Plant Archives Vol. 26, Supplement 2, 2026 pp. 2471-2475 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.311

COMBINING ABILITY AND GENE ACTION IN BARLEY (*Hordeum vulgare* L.) FOR SEEDLING CHARACTERS

Suman Choudhary[1]*, D.K. Gothwal[1], Manohar Ram[1], G.K. Mittal[2], D.K. Jajoria[3] and B. L. Kakraliya[4]

[1]Department of Genetics and Plant Breeding, Sri Karan Narendra Agricultural University, Jobner-303329, Jaipur, Rajasthan, India

[2]Deparment of Biochemistry, Sri Karan Narendra Agricultural University, Jobner-303329, Jaipur, Rajasthan, India

[3]Department of Agronomy, Sri Karan Narendra Agricultural University, Jobner-303329, Jaipur, Rajasthan, India

[5] Retd. Professor, Plant Physiology, Sri Karan Narendra Agricultural University, Jobner-303329, Jaipur, Rajasthan, India

*Corresponding author E-mail: sumanchoudhary31210@gmail.com

(Date of Receiving : 26-04-2026; Date of Revision : 04-06-2026; Date of Acceptance : 29-06-2026)

ABSTRACT

The present investigation was conducted to assess combining ability and gene action in Barley (*Hordeum vulgare* L.) using a diallele mating design. The experimental material comprised eight genotypes, along with their twenty eight F_1s. Eight genetically diverse parents were crossed in diallel fashion excluding reciprocals during Rabi 2023–24. These genotypes, along with their F_1s were evaluated in a Completely Randomized Block Design with four replications in laboratory during Rabi 2024–25 at S.K.N. College of Agriculture, Jobner, Rajasthan. Observations were recorded for six seedling traits. Analysis of variance revealed significant genetic variability among genotypes, parents, and crosses for all characters except parents for seed germination. Combining ability analysis indicated that specific combining ability (SCA) variance was higher than general combining ability (GCA) variance for all the traits, suggesting the predominance of non-additive gene action. Several parents, notably RD-2052, RD-2624, RD-2899, DWRB-137 and RD-2508, were identified as good general combiners for most of the traits. Among the hybrids, RD-2035 x RD-2052, RD-2899 x BH-959, RD-2052 x BH-959, RD-2508 x DWRB-137 and RD-2035 x RD-2899 exhibited high and significant SCA effects for most of the traits.

***Keywords* :** *Hordeum vulgare* L., GCA, SCA, seedling

Introduction

Barley (*Hordeum vulgare* L.) is one of the most important cereal crop in the world. Rajasthan is most important and leading state for the barley cultivation in India. Rajasthan state contributes largest area, 329.79 thousand hectare (>54% of total area) and highest production, 1102.16 thousand tones (>%59 of total production) of the country with a productivity of 3342 kg/ha (Anonymous, 2024-25). It is mainly cultivated in Sriganganagar, Jaipur, Ajmer, Bhilwara, Sikar, Hanumangarh, Churu and Nagaur districts of the Rajasthan. Barley has a superior nutritional quality like acetylcholine substance (energize our nervous system and recover memory loss), low gluten, soluble and digestible fibers, lysine, thiamine, riboflavin, vitamin B_5 and also has antioxidant which improves our immune system (Kumari *et al*., 2020). The major components of barley grains are carbohydrate (78%), protein (10%), fat (1%), β-glucan (3.9%), crude fiber (5%) and 2% of calcium (Shaveta *et al*., 2019). Barley protein is rich in prolamin storage proteins (hordeins) and has moderate nutritional quality being particularly deficient in lysine (Pomeranz *et al.*, 1976; Jorgensen *et al*., 1999).

The assessment of seedling traits is important in barley breeding programmes because these traits are closely associated with early vigour, crop establishment and subsequent plant growth. Seedling characteristics such as seed germination, seedling length, seedling fresh weight, seedling dry weight, seedling vigour index-l and seedling vigour index-ll are considered reliable indicators of seedling vigour and stress tolerance. Knowledge of the genetic control of these traits helps breeders to identify superior parents and develop high-yielding genotypes with better adaptability. Therefore, the study of combining ability and gene action for seedling traits is complement for formulating effective breeding strategies and improving barley productivity.

Material and Methods

The eight parents were selected on the basis of diversity *viz.*, RD-2035, RD-2052, RD-2508, RD-2624, RD-2899, BH959, NDB1173 and DWRB137 crossed (*Rabi* 2023-24) in a diallele fashion excluding reciprocals. The eight parents and resultant twenty eight F_1's were grown in petridishes using 4 replications, in laboratory in CRD for seedling characters at Department of Genetics and Plant Breeding, S.K.N. College of Agriculture, Jobner, Jaipur, Rajasthan, India. Ten seeds from each genotype were placed in Petri dishes lined with two layers of Whatman No. 1 filter paper moistened with distilled water. The Petri dishes were incubated in a germination chamber maintained at 20 ± 2°C, 90% relative humidity, and a 12 h light/12 h dark photoperiod. Germination was recorded daily, and final observations were taken on the seventh day after sowing. The observations *viz.*, seed germination, seedling length, seedling fresh weight, seedling dry weight, seedling vigour index-I and seedling vigour index-II, were recorded on randomly selected five seedlings of each genotype in each replication except seed germination, which were recorded for all the planted seeds. The replication wise mean values of each genotype for various traits were subjected to statistical analysis as per the procedure as suggested by Panse and Sukhatme (1985) and Analysis of variance for combining ability by Griffing's (1956) Method II, Model I.

Results and Discussion

Analysis of variance (Table 1) revealed that significant differences existed between genotypes for all the characters studied *viz.* germination percentage, seedling length, seedling fresh weight, seedling dry weight, seedling vigour index-I and seedling vigour index-II. The analysis of variance revealed that there were significant differences among the genotypes including parents and F_1's for all the characters under investigation except parents for seed germination percentage. The significant differences stated wide diversity among parents and F_1's Similar findings were also reported for most of the characters studied in the present investigation by Gorny (2000), Akram *et al*. (2004), Malik *et al.* (2011), Awan *et al*. (2012), Malarvizhi *et al*. (2012) and Iqbal *et al*. (2017).

The mean sum of squares due to parents vs. F_1's displayed significant difference for all the studied characters except seed germination percentage, indicating that between parents and between hybrids difference was significant. These findings were in close agreement with those reported by Gorny (2000), Malik *et al.* (2011), Awan *et al*. (2012), Iqbal *et al*. (2017).

The combining ability analysis revealed that the GCA and SCA variances were significant for all the characters, indicating the importance of both additive and non-additive genetic control of all the characters under study (Table 2). This might be possible due to the parental line involved in the present investigation possessed high selection history for these traits. The results were in conformity with findings obtained by Akram *et al*. (2004) and Malarvizhi *et al*. (2012). The variances for SCA were higher than their respective GCA variances for all the characters, indicating that non-additive type of gene action played role in the expression of all these traits. Similar results were also reported by Gorny (2000). This indicated that the variances due to GCA and SCA had played an important role in buildup of the differences among the parents and crosses for the general and specific combining ability effects, respectively.

GCA/SCA ratio (predictability ratio) was less than unity for all the characters under study which indicated the preponderance of non-additive gene action in governing the inheritance of these traits. Such findings were also reported by Gorny (2000), Malik *et al.* (2011), Awan *et al*. (2012).

The combining ability effects were computed to obtain information on selection of suitable parents and their crosses for further use in future breeding programmes and tangible advancement of barley. Meanwhile, the significant differences were described for all the characters studied, desirable estimates of general combining ability effects (gi) of the parents and specific combining ability effects (sij) of the crosses in F_1generation for seedling characters (Table 3).

Among the genotypes top three parents and crosses on the basis of high mean, high GCA and high SCA were observed. For seed germination top three parents on the basis of high mean were NDB-1173, RD-2624 and RD-2035, top three high mean F_1's were RD-2508 x BH-959, RD-2899 x BH-959 and RD-2035 x RD-2052, top three high GCA parents were NDB-1173, BH-959 and RD-2035, top three high SCA F_1's were RD-2508 x DWRB-137, RD-2035 x RD-2052 and RD-2035 x RD-2899. For seedling length top three parents on the basis of high mean were RD-2899, DWRB-137 and RD-2052, top three high mean F_1's were RD-2052 x BH-959, BH-959 x NDB-1173 and RD-2035 x RD-2052, top three high GCA parents were RD-2052, RD-2899 and DWRB-137, top three high SCA F_1's were BH-959 x NDB-1173, RD-2035 x RD-2052 and RD-2035 x RD-2899.

For seedling fresh weight top three parents on the basis of high mean were RD-2624, DWRB-137 and RD-2899, top three high mean F_1's were RD-2052 x BH-959, RD-2899 x BH-959 and RD-2035 x RD-2052, top three high GCA parents were DWRB-137, RD-2624 and RD-2899, top three high SCA F_1's were RD-2052 x BH-959, BH-959 x NDB-1173 and RD-2035 x RD-2052. For seedling dry weight top three parents on the basis of high mean were RD-2052, DWRB-137 and RD-2624, top three high mean F_1's were RD-2035 x RD-2052, RD-2624 x DWRB-137 and RD-2508 x DWRB-137, top three high GCA parents were RD-2052, DWRB-137, and RD-2508, top three high SCA F_1's were RD-2035 x RD-2052, RD-2899 x BH-959 and RD-2899 x NDB-1173.

For seedling vigour index-I top three parents on the basis of high mean were RD-2624, RD-2899 and DWRB-137, top three high mean F_1's were RD-2052 x BH-959, RD-2508 x DWRB-137 and BH-959 x NDB-1173, top three high GCA parents were RD-2624, RD-2052, and RD-2899, top three high SCA F_1's were RD-2508 x DWRB-137, RD-2035 x RD-2052 and RD-2052 x BH-959. For seedling vigour index-II top three parents on the basis of high mean were DWRB-137, RD-2624, and RD-2052, top three high mean F_1's were RD-2035 x RD-2052, RD-2508 x DWRB-137 and RD-2899 x BH-959, top three high GCA parents were RD-2052, DWRB-137, and RD-2624, top three high SCA F_1's were RD-2035 x RD-2052, RD-2899 x BH-959 and RD-2508 x DWRB-137.

The involvement of these superior general combiners in high-performing crosses suggested that both parental breeding value and specific parental combinations contributed to enhanced seedling vigour.

Parents RD-2052, RD-2624, RD-2899, DWRB-137 and RD-2508 were good general combiners for seedling characters. An overall appraisal of general combining ability effects of parents revealed that RD-2052 was good general combiner for most of the seedling traits except seed germination and seedling fresh weight. Likewise, parents RD-2624 was found to be good general combiner for most of the traits except seed germination and seedling length. Parent RD-2899 was good general combiner for seedling length, seedling fresh weight and seedling vigour index-I. Parent DWRB-137 was good general combiner for seedling fresh weight, seedling dry weight and seedling vigour index-II . Parent RD-2508 was good general combiner for seedling dry weight and seedling vigour index-II . Good general combiner for these traits was also reported earlier by Akram *et al*. (2004), Malarvizhi *et al*. (2012) and Iqbal *et al*. (2017).

A perusal of data resulted that none of the crosses had high ranking sca effects for all the traits under study. The Crosses RD-2035 x RD-2052, RD-2899 x BH-959, RD-2052 x BH-959, RD-2508 x DWRB-137 and RD-2035 x RD-2899 revealed significant sca effects for most of the traits. An overall appraisal of specific combining ability effects of crosses revealed that RD-2035 x RD-2052 was good specific combiner for most of the traits except seedling fresh weight. Likewise, cross RD-2899 x BH-959 found was good specific combiner for most of the traits except seedling fresh weight and seedling dry weight. Cross RD-2052 x BH-959 was good specific combiner for seed germination, seedling fresh weight and seedling vigour index-I. The cross RD-2508 x DWRB-137 was good specific combiner for seed germination, seedling vigour index-I and seedling vigour index-II. The cross RD-2035 x RD-2899 was good specific combiner for seed germination and seedling vigour index-II.

Table 1 : Analysis of variance showing mean sum of square for seedling characters

Characters	**Source of variance**					
	Rep	**Genotypes**	**Parents**	**F_1**	**P vs F_1**	**Error**
df	(3)	(35)	(7)	(27)	(1)	(105)
Seed Germination (%)	59.95	243.08**	57.14	296.40**	104.96	29.95
Seedling length (cm)	4.57	62.58**	86.65**	34.47**	653.15**	3.06
Seedling fresh weight (mg)	0.28	5.00**	10.15**	0.84**	81.08**	0.39
Seedling dry weight (mg)	0.01	0.08**	0.09**	0.04**	1.21**	0.01
Seedling vigour index-I	105756.73*	914741.85**	682476.57**	807409.09**	5438583.38**	38706.14
Seedling vigour index-II	22.01	797.95**	864.66**	367.97**	11940.37**	26.43

*,** Significant at 5 per cent and 1 per cent levels, respectively.

Table 2: Analysis of variance for general and specific combining ability for seedling characters

Characters	Source of variance			GCA/SCA
	GCA	SCA	Error	
df	(7)	(28)	(105)	
Seed Germination (%)	53.17**	62.67**	7.49	0.02
Seedling length (cm)	8.46**	17.44**	0.77	0.01
Seedling fresh weight (mg)	0.88**	1.34**	0.10	0.02
Seedling dry weight (mg)	0.02**	0.02**	0.00	0.02
Seedling vigour index-I	103755.60**	259917.93**	9676.54	0.01
Seedling vigour index-II	112.66**	221.19**	6.61	0.01

**Significant at 1percent

Table 3: Estimates of general and specific combining ability effects for seedling characters

Genotypes	Seed Germination (%)	Seedling length (cm)	Seedling fresh weight (mg)	Seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II
GCA effects						
RD-2035	-1.06	-1.68**	-0.47**	0.01	-189.84**	0.27
RD-2052	-0.81	1.35**	0.11	0.05**	74.68*	4.06**
RD-2508	-0.31	0.02	0.00	0.02**	-0.07	1.69*
RD-2624	0.69	-0.01	0.26**	0.02*	90.73**	1.92*
RD-2899	-0.06	0.72**	0.25**	-0.04**	60.38*	-3.82**
BH-959	1.69*	-0.66*	-0.11	-0.06**	49.66	-5.33**
NDB-1173	3.94**	-0.23	-0.36**	-0.04**	37.88	-1.85*
DWRB-137	-4.06**	0.50	0.32**	0.05**	-123.42**	3.06**
SE(gi)	0.81	0.26	0.09	0.01	29.10	0.76
SE(gi-gj)	1.22	0.39	0.14	0.01	43.99	1.15
SCA effects						
RD-2035 x RD-2052	8.47**	3.19**	0.46	0.21**	599.86**	25.58**
RD-2035 x RD-2508	-22.03**	-0.35	-0.08	-0.05*	-839.64**	-14.85**
RD-2035 x RD-2624	1.97	-3.22**	-0.29	-0.06**	-102.19	-5.05*
RD-2035 x RD-2899	7.72**	-1.50	-0.12	-0.04*	181.66*	-0.54
RD-2035 x BH-959	-4.03	1.03	0.06	-0.01	-11.86	-2.45
RD-2035 x NDB-1173	3.72	3.03**	-0.08	-0.10**	336.66**	-8.26**
RD-2035 x DWRB-137	-3.28	-3.08**	-1.00**	-0.07**	-284.79**	-8.62**
RD-2052 x RD-2508	2.72	-3.51**	-0.48	-0.05*	-226.91*	-3.57
RD-2052 x RD-2624	1.72	0.82	-1.51**	-0.16**	110.79	-14.55**
RD-2052 x RD-2899	-2.53	-0.46	-0.57*	-0.04	-46.86	-4.49
RD-2052 x BH-959	5.72*	2.97**	0.56	-0.06**	415.36**	-3.08
RD-2052 x NDB-1173	0.97	-3.21**	-0.93**	-0.19**	-204.86*	-17.76**
RD-2052 x DWRB-137	-13.53**	-7.02**	-1.55**	-0.21**	-1097.06**	-24.29**
RD-2508 x RD-2624	1.22	2.71**	-1.04**	-0.04	264.79**	-2.67
RD-2508 x RD-2899	1.97	-4.85**	-1.20**	-0.15**	-591.61**	-13.06**
RD-2508 x BH-959	5.22*	-0.17	0.11	-0.03	117.61	-1.20
RD-2508 x NDB-1173	-4.53	-4.25**	0.24	-0.07**	-417.61**	-8.13**
RD-2508 x DWRB-137	10.97**	1.22	-0.47	0.04	620.69**	9.41**
RD-2624 x RD-2899	-4.03	-7.82**	-1.16**	-0.10**	-758.41**	-10.69**
RD-2624 x BH-959	1.72	-4.38**	-0.79**	-0.03	-374.19**	-2.38
RD-2624 x NDB-1173	1.97	-1.06	-0.27	-0.16**	-111.41	-14.67**
RD-2624 x DWRB-137	-15.03**	1.13	-0.59*	0.06**	-490.86**	-4.62
RD-2899 x BH-959	4.97*	0.23	0.03	0.10**	292.16**	11.56**
RD-2899 x NDB-1173	-7.28**	-1.52	0.08	0.09**	-293.06**	5.35*
RD-2899 x DWRB-137	5.72*	-1.88*	-0.82**	-0.10**	25.24	-6.91**
BH-959 x NDB-1173	0.97	4.06**	0.47	0.01	402.16**	1.08
BH-959 x DWRB-137	-11.03**	-2.67**	-0.18	-0.07**	-484.54**	-10.62**
NDB-1173 x DWRB-137	6.72**	-1.30	-0.10	-0.10**	60.24	-6.80**

Sii	2.16	0.69	0.25	0.02	77.59	2.03
Sij	2.48	0.79	0.28	0.02	89.20	2.33
Sij-ik	3.67	1.17	0.42	0.03	131.98	3.45
Sij-Skl	3.46	1.11	0.39	0.03	124.43	3.25

*,**Significant at 5 per cent and 1 per cent levels, respectively

Conclusion

The present study revealed significant genetic variability among barley genotypes for all seedling traits, indicating ample scope for genetic improvement. Combining ability analysis showed that both additive and non-additive gene effects were involved in the inheritance of these traits; however, non-additive gene action was predominant due to higher SCA variance than GCA variance. Parents RD-2052, RD-2624, RD-2899, DWRB-137, and RD-2508 were identified as good general combiners for most traits. The crosses RD-2035 × RD-2052, RD-2899 × BH-959, RD-2052 × BH-959, RD-2508 × DWRB-137, and RD-2035 × RD-2899 exhibited superior SCA effects and performance. These parents and crosses may be effectively utilized in barley breeding programmes aimed at improving seedling vigour and early establishment.

References

Akram, M., Munir, M. and Ajmal, S. U. (2004). Traits in rice (*Oryza Sativa* L.). *Pakistan Journal of Agricultural Research*, **18**(1), 65-77.

Anonymous (2024-25). Progress report of All India Coordinated Barley and Wheat Improvement Project. Indian Institute of Wheat and Barley Research, Karnal, India.

Awan, S. I., Ahmed, M. S., Farooq, J., Ahmad, S. D., Ilyas, M., Shah, A. H. and Hasan, L. (2012). Genetic model analysis on seedling and maturity traits in wheat under rainfed conditions. *Frontiers of Agriculture in China*, **5,** 486-496.

Gorny, A. G. (2000). The influence of nutrient shortage on the expression of combining ability effects for root characters in spring barley (*Hordeum vulgare* L.). *Journal of Applied Genetics*, **41**(2), 63-73.

Grifing B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Austrian Journal ofBiological Science*,**9 (4),** 463- 493.

Iqbal, M. A., Zafar, R., Saif, R., Bibi, A. and Ali, I. (2017). Exploiting heterosis and combining ability of sunflower at seedling stage. *Global Journal of Plant Breeding and Genetics*, **4**(6),389-393.

Jorgensen, H., Gabert, V. M. and Fernandez, J. A. (1999). Influence of nitrogen fertilization on the nutritional value of high-lysine barley determined in growing pigs. *Animal Feed Science and Technology*, **79**(1-2), 79-91.

Kumari, A., Vishwakarma, S. R. and Singh, Y. (2020). Evaluation of combining ability and gene action in barley (*Hordeum vulgare* L.) using Line x Tester analysis. *Electronic Journal of Plant Breeding*, **11**(1), 97-102.

Malarvizhi, D., Thiyagarajan, K. and Vijayalakshmi, C. (2012). Genetic analysis for yield and physiological traits in developing rice hybrids for aerobic environment. *ORYZA-An International Journal on Rice*, **48**(3), 211-221.

Malik, W., Ashraf, M., Qayyum, A. and Iqbal, M. Z. (2011). Genetic behavior of seedling traits in cotton (*Gossypium hirsutum* L.) through diallel analysis. *Journal of Agricultural Research*, **49**(1), 1–10.

Panse, V. G. and Sukhatme, P. V. (1985). Statistical methods for agricultural workers, ICAR, New Delhi.

Pomeranz, Y., Robbins, G. S., Smith, R. T., Craddock, J. C. and Gilbertson, J. T. (1976). Protein content and amino acid composition of barley from the world collection. *Cereal Chemistry*, **53**(4), 497-504.

Shaveta, S., Kaur, H. and Kaur, S. (2019). Hulless barley, A new era of research for food purposes. *Journal of Cereal Research*, **11**(2), 114-124.