https://doi.org/10.29321/MAJ.10.A02643

Madras agric. J. 70. (7) : 441—445 July 1983

COMBINING ABILITY IN BARLEY BREEDING

R. P. SINGH

Combining ability was studied for grain yield and its component using the F_1, F_2 and F_3 of a 6 x 6 diallel set in barley. Both GCA and SCA variances were significant for all the traits in each generation. The GCA effects were associated with *per se* performance of parents for almost all the traits. Jyoti, DL 70 and PL 102 were found to be good general combiners for most of the characters and thus, could be used effectively in a barley breeding programme. Significant and desirable SCA effects for grain yield revealed that seven, six and five crosses in F_1, F_2 and F_3 respectively, involved high x high and high x low general combiners. Jyoti x DL 70, PL 102 x DL 70 and Jyoti x PL 102 in each generation involved parents of high x high general combiners. These hybrids showed high mean coupled with significant SCA effects in F_2 and F_3 which reflected the presence of additive x additive interaction effects. Therefore, it is expected that better strains may be obtained in advanced generations through standard selection procedures. Some of the crosses involved high x low general combiners Such crosses may throw out desirable transgressive segregates.

Combining ability analysis helps plant breeder in identifying potential parents either to be used for heterosis breeding or for hybridization and selection of desirable homozygous lines from segregating generations of their crosses. However, the extent to which the estimates would be useful will depend upon the stability of the estimates. In comparision to F_1 diallel, limited information is available in F_2 and F_3 generations. In order to fill this lacunae, an investigation was undertaken to study the combining ability in F_1, F_2 and F_3 generations for yield and its components using a 6 x 6 diallel set involving barley cultivars.

MATERIAL AND METHODS

Six barley cultivars, Jyoti, K 252, BH 13, PL 102, DL 70 and P 100 were crossed in all possible combinations without reciprocals. The F_1's, F_2's, F_3's and parental populations were grown during rabi 1978-79 in a randomized block design with three replications, keeping single row of parents and F_1's and two rows of F_2's and F_3's with three meter row length. The spacing within and between rows was 10x30 cm Observations were recorded from 10 (Parents and F_1's) and 20 (F_2's and F_3's) plants taken at random for days to heading, plant height (cm), number of productive tillers/plant, length of spike (cm), number of grains/spike, 1,000-grain weight (g) and grain yield/plant (g). The combining ability analyses were done according to Model, I, Method 2 of Griffing (1956).

*Department of Agricultural Botany, S. D. J. Post Graduate College, Chandeshwar, Azamgarh, U P.

RESULTS AND DISCUSSION

The variances due to GCA and SCA were highly significant in each generation (F_1, F_2 and F_3) for all the characters (Table 1). However, the variation due to SCA was greater than due to GCA for length of spike and 1,000-grain weight in each generation. These results indicated that (i) parents and crosses differed significantly in their combining ability effects, (ii) additive and non-additive genetic components played significant role in bringing out heterotic effects and (iii) the presence of more additive genetic variance for majority of the traits under study. Earlier studies by Verma and Gulati (1976) and Borthakur (1977) also showed predominantly additive genetic control for one or more of these characters.

An examination of GCA effects (Table 2) revealed that the *per se* performance of parents was related with their general combining ability for all the traits in each generation except BH 13 for number of productive tillers in F_2 and F_3 generations. In no case the poor *per se* performers were the top general combiners. Thus, if a character is unidirectionally controlled by alleles and additive effects are important, the choice of parents on the basis of *per se* performance may be effective. Jain (1974) also observed a close association between *per se* performance of parents and their GCA effects in wheat.

Some parents like, PL 102 for productive tillers and 1,000-grain weight and DL 70 for spike length were the best general combiners which are the direct components of yield. Moreover, these parents were not best combiners for yield itself. It may be due to mutual cancellation of the contribution by other characters towards total yield. Considering the performance of parents and their GCA effects in each generation, it was observed that Jyoti, DL70 and PL 102 are superior for several characters including yield.

Jinks and Jones (1958) suggested that the superiority of hybrids *per se* might not indicate their ability to produce transgressive segregates due to non-fixable effects. Therefore, in an autogamous crop like barley, a study of segregating generations for SCA effects would be important. SCA effects for F_1, F_2 and F_3 were worked out but only significant and desirable crosses were taken (Table 3). Seven, six and five crosses in F_1's, F_2's and F_3's respectively as judged from significant and desirable SCA effects for grain yield/plant involve the parents of high x high and high x low general combiners. The hybrids Jyoti x DL 70, PL 102 x DL 70 and Jyoti x PL 102 showed significant and desirable SCA effects in F_1 and high mean coupled with significant SCA estimates in F_2 and F_3 generations indicated the involvement of additive x additive interaction effects. These crosses also showed high x high general combiners for desirable yield components even in F_2 and F_3 generations. Therefore, it becomes evident that better strains can be developed in advanced generations by standard selection procedures.

On the other hand, the crosses showing high SCA effects involving

Table: 1 Anova for Combining Ability in a 6x6 Diallel Cross in Barley-Mean Squares

Generation	Source	d.f	days to heading	Plant height	Number of productive tillers	Length of spike	Number of Grains per spike	1,000 grain weight	Grain yield per plant
F_1	GCA	5	1547.3**	45.3**	31.4**	0.85**	79.6**	872.7**	342.4**
	SCA	15	98.2**	39.2**	28.4**	1.6**	25.8**	1970.2**	210.4**
	ERROR	40	0.1	0.3	1.3	0.0	6.3	3.42**	2.1
F_3	GCA	5	1478.3**	60.3**	38.4**	1.4**	88.4**	947.2**	412.3**
	SCA	15	101.2**	31.3**	24.3**	3.2**	20.3**	1872.3**	376.4**
	ERROR	40	0·03	0.2	1.3	0.1	4.3	6.2	1.7
F_6	GCA	5	1506.4**	38.2**	36.2**	3.4**	59.4**	1012.4**	375.8**
	SCA	15	80.4**	20.3**	35.1**	5.7**	22.4**	1459.3**	215.4**
	ERROR	40	3.2	1.2	3.2	0.1	3.7	6.2	2.7

** Significant at P = 0.01.

one good and one poor general combiner, could produce desirable trans-gressive segregants, if the additive genetic system present in the good combiner and the complementary epistatic effects in the F_1's act in the same direction to maximise the desirable plant attributes. Therefore, in order to exploit the additive genetic variance, it is suggested to undertake *inter se* mating of these crosses in all possible combinations for multiple parents in put into a central gene pool which will supplement in faster speed of recombinations and also to break the genetic barriers if present. Redden and Jensen (1974) reported on the use of this method in wheat and showed that mass selection with concurrent random mating could be a useful breeding procedure.

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TABLE 2

Ranking of desirable parents and GCA effects in a 6 x 6 diallel cross of barley for seven traits (F_1F_2 and F_3)

Character	Best parent per se performance	Best General Combiners F_1	F_2	F_3	Best common parents in F_1 F_2 & F_3
Days to heading	Jyoti, BH 13, DL 70.	Jyoti**, DL 70**, BH 13**	Jyoti**, DL 70**, BH 13**	Jyoti**, DL 70**, BH 13*	Jyoti, DL 7., BH 13.
Plant height	Jyoti, DL 70, PL 102.	Jyoti** PL 102** DL 70*.	Jyoti** PL 102* DL 70*	Jyoti** PL 102**	Jyoti, PL 102.
Number of productive tillers	PL 102, DL 70, Jyoti, BH 13.	PL 102** DL 70** BH.13** Jyoti*	PL 102** DL 70** Jyoti**	PL 102** DL 70** Jyoti*	PL 102, DL 70, Jyoti.
Spike length	DL 70, BH 13, PL 102.	DL 70** PL 102**	DL 70** PL 102**	DL 70** PL 102*	DL 70, PL 102.
Number of grains/spike	Jyoti, DL 70	Jyoti**	De 70** Jyoti**	Jyoti** DL 70**	Jyoti, DL 70.
1,000-grain weight	DL 102, DL 70, Jyoti.	Jyoti** PL 102**	PL 102** Jyoti** DL 70.	PL 102** DL 70**	PL 102, DL 70.
Grain yield per plant	Jyoti, PL 102 DL 70.	Jyoti** DL 70* PL 102*	Jyoti** PL 102** PL 70*	Jyoti** DL 70** PL 102*	Jyoti, DL 70 PL 102.

*Significant at P = 0.05, **Significant at P = 0.01.

Table 3. Best specific combiners for grain yield/plant and their performance in other traits in a 6 x 6 diallel cross of Barley (F_1, F_2 and F_3)

Desirable cross	*Per se* Performance	SCA effects	GCA effect P_1	GCA effect P_2	Desirable SCA effects in other traits
F_1					
Jyoti x DL 70	53.2	11 45**	5.02**	4.26**	I (—0.76), II (3.98**), III (5.02**), IV (1.82), V (6.34**).
PL 102 x DL 70	51,3	10 36**	2.14**	4.26**	II (-3.42**), III (6.32**), IV (1.56**), V (7 46**), VI (3.86*)
Jyoti x PL 102	50 1	9.31**	5 02**	2.14**	I (—1.35**), IV (1.85**) V (7.31**).
PL 102 x P 100	48.7	7.48**	2.14**		IV (0.49*).
BH 13 x PL 102	49.2	6.32*	—	2.14**	I (—1.32**) III (4.14**), IV (4.45).
Jyoti x P 100	49.7	4.46*	5.02*	--	I (—1.92**), II (—5.89**), III (3,42**), V (0.85*)
DL 70 x P 100	48 2	3.39*	4 26**	—	I (—0.38).
F_2					
PL 102 x DL 70	48.3	12.76**	3 01**	4.21**	I (—3.46**), II (—3.42**), III (6.32**), IV (2.41**), V (6.04**), VI (4.35**).
Jyoti x DL 70	50 1	12.31**	4 72**	4.21**	I (—2 80**), II (—5.26**), III (2.85*), IV (1.62**), V (4.45**), VI (2.42).
Jyoti x PL 102	48 2	7.86**	4.72**	3 01**	I (—4.01**), II (1.46*), III (4.96**), IV (1.42*), VI (8 46**).
BH 13 x DL 70	37.4	4.77*	—	4.21**	III (3.28**), IV (1.41**).
DL 70 x P 100	41.4	4.32*	4.21**	—	I (—2.76**), IV (2.61**).
BH 13 x PL 102	40.9	3.89*	—	3.01**	I (2.45**), II (—6.49**), III (5.12**), IV (1.45**), VI (5.78**).
F_3					
PL 102 x DL 70	46.2	12.36**	2.72**	2.85**	I (—3.04*) II (2.84**), III (4.38), IV (4.32**), V (7.09**), VI (5.82**).
Jyoti x DL 70	47.2	10.73**	4.96**	2.85**	I (—2.98**), II (—7.36**), III (3.32**), IV (1.92**), V (4.65), VI (5.98*).
Jyoti x PL 102	43.4	8.38**	4.96**	2.72**	I (—3.37**), II (—2.89*), III (4.21*), IV (2.24**), V (6.25**).
BH 13 x PL 102	36.3	5.79*	—	2.72**	I (—3.01**), III (5.02**), VI (6.41**).
PL 102 x P 100	37.3	4.06*	2.72*	—	III (2.98), IV (3.42**), V (4.32*).

*Significant at P = 0.05 **Significant at P = 0.01.

I Days to heading
II Plant height
III Number of productive tillers
IV Length of spike.
V Number of grains/spike
VI 1,000-grain weight.