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RESEARCH ARTICLE

Combining ability and heterotic response for yield and its attributing traits in wheat (*Triticum aestivum* L.)

■ NAND KISHOR YADAV, PREM CHANDRA YADAV, SHWETA, R.K. YADAV, LOKENDRA SINGH AND YOGESH PANDEY

SUMMARY

Diverse lines of wheat (*T. aestivum*) were taken to study the combining ability and heterotic response for yield and its attributing traits. Thirty six F_1 crosses were obtained by crossing nine parents in a half-diallel mating design and evaluated along with parents for eight characters. Analysis of variance for combining ability revealed the presence of genetic variability due to GCA among the parents and due to SCA among the crosses for all the traits studied. The estimated value of additive genetic component effect of genes were highly significant for plant height, days to 75 per cent flowering, days to maturity and spike length. Dominance component was highly significant for plant height, days to flowering, number of productive tillers per plant, ear length and grain weight per ear. PBW-343 was identified as best general combiner for all the traits studied, except for days to flowering, grain weight per ear, 1000-grain weight and grain yield per plant. The parent, K-8027 and PBW-343 for early flowering and days to maturity, K 9423 and NW 2036 for more number of grains per spike and grain yield per plant were identified as good general combiners. K 8027 was identified best common parent on the basis of GCA and per se performance whereas cross K9465 x NW2036 for grain yield per plant, grain weight per ear, number of grains per ear and ear length was recorded in hybrids. As well as K 9423 x K8962 and K 9533 x K 9465 were superior economic heterotic combiners. The level of heteroic observed in these crosses justifies the development of commercial hybrids in wheat.

Key Words : Combining ability, Heterosis, GCA, SCA, Wheat

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Wheat is one of the most important cereal crop of the world and constitutes important source of carbohydrate and protein. At global level, India ranks second largest wheat producing nation with 13.43 per cent global wheat production after China which contributes 17.7 per cent to the world wheat production (USDA 2012). The other major wheat producing countries are Russian Federation, United States of America and Canada and these 5 countries together contribute more than half of the global wheat production (Singh *et al.*, 2010) The importance of wheat at global level can be realized from the fact that the FAO's symbol is a breaded wheat spike with the Latin motto 'Flat Rain's; meaning 'Let there be bread'. wheat occupies a premier position among cultivated food cereals at national and international levels in both area and population. It contributes towards food front to the tune of more than 36 per cent of the world population and provides not less than 20 per cent of the total global caloric supply. The present wheat production is about 682.4 million tones (world economy survey) during the crop year 2010-11. Final estimation of wheat production is about 86.87 million tones and advance estimation for 2011-12, 88.31 million tones (Pratiyogita Darpan).

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
PREM CHANDRA YADAV, Department of genetics and Plant breeding, C.S. Azad University of Agriculture and Technology, KANPUR (U.P.) INDIA
Email: prem8250@gamil.com

Address of the Co-authors:
NAND KISHOR YADAV, SHWETA, R.K. YADAV, LOKENDRA SINGH AND YOGESH PANDEY, Department of genetics and Plant breeding, C.S. Azad University of Agriculture and Technology, KANPUR (U.P.) INDIA

The average yield in U.P. during the said year was 25.96q/ha, which received great attention of breeders for its genetic improvement as it has exhibited greater production potential under varying environment. To enhance the present yield level and overcome yield stagnation, it is essential to reshuffle the gene through hybridization using suitable parents. for this, it is necessary to identify the suitable parents and gene action involved in the expression for various yield-contributing characters. The present investigation was, therefore, combining ability variances and identification of good combiners responsible for high yield potential on wheat.

MATERIAL AND METHODS

The experimental material comprised of nine morphologically diverse parents/strains (K 8027, K 9465, NW 2036, K 9533, Raj 4120, PBW 343, K 9107, K 9423 and K 0424) and their thirty six cross combination developed during *Rabi* season 2009-10. Using half diallel mating design, 36 hybrids along with 9 parents were evaluated for eight characters in a Randomized Complete Block Design with three replications during *Rabi* 2009-10 at crop research farm, Nawabganj, C.S. Azad university of Agriculture and Technology, Kanpur. Each parent and F_1s was planted in a single row of four meter length with inter and spacing of 23x10 cm. All recommended agronomic practices were adopted for raising a good crop. The observations were recorded on five randomly taken plants from each plots for characters, *viz.*, days to 75 per cent flowering, days to maturity, plant height, numbers of productive tillers per plant, length of spike, number of grains per ear, 1000-grain weight and grain yield per plant. Heterosis was calculated over economic parent K 9107. following the standard procedure the data were also subjected to combining ability analysis.

RESULTS AND DISCUSSION

Analysis of variance indicated significant differences among the treatments for all the characters under study. Parent and crosses also differed significantly for all the character except the grain weight per ear indicating considerable amount of heterotic response in cross combinations for the traits.

Analysis of variance for combining ability revealed the existence of both GCA and SCA variance. Both variances were highly significant for all the traits studied which indicated that both additive and non-additive gene action together play a role in the inheritance of these characters.

Combining ability helps in selection of good combiners and provides opportunity for the use of them in hybridization programme. General combining ability (GCA) is primarily a function of additive gene action and additive x additive interaction, whereas specific combining ability (SCA) is due to non-allelic gene interaction, the best tool for judging the potentiality of the parent in combining ability analysis (Sprague and Tatum, 1942, Griffing, 1926). The parent as well as their general combining ability effect along with per se performance has been presented in Table 1.

In general the parents which had high per se performance were also good general combiners for yield and its components.The values of ratio GCA and SCA estimates were observed less than unity for all the traits (Walia *et al.*, 1995; Pandey *et al.*,1999 and Sameena *et al.*,2000). For 1000-grains weights have also reported the ratio of additive gene action.The promising combiner based on significant GCA effects of per se performance for days to flowering and days to maturity were K 9423, K 9533, K 9465 and K 0424, K 9423, K 9533, respectively. For plant height Raj 4120, K 9423, PBW 343; for number of productive tillers per plant PBW 343, Raj 4120 and K 9107; for number of grains per ear K 9465, PBE 343 and K 9533; for 1000-grain weight (g) Raj 4120, K 8027 and K 9465; for grain yield per plant Raj 4120, K 9533 and K 8027. The promising combiners based on significant GCA effects and per se performances for days to 75 per cent flowering and days to maturity were found to be more desirable combiners in F_1 generation. The parents discussed above had high general combining ability and thus, had fixable components of effects like additive and additive x additive epistasis. These could be

Table 1: Analysis of variance for combining ability along with estimates of components of variance and degree of dominance

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height	No. of productive tiller/plant	Spike length	Number of grains/ear	1000-grain yield	Grain yield/ plant (g)
Replication	8	3.97**	119.45**	43.43**	0.34**	2.29**	6.06**	18.80**	7.79**
Treatment	36	2.87**	52.07**	12.93**	0.56**	1.21**	1.21**	19.68**	4.14**
Error	88	.43	0.44	0.305	0.094	0.003	0.003	0.21	0.18
$\hat{S}_g^2$		0.321	10.819	3.920	0.027	0.207	0.207	1.69	0.691
$\hat{S}_s^2$		2.44	51.63	12.62	0.466	1.207	1.207	19.47	3.96
$\hat{S}_g^2 / \hat{S}_s^2$		0.161	0.256	0.379	0.057	0.210	0.210	0.105	0.212
$\hat{S}_s^2 / \hat{S}_g^2$		0.401	0.505	0.615	0.238	0.458	0.458	0.324	0.460

** indicate significance of value at P=0.01

successfully used for improving particular character for which important is desired. These parents/lines might to be utilized for producing the inter-mating population in order to get desirable recombinants in wheat. Analysis of SCA is important parameter for judging the specific combinations for exploiting it through heterosis breeding programme. Many workers have reported similar results on heterosis for yield and yield components in wheat (Atale and Vitkare, 1990; Krishna and Ahmad, 1992; Islam and Srivastava, 2001).

The good specific cross combinations were selected based on their F_1 hybrids. Raj 4120 x K 9423, K 8027 x PBW 343 and NW 2036 x K 9107 for days to 75 per cent flowering; Raj 4120 x PBW 343, K 9465 x Raj 4120 and K 9533 x K 9107 for day to maturity; K 9533 x K 9423, NW 2036 x K 9423 and K 8027 and K 9107 for plant height; K 9107 x K 9423, K 9107 x K 0524 and Raj 4120 x K 0424 for number of productive tillers per plant; Raj 4120 x K 0424, K 9465 x K 0424 and K 8027 x Raj 4120 for spike length (cm); K 8027 x K 9107, NW 2036 x PBw 343 and K 9533 x PBW 343 for number of grains per ear; raj 4120 x PBW 343, Raj 4120 x K 9423 and K 9533 x k 9107 for 1000 grain weight (g); Raj 4120 x PBW 343, Raj 4120 x K 9423, K 9423 x Raj 4120 x PBW 343, Raj 4120 x K 9423 and K 9423 x K 0424 for grains yield per plant were found to be good specific cross combination for different traits (Table 2).

Table 2: Estimation of gca and sca effect and mean performance of nine parents for 8 characters in F_1 generation of wheat

Sr. No.	Characters	Results	Per se performance	gca effects	Crosses	Per se performance	sca effect
1.	Days to 75% flowering	K 9423	66.68	-1.21**	Raj 4120 x K 9423	66.33	-2.62**
		K 9533	67.46	-0.52**	K 8027 x PBW 343	67.66	-2.79**
		K 9465	67.43	-0.25	NW 2036 x K 9107	68.00	-2.15**
2.	Days to maturity	K 0424	84.46	-5.04**	Raj 4120 x PBW 343	111.30	-9.26**
		K 9423	87.54	-4.42**	K 9465 x Raj 4120	111.60	-3.90**
		K 9533	107.00	-1.70**	K 9533 x K 9107	113.30	-32.11**
3.	Plant height	Raj 4120	54.06	-1.85**	K 9533 x K 9423	51.50	-5.60**
		K 9423	56.00	-1.19**	NW 2036 x K 9423	53.13	-6.54**
		PBW 343	56.30	-1.50**	K 8027 x K 9107	53.53	-1.76**
4.	Number of productive tillers/plant	PBW 343	7.68	0.19**	K 9107 x K 9423	8.63	1.58**
		Raj 4120	7.34	0.15**	K 9107 x K 0424	8.41	1.14**
		K 9107	6.67	0.08**	Raj 4120 x K 0424	8.20	0.86**
5.	Spike length (cm)	K 8027	12.40	0.70**	Raj 4120 x K 0424	11.75	2.39**
		K 9423	10.00	0.17**	K 9465 x K 0424	11.37	1.36**
		K 9465	9.50	0.52**	K 8027 x Raj 4120	11.01	1.27**
6.	Number of grains/ear	K 9533	45.20	0.47**	K 9533 x PBW 343	49.93	6.58**
		PBW 343	40.26	0.55**	NW 2036 x PBW 343	50.13	6.92**
		K 9465	42.28	0.67**	K 8027 x K K 9107	50.95	9.07**
7.	1000-grain weight (g)	Raj 4120	46.86	2.57**	Raj 4120 x PBW 343	46.23	4.29**
		K 8027	44.26	0.49**	Raj 4120 x K 9423	45.65	3.22**
		K 9465	42.45	0.44**	K 9533 x K 9107	44.60	6.17**
8.	Grain yield/plant (g)	Raj 4120	14.57	1.06**	Raj 4120 x PBW 343	14.79	2.09**
		K 9533	13.21	0.56**	Raj 4120 x K 9423	13.63	1.91**
		K 8027	11.95	0.36**	K 9423 x K 0424	12.36	2.02**

** indicate significance of value at P=0.01

Table 3: Top five crosses showing maximum economic heterosis per se performance and sca effect in wheat

Cross combination	Per se performance	Sca effect	Economic heterosis
Raj 4120 x K 9423	13.63	1.91**	6.36**
K 9465 x K 0424	15.65	3.38**	40.74**
K 9465 x NW 2036	13.82	3.79**	36.16**
Raj 4120 x PBW 343	14.70	2.09**	31.44**
K 8027 x K 9465	13.36	1.27**	27.12**

** indicate significance of value at P=0.01

The GCA and SCA in term of covariance of half-sib and full sibs (Kempthorne, 1957), respectively, which is analogous to design II of Comstock and Robinson (1948 and 1952). Point out that magnitude of gene action based on combining ability variance was not much reliable due to serious bias from genotype x environment interaction (Moll *et al.*,1960).

None of the cross combination was good specific combiner for all the traits. However, out of 36 combination K 9107 x K 9423, K 9107 x K 0424 and Raj 4120 x K 0424 for number of productive tillers per plant; K 8027 x K 9107, NW 2036 x PBW 343 and K 9533 x PBW 343 for number of grains per ear; Raj 4120 x PBW 343, Raj 4120 x K 9423 and K 9423 x K 0424 for grains yield per plant. This study indicated that high level of heterosis as well as specific combining ability for various hybrids would lead to the development of elite segregates in segregating generation which need to be isolated and exploited for further wheat improvement.

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