www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 1797-1800

www.thepharmajournal.com
Received: 10-10-2021
Accepted: 24-12-2021

Sohan Lal Kajla
Ph.D., Scholar, Department of Genetics & Plant Breeding, College of Agriculture, SKRAU, Bikaner, Rajasthan, India

AK Sharma
Professor and Head, Department of Genetics & Plant Breeding, College of Agriculture, SKRAU, Bikaner, Rajasthan, India

Hoshiyar Singh
Professor and Ex- I/C. AICW&BIP, Department of Plant Breeding & Genetics, Rajasthan Agriculture Research Institute, Durgapura SKNAU, JOBNER, Rajasthan, India

Mukesh Bhakal
Ph.D., Scholar, Department of Plant Breeding & Genetics, SKN College of Agriculture, Jobner, SKNAU, JOBNER, Rajasthan, India

Neelu Kumari
M.Sc. Department of Genetics & Plant Breeding, College of Agriculture, SKRAU, Bikaner, Rajasthan, India

Moti Ram Natwaria
Ph.D., Scholar, Department of Genetics & Plant Breeding, College of Agriculture, SKRAU, Bikaner, Rajasthan, India

Corresponding Author:
Sohan Lal Kajla
Ph.D., Scholar, Department of Genetics & Plant Breeding, College of Agriculture, SKRAU, Bikaner, Rajasthan, India

Combining ability analysis for grain yield and it's contributing traits in bread wheat (*Triticum aestivum*) over environments

Sohan Lal Kajla, AK Sharma, Hoshiyar Singh, Mukesh Bhakal, Neelu Kumari and Moti Ram Natwaria

Abstract
Ten wheat varieties/lines were crossed in 10 x 10 diallel cross to estimate combining ability. The analysis of variance for each environment indicated the presence of sufficient genetic variability among the genotypes. Genotypes x environment was significant for all the traits except spike length and biological yield per plant suggesting differential response of genotypes to varying environments for attributes used. The GCA / SCA variance ratio (predictability ratio) was less than unity emphasizing the role of non-additive gene action for all the traits. On the basis of GCA effects and *per se* performance over the environments, parent Raj 3765 prominent as good general combiners for grain yield per plant and its contributing traits in all three environments. Therefore, this parent could be intensively used in the hybridization programme for further tangible advancement of wheat. On the basis of SCA effects and *per se* performance the cross combinations namely Raj 3765 x Raj 3077 and WH 1021 x PBW 550 were good specific cross combinations for grain yield per plant in varying environmental conditions. These crosses hold great promise in improving the grain yield in future breeding programs of bread wheat.

Keywords: Wheat, General combining ability, specific combining ability

Introduction
Wheat is the second most important food crop after rice of the country, which contributes nearly one-third of the total food grains production. This contribution has increased over years and was less than 10% in early fifties.

Information's about the general combining ability (GCA), specific combining ability (SCA) and the action of genes in the breeding material is a prerequisite for launching an effective wheat breeding program. The diallel analysis is one of the breeding strategies for assessing the combined effects of the ability of genotypes, and also provides information about the genetic mechanisms controlling various traits. Knowledge of GCA and SCA, affecting the crop and its components, is becoming increasingly important for breeders when choosing suitable parents for the development of potential hybrids in many crops (Khokhar *et al.* 2019) [7]. The purpose of the research study was to evaluate the performance of parents and F_1 hybrids of bread wheat genotypes to determine general and specific combining ability of parents and F_1 hybrids for various traits in bread wheat.

Materials and Methods
The experimental material for the present study consisted of ten diverse wheat (*Triticum aestivum* L. em. Thell.) Genotypes (Raj 4238, Raj 4079, Raj 3765, Raj 3077, Raj 1482, Raj 3777, WH 1021, DBW 90, PBW 550 and HD 3086) which were selected on the basis of genetic diversity and their stability for different yield traits. These genotypes were crossed in diallel fashion (Excluding reciprocals) during Rabi 2016-17 and obtained 45 crosses. In *Rabi* 2017-18 ten genotypes along with their 45 F_1's progenies were evaluated in three environments *viz*., three different dates of sowing 15 Nov. (timely sown), 1 Dec. (late sown) and 15 Dec. (very late sown) with 3 replications at Research Farm, College of Agriculture, SKRAU, Bikaner. Row length was 4 meter. Row to row and plant to plant distance was kept 22.5 cm and 10 cm, respectively.

Data were recorded on parental line and F_1s for all the traits under study averaged and utilized for statistical analysis. Analysis of variance was done using by a (Panse and Sukhatme 1967) [9] and combining ability analysis was done using Griffing's method II, model I (1956).

Results and Discussion

The analysis of variance for combining ability in the individual environment separately revealed that mean squares due to GCA and SCA were significant for all the characters in each of the three environments indicating that both additive and non- additive gene action controlled the genetic mechanism of these studied traits. Similar results were earlier reported by Joshi *et al.* (2004) [6], Yao *et al.* (2011) [17], Singh *et al.* (2012), and Rahul (2017) [10]. The GCA / SCA variance ratio (predictability ratio) was less than unity emphasizing the role of non-additive gene action for all the traits. These results were confirmed by Singh *et al.* (2013) and Yadav *et al.* (2017) [16]. The results of combining ability analysis pooled over three environments revealed that mean squares due to general and specific combining ability were significant for all the attributes. This reveals the presence of both additive and non-additive gene effects in the inheritance of the traits under study. This is in conformity with the findings obtained by Rahul (2017) [10], Yadav *et et al*. (2017) [16] and Rajput and Kandalkar (2018) [11].

In combined analysis of variance significant differences among genotypes indicated that the material used had enough genetic variability. The genotype x environment interactions was found significant for all the characters studied except spike length and biological yield per plant, indicated existence of non-linear response of genotypes to the varying environments. This is in conformity with the general belief that the genotypes x environment interactions are common in crop plant species (Allard and Bradshaw, 1964) [1]. Sprague and Federer (1951) [15] suggested that the biasness caused by genotype x environment interaction in the estimates of genetic parameters is of unknown magnitude and direction and it may not be same for each parameter.

The GCA effects of parents, in general, were found to be inconsistent for most of the characters over environments, which could be attributed to the presence of GCA x E. An overall appraisal of general combining ability effects revealed that some parents had consistent significant GCA effects for a few specific characters over the environments with varied magnitudes. Best parents possessing high desirable GCA effects along with their *per se* performance grain yield and significant desirable GCA effects for other traits in over the environments are presented in Table 1. It was revealed that the GCA effect and *per se* performance were positively correlated in most of the best parents. Though, such pattern was not prevailed in all the cases. Perusal of Table 1 revealed that the parents, who showed desirable, GCA effects for grain yield per plant, also exhibited desirable GCA effects for one or more yield attributing traits. The parents Raj 3765, Raj 3777 and PBW 550 in E_1; Raj 3765, Raj 3777 and Raj 3077in E_2 and Raj 3765, Raj 3077 and WH 1021 in E_3 emerged as good general combiners for grain yield and some associated traits. An overall appraisal revealed that the parents Raj 3765 in E_1, E_2 and E_3; Raj 3077 in E_2 and E_3 ; Raj 3777 in E_1 and E_2 and PBW 550 in E_1 appeared as good general combiners for grain yield with simultaneous consideration of other characters. Earlier, Bhardwaj *et al.* (2017) [3], Kumar *et al.* (2017) [8], Rahul (2017) [10], Yadav *et al*. (2017) [16] and Rajput and Kandalkar (2018) [11], provided similar informations on combining ability in wheat. In all such cases where GCA effect was more pronounced for particular trait indicating preponderance of additive gene action, so these genotypes should be involved in crosses to improve the specific trait in future breeding programme.

Present investigation indicated that parents Raj 3765 and Raj 3077 apparent as good general combiner in case of very late sown condition (E_3), it means, they possessed the genes for high temperature tolerance during grain filling period. These genotypes also possessed desirable significant GCA effects for days to heading, grain filling period, number of effective tillers per plant, spike length, 1000-seed weight as mentioned in Table 1. Shah (1998) [12] reported that biological yield was the trait identified for selection with high temperature. Blum *et al*. (1997) [4] emphasized that selection for high biomass yield should bring about positive improvement in grain yield, effective tillers per plant and number of kernels per spike. These results were agreed with those reported by Bhardwaj *et al*. (2017) [3], Kumar *et al*. (2017) [8], and Yadav *et al*. (2017) [16].

On the basis of SCA effects and per se performance of the hybrids, it was noted that the crosses were not exactly in the same order of ranking. In the present findings, best combinations mostly involved high × low and low × low general combiners for the characters under study. There was very rare case in which high × high general combiners were involved for best combinations. The same type of result was also observed by Kumar *et al*. (2017) [8]. Thus, it is evident that high specific combiners are not always obtained between high general combiners but may occur between low × low or high × low general combiners. This might be probably due to the presence of dominant and epistatic gene interactions. Therefore, crosses involving high × low general combiners in respect of different characters in the present study may be utilized for obtaining transgressive segregants in the next generation resulting from dominance gene interaction.

In the present study both GCA and SCA effects were significant for majority of the characters. A number of crosses exhibited changes in the magnitude as well as direction of SCA effects in different environments is a general consequence of highly significant SCA x environment interaction. For character like, days to heading, the cross Raj 4238 X HD 3086 had significant positive SCA effect in E_1 and E_2 but exhibited significant negative effect in E_3 and grain yield per plant the cross Raj 3077 x DBW 90 had significant positive effect in E_1 but expressed significant negative effect in E_2 and E_3. Such changes in the direction and magnitude of SCA effects of several crosses in different environments were also observed for other characters as well.

In the present investigation, none of the cross showed consistently high SCA effects for all the characters over the environments. An overall appraisal of specific combining ability effects revealed that some crosses had significant SCA effects for a few specific characters across the environments with varied magnitudes. The cross combinations, Raj 3765 x Raj 3077 for number of effective tillers per plant, spike length, number of grains per spike, 1000-seed weight, biological yield per plant, harvest index and grain yield per plant; Raj 3765 x HD 3086 for days to heading, grain filling period, number of effective tillers per plant, spike length, number of grains per spike, 1000-seed weight, biological yield per plant, harvest index and grain yield per plant and DBW 90 x PBW 550 for days to maturity, number of effective tillers per plant, spike length, number of grains per spike, 1000-seed weight, biological yield per plant, harvest index and grain yield per plant showed positive SCA effects across the environments.

Perusal of Table 2 revealed that the crosses, which showed desirable significant SCA effects for grain yield per plant, also exhibited desirable SCA effects for one or more yield contributing traits. The crosses Raj 3765 x Raj 3077, WH 1021 x PBW 550 and Raj 3765 x HD 3086 in E_1; WH 1021 x PBW 550, Raj 3765 x Raj 3077 and Raj 3765 x HD 3086 in E_2 and WH 1021 x PBW 550, Raj 3765 x Raj 3077 and Raj 4238 x WH 1021 in E_3 emerged as good specific cross combinations for grain yield per plant. An overall appraisal revealed that the crosses Raj 3765 x Raj 3077 and WH 1021 x PBW 550 in all the three environments comming up as good specific cross combinations. The parents Raj 3765, Raj 3077, Raj 3777 and WH 1021 involved in these crosses were good general combiners for grain yield and one or two yield contributing traits while the other parents were found as poor combiners. It is interesting to note that SCA effects of best crosses and GCA effects of their parents indicated that the good specific cross combinations were the result of good x good, good x poor or poor x poor combinations. Thus, it was evident that a good cross combination is not necessarily the result of good x good general combiners; rather it might occur from good x poor or poor x poor combiners as well. Similar findings were also reported by Singh *et al*. (2012), Bhardwaj *et al.* (2017) [3], Yadav *et al.* (2017) [16] and Kumar *et al.* (2017) [8].

High SCA effect due to good x good combiners reflect additive x additive type of gene interaction and superiority of favorable genes contributed by the parents, while those involving good x poor or poor x poor combiners indicate the interaction of additive x dominance or dominance x dominance, respectively. Biparental progeny selection suggested by Andrus (1963) may be used to get some transgressive segregants from crosses involving good x good and good x poor combiners. Best crosses having desirable SCA effects for grain yield per plant in different environments revealed that the SCA effects and *per se* performance were positively correlated in most of the crosses, though, such pattern was not prevailed in all the cases.

Table 1: Best wheat parent possessing high GCA along with their *per se* performance grain yield per plant and significant desirable GCA effects for other traits in over the environments.

Environments	Best parent	GCA effect	Grain yield per plant	Desirable GCA effect										
				Days to heading	Days to maturity	Grain filling period	Plant height	Flag leaf area	Number of effective tillers per plant	Spike length	Number of grains per spike	1000-seed weight	Biological yield per plant	Harvest index
E_1	Raj 3765	1.19	22.18	-	-1.33**	-	-	-	0.33**	0.82**	0.60*	-	-	1.66**
	Raj 3777	0.83	20.64	-	-	-	-	-	-	-	1.28**	-	-	-
	PBW 550	0.43	19.36	-	-	1.89**	-	0.72**	-	0.48**	-	1.19*	-	-
E_2	Raj 3765	1.50	19.64	-	-	-	-	-	0.32**	0.60**	-	-	-	2.53**
	Raj 3777	0.50	18.26	-	-	-	-	-	-	-	0.71*	-	1.08*	-
	Raj 3077	0.16	14.85	-0.85**	-1.69**	-	-	-	0.57**	0.62**	1.22**	0.84**	-	-
E_3	Raj 3765	1.56	14.49	-0.47*	-	1.40**	-	-	0.30**	0.84**	-	-	-	3.82**
	Raj 3077	1.06	12.94	-	-0.51*	-	-	-	0.49**	0.33*	1.68**	0.91**	-	-
	WH 1021	0.92	10.33	-	-	1.21**	-1.50**	-	-	-	0.87**	1.00**	-	-

* and ** indicates significance of values at $P< 0.05$ and 0.01, respectively

Table 2: Best crosses possessing high SCA effects with their *per se* performance of grain yield and significant desirable SCA effects for other traits in over the environments.

Environments	Crosses	SCA effect	Grain yield per plant	Desirable SCA effect										
				Days to heading	Days to maturity	Grain filling period	Plant height	Flag leaf area	Number of effective tillers per plant	Spike length	Number of grains per spike	1000-seed weight	Biological yield per plant	Harvest index
E_1	Raj 3765 x Raj 3077	10.31**	30.16	-	-	-	-	-	1.99**	2.53**	10.57**	4.76**	14.98**	6.75**
	WH 1021 x PBW 550	10.06**	29.59	-4.45**	-2.63**	1.83*	-	3.49**	2.96**	1.92**	11.57**	4.37**	11.22**	9.47**
	Raj 3765 x HD 3086	8.13**	28.14	-2.90**	-	5.91**	-	-	2.10**	1.71**	11.28**	3.82*	11.58**	5.97**
E_2	WH 1021 x PBW 550	9.75**	25.80	-6.09**	-	5.78**	-	3.49**	2.25**	1.27*	9.43**	2.83**	11.36**	10.79**
	Raj 3765 x Raj 3077	8.39**	26.57	-	-	-	-	-	1.53**	3.33**	11.92**	5.15**	11.12**	6**.97
	Raj 3765 x HD 3086	7.13**	25.68	-2.87**	-	5.91**	-	-	2.30**	2.63**	12.40**	3.69**	10.55**	6.54**
E_3	WH 1021 x PBW 550	7.48**	20.35	-3.54**	-	3.30**	-	2.26*	1.95**	2.05**	10.34**	5.45**	10.11**	9.63**
	Raj 3765 x Raj 3077	7.28**	21.52	-	-1.77**	-	--	-	2.33**	2.82**	12.20**	5.13**	11.62**	5.75**
	Raj 4238 x WH 1021	7.04**	18.91	-2.23**	-	-	-	-	1.59**	1.88**	5.73**	1.99*	12.31**	6.37**

* and ** indicates significance of values at $P< 0.05$ and 0.01, respectively

Conclusion

The results in the present study, advocated that diallel selective mating, use of multiple crosses and bi-parental mating may be effective alternative approaches for tangible advancement of wheat yield in the coming years.

Acknowledgments

Studentship support, provided by the college of agriculture, Swami Keshwan and Rajasthan Agricultural University, Bikaner to conduct present work as part of Ph.D thesis, is duly acknowledged.

References

1. Allard RW, Bradshaw AD. Implications of genotype x environment interactions in applied plant breeding. Crop Science. 1964;4:503-8.
2. Andrus CF. Plant breeding systems. Euphytica. 1963;12: 205-228.
3. Bhardwaj R, Sain RS, Mundiyara R, Sharma A. Combining ability analysis of F_1 and F_2 generations of ten parent half diallel in bread wheat (*Triticum aestivum* L. em. Thell.). International Journal of Agricultural Science. 2017;9(2):4238-424.

4. Blum A, Sullivan CY, Naguyen HT. The effect of plant size of wheat in responses to drought stress II. Water deficit, heat and ABA. Australian journal of Plant Physiology. 1997;24:43-48.
5. Grifing B. Concept of general and specific combining ability in relation to diallel crossing system. Australian journal of Biological Sciences. 1956;9(4):463-493.
6. Joshi SK, Sharma SN, Singhania DL, Sain RS. Combining ability in the F_1 and F_2 generations of diallel cross in hexaploid wheat (*Triticum aestivum* L. em Thell). Hereditas. 2004;141(2):115-121.
7. Khokhar AA, Jatoi WA, Nizamani FG, Rind RA, Nizamani MM, Wang HF. Study of heterosis analysis in F_1 population of bread wheat. Pure and Applied Biology. 2019;8(2):1757-1770.
8. Kumar J, Singh SK, Singh L, Kumar M, Srivastava M, Singh J. Combining ability analysis for yield and its components in bread wheat (*Triticum aestivum* L.). International journal of Current Microbiology and Applied Science. 2017;6(3):24-39.
9. Panse VC, Sukhatme PV. Statistical methods for agricultural workers. Published by ICAR, New Delhi. 1967.
10. Rahul SR. Combining ability and heterosis for morpho-physiological characters on bread wheat (*Triticum aestivum* L.). Agricultural Research and Technology. 2017;13(1)555868. DOI: 10.19080/ ARTOAJ.
11. Rajput RS, Kandalkar VS. Combining ability and heterosis for grain yield and its attributing traits in bread wheat. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):113-119.
12. Shah MA. Genetic studies for grain and temperature attributes in wheat (T. *aestivum*). Indian Journal of Agricultural Research. 1998;32:105-110.
13. Singh K, Sharma SN, Sharma Y, Tyagi BS. Combining ability for high temperature tolerance and yield contributing traits in bread wheat. Journal of Wheat Research. 2012;4(1):29-37.
14. Singh K, Singh UB, Sharma SN. Combining ability analysis for yield and its components in bread wheat (*Triticum aestivum* L. em. Thell.). Journal of Wheat Research. 2013;5(1):63-67.
15. Sprague GE, Federer WT. A comparison of variance components in corn yield traits. II: Error, year x variety, location x variety and variety components. Agronomy Journal. 1951;43:535-541.
16. Yadav J, Sharma SN, Jakhar ML, Shweta. Combining ability analysis for yield and its components in bread wheat over environments. International Journal of Plant Sciences. 2017;12(2):95-101.
17. Yao JB, Ma HX, Ren LJ, Zhang PP, Yang XM, Yao GC. Genetic analysis of plant height and its components in diallel crosses of bread wheat (*Triticum aestivum* L.). Australian journal of Crop Science. 2011;5(11):1408-1418.