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Line x Tester Analysis in Barley (*Hordeum vulgare* L.) Across Environments

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Abstract

A combining ability effects study was conducted through line x tester analysis under normal fertile and saline sodic soil environments. The results indicated the predominance of non-additive gene action for all the traits. The line Kedar and tester K-560 in normal fertile soil and tester Lakhan in saline sodic soil while RD-2552, Narendra Jau-4 and NDB-1173 under both environments proved good general combiners for seed yield and quality components characters. The crosses Kedar x K-560, K-603 x K-560, DL-88 x Lakhan and RD-2035 x K-560 in normal and RD-2552 x Narendra Jau-3, Narendra Jau-1 x K-560, Narendra Jau-4 x Lakhan, NDB-1173 x K-560, and RD-2624 x K-560, in saline sodic soil while RD-2552 x Lakhan, RD-2035 x Narendra Jau-3, BL-2 x Lakhan and Jagrati x K-560 in both environment exhibited highest sca effects for seed yield and other quality traits, showing their desirability to offer transgressive segregants in succeeding generations.

Key words: barley, combining ability, gene action, protein content, lysine content.

Introduction

Research on barley (*Hordeum vulgare* L.) bears special significance due to its great elasticity of adaptation under various stresses and lot of potential both for domestic and industrial uses. Barley also has been very important winter cereal crop in India , because of its versatile nature, lower cost of cultivation, superior nutritional qualities and many other uses. The major uses of barley grains, however are in the production of malt, which is used to make beer, beverage industrial alcohol, whisky, malt syrups, malted milk and vinegar. The spent malt after brewing is used as feed. Combining ability analysis helps in identification of desirable parents and crosses for their further exploitation in breeding programme. Therefore, the present study was undertaken to estimate combining ability effects for yield and quality components characters and also to identify suitable parents and crosses in barley under normal fertile and saline soil environments.

Materials and Methods

The material consisted of 15 lines, namely RD-2552, Narendra Jau-1, Narendra Jau-2, Narendra Jau-4, RD-2035, BL-2, BH-512, Ratna, Kedar, Jagrati, DL-88, Azad, K-603, NDB-1173 and RD-2624 with 3 testers viz., Narendra Jau-3, K-560 and Lakhan crosses were attempted in line x tester fashion. The resulting 45 F_{1s} along with lines and testers were planted in a randomized block design with three replicates during *rabi* 2004-2005 under normal fertile soil and saline sodic environments at Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad. Each treatment (genotype) was shown in 3 m length having row to row and plant to plant distance of 25 cm and 10 cm, respectively. The observations were recorded on days to maturity, plant height (cm), number of effective tillers/plant, length of main

spike (cm), grains per spike, seed yield/plant (g), 1000 seed weight (g), pelshenke value (minutes), protein content (%), lysine content (%) and husk content (%) on five randomly selected plants from each replication and environments. The combining ability analysis was carried out following the method proposed by (Kempthorne,1957).

Results and Discussion

The analysis of variance for combining ability for eleven characters showed that variances due to gca and sca were significant for the characters like days to maturity, plant height, length of main spike, grains per spike, seed yield per plant, 1000 seed weight, pelshenke value, protein content and husk content under both normal fertile and saline sodic soil conditions, suggesting thereby importance of both additive and non additive gene actions for the inheritance of these characters. The role of both additive and non-additive effects to grain yield and its component characters in barley have been reported previously (Choo *et al.*,1988; Bhatnagar and Sharma1995;1998). However, the component of variation due to sca was higher than gca for all the characters in all the environments indicating the predominance of non-additive gene action. Such results infers that the chosen material had high selection history. Similar results of predominance of sca variance over gca variance have also been reported by (Guo and Xu,1994; Phogat *et al.*1995; Madic,1996; El-Seidy,1997a & 1997b; Bouzerzour and Djakoune,1998).

A perusal of the gca estimates (Table1) showed that the parents RD-2552, Narendra Jau-4, NDB-1173 in both environments while, Kedar & K-560 in E_1, and Lakhan in E_2 were the best combiners for seed yield and good/ medium combiner for most of the important yield and quality component characters. Further the parents Ratna, Narendra Jau-1, RD-2552, Narendra Jau-3, Narendra Jau-1 for early maturity, Lakhan, Narendra Jau-1 for dwarf plant height, Azad, RD-2624, NDB-1173 and Ratna for high protein content and Narendra Jau-1, Narendra Jau-2 and Lakhan for high lysine content were found to be good general combiners in both the environments.

Significant gca values indicated the importance of additive or additive x additive gene effect as earlier reported by (Griffing,1956). In view of this, these parents offered the best possibilities for the development of improved lines of barley through hybridization programme. It is, therefore, recommended that to improve yield one should breed for superior combining ability for the component traits with an ultimate objective to improve the pace of its genetic improvement.

The estimates of specific combining ability effects of top five ranking crosses for all the characters are present in Table 2. The perusal of sca effects revealed that crosses Kedar x K-560, K-603 x K-560, DL-88 x Lakhan RD-2552 x K-560 in normal and RD-2552 x Narendra Jau-3, Narendra Jau-1 x K-560, Narendra Jau-4 x Lakhan, NDB-1173 x K-560 & RD-2624 x K-560 in saline sodic and RD-2552 x Lakhan, RD-2035 x Narendra Jau-3, BL-2 x Lakhan and Jagrati x K-560 under both environments were for seed yield per plant and with other characters. The crosses RD-2035 x Narendra Jau-3 and BL-2 x Lakhan are excellent crosses for seed yield in both environments. Therefore, these crosses should be particularly exploited vigorously in future breeding programmes to obtain good segregants which would lead to buildup a population with high genetic yield potential with develop salt tolerant genotypes.

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Table 1. Estimates of general combining ability (gca) effects of parents (lines & testers) for 11 characters in barley under normal fertile soil condition (E_1) & saline sodic soil condition (E_2)

Parents	Environ-ments	Days to maturity	Plant height (cm)	No. of effective tillers /plant	Length of main spike (cm)	Grains /spike	Seed yield/ plant (g)	1000 seed weight (g)	Pelshenke value (minute)	Protein content (%)	Lysine content (%)	Husk content (%)
Kedar	E_1	0.63**	3.45**	0.40*	-0.18*	-0.71	1.02*	1.10*	6.58**	0.39**	-0.12**	2.30**
	E_2	1.23**	5.76**	0.26	-0.13	-0.72	0.73	0.99**	5.25**	0.27**	-0.26**	1.35**
K-603	E_1	-0.12	-0.62	0.20	-0.26**	-3.08**	-0.45	-1.04*	-1.92*	0.26**	-0.18**	0.13
	E_2	-1.27**	3.62**	-0.27	-0.60**	-5.51**	-1.58**	-1.67**	-1.67	0.26**	-0.13**	0.44*
DL-88	E_1	0.63**	3.85**	-1.02**	-0.63**	-4.14**	-3.04**	-0.74	0.33	-0.21**	0.02	-1.67**
	E_2	-0.19	3.40**	-0.34	-0.46**	-1.82*	-0.77	-0.86**	0.58	-0.32**	0.07**	-1.23**
RD-2552	E_1	-0.62**	-4.96**	0.14	0.04	6.76**	1.19*	-1.11*	-9.92**	-0.68**	0.25**	-1.88**
	E_2	-0.69**	-2.65**	0.37*	0.11	4.37**	1.83**	-0.83**	-7.58**	-0.52**	0.33**	-1.15**
Azad	E_1	2.21**	-6.84**	-0.11	0.17*	4.86**	0.53	0.11	7.16**	2.06**	-0.59**	1.24**
	E_2	2.56**	0.42	0.08	0.18	5.20**	0.57	0.08	6.17**	1.94**	-0.53**	0.93**
Narendra Jau -1	E_1	-0.62**	-2.76**	0.34*	0.32**	-0.54	0.54	0.55	-0.34	-1.38**	0.56**	-0.23
	E_2	-0.52*	-4.57**	0.29	0.19	1.50	0.71	0.67**	0.42	-0.49**	0.59**	-0.60**
Narendra Jau -2	E_1	-1.54**	3.59**	0.08	0.80**	1.23	0.48	0.28	-3.42**	-1.68**	0.51**	1.50**
	E_2	0.06	-4.55**	0.33	0.49**	0.34	0.46	0.14	-3.25**	-1.77**	0.52**	1.44**
Narendra Jau -4	E_1	0.29	-2.66**	1.31**	0.65**	4.73**	3.54**	-0.32	-6.76**	-1.01**	0.34**	0.35
	E_2	1.14**	2.68**	0.50**	0.50**	1.78	0.90*	-0.29	-6.83**	-1.05**	0.10**	0.69**
NDB-1173	E_1	-2.71**	-1.98**	-0.11	0.71**	6.99**	2.14**	1.75**	-1.76*	0.93**	-0.28**	-1.99**
	E_2	-2.11**	-4.08**	0.00	0.52**	6.08**	1.24**	2.09**	-1.67	0.99**	-0.32**	-1.98**
RD-2035	E_1	0.13	0.22	-0.21	-0.23*	4.15**	0.66	-0.99*	-2.34**	-0.35**	0.11**	1.05**
	E_2	-0.36	-1.69**	0.09	-0.15	3.43**	0.02	-0.94**	-2.08*	-0.46**	0.12**	0.98**
RD-2624	E_1	0.71**	-3.44**	-0.45**	-0.38**	-9.32**	-3.52**	-1.60**	0.08	1.63**	-0.40**	-0.63**
	E_2	-0.19	-0.77	-0.60**	-0.05	-3.70**	-2.36**	-1.47**	0.33	1.54**	-0.35**	-0.40
BL-2	E_1	1.54**	1.89**	0.43*	-0.13	-2.49*	0.63	0.29	3.24**	-0.09*	-0.03	-1.33**
	E_2	0.23	-2.29**	0.36*	-0.08	-3.35**	0.66	0.03	3.33**	-0.18**	-0.04**	-1.35**
Jagrati	E_1	1.13**	4.50**	-0.26	-0.32**	-4.47**	-1.22**	1.20**	1.24	-0.30**	0.15**	0.93**
	E_2	1.39**	-2.44**	-0.45*	-0.21	-3.45**	-0.98*	1.12**	1.58	-0.47**	0.18**	0.69**
BH-512	E_1	-0.12	7.09**	-0.31	-0.36**	1.19	-0.74	0.03	0.99	0.02	-0.05	2.49**
	E_2	0.31	4.29**	-0.18	-0.35*	0.12	-0.41	0.12	-0.33	-0.07**	-0.03*	2.14**
Ratna	E_1	-1.54**	-1.34*	-0.44**	-0.21*	-5.17**	-1.75**	0.49	6.83**	0.41**	-0.29**	-2.26**
	E_2	-1.61**	2.87**	-0.45*	0.04	-4.27**	-1.04*	0.83**	5.75**	0.33**	-0.25**	-1.94**
SE (gi) lines	E_1	0.22	0.64	0.17	0.09	0.97	0.45	0.45	0.75	0.04	0.03	0.21
	E_2	0.22	0.52	0.17	0.13	0.93	0.45	0.21	0.88	0.03	0.01	0.20
SE(gi-gj) lines	E_1	0.31	0.90	0.23	0.13	1.37	0.64	0.64	1.05	0.06	0.04	0.30
	E_2	0.31	0.74	0.25	0.19	1.31	0.64	0.30	1.24	0.04	0.02	0.29
K-560	E_1	0.88**	1.83**	0.27**	0.18**	0.68	0.76**	0.19	-5.77**	0.18**	-0.04**	-1.20**
	E_2	1.31**	-0.87**	0.07	0.05	0.41	0.41	-0.22*	-5.17**	0.14**	-0.06**	-0.87**
Narendra Jau-3	E_1	-0.81**	2.69**	0.31**	0.09	-0.18	0.21	0.24	1.94**	0.07**	-0.06**	0.17
	E_2	-0.36**	0.59*	-0.04	0.08	0.48	-0.02	0.17	1.97**	0.34**	-0.11**	-0.12
Lakhan	E_1	0.10	-6.63**	-0.90**	-0.16**	0.79	-1.11**	-0.42	2.30**	-0.44**	0.22**	1.37**
	E_2	0.02	-0.70*	0.17	-0.05	0.09	0.78**	0.15	2.06**	-0.60**	0.26**	1.40**
SE (gi) testers	E_1	0.11	0.33	0.09	0.05	0.5	0.23	0.23	0.39	0.02	0.02	0.11
	E_2	0.11	0.27	0.09	0.07	0.48	0.23	0.11	0.45	0.01	0.01	0.10
SE(gi-gj) testers	E_1	0.16	0.46	0.12	0.06	0.71	0.33	0.33	0.54	0.03	0.02	0.15
	E_2	0.16	0.38	0.13	0.10	0.68	0.33	0.15	0.64	0.02	0.01	0.15

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

Table 2. Promising crosses for seed yield and quality component in barley under normal fertile soil and saline sodic soil condition.

Characters	Normal fertile soil environment	Saline sodic soil environment
Days to maturity	Kedar x Lakhan, RD-2552 x K-560, RD-2552 x Narendra Jau-3, Narendra Jau-1 x K-560, RD-2624 x Lakhan	K-603 x K-560, RD-2624 x Lakhan, Narendra Jau-1 x K-560, Kedar x Lakhan, Jagrati x Narendra Jau-3
Plant height (cm)	Jagrati x Lakhan, BL-2 x Lakhan, Narendra Jau-2 x Lakhan, RD-2035 x Lakhan, Kedar x Narendra Jau-3	Ratna x Narendra Jau-4, BL-2 x Lakhan, DL-88 x K-560, RD-2035 x Lakhan, RD-2624 x Lakhan
Number of effective tillers/plant	RD-2035 x K-560, BL-2 x Narendra Jau-3, Jagrati x K-560, BL-2 x Lakhan	Narendra Jau-1 x K-560, Narendra Jau-4 x Lakhan, NDB-1173 x K-560, RD-2035 x Narendra Jau-3
Length of main spike (cm)	K-603 x K560, K-603 x Narendra Jau-3, DL-88 x Lakhan, RD-2035 x K-560,Jagrati x K-560	DL-88 x Lakhan, NDB-1173 x Lakhan, RD-2035 x Lakhan
Grains/spike	BL-2 x Lakhan, Kedar x K-560, K-603 x K-560, DL-88 x Lakhan, RD-2035 x Lakhan	BL-2 x Lakhan, RD-2624 x K-560, DL-88 x Lakhan, Narendra Jau-4 x Narendra Jau-3, RD-2035 x Narendra Jau-3
Seed yield per plant (g)	BL-2 x Lakhan, RD-2035 x Narendra Jau-3, Jagrati x K-560, RD-2552 x Lakhan, Kedar x K-560	Narendra Jau-1 x K-560, Narendra Jau-4 x Lakhan, NDB-1173 x K560, RD-2053 x Narendra Jau-3, BL-2 x Lakhan
1000-seed weight (g)	BL-2 x Lakhan, Jagrati x K-560, RD-2035 x Narendra Jau-3, Narendra Jau-4 x Lakhan,	BL-2 x Lakhan, Narendra Jau-4 x Lakhan RD-2552 x Narendra Jau-3, RD-2035 x Narendra Jau-3, Jagrati x Narendra Jau-3
Pelshenke value (minute)	Narendra Jau- 1 x K-560, RD-2552 x K-560, RD-2624 x Lakhan, Narendra Jau- 4 x K-560, BL-2 x Narendra Jau-3	RD-2552 x K-560, Narendra Jau- 4 x Lakhan, RD-2552 x Narendra Jau-3, RD-2035 x Narendra Jau-3, Jagrati x Narendra Jau-3
Protein content (%)	RD-2552 x K-560, Narendra Jau-4 x K-560, Kedar x Narendra Jau-3, BH-512 x Lakhan, Ratna x K-560	Narendra Jau-4 x K-560, RD-2552 x K-560, K-603 x Narendra Jau-3, NDB-1173 x K-560, Kedar x Narendra Jau-3
Lysine content (%)	DL-88 x K-560, Kedar x K-560, K-603 x K-560, RD-2035 x Narendra Jau-3, RD-2552 x Lakhan	K-603 x K-560, DL-88 x K-560, Narendra Jau-4 x Lakhan, Kedar x Lakhan, Narendra Jau-4 x Narendra Jau-3
Husk content (%)	Narendra Jau-2 x Narendra Jau-3, Kedar x Narendra Jau-3, K-603 x K-560, Azad x K-560, DL-88 x K-560	Narendra Jau-2 x Narendra Jau-3, Kedar x Narendra Jau-3, Narendra Jau-4 x Narendra Jau-3, K-603 x K-560, DL-88 x K-560