International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 3061-3065

Received: 25-10-2020
Accepted: 27-11-2020

Sunil Kumar Nag
Department of Genetics & Plant Breeding, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh, India

Chandrakanti Painkra
Department of Genetics & Plant Breeding, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh, India

Ajay Tiwari
Department of Genetics & Plant Breeding, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Sunil Kumar Nag
Department of Genetics & Plant Breeding, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh, India

Heterosis for seed yield and associated traits in soybean [*Glycine max* (L.) Merrill]

Sunil Kumar Nag, Chandrakanti Painkra and Ajay Tiwari

DOI: https://doi.org/10.22271/chemi.2020.v8.i6aq.12033

Abstract
An experiment was conducted to estimate the genetic parameters for different traits in soybean. The crop was sown during June, 2015 at Research cum Instructional Farm Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Raipur (C.G.). The experiment was laid out in RCBD with two replications. Heterosis for seed yield and associated traits. The mean are relative heterosis for seed yield per plant RSC-10-46 x JS-97-52 and RSC-10-46x JS-93-05. The highest significant negative heterosis over mid parent recorded by cross RSC-10-46 x JS-97-52. The heterobeltiosis mean are RSC-10-46 x JS-97-52 and RSC-10-46 x JS-93-05. The standard heterosis for seed yield per plant RSC-10-46 x JS-335 and RSC-10-04 x JS-97-52. The top most crosses exhibited significant negative standard heterosis. *viz.,* RSC-10-46 x JS-335, RSC-10-17 x JS-93-05, RSC-10-30 x JS-93-05. Most of the yield and yield contributing characters showed considerable heterosis, hence their exploitation in the heterosis breeding will be useful. However, heterosis breeding is not practically exploited in crops like soybean.

Keywords: Heterosis, seed yield, soybean

Introduction
Soybean [*Glycine max* (L.) Merrill] is a wonderful crop gifted by the nature to mankind which is one of the richest sources of oil as well as protein. It belongs to the family Leguminosae and is a self-pollinated crop having chromosome number of 2n=40. Genetic variability is the basic requirement for crop improvement as this provides wider scope for selection. Thus, effectiveness of selection is dependent upon the nature, extent and magnitude of genetic variability present in material and extent to which it is heritable. Soybean is a dominant oil seed crop in the world trade accounting about 25% world's total oil and fats production. India stands at fifth place in area and production in soybean at global level. Currently, soybean is at first place among the nine oil seed crops in India with a mean national productivity 1.2 t/h. Soybean has become the major source of edible vegetable oil and high quality proteins for food and feed supplement all over the world. A successful breeding programme for yield improvement through phenotypic selection is mainly dependent on the nature and magnitude of variation in the available material and part played by the environment in the expression of the plant characters i.e. phenotype. Heterosis is a performance of F_1/F_2 genotypic combinations and is useful in determining the most appropriate parents for specific traits. Heterosis has substantially remained as one of the significant developments in soybean breeding programmes. Therefore the objective of the present study was to estimate the effects of heterosis in F_1 cross combinations to obtain information on heterotic potential so as to develop hybrids with improved nutritional qualities through Line x Tester analysis. The success of crop improvement programme depends on the identification of genotype with ability to transmit high production potential trait in to specific genotypic combinations. Heterosis is a performance of F_1 genotypic combinations and is useful in determining the most appropriate parents for specific traits. Heterosis has substantially remained as one of the significant developments in soybean breeding programmes Nag, *et al.* (2018) [3].

Materials and methods
The experimental material used in the present study was obtained from All India Coordinated Research Project on Soybean, Department of Genetics and Plant Breeding, IGKV, Raipur (C.G.) which consisted of 8 diverse genotypes *viz.*, RSC 10-04, RSC 10-17, RSC 10-30, RSC

10-46, JS 97-52, JS 93-05, JS 335 and NRC 37. The experiment was comprised of 4 lines and 4 testers of soybean and cross were attempted using L x T design (Kempthorne, 1957) [2]. Two varieties were used as a check. The F_1 were obtained by crossing each of the 4 lines with 4 testers during the *Kharif* season 2014-15 and evaluated in RCBD with 2 replication during *Kharif* season 2015-16. Each entry was grown in a single row of 2 m length spaced at 30 cm and 20 cm between plants. The data were recorded on days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, pod bearing length, number of pod bearing nodes, number of pods per plant, number of seeds per pod, 100 seed weight (g), protein content (%), oil content (%) and seed yield per plant (g). Heterosis for each trait was worked out by utilizing the overall mean of each hybrid over replication for each trait. Relative heterosis was estimated as per cent deviation of hybrid value from its mid parental value.

Results and discussion

Heterosis

Investigations on heterosis provides fundamental information regarding the utility of the cross combinations and its use for commercial exploitation. The magnitude of heterosis for yield, yield components and quality traits depends to a large extent on genetic variation, genetic base and adaptability of parents. The presence of significant amount of non additive gene action is a prerequisite for the commercial exploitation of heterosis. It is estimated for all the 18 characters and among all the crosses attempted in a Line x Tester cross in grasspea all the three types of heterosis *viz.*, relative heterosis, heterobeltiosis and standard heterosis were estimated. The results obtained for different characters have been described below (Table-1).

Days to 50 % flowering

The relative heterosis for this trait ranged from -9.08 per cent (RSC-10-04 x NRC-37) to 21.78 per cent (RSC-10-30 x JS-93-05). Among 16 hybrids, four hybrids showed significant negative heterosis and five hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-04 x NRC-37 (-9.08%) followed by RSC-10-46 x JS-97-52 (-8.85%) and RSC-10-30 x NRC-37 (-6.12%). The heterobeltiosis ranged from -15.24 per cent (RSC-10-46 x JS-97-52) to 20. 97 per cent (RSC-10-30 x JS-93-05). 9 out of 16 All crosses showed significant negative heterobeltiosis. Rest of the hybrids showed significant positive heterobeltiosis for this trait. The standard heterosis for days to 50 per cent flowering ranged from -15.45 per cent (RSC-10-46 x JS-97-52) to 1.32 per cent (RSC-10-30 x JS-93-05). All 16 crosses showed significant negative standard heterosis for this trait except RSC-10-30 x JS-93-05. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-46 x JS-97-52, RSC-10-46 x JS-93-05, RSC-10-30 x NRC-37 and RSC-10-04 x JS-93-05, indicates the possibility of exploiting these crosses for earliness Nag, *et al.* (2018) [3].

Days to maturity

The relative heterosis for this trait ranged from -5.95 per cent (RSC-10-30 x JS-335) to 3.09 per cent (RSC-10-17 x NRC-37). Among 16 hybrids, six hybrids showed significant negative heterosis and four hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-30 x JS-335 (-5.95 %) followed by RSC-10-30 x JS-97-52 (-4.62%) and RSC-10-04 x NRC-37 (-4.43%). Similar findings were also reported by authors, Abd E1 and Nassar (2013) [1]. The heterobeltiosis ranged from -6.16 per cent (RSC-10-30 x JS-335) to 0.89 per cent (RSC-10-46 x JS-97-52). 10 out of 16 crosses showed significant negative heterobeltiosis while, rest of them exhibited non-significant heterosis. The standard heterosis for days to maturity ranged from -7.02 per cent (RSC-10-04 x NRC-37) to 0.57 per cent (RSC-10-46 x JS-97-2-52). Among the 16 crosses, 11 crosses showed significant negative standard heterosis for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-04 x NRC-37, RSC-10-04 x JS-93-05, RSC-10-04 x JS-97-52 and RSC-10-30 x JS-335 Nag, *et al.* (2018) [3].

Plant height (cm)

The relative heterosis for this trait ranged from -15.78 per cent (RSC-10-04 x JS-97-52) to 10.20 per cent (RSC-10-46 x NRC-37). Among 16 hybrids, eight hybrids showed significant negative heterosis and nine hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-04 x JS- 97-05 (-15.78%) followed by RSC-10-17 x JS-97-52 (-13.28%) and RSC-10-46 x JS-335 (-10.66%). The heterobeltiosis ranged from -21.86 per cent (RSC-10-17 x JS-97-52) to 6.53 per cent (RSC-10-46 x NRC-37). 9 out of 16 all crosses showed significant negative heterobeltiosis and 2 crosses showed significant positive heterosis. Rest of the hybrids showed non-significant heterobeltiosis for this trait. The standard heterosis for plant height ranged from -26.88 per cent (RSC-10-30 x NRC-37) to 0.41 per cent (RSC-10-04 x JS-335). Among 16 crosses 11 crosses showed significant negative standard heterosis for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-30 x NRC-37, RSC-10-46 x JS-335, RSC-10-17 x JS-93-05 and RSC-10-46 x JS-93-05 it could be exploited in future breeding programme to obtain dwarf plant and Nag, *et al.* (2018) [3].

Number of primary branches per plant

The relative heterosis for this trait ranged from -26.60 per cent (RSC-10-46 x NRC-37) to 14.39 per cent (RSC-10-04 x JS-335). Among 16 hybrids, 11 hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-46 x NRC-37 (-26.60%) followed by RSC-10-04 x JS-93-05 (-23.67%) and RSC-10-30 x JS-93-05 (-22.99%). The heterobeltiosis ranged from -30.68 per cent (RSC-10-46 x NRC-37) to 14.95 per cent (RSC-10-17 x JS-97-52). Among 16 crosses, 11 crosses showed significant negative heterobeltiosis and 3 crosses showed significant positive heterosis. Rest of the hybrids showed non-significant heterobeltiosis for this trait. The standard heterosis for number of primary branches ranged from -27.43 per cent (RSC-10-46 x NRC-37) to 15.45 per cent (RSC-10-17 x JS-97-52). Among the 16 crosses, 11 crosses showed significant negative standard heterosis and five crosses showed significant positive heterosis for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-46 x NRC-37, RSC-10-04 x JS-93-05, RSC-10-17 x NRC-37 and RSC-10-04 x NRC-37. More number of branches coupled with more number of flowers and ultimately to seed yield. Present findings are in agreement with the findings of Ramana and Satynarayana (2006) [5].

Pod bearing length (cm)

The relative heterosis for this trait ranged from -16.18 per cent (RSC-10-04 x JS-97-52) to 13.59 per cent (RSC-10-46 x JS-NRC-37). Among 16 hybrids, six hybrids showed significant negative heterosis and 4 hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-04 x JS-97-52 (-16.18%) followed by RSC-10-17 x JS-97-52 (-12.53%) and RSC-10-17 x JS-93-05 (-12.52%). The heterobeltiosis ranged from -21.45 per cent (RSC-10-17 x JS97-52) to 10.95 per cent (RSC-10-46 x NRC-37). Among 16 crosses, nine crosses showed significant negative heterobeltiosis and only one cross RSC-10-46 x NRC-37 showed significant positive heterosis. Rest of the hybrids showed non-significant heterobeltiosis for this trait. The standard heterosis for pod bearing length ranged from -25.51 per cent (RSC-10-17 x NRC-37) to 0.22 per cent (RSC-10-30 x JS-93-05). Among the 16 crosses, 12 crosses showed significant negative standard heterosis and rest of the hybrids showed non-significant for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-17x JS-93-05, RSC-10-17 x NRC-37, RSC-10-46 x JS-335 and RSC-10-04 x JS-97-52 Nag, *et al.* (2018) [3].

Number of pod bearing nodes

The relative heterosis for this trait ranged from -22.84 per cent (RSC-10-30 x JS-335) to 13.00 per cent (RSC-10-30 x NRC-37). Among 16 hybrids, nine hybrids showed significant negative heterosis while the rest hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-30 x JS-335 (-22.84%) followed by RSC-10-46 x JS-335 (-14.76%) and RSC-10-30 x NRC-37 (-13.0%). The heterobeltiosis ranged from -25.17 per cent (RSC-10-30 x JS-335) to 6.69 per cent (RSC-10-30 x NRC-37). Among 16 crosses, 11 crosses showed significant negative heterobeltiosis and 4 crosses showed significant positive heterosis. Rest of the hybrids showed non-significant heterobeltiosis for this trait. The standard heterosis for number of pod bearing nodes ranged from -3.46 per cent (RSC-10-04 x JS-335) to 33.66 per cent (RSC-10-04 x JS-335). All 16 crosses showed significant positive heterosis for this trait. The top most crosses exhibited significant positive standard heterosis. *viz.*, RSC-10-04 x JS-335, RSC-10-30 x NRC-37, RSC-10-17 x JS-335 and RSC-10-30 x JS-97-52 Nag, *et al.* (2018) [3].

Number of pods per plant

The relative heterosis for this trait ranged from -18.34 per cent (RSC-10-04 x NRC-37) to 30.38 per cent (RSC-10-30 x JS-97-52). Among 16 hybrids, seven hybrids showed significant negative heterosis and five hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-04 x NRC-37 (-18.34%) followed by RSC-10-17 x JS-335 (-17.53%) and RSC-10-46 x JS-335 (-17.33%). The heterobeltiosis ranged from -29.68 per cent (RSC-10-17 x JS-335) to 30.38 per cent (RSC-10-30 x JS-97-52). Among 16 crosses, 11 crosses showed significant negative heterobeltiosis and three crosses showed significant positive heterosis. Rest of the hybrids showed non-significant heterobeltiosis for this trait. The standard heterosis for number of pods per plant ranged from -7.32 per cent (RSC-10-46 x NRC-37) to 30.36 per cent (RSC-10-30 x JS-97-52). Among the 16 crosses, 2 crosses showed significant negative standard heterosis and 10 crosses showed significant positive standard heterosis and rest of the hybrids showed non-significant for this trait. The top most crosses exhibited significant positive standard heterosis. *viz.*, RSC-10-30 x JS-97-52, RSC-10-30 x NRC-37, RSC-10-30 x JS-93-05 and RSC-10-04 x JS-97-52. Similar findings were also reported by Sudaric, *et al.* (2009) [7].

Number of seeds per pod

The relative heterosis for this trait ranged from -24.92 per cent (RSC-10-17 x JS-335) to 19.26 per cent (RSC-10-04 x JS-335). Among 16 hybrids, ten hybrids showed significant negative heterosis and six crosses showed significant positive standard heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-17 x JS-335 (-24.92%) followed by RSC-10-04 x NRC-37 (-21.37%) and RSC-10-17 x NRC-37 (-13.46%). The heterobeltiosis ranged from -29.16 per cent (RSC-10-30 x NRC-37) to 17.57 per cent (RSC-10-04 x JS-335). Among 16 crosses, 12 crosses showed significant negative heterobeltiosis and 4 crosses showed significant positive heterosis. The standard heterosis for number of seeds per plant ranged from -33.22 per cent (RSC-10-17 x JS-335) to 1.37 per cent (RSC-10-04 x NRC-37). All 16 crosses showed significant negative heterosis except RSC-10-46 x NRC-37 for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-30 x JS-335, RSC-10-04 x NRC-37, RSC-10-17 x JS-93-05 and RSC-10-30 x JS-97-52. Similar findings were also reported by Sudaric, *et al.* (2009) [7].

100 seed weight (g)

The relative heterosis for this trait ranged from -9.90 per cent (RSC-10-17 x NRC-37) to 12.69 per cent (RSC-10-46 x JS-93-05). Among 16 hybrids, nine hybrids showed significant negative heterosis and seven hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-17 x NRC-37 (-9.90 %) followed by RSC-10-17 x JS-335 (-6.76%) and RSC-10-46 x NRC-37 (-4.33%). The heterobeltiosis ranged from -18.02 per cent (RSC-10-17 x JS-NRC-37) to -1.04 per cent (RSC-10-30 x NRC-37). All 16 crosses showed significant negative heterobeltiosis. The standard heterosis for 100 seed weight (g) ranged from -15.32 per cent (RSC-10-17 x NRC-37) to 19.17 per cent (RSC-10-17 x JS-335, RSC-10-46 x JS-93-05). Among the 16 crosses, 10 crosses showed significant negative standard heterosis and four hybrids showed significant positive heterosis for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-17 x JS-93-05, RSC-10-46 x JS-93-05, RSC-10-46 x NRC-37. Similar findings were also reported by Sudaric, *et al.* (2009) [7].

Protein content (%)

The relative heterosis for this trait ranged from -7.63 per cent (RSC-10-17 x JS-335) to 6.25 per cent (RSC-10-04 x JS-97-52). Among 16 hybrids, seven hybrids showed significant negative heterosis and 6 crosses showed significant positive standard heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-17 x JS-335 (-7.63%) followed by RSC-10-46 x JS-93-05 (-6.87%) and RSC-10-46 x JS-97-52 (-13.46%). The heterobeltiosis ranged from -9.84 per cent (RSC-10-17 x JS-335) to 4.67 per cent (RSC-10-30 x JS-93-05). Among 16 crosses, 10 crosses showed significant negative heterobeltiosis and 5 crosses showed significant positive heterosis. The standard heterosis for protein content (%)

ranged from 10.53 per cent (RSC-10-04 x JS-335) to 7.89 per cent (RSC-10-04 x JS-97-52). All 16 crosses showed significant positive heterosis for this trait. The top most crosses exhibited significant positive standard heterosis. *viz.*, RSC-10-04 x JS-335, RSC-10-30 x JS-335, RSC-10-17 x JS-93-05. Similar findings were also reported by Perez, *et al.* (2009) [4].

Oil content (%)
The relative heterosis for this trait ranged from -10.62 per cent (RSC-10-04 x JS-97-52) to 16.26 per cent (RSC-10-17 x JS-335). Among 16 hybrids, four hybrids showed significant negative heterosis and ten hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-04 x JS-97-52 (-10.62%) followed by RSC-10-04 x NRC-37 (-9.23%) and RSC-10-30 x JS-97-52 (-8.02%). The heterobeltiosis ranged from -13.34 per cent (RSC-10-04 x NRC-37) to -15.84 per cent (RSC-10-04 x JS-97-52). Among 16 crosses, 7 crosses showed significant negative heterobeltiosis and 6 crosses showed significant positive heterosis and rest crosses showed non significant heterobeltiosis. The standard heterosis for oil content (%) ranged from -9.69 per cent (RSC-10-30 x NRC-37) to 14.29 per cent (RSC-10-30 x JS-97-52). Among the 16 crosses, 7 crosses showed significant negative standard heterosis and 4 hybrids showed significant positive heterosis for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-30 x NRC-37, RSC-10-17 x JS-93-05, RSC-10-30 x JS-335 Nag, *et al.* (2018) [3].

Seed yield per plant (g)
The relative heterosis for this trait ranged from -21.48 per cent (RSC-10-46 x JS-97-52) to 24.26 per cent (RSC-10-46x JS-93-05). Among 16 hybrids, 9 hybrids showed significant negative heterosis and the rest hybrids showed significant positive heterosis for this trait. The highest significant negative heterosis over mid parent recorded by cross RSC-10-46 x JS-97-52 (-21.48%) followed by RSC-10-17 x JS-97-52 (-20.15%) and RSC-10-46 x JS-335 (17.26%). The heterobeltiosis ranged from -27.02 per cent (RSC-10-46 x JS-97-52) to -15.31 per cent (RSC-10-46 x JS-93-05). Among 16 crosses, 10 crosses showed significant negative heterobeltiosis and 3 crosses showed significant positive heterosis and rest crosses showed non significant heterobeltiosis. The standard heterosis seed yield per plant ranged from -31.02 per cent (RSC-10-46 x JS-335) to 0.62 per cent (RSC-10-04 x JS-97-52). All 16 crosses showed significant negative standard heterosis except RSC-10-46 x JS-97-52 for this trait. The top most crosses exhibited significant negative standard heterosis. *viz.*, RSC-10-46 x JS-335, RSC-10-17 x JS-93-05, RSC-10-30 x JS-93-05.Present findings are in agreement with the findings of Ramana and Satynarayana (2006) [6] and Nag, *et al.* (2018) [3].

Table 1: Mid-parent heterosis, Heterobeltiosis and standard heterosis for qualitative and quantitative characters in soybean

Crosses	Days to 50% flowering			Days to maturity			Plant height (cm)			Number of primary branches plant^{-1}		
	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
RSC-10-04 X JS-97-52	-1.65	-5.36**	-5.60**	-3.75**	-5.82**	-6.13**	-15.78**	-18.05**	-16.84**	2.52**	2.25**	2.60**
RSC-10-04 X JS-93-05	-0.43	-4.99**	-12.39**	-2.80**	-3.41**	-6.70**	2.57	-0.72	-4.67*	-23.67**	-26.36**	-20.49**
RSC-10-04 X JS-335	2.27*	1.12	-6.76**	2.19*	-0.19	-0.14	5.45**	4.57*	0.41	14.39**	11.42**	11.81**
RSC-10-04 X NRC-37	-9.08**	-13.44**	-11.71**	-4.43**	-6.27**	-7.02**	1.08	-8.05**	-11.71**	-15.66**	-17.41**	-13.54**
RSC-10-17 X JS-97-52	-0.25	-6.13**	-6.36**	-1.14	-4.23**	-4.54**	-13.27**	-21.86**	-20.70**	14.95**	14.26**	15.45**
RSC-10-17 X JS-93-05	5.64**	3.10**	-9.29**	2.41*	0.74	-2.70**	-4.92*	-9.41**	-18.59**	-12.95**	-15.76**	-9.03**
RSC-10-17 X JS-335	10.75**	9.43**	-1.36	0.33	-2.99**	-2.94**	9.72**	2.14	-3.56	-4.42**	-7.22**	-6.25**
RSC-10-17 X NRC-37	-3.90**	-10.50**	-8.71**	3.09**	0.097	-0.70	-8.63**	-10.15**	-26.88**	-16.62**	-18.07**	-14.24**
RSC-10-30 X JS-97-52	1.58	-7.13**	-7.36**	-4.62**	-4.99**	-4.54**	-1.53	-3.19	-1.76	-18.79**	-21.86**	-15.63**
RSC-10-30 X JS-93-05	21.78**	20.97**	1.32	0.21	-1.73	-1.26	3.28	-1.04	-2.95	-22.99**	-22.99**	-16.84**
RSC-10-30 X JS-335	11.25**	6.62**	-3.89**	-5.95**	-6.16**	-5.71**	-5.39**	-7.15**	-8.95**	0.85**	-5.14**	2.43**
RSC-10-30 X NRC-37	-6.12**	-15.03**	-13.33**	-3.51**	-4.12**	-3.66**	3.87*	-6.39**	-8.21**	-11.18**	-12.54**	-5.56**
RSC-10-46 X JS-97-52	-8.85**	-15.24**	-15.45**	2.35*	0.89	0.57	5.00**	-3.89*	-2.47	-5.85**	-9.04**	-9.20**
RSC-10-46 X JS-93-05	0.43	-0.76	-14.87**	-1.50	-1.62	-4.75**	-5.26**	-8.19**	-17.51**	7.42**	0.00	7.99**
RSC-10-46 X JS-335	2.26*	-0.21	-10.05**	-1.39	-2.98**	-2.94**	-10.66**	-15.44**	-20.17**	-2.95**	-4.02**	-8.68**
RSC-10-46 X NRC-37	-1.62	-9.44**	-7.63**	-2.79	-3.95**	-4.72**	10.20**	6.53**	-10.20**	-26.60**	-30.68**	-27.43**
SE	**1.02**			**1.01**			**1.93**			**0.09**		

Crosses	Pod bearing length (cm)			Number of pod bearing nodes			Number of pods per plant			Number of seeds per pod		
	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
RSC-10-04 X JS-97-52	-16.18**	-17.35**	-17.41**	11.23**	5.65**	17.42**	9.95**	8.68**	8.68**	-2.91**	-11.60**	-11.30**
RSC-10-04 X JS-93-05	5.03**	0.503	-2.37	-5.02**	-8.06**	9.20**	-1.88	-7.33**	1.84	13.62**	11.02**	-8.56**
RSC-10-04 X JS-335	0.049	-0.309	-3.16	11.31**	3.61**	33.66**	0.31	-12.83**	15.38**	19.26**	17.57**	-0.34*
RSC-10-04 X NRC-37	1.72	-8.275**	-10.90**	4.55**	2.92**	14.39**	-18.34**	-28.32**	-7.32**	-21.37**	-29.16**	-27.23**
RSC-10-17 X JS-97-52	-12.53**	-21.45**	-21.50**	5.23**	-3.60**	15.85**	0.96	-2.39	-2.39	-19.65**	-22.53**	-22.26**
RSC-10-17 X JS-93-05	-12.52**	-17.07**	-26.37**	-9.78**	-10.31**	7.79**	7.88**	-0.23	9.65**	9.87**	1.28**	-5.65**
RSC-10-17 X JS-335	9.45**	-0.14	-3.69*	1.62**	-1.85**	26.62**	-17.53**	-29.68**	-6.93**	-24.92**	-28.31**	-33.22**
RSC-10-17 X NRC-37	-5.47**	-6.36**	-25.51**	-9.19**	-13.91**	3.46**	-2.37	-15.94**	8.68**	-13.46**	-17.50**	-15.24**
RSC-10-30 X JS-97-52	-1.36	-1.48	-1.54	10.47**	0.80	22.19**	30.38**	30.36**	30.36**	-4.05**	-7.16**	-6.85**
RSC-10-30 X JS-93-05	6.35**	0.52	0.22	-8.18**	-9.10**	10.17**	13.66**	8.52**	19.27**	-2.28**	-10.22**	-15.75**
RSC-10-30 X JS-335	-5.94**	-7.47**	-7.76**	-22.84**	-25.17**	-3.46**	-13.01**	-23.65**	1.05	-12.17**	-16.42**	-21.58**

RSC-10-30 X NRC-37	1.13	-9.85**	-10.12**	13.00**	6.69**	29.33**	5.39**	-6.55**	20.82**	-7.66**	-11.67**	-9.25**
RSC-10-46 X JS-97-52	0.92	-8.22**	-8.27**	-11.03**	-20.78**	1.46**	-4.89*	-14.82**	7.65**	-3.48**	-10.06**	-9.76**
RSC-10-46 X JS-93-05	2.55	-1.45	-12.51**	-5.52**	-8.95**	16.61**	-14.40**	-19.98**	1.12	1.55**	-3.16**	-16.10**
RSC-10-46 X JS-335	-9.90**	-16.72**	-19.68**	-14.76**	-15.06**	9.58**	-17.33**	-19.21**	6.94**	8.69**	7.51**	-6.85**
RSC-10-46 X NRC-37	13.59**	10.95**	-9.19**	-1.58**	-9.42**	16.02**	-10.51**	-11.53**	14.39**	7.05**	-1.33**	1.37**
SE	**1.65**			**0.48**			**1.99**			**0.10**		

Crosses	100 seed weight (g)			Protein content (%)			Oil content (%)			Seed yield per plant (g)		
	MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
RSC-10-04 X JS-97-52	-2.72**	-5.29**	-5.29**	6.25**	4.66**	7.89**	-10.62**	-12.79**	-8.33**	18.58**	0.66	0.62
RSC-10-04 X JS-93-05	-3.41**	-13.32**	3.27**	-2.71**	-4.93**	2.70**	-0.36	-4.87**	0.00	4.33**	1.69**	-25.29**
RSC-10-04 X JS-335	0.93*	-1.47**	-6.69**	5.93**	4.67**	10.53**	-0.18	-9.40**	-4.76**	-3.56**	-10.21**	-27.35**
RSC-10-04 X NRC-37	2.95**	-2.50**	-7.66**	-1.52*	-2.99**	0.00	-9.23**	-13.34**	-8.90**	3.40**	0.59	-25.81**
RSC-10-17 X JS-97-52	-1.62**	-3.19**	0.00	-2.62**	-7.41**	2.70**	12.46**	4.76**	4.76**	-20.15**	-23.98**	-24.01**
RSC-10-17 X JS-93-05	7.14**	0.00	19.17**	-1.44*	-2.73**	7.89**	0.79*	-4.11**	-8.33**	-12.21**	-20.43**	-28.08**
RSC-10-17 X JS-335	-6.76**	-12.67**	-9.80**	-7.63**	-9.84**	0.00	16.26**	15.86**	0.00	-5.53**	-10.47**	-19.09**
RSC-10-17 X NRC-37	-9.90**	-18.02**	-15.32**	0.00	-4.92**	5.46**	4.71**	-0.37	-4.76**	7.53**	-2.35**	-11.75**
RSC-10-30 X JS-97-52	-2.01**	-5.29**	-5.29**	2.76**	0.18	5.46**	5.13**	0.28	0.29	-12.15**	-23.98**	-24.01**
RSC-10-30 X JS-93-05	-2.77**	-13.32**	3.27**	3.64**	2.31**	10.53**	-8.02**	-10.34**	-14.29**	-1.82**	-2.09**	-28.08**
RSC-10-30 X JS-335	1.69**	0.00	-6.69**	4.84**	4.67**	10.53**	2.52**	-0.34	-9.52**	5.10**	0.00	-19.09**
RSC-10-30 X NRC-37	3.76**	-1.04*	-7.66**	5.05**	2.45**	7.82**	-3.09**	-5.53**	-9.69**	3.37**	2.88**	-24.12**
RSC-10-46 X JS-97-52	3.98**	0.00	0.00	-3.85**	-7.41**	0.00	11.07**	8.62**	8.62**	-21.48**	-27.02**	-27.06**
RSC-10-46 X JS-93-05	12.69**	0.00	19.17**	-6.87**	-6.88**	2.50**	7.09**	7.09**	2.38**	24.26**	15.31**	-1.03*
RSC-10-46 X JS-335	-1.17**	-2.32**	-9.80**	-0.52	-1.63*	6.25**	11.67**	5.90**	1.24**	-17.26**	-19.63**	-31.02**
RSC-10-46 X NRC-37	-4.33**	-8.29**	-15.32**	-1.32	-4.98**	2.63**	2.47**	2.47**	-2.05**	-7.01**	-13.56**	-25.81**
SE	**0.39**			**0.73**			**0.39**			**0.56**		

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

Conclusion

Most of the yield and yield contributing characters showed considerable heterosis, hence their exploitation in the heterosis breeding will be useful. However, heterosis breeding is not practically exploited in crops like soybean.

References

1. Abd El MA, Nassar G. Heterosis and combining ability for yield and its components in some crosses of soybean. Aust. J Basic & Appl. Sci 2013;7(1):566-572.
2. Kempthorne O. An introduction to genetic studies. John Willey and Sons Inc., New York, USA 1957.
3. Nag SK, Sarawgi AK, Mehta N, Painkra P, Tiwari A. Combining ability studies for yield and its attributes in Soybean (*Glycine max* L. Merrill). Trends in Biosciences 2018;11(16):2603-2607.
4. Perez PT, Cianzio SR, Palmer RG. Evaluation of soybean [*Glycine max* (L.) Merrill] F_1 Hybrids. J Crop Improve 2009;23(1):1-18.
5. Ramana MV, Satyanarayana A. Heterosis in soybean. [*Glycine* max (L.) Merrill] Legume Res 2006;29(4):247-251.
6. Ramana MV, Satyanarayana A. Heterosis in soybean. [*Glycine* max (L.) Merrill] Legume Res 2006;29(4):247-251.
7. Sudaric Vrataric A, Volenik M, Matosa MM, Duvnjak V. Heterosis and heterobeltiosis for grain yield components in soybean. (Croatian) Poljoprivreda/Agriculture 2009;15(2):26-31.