	12.50
L3 × T1	7.79 **	16.08 **	-8.29 **	4.40	50.00 **	31.46 **	39.29 **	-2.50	53.85 **	42.86 **	11.11	25.00 *
L3 × T2	7.49 **	15.38 **	-8.84 **	3.77	17.43 **	-0.52	14.29 **	-20.00 **	53.85 **	42.86 **	11.11	25.00 *
L3 × T3	0.61	14.69 **	-9.39 **	3.14	25.70 **	14.52 **	11.11 **	-22.22 **	50.00 **	33.33 **	33.33 **	50.00 **
L3 × T4	1.55	14.69 **	-9.39 **	3.14	33.11 **	19.64 **	19.64 **	-16.25 **	25.00 *	11.11	11.11	25.00 *
L3 × T5	15.23 **	21.68 **	-3.87	9.43 **	9.63 **	-14.58 **	22.02 **	-14.58 **	-0.01	-11.11	-11.11	0.01
L4 × T1	1.16	-2.79	-3.87	9.43 **	54.00 **	46.07 **	54.76 **	8.33 **	-14.29	-25.00 *	-33.33 **	-25.00 *
L4 × T2	-23.03 **	-26.26 **	-27.07 **	-16.98 **	39.51 **	27.46 **	46.43 **	2.50	14.29	-0.01	-11.11	0.01
L4 × T3	-0.55	0.56	-0.55	13.21 **	39.46 **	38.04 **	33.93 **	-6.25 *	-5.88	-11.11	-11.11	0.01
L4 × T4	-3.62	-3.35	-4.42	8.81 **	34.28 **	30.95 **	30.95 **	-8.33 **	29.41 **	22.22 *	22.22 *	37.50 **
L4 × T5	-2.37	-7.82 **	-8.84 **	3.77	33.61 **	11.25 **	58.93 **	11.25 **	5.88	0.01	0.01	12.50

Table 1. Percentage of heterosis for days to 50% flowering, plant height and number of tillers

Table 1. Contd..

Crosses	Days to 50% flowering				Plant height				Number of tillers			
	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)
L5 × T1	0.01	0.01	-8.84 **	3.77	-5.44	-7.30 *	-1.79	-31.25 **	20.00	0.01	0.01	12.50
L5 × T2	11.25 **	10.91 **	1.10	15.09 **	32.42 **	24.87 **	43.45 **	0.42	20.00	0.01	0.01	12.50
L5 × T3	5.17 *	10.91 **	1.10	15.09 **	5.39	2.92	4.76	-26.67 **	-11.11	-11.11	-11.11	0.01
L5 ×T4	4.93 *	9.70 **	0.01	13.84 **	12.09 **	11.11 **	13.10 **	-20.83 **	0.01	0.01	0.01	12.50
L5 × T5	7.41 **	5.45	-3.87	9.43 **	-0.73	-15.00 **	21.43 **	-15.00 **	-11.11	-11.11	-11.11	0.01
L6 ×T1	4.93 *	0.56	0.01	13.84 **	15.82 **	2.81	8.93 *	-23.75 **	38.46 **	28.57 *	0.00	12.50
L6 × T2	-3.49	-7.78 **	-8.29 **	4.40	19.23 **	2.25	17.46 **	-17.78 **	23.08	14.29	-11.11	0.01
L6 × T3	-7.44 **	-6.67 *	-7.18 **	5.66	34.22 **	23.93 **	20.24 **	-15.83 **	12.50	0.01	0.01	12.50
L6 ×T4	-10.00 **	-10.00 **	-10.50 **	1.89	37.47 **	25.20 **	25.20 **	-12.36 **	25.00 *	11.11	11.11	25.00 *
L6 × T5	-2.65	-8.33 **	-8.84 **	3.77	5.11 *	-17.22 **	18.25 **	-17.22 **	-0.01	-11.11	-11.11	0.01
L7 × T1	-2.42	-2.42	-11.05 **	1.26	61.09 **	32.58 **	40.48 **	-1.67	50.00 **	50.00 **	0.01	12.50
L7 × T2	-3.34	-3.64	-12.15 **	0.01	15.37 **	-7.94 **	5.75	-25.97 **	66.67 **	66.67 **	11.11	25.00 *
L7 ×T3	-2.87	2.42	-6.63 *	6.29 *	33.81 **	14.11 **	10.71 **	-22.50 **	20.00	0.01	0.01	12.50
L7 × T4	-0.87	3.64	-5.52 *	7.55 *	26.03 **	6.15	6.15	-25.69 **	-6.67	-22.22 *	-22.22 *	-12.50
L7 × T5	-16.67 **	-18.18 **	-25.41 **	-15.09 **	37.46 **	1.67	45.24 **	1.67	20.00	0.01	0.01	12.50
SE	1.38	1.59	1.14	1.14	4.80	5.54	4.18	4.18	0.27	0.31	0.23	0.23

d_i: Relative heterosis d_{ii} : Heterobeltiosis d_{iii} (a) : Standard heterosis over CO 27 d_{iii} (b) : Standard heterosis over COFS 29

*, ** Significant at 5% and 1% level, respectively

Table 2. Percentage of heterosis for number of leaves, leaf length and leaf breadth

Crosses	Number of leaves				Leaf length				Leaf breadth			
	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)
L1 × T1	7.69	3.70	3.70	-3.45	-3.12	-8.86 **	-23.59 **	-3.70	-0.28	-11.44 **	-4.81	5.33
L1 × T2	9.43	7.41	7.41	0.01	9.72 **	2.20	-12.46 **	10.32 **	15.42 **	15.42 **	24.06 **	37.28 **
L1 × T3	-8.47	-15.63 **	0.01	-6.90	7.50 **	4.85	-18.48 **	2.74	-7.16 *	-7.84 *	0.53	11.24 **
L1 × T4	0.01	0.01	0.01	-6.90	9.47 **	1.38	-12.07 **	10.82 **	13.39 **	7.46 *	15.51 **	27.81 **
L1 × T5	10.71 *	6.90	14.81 *	6.90	24.46 **	16.14 **	-0.91	24.89 **	23.37 **	19.63 **	36.90 **	51.48 **
L2 × T1	20.69 **	6.06	29.63 **	20.69 **	19.87 **	19.18 **	1.09	27.40 **	55.87 **	38.12 **	49.20 **	65.09 **
L2 × T2	-15.25 **	-24.24 **	-7.41	-13.79 *	-4.31	-4.78	-18.44 **	2.79	21.59 **	21.29 **	31.02 **	44.97 **
L2 × T3	-13.85 **	-15.15 **	3.70	-3.45	3.23	-1.07	-16.09 **	5.75	31.03 **	30.39 **	42.25 **	57.40 **
L2 × T4	-10.00 *	-18.18 **	0.01	-6.90	12.73 **	11.49 **	-3.30	21.87 **	30.37 **	23.27 **	33.16 **	47.34 **
L2 × T5	3.23	-3.03	18.52 **	10.34	5.07 *	4.76	-10.62 **	12.65 **	22.60 **	19.16 **	36.36 **	50.89 **
L3 × T1	-12.28 *	-21.88 **	-7.41	-13.79 *	2.07	1.12	-15.22 **	6.85 *	21.29 **	4.65	20.32 **	33.14 **
L3 × T2	-10.34 *	-18.75 **	-3.70	-10.34	-2.83	-4.74	-18.41 **	2.83	8.17 **	4.65	20.32 **	33.14 **
L3 × T3	6.25	6.25	25.93 **	17.24 **	2.83	0.01	-17.72 **	3.70	-15.99 **	-18.14 **	-5.88	4.14
L3 × T4	-1.69	-9.38	7.41	0.01	4.18	1.50	-11.96 **	10.96 **	7.85 **	-0.93	13.90 **	26.04 **
L3 × T5	-11.48 *	-15.63 **	0.01	-6.90	6.40 **	4.50	-10.83 **	12.37 **	8.62 **	8.37 **	24.60 **	37.87 **
L4 × T1	21.57 **	19.23 **	14.81 *	6.90	20.17 **	13.05 **	-5.22 *	19.45 **	42.26 **	20.44 **	44.92 **	60.36 **
L4 × T2	3.85	3.85	0.01	-6.90	15.62 **	7.70 **	-7.75 **	16.26 **	1.41	-4.00	15.51 **	27.81 **
L4 × T3	10.34 *	-0.01	18.52 **	10.34	21.88 **	18.87 **	-7.57 **	16.48 **	13.29 **	8.00 **	29.95 **	43.79 **
L4 × T4	16.98 **	14.81 *	14.81 *	6.90	13.71 **	5.30 *	-8.66 **	15.11 **	25.43 **	12.89 **	35.83 **	50.30 **
L4 × T5	5.45	-0.01	7.41	0.01	20.41 **	12.36 **	-4.13	20.82 **	17.08 **	14.22 **	37.43 **	52.07 **

Table 2. Contd…

Crosses	Number of leaves				Leaf length				Leaf breadth			
	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)
L5 × T1	7.69	3.70	3.70	-3.45	4.85	-3.24	-18.88 **	2.24	18.54 **	0.01	21.39 **	34.32 **
L5 × T2	5.66	3.70	3.70	-3.45	22.24 **	11.72 **	-4.31	20.59 **	14.49 **	7.93 **	31.02 **	44.97 **
L5 × T3	8.47	-0.01	18.52 **	10.34	8.21 **	3.45	-19.57 **	1.37	-1.16	-6.17 *	13.90 **	26.04 **
L5 ×T4	11.11 *	11.11	11.11	3.45	17.26 **	6.56 *	-7.57 **	16.48 **	10.57 **	-0.88	20.32 **	33.14 **
L5 × T5	7.14	3.45	11.11	3.45	7.14 **	-1.91	-16.30 **	5.48	-18.37 **	-20.70 **	-3.74	6.51
L6 ×T1	-5.08	-17.65 **	3.70	-3.45	18.96 **	11.84 **	-6.23 **	18.17 **	17.14 **	-2.55	22.46 **	35.50 **
L6 × T2	10.00 *	-2.94	22.22 **	13.79 *	7.02 **	-0.38	-14.67 **	7.53 *	-2.75	-9.79 **	13.37 **	25.44 **
L6 × T3	-12.12 **	-14.71 **	7.41	0.01	16.18 **	13.23 **	-11.96 **	10.96 **	-10.71 **	-16.60 **	4.81	15.98 **
L6 ×T4	-8.20	-17.65 **	3.70	-3.45	6.88 **	-1.09	-14.20 **	8.13 **	1.20	-10.64 **	12.30 **	24.26 **
L6 × T5	-7.94	-14.71 **	7.41	0.01	6.92 **	-0.30	-14.93 **	7.21 *	-2.45	-6.81 *	17.11 **	29.59 **
L7 × T1	7.41	-0.01	7.41	0.01	-1.38	-2.72	-18.44 **	2.79	7.69 *	-10.26 **	12.30 **	24.26 **
L7 × T2	-1.82	-6.90	0.01	-6.90	-7.69 **	-9.90 **	-22.83 **	-2.74	-9.43 **	-15.81 **	5.35	16.57 **
L7 ×T3	4.92	-0.01	18.52 **	10.34	5.44 *	2.98	-16.01 **	5.84 *	-6.39 *	-12.39 **	9.63 **	21.30 **
L7 × T4	3.57	-0.01	7.41	0.01	-2.82	-5.72 *	-18.22 **	3.06	4.35	-7.69 **	15.51 **	27.81 **
L7 × T5	-6.90	-6.90	0.01	-6.90	13.03 **	10.53 **	-5.69 *	18.86 **	7.14 **	2.56	28.34 **	42.01 **
SE	0.45	0.52	0.37	0.37	1.82	2.10	1.52	1.50	0.19	0.22	0.16	0.16

d_i: Relative heterosis d_{ii} : Heterobeltiosis d_{iii} (a) : Standard heterosis over CO 27 d_{iii} (b) : Standard heterosis over COFS 29

*, ** Significant at 5% and 1% level, respectively

Table 3. Percentage of heterosis for stem diameter, green fodder yield and dry fodder yield

Crosses	Stem diameter				Green fodder yield				Dry fodder yield			
	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)
L1 × T1	-25.84 **	-34.00 **	-23.08 **	77.42 **	7.86 **	2.14	3.14	-20.57 **	8.26 **	2.61	4.73 *	-21.51 **
L1 × T2	-15.04 **	-23.81 **	11.89 **	158.06 **	3.02 *	-11.11 **	23.68 **	-4.75 **	9.59 **	-6.54 **	35.21 **	1.33
L1 × T3	-29.41 **	-30.77 **	-16.08 **	93.55 **	-4.44 **	-4.49 *	-3.46	-25.65 **	-1.93	-4.35 *	-2.37	-26.83 **
L1 × T4	-16.13 **	-22.00 **	-9.09 *	109.68 **	-6.29 **	-6.75 **	-5.84 **	-27.48 **	-0.44	-1.45	0.59	-24.61 **
L1 × T5	1.89	-3.57	25.87 **	190.32 **	66.18 **	47.71 **	91.78 **	47.71 **	56.28 **	37.92 **	84.02 **	37.92 **
L2 × T1	0.01	-11.76 **	4.90	141.94 **	50.03 **	40.67 **	45.08 **	11.74 **	45.70 **	36.44 **	42.90 **	7.10 **
L2 × T2	-26.32 **	-33.33 **	-2.10	125.81 **	-1.56	-14.30 **	19.24 **	-8.16 **	4.63 **	-9.82 **	30.47 **	-2.22
L2 × T3	-0.97	-1.92	18.88 **	174.19 **	49.92 **	48.43 **	53.08 **	17.90 **	53.67 **	48.02 **	55.03 **	16.19 **
L2 × T4	-8.51 *	-15.69 **	0.23	131.18 **	5.48 **	3.88 *	7.14 **	-17.49 **	6.07 **	3.67	8.58 **	-18.63 **
L2 × T5	-10.28 **	-14.29 **	11.89 **	158.06 **	22.78 **	10.16 **	43.03 **	10.16 **	15.03 **	2.66	36.98 **	2.66
L3 × T1	-6.80 *	-25.00 **	11.89 **	158.06 **	16.11 **	4.40 **	18.05 **	-9.08 **	16.09 **	4.39 *	19.53 **	-10.42 **
L3 × T2	-37.01 **	-37.50 **	-6.76	115.05 **	-23.36 **	-30.54 **	-3.35	-25.56 **	-24.43 **	-32.31 **	-2.07	-26.61 **
L3 × T3	-25.86 **	-32.81 **	0.23	131.18 **	-24.48 **	-28.49 **	-19.14 **	-37.72 **	-24.48 **	-30.23 **	-20.12 **	-40.13 **
L3 × T4	-12.15 **	-26.56 **	9.56 *	152.69 **	28.77 **	21.32 **	37.19 **	5.66 **	22.48 **	14.73 **	31.36 **	-1.55
L3 × T5	-15.00 **	-20.31 **	18.88 **	174.19 **	9.21 **	2.16	32.65 **	2.16	8.11 **	0.44	34.02 **	0.44
L4 × T1	37.35 **	29.55 **	32.87 **	206.45 **	50.85 **	32.37 **	58.27 **	21.90 **	62.95 **	43.03 **	73.08 **	29.71 **
L4 × T2	0.93	-14.29 **	25.87 **	190.32 **	7.98 **	0.39	39.68 **	7.58 **	6.46 **	-2.25	41.42 **	5.99 **
L4 × T3	2.08	-5.77	14.22 **	163.44 **	38.56 **	27.85 **	52.86 **	17.74 **	34.60 **	21.27 **	46.75 **	9.98 **
L4 × T4	33.33 **	31.82 **	35.20 **	211.83 **	36.39 **	25.23 **	49.73 **	15.32 **	37.08 **	25.18 **	51.48 **	13.53 **
L4 × T5	4.00	-7.14 *	21.21 **	179.57 **	27.70 **	22.65 **	59.24 **	22.65 **	26.74 **	20.84 **	61.24 **	20.84 **

Table 3. Contd…

Crosses	Stem diameter				Green fodder yield				Dry fodder yield			
	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)	d_i	d_{ii}	d_{iii} (a)	d_{iii} (b)
L5 × T1	4.88	0.01	0.23	131.18 **	2.96	-0.11	-4.11 *	-26.14 **	2.98	-0.01	-2.96	-27.27 **
L5 × T2	18.87 **	0.01	46.85 **	238.71 **	16.14 **	-1.86	36.54 **	5.16 **	14.32 **	-4.50 **	38.17 **	3.55 *
L5 × T3	11.58 **	1.92	23.54 **	184.95 **	12.01 **	9.20 **	10.38 **	-14.99 **	15.24 **	15.24 **	11.83 **	-16.19 **
L5 ×T4	44.19 **	44.19 **	44.52 **	233.33 **	31.61 **	28.97 **	28.97 **	-0.67	32.43 **	30.47 **	30.47 **	-2.22
L5 × T5	-1.01	-12.50 **	14.22 **	163.44 **	-30.30 **	-39.38 **	-21.30 **	-39.38 **	-34.53 **	-43.46 **	-24.56 **	-43.46 **
L6 ×T1	16.13 **	0.01	25.87 **	190.32 **	40.74 **	37.44 **	30.16 **	0.25	36.92 **	30.50 **	31.66 **	-1.33
L6 × T2	-26.50 **	-31.75 **	0.23	131.18 **	8.18 **	-9.09 **	26.49 **	-2.58	6.99 **	-9.20 **	31.36 **	-1.55
L6 × T3	-24.53 **	-25.93 **	-6.76	115.05 **	19.38 **	15.61 **	16.86 **	-9.99 **	19.58 **	17.30 **	18.34 **	-11.31 **
L6 ×T4	3.09	-7.41 *	16.55 **	168.82 **	10.38 **	7.46 **	7.46 **	-17.24 **	11.05 **	10.56 **	11.54 **	-16.41 **
L6 × T5	-29.09 **	-30.36 **	-9.09 *	109.68 **	-5.25 **	-18.07 **	6.38 **	-18.07 **	-10.61 **	-21.51 **	4.73 *	-21.51 **
L7 × T1	5.38	-9.26 **	14.22 **	163.44 **	43.04 **	32.93 **	20.00 **	-7.58 **	44.62 **	36.89 **	25.15 **	-6.21 **
L7 × T2	-23.08 **	-28.57 **	4.90	141.94 **	-16.47 **	-34.97 **	-9.51 **	-30.31 **	-23.40 **	-40.08 **	-13.31 **	-35.03 **
L7 ×T3	-3.77	-5.56	18.88 **	174.19 **	24.21 **	9.73 **	10.92 **	-14.57 **	25.83 **	15.85 **	12.43 **	-15.74 **
L7 × T4	-5.15	-14.81 **	7.23	147.31 **	13.64 **	0.86	0.86	-22.31 **	12.38 **	2.07	2.07	-23.50 **
L7 × T5	-12.73 **	-14.29 **	11.89 **	158.06 **	48.38 **	18.48 **	53.84 **	18.48 **	44.98 **	16.85 **	55.92 **	16.85 **
SE	0.05	0.06	0.04	0.04	5.04	5.82	4.29	4.29	1..93	2.23	1.65	1.65

d_i: Relative heterosis d_{ii} : Heterobeltiosis d_{iii} (a) : Standard heterosis over CO 27 d_{iii} (b) : Standard heterosis over COFS 29

*, ** Significant at 5% and 1% level, respectively