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Heterosis for yield and phytic acid content in soybean *Glycine max* L (Merr)

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ABSTRACT

Heterosis is an important factor in development of hybrid cultivars. Twenty five F_1 hybrids synthesized by crossing five lines and five testers in a line × tester mating design were used to produce information on the degree of heterosis over mid better and standard parents in soybean. All the parents and crosses including one check/standard variety Co (Soy)3 were evaluated in a randomized block design with two replications. The maximum standard heterosis for seed yield per plant was observed to be 56.69 per cent and minimum standard heterosis for phytic acid content was recorded to be 66.72 per cent. High heterosis for seed yield per plant and low for phytic acid content were observed in four hybrids viz RKS 18 × lpa 5-2, Co(Soy)3 × lpa 5-2, Co(Soy)3 × lpa 5-1 and Co(Soy)3 × lpa 13-1. They also exhibited high heterosis for many yield attributing traits in desirable directions. These hybrids offer best possibilities for future exploitation of hybrid vigour in soybean.

Keywords: Soybean; line × tester analysis; relative heterosis; heterobeltiosis; standard heterosis

INTRODUCTION

Soybean is an amazing versatile crop and referred as miracle crop of 21st century as it is rich in protein (40%) as well as oil (20%). It is also a rich source of lysine (6.4%) in addition to other essential amino acids, vitamins and minerals. It is expected that soybean production will increase as population and living standards increase in India (James 2010). Exploitation of hybrid vigour in crop plants for quantum jump in yield and other quantitative characters is one of the approaches in crop improvement to cope up with the ever increasing demand for food production with considerable quality. Soybean is a highly self-pollinated crop and the scope for exploitation of hybrid vigour will depend on the direction and magnitude of heterosis and nature of gene action. Estimation of heterosis over better parent may be useful in identifying true heterotic crosses combinations but these crosses can be of immense practical value if they show superiority over the standard parent or the best variety of the area. The present investigations were therefore planned to estimate the extent of heterosis over mid, better and standard parents in 25 F_1s of soybean for 11 characters.

MATERIAL and METHODS

The material for the study consisted of five released varieties (lines) viz Bragg, RKS 18, Co 2, Co (Soy)3 and JS 335 and five mutant lines (testers) viz lpa 5-1, lpa 5-2, lpa 5-3, lpa 13-1 and lpa 18. The lines are rich in phytic acid content and testers are low in phytic acid content. Crosses were made between theses lines and testers in order to develop low phytic acid genotypes with high yield. The parents were crossed in line × tester mating fashion to synthesize 25 F_1 hybrids at the Department of Pulses, Centre for Plant Breeding and Genetics, TNAU, Coimbatore during Kharif 2013. Individual cross combinations along with their parents were raised in randomized block design (RBD) with two replications in four meter row with spacing of 30 × 10 cm. Recommended cultural practices were adopted to raise good crop.

Five plants in parents and hybrids were randomly selected in each replication and observations were recorded for days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of clusters per plant, number of pods per plant, number of seeds per pod, 100-seed weight (g), seed yield per plant (g), harvest index (%) and phytic acid content (mg/g). The mean values of 5 plants were utilized for estimation of heterosis over mid, better and standard parents using standard procedures. Heterosis over better parent (BP) as per Fonseca and Patterson (1968) was calculated while standard heterosis (SH) using Co (Soy)3 variety as standard check was calculated as per Meredith and Bridge (1972).

RESULTS and DISCUSSION

The range of heterosis over the mid, better and standard parents for 11 characters is presented in Table 1. The range of heterosis exhibited by hybrids over the respective mid, better and standard parents for seed yield per plant was -33.09 to 67.20, -44.58 to 56.61 and -56.17 to 56.69 per cent respectively (Table 1).

Heterosis in negative direction is considered desirable for days to 50 per cent flowering, days to maturity, plant height and phytic acid content. For days to 50 per cent flowering one hybrid for relative heterosis, four for heterobeltiosis and seven hybrids for standard heterosis recorded highly significant negative heterosis. For days to maturity seven for relative heterosis, fourteen for heterobeltiosis and sixteen hybrids for

Table 1. Range of heterosis for 11 yield and yield related traits in soybean

Character	Parent heterosis		
	Mid	Better	Standard
Days to 50% flowering	-13.64 to 6.15	-19.72 to 2.99	-20.83 to 1.39
Days to maturity	-8.67 to 2.08	-11.24 to 0.58	-10.47 to 1.16
Plant height (cm)	-22.56 to 22.61	-42.66 to 20.88	-49.90 to -3.43
# branches/plant	-7.83 to 31.67	-18.03 to 29.51	-19.67 to 29.51
# clusters/plant	-13.63 to 32.69	-32.42 to 25.00	-41.92 to 28.08
# pods/plant	-23.16 to 32.40	-41.71 to 18.18	-55.41 to 17.82
# seeds/pod	-13.04 to 25.00	-23.08 to 25.00	0 to 25.00
100-seed weight (g)	-28.91 to 16.78	-37.14 to 16.36	-27.00 to 16.63
Seed yield/plant (g)	-33.09 to 67.20	-44.58 to 56.61	-56.17 to 56.69
Harvest index (%)	-6.40 to 22.84	-10.89 to 18.52	-17.32 to 18.09
Phytic acid content (mg/g)	-49.40 to 24.01	-66.72 to -1.18	-66.72 to -5.98

standard heterosis recorded highly significant negative heterosis. Similar results were also reported by Arya et al (2010). Seven for relative heterosis, nineteen for heterobeltiosis and twenty four hybrids for standard heterosis recorded significant negative heterosis for plant height. Similar results were also reported by Perez et al (2009). Twelve for relative heterosis, twenty three for heterobeltiosis and twenty four hybrids for standard heterosis recorded significant negative heterosis for phytic acid content (Table 2-4).

Number of clusters per plant, number of pods per plant and 100-seed weight are the main components of yield. In terms of number of clusters per plant, nine, four and four hybrids manifested highly significant positive heterosis over mid, better and standard parents respectively. Ten for relative heterosis, four for heterobeltiosis and four hybrids for standard heterosis recorded highly significant positive heterosis for number of pods per plant while five for relative heterosis, four for heterobeltiosis and five hybrids for standard heterosis recorded highly significant positive heterosis for 100-seed weight (Table 2-4). Similar results were also reported by Sudaric et al (2009).

For harvest index eleven, five and three hybrids showed highly significant positive heterosis over mid, better and standard parents while eight, five and four hybrids showed highly significant positive heterosis over mid, better and standard parents respectively for seed yield per plant. For seed yield per plant maximum standard parent heterosis was recorded in the cross RKS 18 × lpa 5-2 (56.69 %) followed by Co (Soy)3 × lpa 5-2 (56.61%) and Co (Soy)3 × lpa 5-1(33.48%) (Table 2-4). These hybrids were also superior on per se

Table 2. Mid parent heterosis for 11 yield and yield related traits in soybean

Hybrid	Days to 50% flowering	Days to maturity	Plant height (cm)	# branches /plant	# clusters /plant	# pods /plant	# seeds /pod	100-seed weight (g)	Seed yield /plant (g)	Harvest index (%)	Phytic acid content (mg/g)
BRAGG x lpa 5-1	-2.19	-4.17*	-15.28**	-7.83	-13.63**	-23.16**	-4.55	4.01	-16.84*	-6.10	18.60**
BRAGG x lpa 5-2	-1.45	-2.06	-17.58**	-0.90	-10.79*	-10.74**	-6.98	-16.92**	-33.09**	6.01	6.64
BRAGG x lpa 5-3	5.04	2.08	-11.50*	-2.75	15.73*	6.49	-6.98	-11.30**	-17.08*	0.81	24.01**
BRAGG x lpa 13-1	-8.82	-0.29	1.32	-5.45	1.42	3.94	-6.98	-12.36**	-19.99*	-0.20	23.58**
BRAGG x lpa 18	-3.88	-5.81**	2.58	10.11	6.96	15.17**	-6.12	-28.91**	-24.80**	-5.77	12.34*
RKS 18 x lpa 5-1	-7.69	-1.46	-14.93**	7.20	8.03 *	5.23 *	-2.44	-5.69	4.31	3.63	21.45**
RKS 18 x lpa 5-2	-9.72	-8.67**	2.61	25.62**	25.19**	23.56**	25.00**	15.69**	62.36**	18.24**	-44.28**
RKS 18 x lpa 5-3	-4.83	-0.58	-0.69	14.29**	17.70**	4.81	5.00	3.52	14.84*	11.43**	-39.14**
RKS 18 x lpa 13-1	-5.63	-0.57	3.90	5.00	4.70	1.54	0.00	-4.63	-5.54	6.39	21.96**
RKS 18 x lpa 18	2.22	-3.59	-12.40*	23.23**	-11.37*	-10.28**	-8.70*	-12.90**	-28.14**	-1.25	0.54
CO 2 x lpa 5-1	-2.90	-0.88	-0.27	10.34*	-9.31	-14.98**	-2.44	-4.41	-15.21*	2.09	12.64*
CO 2 x lpa 5-2	-3.60	-2.91	-11.07	16.07**	-11.73 *	-12.22**	0.00	-3.38	-17.15*	9.54**	-9.57
CO 2 x lpa 5-3	2.86	-1.17	16.39**	23.64**	32.69**	32.40**	15.00**	7.77*	67.20**	22.84**	-34.31**
CO 2 x lpa 13-1	-2.19	-6.32**	7.29	17.12**	6.10	-0.61	0.00	-0.42	-10.96	12.74**	-12.75**
CO 2 x lpa 18	6.15	-4.82*	12.97	8.89	7.22	4.81	-8.70*	-2.07	-10.72	1.42	-22.55**
CO (Soy) 3 x lpa 5-1	-9.09	-3.86	-14.00**	16.13**	11.65**	10.06**	17.07**	4.32	35.60**	14.68**	-31.63**
CO (Soy) 3 x lpa 5-2	-6.94	-6.47**	5.73	31.67**	25.97**	24.36**	25.00**	16.78**	64.91**	20.20**	-49.40**
CO (Soy) 3 x lpa 5-3	-4.83	-2.96	3.45	22.03**	15.60**	10.46**	0.00	1.54	14.92*	10.44**	-18.63**
CO (Soy) 3 x lpa 13-1	-9.86	-5.23*	-3.70	15.97**	24.78**	14.94**	15.00**	9.37**	32.36**	12.03 **	-46.62**
CO (Soy) 3 x lpa 18	-2.22	-1.83	1.90	2.04	7.47	-0.90	-13.04**	-4.11	-16.91**	-0.08	-5.17
JS 335 x lpa 5-1	-13.64*	1.23	-22.56**	-1.82	2.53	-17.69**	-13.04**	-0.61	-19.38**	0.32	-6.02
JS 335 x lpa 5-2	-5.26	-1.53	6.26	16.98**	14.74**	16.76**	2.22	11.01**	30.33**	12.69**	-31.71**
JS 335 x lpa 5-3	-7.46	0.92	3.69	11.54*	12.67	11.87**	-11.11**	1.01	1.58	7.49*	0.06
JS 335 x lpa 13-1	-8.40	-1.51	4.02	8.57	8.86	5.65	-6.67	0.25	-4.85	6.23	-8.38*
JS 335 x lpa 18	-6.45	-1.59	22.61**	28.57**	8.24	5.55	-9.80**	-3.79	-4.42	3.10	-20.08**
SE	1.4308	1.3724	1.4784	0.2098	0.8219	2.0397	0.0747	0.2726	1.0153	1.3978	0.1382

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

Table 3. Better parent heterosis for 11 yield and yield related traits in soybean

Hybrid	Days to 50% flowering	Days to maturity	Plant height (cm)	# branches /plant	# clusters /plant	# pods /plant	# seeds /pod	100-seed weight (g)	Seed yield /plant (g)	Harvest index (%)	Phytic acid content (mg/g)
BRAGG x lpa 5-1	-5.63	-5.85 *	-36.29 **	-15.87 **	-31.25 **	-40.23 **	-8.70	-5.30	-33.07 **	-9.78 *	-17.24 **
BRAGG x lpa 5-2	-5.56	-2.92	-27.34 **	-6.78	-27.34 **	-26.44 **	-13.04 **	-21.13 **	-44.58 **	3.87	-26.84 **
BRAGG x lpa 5-3	0.00	0.58	-24.87 **	-7.02	10.80	0.53	-13.04 **	-14.96 **	-19.05 *	-3.44	-4.90
BRAGG x lpa 13-1	-11.43	-0.58	-18.01 **	-10.34 *	-6.77	-8.00 *	-13.04 **	-16.80 **	-27.00 **	-1.29	-1.18
BRAGG x lpa 18	-6.06	-9.94 **	-1.15	-5.77	4.97	-0.89	-11.54 **	-37.14 **	-25.80 **	-9.35 *	-20.67 **
RKS 18 x lpa 5-1	-8.33	-5.06 *	-16.41 **	6.35	7.25	4.53	-4.76	-8.42 *	1.17	0.79	-19.58 **
RKS 18 x lpa 5-2	-9.72	-11.24 **	-13.60 **	22.58 **	20.65 **	15.46 **	25.00 **	13.94 **	52.00 **	12.78 **	-63.64 **
RKS 18 x lpa 5-3	-5.48	-3.93	-13.20 **	9.68 *	-3.62	-14.37 **	5.00	0.93	-8.04	0.16	-56.26 **
RKS 18 x lpa 13-1	-6.94	-2.25	-4.20	1.61	-11.23 *	-12.11 **	0.00	-6.06	-19.96 **	-1.48	-9.07 **
RKS 18 x lpa 18	-4.17	-9.55 **	-35.00 **	-1.61	-30.80 **	-36.93 **	-19.23 **	-18.06 **	-44.03 **	-10.89 **	-32.74 **
CO 2 x lpa 5-1	-5.63	-3.98	-27.41 **	1.59	-31.99 **	-36.60 **	-4.76	-11.05 **	-35.91 **	-2.62	-21.37 **
CO 2 x lpa 5-2	-6.94	-5.11 *	-24.85 **	10.17 *	-32.42 **	-30.96 **	0.00	-6.16	-35.73 **	6.54	-37.94 **
CO 2 x lpa 5-3	-1.37	-3.98	-5.08	19.30 **	17.61 *	18.18 **	15.00 **	5.73	50.45 **	18.52 **	-49.61 **
CO 2 x lpa 13-1	-4.29	-7.39 **	-16.35 **	12.07 *	-9.38	-16.46 **	0.00	-3.29	-24.65 **	12.35 **	-30.20 **
CO 2 x lpa 18	2.99	-10.23 **	11.57	-7.55	0.65	-4.87	-19.23 **	-11.59 **	-16.86	-1.73	-45.29 **
CO (Soy) 3 x lpa 5-1	-9.72	-5.81 *	-15.83 **	14.29 **	9.19 *	8.24 **	14.29 **	0.17	33.48 **	14.09 **	-54.36 **
CO (Soy) 3 x lpa 5-2	-6.94	-7.56 **	-10.69 *	29.51 **	25.00 **	17.31 **	25.00 **	16.36 **	56.61 **	17.22 **	-66.72 **
CO (Soy) 3 x lpa 5-3	-5.48	-4.65 *	-9.27 *	18.03 **	-3.08	-9.04 **	0.00	0.14	-6.91	1.34	-40.91 **
CO (Soy) 3 x lpa 13-1	-11.11	-5.23 *	-10.89 *	13.11 **	8.46	0.34	15.00 **	8.97 *	13.57 *	5.99	-59.75 **
CO (Soy) 3 x lpa 18	-8.33	-6.40 **	-24.19 **	-18.03 **	-14.23 **	-29.92 **	-23.08 **	-10.77 **	-34.57 **	-7.94 *	-36.02 **
JS 335 x lpa 5-1	-19.72 **	-0.61	-42.66 **	-14.29 **	-25.37 **	-41.71 **	-20.00 **	-4.42	-36.91 **	-6.63	-35.07 **
JS 335 x lpa 5-2	-12.50 *	-4.17	-8.19	5.08	-14.84 **	-13.27 **	-8.00	10.43 **	4.84	6.89	-53.59 **
JS 335 x lpa 5-3	-15.07 **	-1.20	-13.64 *	1.75	-3.98	-6.85	-20.00 **	-0.54	-4.37	6.40	-24.20 **
JS 335 x lpa 13-1	-14.29 *	-5.23 *	-17.30 **	-1.72	-10.42	-16.69 **	-16.00 **	-0.27	-16.05 *	3.88	-27.69 **
JS 335 x lpa 18	-7.94	-2.52	20.88 *	14.89 *	-2.58	3.56	-11.54 **	-10.34 **	-6.71	2.51	-44.14 **
SE	1.4308	1.3724	1.4784	0.2098	0.8219	2.0397	0.0747	0.2726	1.0153	1.3978	0.1382

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

Table 4. Standard parent heterosis for 11 yield and yield related traits in soybean

Hybrid	Days to 50% flowering	Days to maturity	Plant height (cm)	# branches /plant	# clusters /plant	# pods /plant	# seeds /pod	100-seed weight (g)	Seed yield /plant (g)	Harvest index (%)	Phytic acid content (mg/g)
BRAGG x lpa 5-1	-6.94	-6.40 **	-33.47 **	-13.11 **	-28.08 **	-38.19 **	5.00	2.90	-35.16 **	-10.71 **	-29.88 **
BRAGG x lpa 5-2	-5.56	-3.49	-49.90 **	-9.84 *	-28.46 **	-34.78 **	0.00	-21.70 **	-50.16 **	-1.28	-38.01 **
BRAGG x lpa 5-3	1.39	0.00	-43.35 **	-13.11 **	-25.00 **	-34.95 **	0.00	-17.31 **	-49.80 **	-11.93 **	-19.42 **
BRAGG x lpa 13-1	-13.89 *	-0.58	-30.24 **	-14.75 **	-31.15 **	-31.37 **	0.00	-17.40 **	-47.72 **	-9.97 **	-16.27 **
BRAGG x lpa 18	-13.89 *	-10.47 **	-47.98 **	-19.67 **	-35.00 **	-43.05 **	15.00 **	-27.00 **	-56.17 **	-17.32 **	-32.78 **
RKS 18 x lpa 5-1	-8.33	-1.74	-12.70 **	9.84 *	13.85 **	8.10 **	0.00	-0.50	4.29	5.54	-16.85 **
RKS 18 x lpa 5-2	-9.72	-8.14 **	-12.90 **	24.59 **	28.08 **	17.82 **	25.00 **	16.63 **	56.69 **	18.09 **	-62.41 **
RKS 18 x lpa 5-3	-4.17	-0.58	-12.50 **	11.48 *	2.31	-12.62 **	5.00	3.31	-5.20	4.88	-54.77 **
RKS 18 x lpa 13-1	-6.94	1.16	-3.43	3.28	-5.77	-10.32 **	0.00	-3.85	-17.49 **	3.16	-5.98
RKS 18 x lpa 18	-4.17	-6.40 **	-34.48 **	0.00	-26.54 **	-35.64 **	5.00	-4.85	-42.30 **	-6.69	-30.46 **
CO 2 x lpa 5-1	-6.94	-1.74	-24.19 **	4.92	-28.85 **	-34.44 **	0.00	-3.35	-37.91 **	-3.62	-33.44 **
CO 2 x lpa 5-2	-6.94	-2.91	-48.19 **	6.56	-33.46 **	-38.79 **	0.00	-6.84	-42.20 **	1.26	-47.47 **
CO 2 x lpa 5-3	0.00	-1.74	-28.43 **	11.48 *	-20.38 **	-23.53 **	15.00 **	2.81	-6.71	6.47	-57.34 **
CO 2 x lpa 13-1	-6.94	-5.23 *	-28.83 **	6.56	-33.08 **	-37.68 **	0.00	-3.99	-46.04 **	0.94	-40.91 **
CO 2 x lpa 18	-4.17	-8.14 **	-45.56 **	-19.67 **	-40.00 **	-51.66 **	5.00	2.67	-52.20 **	-11.71 **	-53.69 **
CO (Soy) 3 x lpa 5-1	-9.72	-5.81 *	-12.10 **	18.03 **	14.23 **	11.94 **	20.00 **	8.84 *	33.48 **	14.09 **	-54.36 **
CO (Soy) 3 x lpa 5-2	-6.94	-7.56 **	-10.69 *	29.51 **	25.00 **	17.31 **	25.00 **	16.36 **	56.61 **	17.22 **	-66.72 **
CO (Soy) 3 x lpa 5-3	-4.17	-4.65 *	-9.27 *	18.03 **	-3.08	-9.04 **	0.00	0.14	-6.91	1.34	-40.91 **
CO (Soy) 3 x lpa 13-1	-11.11	-5.23 *	-10.89 *	13.11 **	8.46	0.34	15.00 **	8.97 *	13.57 *	5.99	-59.75 **
CO (Soy) 3 x lpa 18	-8.33	-6.40 **	-24.19 **	-18.03 **	-14.23 **	-29.92 **	0.00	3.62	-34.57 **	-7.94 *	-36.02 **
JS 335 x lpa 5-1	-20.83 **	-4.65 *	-40.12 **	-11.48 *	-21.92 **	-39.73 **	0.00	3.85	-38.88 **	-7.59 *	-42.99 **
JS 335 x lpa 5-2	-12.50 *	-6.40 **	-36.69 **	1.64	-16.15 **	-23.10 **	15.00 **	10.78 **	-5.72	1.59	-59.25 **
JS 335 x lpa 5-3	-13.89 *	-4.65 *	-34.88 **	-4.92	-35.00 **	-39.73 **	0.00	-0.23	-40.70 **	-9.29 *	-33.44 **
JS 335 x lpa 13-1	-16.67 **	-5.23 *	-29.64 **	-6.56	-33.85 **	-37.85 **	5.00	0.05	-39.89 **	-7.33 *	-36.51 **
JS 335 x lpa 18	-19.44 **	-9.88 **	-39.31 **	-11.48 *	-41.92 **	-55.41 **	15.00 **	4.12	-46.36 **	-12.61 **	-50.95 **
SE	1.4308	1.3724	1.4784	0.2098	0.8219	2.0397	0.0747	0.2726	1.0153	1.3978	0.1382

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

performance. Heterosis for harvest index and seed yield per plant in soybean was also reported by Samant et al (2014), Arya et al (2010) and Sudaric et al (2009).

From the present study it could be predicted that some promising hybrids which showed high value of heterosis were RKS 18 × lpa 5-2 and Co(Soy)3 × lpa 5-2 which recorded significant positive heterosis on all the three basis viz relative heterosis, heterobeltiosis and standard heterosis for seven traits namely number of branches per plant, number of clusters per plant, number of pods per plant, number of seeds per pod, 100-seed weight, single yield per plant and harvest index along with significant negative heterosis for days to maturity and phytic acid content (Table 2-4) which are highly desirable in soybean improvement programmes.

Hybrid Co (Soy)3 × lpa 5-1 exhibited significant positive heterosis on three types of heterosis for six traits viz number of branches per plant, number of clusters per plant, number of pods per plant, number of seeds per pod, single yield per plant and harvest index coupled with significant negative heterosis for phytic acid content. It was followed by hybrid Co (Soy)3 x lpa 13 for four traits viz number of branches per plant, number of seeds per pod, 100-seed weight and single yield per plant with significant negative heterosis for days to maturity and phytic acid content (Table 2-4). These hybrids can be exploited commercially to improve the productivity of the crop. However soybean being the self-pollinated crop and non-availability of workable male sterility system it is difficult to exploit hybrid vigour in near future. Hence these hybrids could be effectively utilized to develop high yielding varieties along with desirable traits in soybean.

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