Indian Journal of Agricultural Sciences **83** (1): 96–8, January 2013/Article

Combining ability analysis for grain yield and its components in malt barley (*Hordeum vulgare*)

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Received: 29 May 2011; Revised accepted: 20 November 2012

ABSTRACT

Combining ability analysis in barley (*Hordeum vulgare* L.) involving seven diverse elite lines suitable for malting and their 21 F_1s generated in half diallel fashion, indicated significant differences among the genotypes for all the seven traits studied. Analysis of variance for combining ability revealed that variances due to *gca* as well as *sca* were highly significant for different traits except spike length. The preponderance of non-additive gene effects for grain yield and of additive gene effects for yield components were detected. Based on the estimates of *gca* effects, good general combiners were identified for different traits. Similarly based on *sca* effects, desirable specific combiners were identified. It was noted that good specific combiners did not necessarily involve good general combiners.

Key words: Barley, Combining ability, gca, Gene effects, *Hordeum vulgare*, sca

Barley (*Hordeum vulgare* L.) is one of the most ancient cereal crops, evolved primarily from a food crop to a feed and malting/brewing/distilling crop over time. It is one of the most genetically diverse cereal grains. Barley is classified as spring or winter type, two-row or six-row, hulled or hull less and malting or feed barley. Its diverse uses necessitate to breed varieties suitable for specific end use purpose. Depending upon usage barley varieties are mainly classified as feed barley and malt barley.

A thorough understanding of the genetics and related aspects of a crop is necessary for improvement of yield and quality parameters. Progress in yield improvement or quality traits of a crop requires information about the nature of combining ability of parents to be involved in the hybridization programme along with the nature of gene effects operative in the inheritance of different traits. General and specific combining ability effects are very important in designing and execution of a breeding programme. Diallel analysis following Griffing (1956) has been extensively used by plant breeders for the selection of parents for hybridization as this analysis provides a unique opportunity to test a number of parental lines in all possible combinations for their combining ability effects. This analysis besides providing reliable information on the combining ability of parents to produce superior progenies, also detect the estimates of additive and non-additive gene effects. Thus, the present study was conducted to identify the best combiners and their crosses based on general and specific combining ability effects for yield and its component traits in malt barley.

MATERIALS AND METHODS

The experimental material for the present investigation consisted of seven elite barley lines suitable for malting (DWRUB 52, UBE 1010, PL 768, BL 335, BH 546, K 729 and RD 2668) which were crossed in a half diallel fashion to produce a set of 21 hybrids. Seven parents along with 21 F1s were planted in a randomized block design with two replications during *rabi* 2009–10 at Experimental Farm of Punjab Agricultural University, Ludhiana, Punjab in a plot 2.30 m × 1.20 m with 23 and 10 cm spacing between row to row and plant to plant, respectively. The recommended package of practices was followed to raise healthy crop. Data were recorded on five randomly selected plants for grain yield/plot (g), days to 50% flowering, tillers/plant, plant height (cm), spike length (cm), spikelets/spike, and 1 000-grain weight (g). Combining ability analyses were carried out as per the method of Griffing (1956).

RESULTS AND DISCUSSION

Analysis of variance revealed significant differences

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Table 1 Analysis of variance for yield and its components in barley

Source of variation	df	Mean sum of squares						
		Grain yield (g)	1 000-grain weight (g)	Tillers/ m	Spikelet spike	Spike length (cm)	Plant height (cm)	Days to flowering
Replications	1	114.29	0.55	0.55	5.79	1.29	598.02	5.77
Genotypes	27	732.87**	0.52**	48.42**	9.37**	1.09*	144.13**	169.75**
Error	27	61.51	0.00	12.82	1.38	0.56	43.35	0.97

*Significant at 5% level,; **significant at 1% level

among genotypes for all the traits studied indicating the presence of sufficient diversity in the material under study (Table 1). Significant differences among genotypes for grain yield and related traits in different sets of material were also reported earlier by Kudla *et al.* (1988), Bhatnagar and Sharma (1995), Sharma *et al.* (2003a and 2003b) and Singh *et al.* (2007).

Analysis of variance for combining ability revealed that variances due to general combining ability (*gca*) as well as due to specific combining ability (*sca*) were highly significant for all the traits except spike length (Table 2). Thus, both additive and non-additive gene effects were important in the genetic control of different traits. Comparison of *gca* and *sca* variance indicated the preponderance of non-additive gene effects for yield and additive gene effects for other traits. The preponderance of non-additive gene effects for yield were also reported by Phogat *et al.* (1995), Sharma *et al.* (2003b) and Verma *et al.* (2007), while of additive gene effects for yield components was reported by Kalashnik and Smyalovskaya (1986), Yang and Lu (1991) and Singh *et al.* (2007).

The estimates of general combining ability (*gca*) effects (Table 3) revealed that DWRUB 52 was a good general combiner for 1000-grain weight and spikelets/spike; UBE 1010 for grain yield and spike length; PL 768 for tillers/meter and dwarfness (reduced height); BL 335 for 1000-grain weight; dwarfness and early flowering; BH 546 for tillers/meter; K 729 and RD 2668 for 1000-grain weight and early flowering. It was noted that none of the parents proved to be good general combiner for grain yield along with dwarfness and early flowering. For each of spikelets/spike and spike length traits only single good general combiner could be identified.

Top three crosses with significant *sca* effects for different traits in the desirable direction are listed in Table 4. It was noted that parents involved in these crosses were not

Table 2 Analysis of variance for combining ability of yield and its components in barley

Source of variation	df	Mean sum of squares						
		Grain yield (g)	1 000-grain weight (g)	Tillers/ m	Spikelet spike	Spike length (cm)	Plant height (cm)	Days to flowering
gca	6	332.17**	0.35**	40.00**	9.92**	0.65	88.05**	159.22**
sca	21	376.23**	0.23**	19.70**	3.19**	0.51	67.50**	63.64**
Error	27	30.75	0.00	6.41	0.69	0.28	21.68	0.49

** Significant at 1% level

Table 3 Estimates of general combining ability (*gca*) effects for yield and its components in barley

Genotype	Mean sum of squares						
	Grain yield (g)	1 000-grain weight (g)	Tillers/ m	Spikelets/ spike	Spike length (cm)	Plant height (cm)	Days to flowering
DWRUB 52	0.55	0.04**(G)	0.34	1.80**(G)	– 0.44*(P)	2.67	8.54**(P)
UBE1010	6.67** (G)	– 0.07**(P)	– 1.21	0.02	0.40*(G)	4.55**(P)	0.37
PL 768	– 9.44** (P)	– 0.25** (P)	1.71*(G)	0.25	0.12	– 3.00*(G)	– 0.13
BL 335	– 6.11**(P)	0.33**(G)	– 4.01**(P)	0.13	0.20	– 3.94* (G)	– 3.51**(G)
BH 546	– 1.39	– 0.19**(P)	2.10*(G)	0.30	– 0.07	1.94	0.71**(P)
K7 29	5.55**(G)	0.11**(G)	– 0.21	– 1.42**(P)	– 0.16	– 1.22	– 4.07**(G)
RD 2668	4.17* (G)	0.03* (G)	1.28	– 1.09**(P)	– 0.05	– 1.00	– 1.90**(G)
SE (gi)	1.71	0.05	0.78	0.25	0.16	1.43	0.21

*Significant at 5% level; **significant at 1% level

(G) and (P) represent good and poor general combiners, respectively

Table 4 Hybrid showing high *sca* effects for different trails in barley

Character	Cross	*sca* effect	gca status of parents
	PL 768 × BL 335	36.80**±4.26	Poor × Poor
Grain yield	BL 335 × K 729	26.80**±4.26	Poor × Good
	PL 768 × K 729	22.64**±4.26	Poor × Good
1 000-grain weight	BL 335 × K 729	0.62**±0.11	Poor × Good
	UBE 1010 × K 729	0.55**±0.11	Good × Good
	PL 768 × K 729	0.48**±0.11	Poor × Good
Tillers/m	PL 768 × BH 546	9.88**±1.93	Good × Good
	DWRUB 52 × UBE 1010	6.96**±1.93	Average × Average
	K 729 × RD 2668	6.42**±1.93	Average × Average
Spikelets/spike	DWRUB 52 × RD 2668	2.75**±0.64	Good × Poor
	PL 768 × RD 2668	2.30**±0.64	Average × Poor
	PL 768 × K 729	2.14**±0.64	Average × Poor
Spike length	PL 768 × RD 2668	1.56**±0.40	Average × Average
	PL 768 × BH 546	0.84*±0.40	Average × Average
	UBE 1010 × BH 546	0.81*±0.40	Good × Average
Plant height	K 729 × RD 2668	– 8.65*±3.55	Average × Average
	DWRUB 52 × RD 2668	– 8.54*±3.55	Average × Average
	PL 768 × BH 546	– 7.32*±3.55	Good × Average
Days to flowering	UBE 1010 × RD 2668	– 10.86**±0.53	Average × Good
	PL 768 × BH 546	– 8.47**±0.53	Average × Poor
	UBE 1010 × PL 768	– 8.14**±0.53	Average × Average

*Significant at 5% level; **significant at 1% level

necessarily good general combiners. Rather the crosses involved mostly average and poor combiners. In some cases none of the parents involved in the cross is a good combiner. The extreme case is of cross PL7 68 × BL 335 which showed high *sca* effect for grain yield and involved both the poor combiner parents. It might have happened due to gene interaction as the two parents involved being good combiners for tillers/m and 1 000-grain weight might have contributed to grain yield in the hybrid. As top three hybrids for grain yield involved only three parents, viz. PL 768, BL 335 and K 729 in different combinations, so it may be inferred that a three way cross of these parents might produce a still better hybrid and transgressive segregants. However for individual traits best crosses are those having high *sca* effects along with both the parents involved with high *gca* effect. In the present study such crosses are BL 335 × K 729 for 1 000-grain weight and PL 768 × BH 546 for tillers/m. Such genotypes/crosses may be useful to evolve desirable hybrid and transgressive segregants or in population improvement programmes.

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