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Combining ability and nature of gene action associated with seed yield and its component traits in field bean [*Lablab purpureus* (L.) Sweet] genotypes

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ABSTRACT

Six lines were crossed with three testers in line x tester mating design to estimate combining ability for yield and yield attributing traits in field bean [*Lablab purpureus* (L.) Sweet]. The variance due to general combining ability (GCA) was lesser than the variance due to specific combining ability (SCA) for all the characters under study except for number of pods per plant and the ratio of GCA to the SCA variance for these traits was less than unity except for number of pods per plant, which indicated the role of dominance gene action in the inheritance of these characters. The female parents DA-11 and DA-12 and the male parent DA-14 were identified as good general combiners for most of the yield attributing characters as they recorded high *per se* with positive significant GCA effects for seed yield per plant. Whereas, DA-12 (female) and DA-13 (male) recorded as good general combiners for protein content. Among 18 crosses evaluated, three crosses DA-11 x DA-15, DA-10 x DA-15 and DA-7 x DA-14 exhibited high and positive significant SCA effects for seed yield per plant.

Kew words: Field bean, combining ability, gene action, GCA effects, SCA effects

INTRODUCTION

Field bean [*Lablab purpureus* (L.) Sweet] is one of the most ancient legume species widely distributed in Indian sub-continent, Africa and South East Asia. Combining ability is the most effective tool for identifying the appropriate parents for hybridisation. For heterosis breeding, it is necessary to select the cross combinations with high degree of specific combining ability (SCA) and preferably the parents involved with high general combining ability (GCA) effect. Therefore, the present investigation was undertaken to study the combining ability of parents and cross combining ability as well as nature of gene action involved for seed yield and yield components.

MATERIALS AND METHODS

Eighteen crosses were obtained by crossing genotypes *viz.,* DA-7, DA-8, DA-9, DA-10, DA-11 and DA-12 as lines with three testers *viz.,* DA-13, DA-14 and DA-15 in line x tester mating design. The resulting 18 crosses were sown along with the parents in single row in a randomised block design with two replications at Main Agricultural Research Station, Dharwad, during Kharif 2009. Each entry was grown in a plot of 2 rows of 2.5 m length with a spacing of 60 cm between rows and 25 cm between plants. Observations were recorded on five randomly selected plants for 13 characters *viz.,* days to 50 per cent flowering, days to maturity, plant height, inflorescence length, number of inflorescence per plant, number of primary branches per plant, number of secondary branches per plant, pod length, number of pods per plant, number of seeds per pod, 100 seed weight, protein content and seed yield per plant. The mean data of each character was subjected to Line x Tester analysis and mean sum of squares along with the variance of general combining ability (GCA) of the parents and specific combining ability (SCA) of the hybrids were worked out based on the procedure developed (Kempthorne, 1957). Considering the mean performance and GCA effects, the parents were ranked as good or high/poor or low combiners.

RESULTS AND DISCUSSION

The analysis of variance for combining ability in respect of thirteen characters under study is presented in Table 1. The analysis of variance for combining ability indicated that, mean sum of squares due to females x males interaction were highly significant for all the traits indicating the manifestation of considerable genetic variability among the hybrids. The GCA and SCA effect of both parents and hybrids were worked out for the different characters and are presented in Table 2 and Table 3 respectively (Fig.1) as well as proportional contribution of lines, testers and their interaction to total hybrids variance in respect of 13 characters as given in fig. 2.

Among the parents, DA-10 and DA-15 were found to be good general combiner for days to 50 per cent flowering. Only 9 hybrids exhibited SCA effects towards negative direction and DA-10 x DA-15 exhibited the highest negative SCA effect followed by DA-11 x DA-14. The cross DA-10 x DA-15 also expressed significant negative heterosis and it involved the parents having low x low GCA effects. The GCA variance was lesser than SCA variance indicating dominant gene action for the inheritance of this trait. Hence exploitation of heterosis would be preferred for such trait to obtain early flowering hybrids. Preponderance of additive and non-additive gene effects for the control of days to 50 per cent flowering corroborates the findings of Patil *et al.* (2013) and Das *et al*. (2014).

The negative GCA effects were recorded in DA-9 among female parents and among males, DA-14 were good general combiner. The hybrids, DA-8 x DA-14, DA-9 x DA-15 and DA-7 x DA-14 were found to be early maturing types. All the three hybrids also recorded negative heterosis for days to maturity. The hybrid DA-8 x DA-14 has the parents with low x low GCA combinations. Generally, maturity has direct influence on seed yield and total biomass production. For this trait, GCA variance was lesser than SCA variance suggesting thatdays to maturity was largely under the control of dominance gene action obtained (Das *et al*., 2014). Therefore, it is advisable to utilise suitable parents having negative GCA effects to obtain early maturing hybrids.

Among the parents, DA-11 and DA-10 were found to be good general combiners for plant height. The highest SCA effect was observed in DA-11 x DA-14 and this hybrid also showed positive heterosis. It has the parents having high SCA x high GCA combinations. GCA variance was lesser than SCA variance indicating dominance gene action for the inheritance of this trait. The results are in conformity with Patil *et al.,* 2013**.**

Number of pods per plant is an important yield attributing character, which greatly influenced by plant height, inflorescence length, number of inflorescence per plant and number of branches. In the present study GCA variance was greater than SCA variance. This reveals that both additive and non-additive gene action is important for the inheritance of this trait. For this trait, DA-9 and DA-14 were found to be good general combiners. The highest SCA effect was observed in DA-11 x DA-14 followed by DA-12 x DA-14. The hybrid DA-12 x DA-14 involving the parents having high SCA x high GCA combination. The GCA variance was greater than SCA variance. This suggests the predominance of additive gene action as given (Desai *et al.* 2003 and Bendale *et al.* 2005).

The GCA effects of the parents indicated that DA-12, DA-10 and DA-13 were found to be good general combiners. The highest SCA effect was observed in DA-11 x DA-13 followed by DA-8 x DA-15 and DA-8 x DA-14, these hybrids also

Table 1. ANOVA for combining ability for 13 different characters in field bean

Character	d.f.	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Female (lines)	5	14.18	85.55**	47.39**	21.22*	42.29**	0.89	5.49**	0.59*	1357.15**	0.15**	8.11**	9.62**	100.32*
Male (testers)	2	29.97	3.11	1	0.77	5.55	0.89	4.05*	0.57	747.50**	0.25**	2.35	4.73**	22.4
Female x male	10	135.94**	62.47**	43.65**	44.90**	59.05**	4.94**	7.63**	1.42**	404.92**	0.22**	9.41**	4.42**	266.23**
Error	17	0.39	0.33	0.45	0.06	0.08	0.12	0.01	0.01	3.81	0	0.05	0.02	0.09

** - Significant at 1% probability level * - Significant at 5% probability level

X_1 - Days to 50% flowering
X_2 - Days to maturity
X_3 - Plant height (cm)
X_4 - Inflorescence length (cm)
X_5 - Number of inflorescence per plant
X_6 - Number of primary branches per plant
X_7 - Number of secondary branches per plant
X_8 - Pod length (cm)
X_9 - Number of pods per plant
X_{10} - Number of seeds per pod
X_{11} - 100 seed weight (g)
X_{12} - Protein content (%)
X_{13} - Seed yield per plant (g)

Table 2. GCA effects of female and male parents for yield and yield attributing traits in field bean over 13 different characters

Source	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Female parents													
DA-7	1.35**	-1.16**	1.61**	-2.85**	-0.49**	0.28	-0.87**	0.15**	7.80**	-0.10**	-0.04	-1.65**	-6.39**
DA-8	0.72*	-2.83**	-0.79*	0.23*	3.08**	-0.25	-0.32**	-0.62**	-6.39**	0.20**	-0.89**	0.02	0.95**
DA-9	-1.47**	-5.16**	-3.72**	0.89**	-2.66**	-0.35*	0.47**	0.14**	18.47**	0.15**	-0.16	-0.80**	1.09**
DA-10	-1.68**	0.87**	2.09**	1.02**	-2.96**	-0.02	-1.14**	0.05	-11.47**	-0.17**	0.87**	-0.01	-3.30**
DA-11	1.93**	3.87**	3.38**	2.29**	3.12**	-0.29	0.48**	0.24**	-20.35**	-0.15**	-1.49**	0.31**	3.33**
DA-12	-0.85**	4.42**	-2.58**	-1.57**	-0.10	0.63**	1.40**	0.04	11.94**	0.07**	1.71**	2.13**	4.33**
GCA lines													
CD @ 1%	1.04	0.96	1.12	0.40	0.48	0.58	0.20	0.19	3.27	0.07	0.39	0.22	0.51
CD @ 5%	0.76	0.70	0.82	0.29	0.35	0.42	0.15	0.14	2.38	0.05	0.28	0.16	0.37
Male parents													
DA-13	0.07	-0.08	-0.13	0.22**	-0.73**	-0.11	0.25**	0.09*	-2.99**	-0.03*	0.49**	0.70**	-1.25**
DA-14	1.55**	-0.46*	0.33	0.06	0.13	-0.20	0.41**	-0.25**	8.95**	-0.13**	-0.37**	-0.20**	1.46**
DA-15	-1.61**	0.54**	-0.20	-0.28**	0.61**	0.31**	-0.66**	0.16**	-5.96**	0.16**	-0.12	-0.50**	-0.21*
GCA testers													
CD @ 1%	0.74	0.68	0.80	0.28	0.34	0.41	0.14	0.14	2.31	0.05	0.28	0.15	0.36
CD @ 5%	0.54	0.50	0.58	0.21	0.25	0.30	0.10	0.10	1.68	0.04	0.20	0.11	0.26

** - Significant at 1% probability level * - Significant at 5% probability level DA-Dharwad Avare

X_1 - Days to 50% flowering
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X_6 - Number of primary branches per plant
X_7 - Number of secondary branches per plant
X_8 - Pod length (cm)
X_9 - Number of pods per plant
X_{10} - Number of seeds per pod
X_{11} - 100 seed weight (g)
X_{12} - Protein content (%)
X_{13} - Seed yield per plant (g)

Table 3. SCA effects of hybrids for different yield and yield attributing traits in field bean over 13 different characters

Crosses	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
DA-7 x DA-13	-1.60**	-0.25	-0.71	2.26**	1.69**	-0.03	1.17**	-0.08	-2.13	0.00	-0.15	-0.12	2.89**
DA-7 x DA-14	-0.58	-1.87**	0.34	-1.55**	-0.04	-0.13	-0.66**	0.03	-0.77	0.05	0.36*	0.06	3.01**
DA-7 x DA-15	2.18**	2.12**	0.37	-0.72**	-1.65**	0.16	-0.51**	0.05	2.90	-0.06	-0.21	0.06	-5.90**
DA-8 x DA-13	1.03*	0.41	0.69	0.21	-0.37	-0.02	-0.20*	-0.16	2.04	0.03	-1.05**	0.63**	1.38**
DA-8 x DA-14	-1.95**	-2.20**	-1.14*	-0.37*	-0.74**	-0.50	-0.14	0.08	-4.25**	0.00	0.39*	0.14	2.42**
DA-8 x DA-15	0.93*	1.79**	0.44	0.16	1.11**	0.51*	0.34**	0.07	2.21	-0.03	0.66**	-0.76**	-3.79**
DA-9 x DA-13	-0.78	-0.25	-1.37*	0.56**	0.86**	-0.29	0.21*	0.25**	3.63*	-0.02	0.22	-0.48**	1.48**
DA-9 x DA-14	-0.25	2.13**	0.17	1.27**	0.50*	0.20	0.25**	-0.24*	-3.93*	0.11**	-0.54**	0.23*	-3.43**
DA-9 x DA-15	1.03*	-1.88**	1.20*	-1.82**	-1.36**	0.09	-0.46**	-0.02	0.30	-0.09*	0.32	0.25*	1.94**
DA-10 x DA-13	2.43**	-0.79	-0.18	-1.95**	-1.12**	0.48	-0.68**	-0.33**	1.61	0.05	-0.32	-0.26*	-2.50**
DA-10 x DA-14	1.95**	1.60**	-0.21	1.41**	1.80**	0.33	0.18	0.51**	-3.02*	-0.09**	0.17	0.04	-0.83**
DA-10 x DA-15	-4.39**	-0.81	0.39	0.54**	-0.68**	-0.81**	0.51**	-0.17*	1.41	0.04	0.14	0.22*	3.33**
DA-11 x DA-13	0.32	-0.29	0.08	-0.22	1.21**	-0.58*	-0.35**	0.23*	-2.80	-0.15**	1.18**	-0.05	-2.00**
DA-11 x DA-14	-2.29**	0.30	2.32**	-0.56**	-1.45**	0.24	0.49**	-0.18*	7.76**	0.08*	-0.34	0.20*	-1.71**
DA-11 x DA-15	1.97**	-0.01	-2.40**	0.78**	0.24	0.33	-0.14	-0.05	-4.95**	0.06	-0.84**	-0.15	3.71**
DA-12 x DA-13	-1.40**	1.16*	1.49**	-0.86**	-2.27**	0.43	-0.15	0.08	-2.35	0.09*	0.12	0.29**	-1.25**
DA-12 x DA-14	3.12**	0.05	-1.47**	-0.20	-0.06	-0.15	-0.11	-0.20*	4.22**	-0.16**	-0.05	-0.67**	0.54*
DA-12 x DA-15	-1.72**	-1.21**	-0.01	1.06**	2.33**	-0.29	0.26**	0.12	-1.87	0.08*	-0.07	0.38**	0.71**
S.Em±	0.62	0.58	0.67	0.24	0.29	0.34	0.12	0.12	1.95	0.04	0.23	0.13	0.30
CD @ 1%	1.80	1.67	1.95	0.69	0.84	1.00	0.35	0.33	5.66	0.12	0.68	0.38	0.88
CD @ 5%	1.31	1.22	1.42	0.50	0.61	0.73	0.25	0.24	4.12	0.09	0.49	0.27	0.64

** - Significant at 1% probability level * - Significant at 5% probability level DA-Dharwad Avare

X_1 - Days to 50% flowering
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X_{10} - Number of seeds per pod
X_{11} - 100 seed weight (g)
X_{12} - Protein content (%)
X_{13} - Seed yield per plant (g)

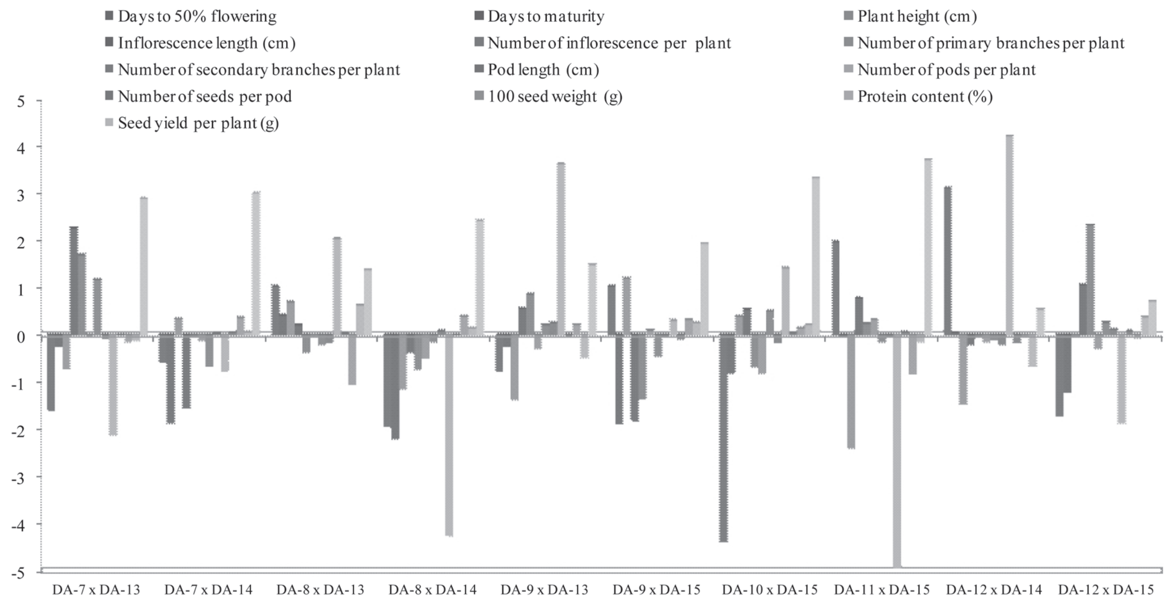

Fig. 1. Specific combining ability (sca) effects of top ten single cross experimental hybrids for seed yield per plant in field bean

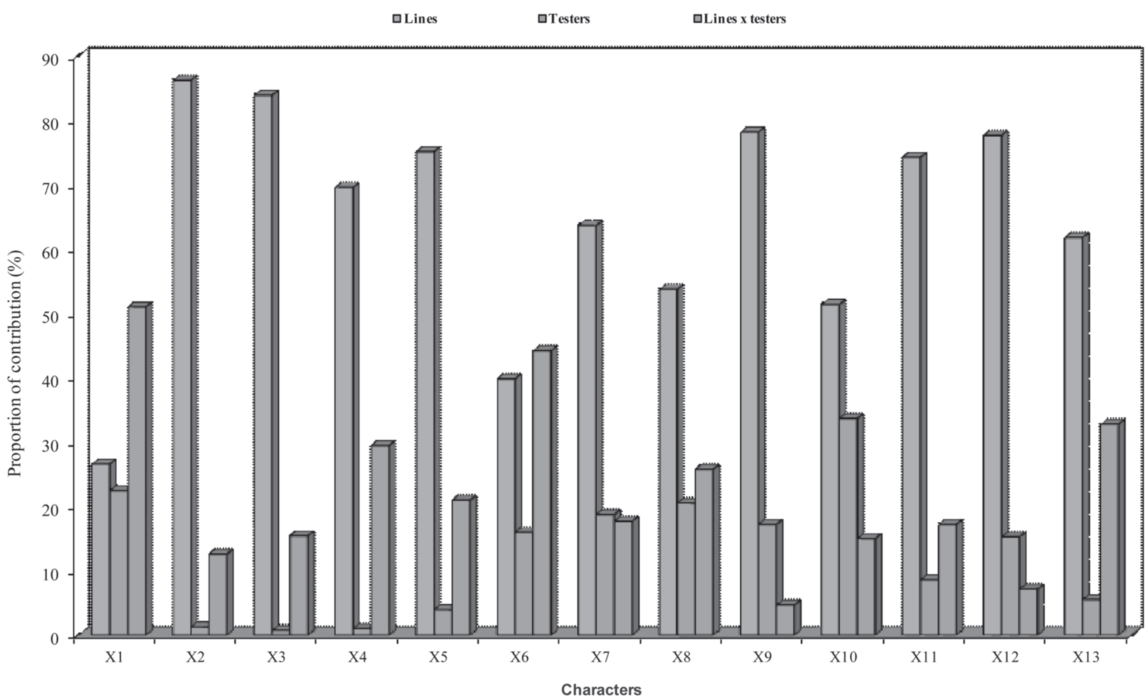

Fig. 2. Proportional contribution of lines, testers and their interaction to total hybrids variance in respect of 13 characters

expressed positive heterosis for this trait. The hybrid DA-11 x DA-13 has the parents with low SCA x high GCA effects. Test weight is one of the important yield attributing characters. The variance for combining ability indicated that GCA variance was lesser than SCA variance. This indicated that 100-seed weight was predominately governed by the dominant gene action in the present material under study; the similar report was noticed by Virja *et al.* 2006.

The GCA effect of the parents suggested that DA-12, DA-11 among females and DA-14 among males were the best general combiners. Ten hybrids recorded significant positive SCA effects and the highest SCA effect were resulted in the hybrids DA-11 x DA-15 followed by DA-10 x DA-15, DA-7 x DA-14 and DA-7 x DA-13. These hybrids also expressed positive heterosis for seed yield per plant. The hybrid DA-11 x DA-15 have high x low GCA combinations. These results in general indicated the possible relationship among SCA effect, heterosis and observed *per se* performance of the hybrids for this character. Seed yield forms the major objective in any plant breeding programme. The GCA variance was lesser than SCA variance. This suggests a strong influence of non-additive gene action in determining seed yield per plant as reported(Virja *et al.,* 2006). The hybrid DA-11 x DA-15 also included into the promising six crosses with regard to the *per se* performance and heterosis for days to maturity, inflorescence length and number of inflorescence per plant. Another promising hybrid DA-12 x DA-14 for seed yield also showed higher heterotic values for days to 50 per cent flowering, number of secondary branches per plant and number of pods per plant. These observations indicated the close association between 50 per cent flowering, days to maturity, inflorescence length, number of inflorescence per plant, number of secondary branches per plant and number of pods per plant. Results are in conformity with the findings of Virja *et al.,* 2006; Patil *et al.* 2013 and Das *et al.* 2014.

The best crosses for seed yield DA-11 x DA-15 and DA-8 x DA-14 involving parents having high x low and high x high GCA combinations respectively and incidentally, the SCA effects along with *per se* performance of these cross was also found to be high. Thus, it is evident that seed yielding ability of the cross is mainly due to both GCA and SCA effects. According to Patil *et al.,* 2013, the general combining ability is due to the additive factors and specific combining ability is due to the non-additive effects including dominance and epistasis. Hence in these cases, high seed yielding ability of the cross is due to additive as well as non-additive gene effects. These crosses can be recommended to be used in hybrid breeding programme.

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