

COMBINING ABILITY OVER ENVIRONMENTS FOR GRAIN YIELD AND ITS COMPONENTS IN BREAD WHEAT (*Triticum aestivum* L.)

*PANSURIYA, A. G., DHADUK, L. K., VANPARIYA, L. G., SAVALIYA, J. J.,
PATEL, M. B., AND MEHTA, D. R.

WHEAT RESEARCH STATION
JUNAGADH AGRICULTURAL UNIVERSITY
JUNAGADH – 362 001, GUJARAT, INDIA

**Email : agpansuriya@jau.in*

ABSTRACT

*A study was carried out to investigate combining ability of grain yield per plant and its components along with biochemical parameters in bread wheat. The pooled analysis of variances for combining ability suggested the role of both additive and non-additive gene action with preponderance of non – additive gene effects in the expression of all the traits studied. The parents GW 366, K 9906 and WR 885 were found to be top good general combiners for grain yield per plant. DL 788-2 for protein content while WR 885 for wet gluten content and water absorption depicted highest GCA effects accompanied with high *per se* performance. The cross K9906 x RAJ 3765 was having highest grain yield per plant coupled with highest SCA effect for the same trait followed by GW 173 X WH 1059 and K 9906 X WR 885. Regarding biochemical parameters the cross combination WH 1059 X K 9906 for protein content, LOK 1 X GW 366 for wet gluten content and GW 366 X WR 885 for water absorption observed to be the best specific combiners.*

KEY WORDS: Combining ability, gca, gene action, sca, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L) occupies the prime position among cereals and is one of the most important agricultural commodities in the international trade. It is the major crop for food and nutritional security in India and also at global level. The global wheat demand by the year 2020 will likely to be more than 1000 million tons. In order to meet food demand for burgeoning population, wheat production growth will have to be increased to more than two per cent per annum, but the resources available for wheat production are likely to be significantly lower. Therefore, productivity

enhancement is only the option to meet anticipated food demand. The hybridization is one of the potent techniques for yield enhancement. The choice of parents to be incorporated in hybridization programme is a crucial step for breeders, particularly if the aim is improvement of complex quantitative characters, such as yield and its components. The knowledge of combining ability together with *per se* performance provides guidelines to plant breeders in selecting the elite parents and desirable cross combinations to be exploited further and at the same time reveal the nature and magnitude of gene action involved in the inheritance of various traits.

Therefore, the present experiment was conducted to study combining ability over environments of grain yield and its components in bread wheat.

MATERIALS AND METHODS

The experimental materials comprised of 10 parents (LOK 1, GW 366, GW 173, HD 2932, DL 788-2, WH 1059, K 9906, KRL 213, RAJ 3765 and WR 885) and their 45 F₁ hybrids. Thus, a set of 55 entries (45 hybrids and 10 parents) was evaluated in three different environments created by sowing wheat at three different dates (E₁ - Early sowing : 26th October, 2011; E₂ - Timely sowing : 17th November, 2011 and E₃ - Late sowing : 6th December, 2011) following randomized block design with three replications in each environment during *rabi* 2011-12 at Wheat Research Station, Junagadh Agricultural University, Junagadh. The observations were recorded for grain yield per plant (g) and their eleven yield component traits viz., days to heading, days to maturity, plant height (cm), number of effective tillers per plant, length of main spike (cm), number of spikelets per main spike, peduncle length of main spike (cm), number of grains per main spike, 1000-grain weight (g), biological yield per plant (g) and harvest index (%), and three biochemical parameters like protein content (%), wet gluten content (%) and water absorption (ml). The data were analyzed for combining ability as per the Method-II, model-I of Griffing (1956).

RESULTS AND DISCUSSION

The general as well as specific combining ability variances were found significant for all the traits studied (Table 1) indicating the role of both fixable and non-fixable variances in the expression of all these traits. The magnitude of GCA and SCA variances revealed that the SCA variances were higher in magnitude than their respective GCA variances for all the

characters. This was further supported by the ratio of $\sigma^2\text{GCA}/\sigma^2\text{SCA}$, which is less than unity confirmed the preponderance of non-additive gene action for all the traits studied and emphasized the utility of hybrid breeding approach to exploit existing heterosis in bread wheat. The predominance of non-additive gene action for grain yield and its component traits were also reported by Rajiv Kumar (2012) and Desale and Mehta (2013) and in bread wheat.

The best three of parents with GCA effects and *pre se* performance and three best hybrids with SCA effects and *per se* performance for each trait are presented in Table 2. The parusal of general combining ability effects of parents revealed that none of the parents was found good general combiner simultaneously for all the characters. The parents GW 366, WR 885, HD 2932 and K 9906 were found good general combiners for grain yield per plant and possessed high concentration of favourable genes as indicated by significant and positive GCA effects for these parents. Parents, LOK 1, GW 173, HD 2932, DL 788-2 and RAJ 3765 expressed significant and negative (desirable) GCA effects and were emerged as good general combiners for early maturity. Parents, GW 173, DL 788-2 and RAJ 3765 for short stature; GW 366, K 9906 and KRL 213 for number of effective tillers per plant; GW 366, WH 1059, K 9906, KRL 213 and WR 885 for length of main spike and number of spikelets per spike; LOK 1, GW 366 and K 9906 for peduncle length of main spike; HD 2932, WH 1059, K 9906, RAJ 3765 and WR 885 for number of grains per spike; all the parents except DL 788-2, KRL 213 and RAJ 3765 for 1000 grain weight; GW 366, K 9906, RAJ 3765 and WR 885 for biological yield per plant; and GW 173, HD 2932, DL 788-2 and WR 885 for harvest index; depicted significant GCA effects in desired

direction and thus, were emerged as good combiners for respective traits. Regarding biochemical parameters, it was found that parents, DL 788-2, K 9906 and WR 885 for protein content; LOK 1, DL 788-2 and WR 885 for wet gluten content; and GW 173, HD 2932, WH 1059 and WR 885 were appeared good general combiners for water absorption. The results, thus, suggested that these parents possessed high concentration of favourable genes for the respective traits may be utilized in crossing programme in order to generate wide genetic variability for effective selection in order to develop bread wheat varieties having high yield, early maturity along with desired biochemical parameters.

It was observed in present study that the parent exhibiting significant GCA effect in desired direction for particular trait was more or less found to exhibit high *per se* performance in desired direction for this particular trait. For instance, the parents GW 366 and WR 885 which exhibited significant and positive GCA effect for grain yield per plant also expressed high *per se* performance for this trait. Similarly, the parents LOK 1, GW 366, GW173, HD 2932, DL 788-2, WH 1059, K 9906, KRL 213, RAJ 3765 and WR 885 which depicted significant GCA effect in desired direction for different traits also showed good *per se* performance for the respective traits (Table 2). The association between *per se* performance of parents and their GCA effects suggested that while selecting the parents for hybridization, *per se* performance of the parents should be given due consideration, as it might predict the combining ability of a genotype. It would also save considerable time required to determine the GCA effect of the parents. Thus, if a character is uni-directionally controlled by a set of alleles and additive effect is important, the choice of parents on

the basis of the *per se* performance may be more effective. Kamani (2009), Zahid *et al.* (2011), Rajiv Kumar (2012) and Desale and Mehta (2013) and have also suggested that parental selection can be done on the basis of *per se* performance, which supports the present findings. High general combining ability effects of parents mostly contributes additive gene action and additive x additive interaction effect and represents the fixable portion of genetic variation. In this context, GW 366, HD 2932, K 9906 and WR 885 offered the best possibilities for exploitation in the development of improved lines with enhanced yielding ability. It is suggested that population involving these lines or varieties in a multiple crossing programme may be developed for isolating desirable recombinants. Further, the varieties or lines showing good general combining ability may be utilized in component breeding for effective improvement in a particular trait and ultimately seeking improvement in yield itself. The high GCA effects for grain yield and its different component traits were also reported by Seboka *et al.* (2009), Zahid *et al.* (2011), Dehghani (2012) and Srivastava *et al.* (2012). The estimates of SCA effects revealed that none of the top crosses for SCA was simultaneously superior for all the traits (Table 2). The crosses K 9906 x RAJ 3765, K9906 x WR 885 and GW 173 x WH 1059 with higher grain yield per plant had high SCA effect for grain yield per plant. The similar trend was also observed in most of the traits studied that the high SCA effects were accompanied high *per se* performance. Thus, on the basis of these results, it is expected that these crosses could be exploited through heterosis breeding and may also give desirable segregants in subsequent generations and hence, it would be worthwhile to use them for improvement in grain yield *per se* performance. The significant SCA effects

for grain yield and different component traits were also recorded by several workers viz., Seboka *et al.* (2009), Zahid *et al.* (2011), Dehghani (2012) and Srivastava *et al.* (2012). Looking to the biochemical parameters, the cross combinations WH 1059 X K 9906, GW 366 X KRL 213 and DL 788-2 X K 9906 for protein content, LOK 1 X GW 366, HD 2932 X WH 1059 and HD 2932 X WR 885 for wet gluten content and GW 366 X WR 885, DL 788-2 X KRL 213 and GW 173 X RAJ 3765 for water absorption were found to be the top three specific combiners. In contrast to general combining ability effects, the specific combining ability effects represent dominance and epistatic components of variation, which are not fixable in nature. But, the crosses showing high SCA effects involving either both or one good general combining parents could be successfully exploited for varietal improvement and expected to show stable performance in transgressive segregants carrying fixable gene effects.

The cross combinations involving good x poor or average x poor general combiners besides exhibiting favourable additive effect of good or average combining parents, manifest complementary interaction effect and thus, result in higher SCA effects. Such cross combinations for grain yield per plant and different traits are presented in Table 2. These crosses may be expected to throw transgressive segregants possessing enhanced yielding ability with stable performance. The cross combinations involving both the good general combining parents offer still better possibilities of exploitation of additive x additive type of gene interaction as they are expected to yield stable segregants in the advance generations and need further exploitation in the breeding programme.

CONCLUSION

On the basis of finding results, it was evident that the characters studied under the present investigation were controlled by both additive and non-additive gene action with preponderance of non – additive gene effects. The parents, GW 366, K 9906 and WR 885 were found top ranked good general combiners for grain yield per plant. The crosses, K9906 x RAJ 3765, GW 173 X WH 1059 and K 9906 X WR 885 with highest grain yield per plant coupled with highest SCA effect for grain yield per plant could be exploited for improvement of yield in wheat.

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Table 1: Analysis of variance for combining ability for grain yield and its components in pooled over environments

Source of Variation	d. f.	Days to Heading	Days to Maturity	Plant Height (cm)	Number of Effective Tillers Per Plant	Length of Main Spike (cm)	Number of Spikelets Per Main Spike	Peduncle Length of Main Spike (cm)	Number of Grains Per Main Spike
Pooled over environments									
GCA	9	176.19**	157.27**	356.85**	6.60**	6.69**	23.67**	61.57**	273.51**
SCA	45	50.56**	18.79**	65.25**	3.06**	1.65**	4.82**	13.59**	54.09**
Environments (E)	2	563.85**	1276.42**	1893.82**	35.58**	16.30**	48.40**	226.08**	1245.06**
Error	324	0.58	0.46	0.65	0.21	0.12	0.16	0.26	5.84
σ^2 gca	-	4.88	4.36	9.89	0.18	0.18	0.65	1.70	7.44
σ^2 sca	-	16.66	6.11	21.53	0.95	0.51	1.55	4.44	16.09
σ^2 gca/ σ^2 sca	-	0.29	0.71	0.46	0.19	0.36	0.42	0.38	0.46

Source of Variation	d. f.	1000-Grain Weight (g)	Grain Yield Per Plant (g)	Biological Yield Per Plant (g)	Harvest Index (%)	Protein Content (%)	Wet Gluten Content (%)	Water Absorption (ml)
Pooled over environments								
GCA	9	57.90**	34.03**	353.93**	58.63**	1.34**	2.50**	17.36**
SCA	45	55.40**	21.12**	191.92**	31.42**	0.82**	2.43**	10.93**
Environments (E)	2	292.67**	347.90**	1469.44**	85.69**	0.09**	95.49**	251.64**
Error	324	0.15	1.04	2.49	1.08	0.01	0.09**	0.43
σ^2 gca	-	1.60	0.92	9.76	1.60	0.04	0.07	0.47
σ^2 sca	-	18.42	6.93	63.14	10.11	0.27	0.78	3.50
σ^2 gca/ σ^2 sca	-	0.09	0.14	0.16	0.16	0.14	0.09	0.13

*,** significant at 5 per cent and 1 per cent levels of significance, respectively.

Table 2: Three best parents and hybrids for *per se* performance as well as GCA and SCA effects for each trait.

Character	Parents	<i>per se</i> Performance	Parents	GCA Effects	Hybrids	<i>per se</i> Performance	Hybrids	SCA Effects
Grain Yield Per Plant (g)	GW 366	19.06	GW 366	1.88**	K 9906 X RAJ 3765	22.84	K 9906(G) X RAJ 3765(P)	5.36**
	WR 885	18.29	K 9906	0.48**	K 9906 X WR 885	22.51	GW 173(A) XWH 1059(A)	5.25**
	HD 2932	17.64	WR 885	0.42**	GW 173 XWH 1059	21.21	K 9906(G) X WR 885(G)	5.20**
Days to Heading	GW 173	44.56	DL788-2	-3.29**	LOK 1 X GW 173	45.44	KRL 213(P) X WR 885(P)	-6.53**
	DL788-2	45.00	GW 173	-3.25**	LOK 1 X DL 788-2	46.22	K 9906(P) X KRL 213(P)	-6.28**
	RAJ 3765	49.78	RAJ 3765	-1.47**	WH 1059 X RAJ 3765	50.22	WH 1059(P) X KRL 213(P)	-6.14**
Days to Maturity	GW 173	95.11	GW 173	-3.44**	LOK 1 X GW 173	97.11	WH 1059(P) X K 9906(P)	-4.72**
	DL788-2	97.67	LOK 1	-2.00**	GW 173 X HD 2932	97.56	HD 2932(G) X WR 885(P)	-4.69**
	LOK 1	98.33	RAJ 3765	-1.48**	GW 173 X RAJ 3765	99.56	KRL 213(P) X RAJ 3765(G)	-3.62**
Plant Height (cm)	GW 173	52.91	GW 173	-4.94**	LOK 1 X DL 788-2	54.96	WH 1059(P) X KRL 213(P)	-8.44**
	DL788-2	54.27	DL788-2	-3.64**	GW 173 X WH 1059	56.91	LOK 1(A) X DL 788-2(G)	-6.50**
	RAJ 3765	56.87	RAJ 3765	-1.38**	GW 173 XHD 2932	57.42	WH 1059(P) X RAJ	-6.18**
Number of Effective Tillers Per Plant	K 9906	11.29	K 9906	0.99**	K 9906 X KRL 213	12.13	GW 173(P) X DL 788-2(P)	2.28**
	GW 366	9.13	KRL 213	0.26**	KRL 213 X WR 885	11.56	KRL 213(G) X WR 885(A)	2.26**
	WR 885	8.64	GW 366	0.22**	K 9906 X WR 885	10.73	K 9906(G) X KRL 213(G)	1.98**
Length of Main Spike (cm)	WH 1059	10.33	KRL 213	0.81**	K 9906 X KRL 213	10.03	DL 788-2(P) X RAJ	2.40**
	KRL 213	9.37	K 9906	0.73**	KRL 213 X WR 885	9.99	KRL 213(G) X WR 885(G)	2.35**
	K 9906	9.16	WR 885	0.23**	LOK 1 X KRL 213	9.90	LOK 1(P) X K 9906(G)	2.07**
Number of Spikelets Per Main Spike	WH 1059	21.11	KRL 213	1.05**	K 9906 X WR 885	18.71	LOK 1(P) X KRL 213(G)	2.21**
	KRL 213	19.07	K 9906	1.02**	LOK 1 X KRL 213	18.49	DL 788-2(P) X RAJ	2.18**
	K 9906	18.91	WR 885	0.61**	K 9906 X KRL 213	17.91	GW 366(G) X RAJ 3765(A)	1.37**

Table 2: Contd...

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Character	Parents	<i>per se</i> Performance	Parents	GCA Effects	Hybrids	<i>per se</i> Performance	Hybrids	SCA Effects
Peduncle Length of Main Spike (cm)	K 9906	32.09	K 9906	3.25**	GW 366 X K 9906	34.22	DL 788-2(P) X WH 1059(P)	7.27**
	LOK 1	28.49	LOK 1	0.87**	K 9906 X KRL 213	34.00	WH 1059(P) X WR 885(P)	3.17**
	GW 366	28.36	GW 366	0.23**	DL 788-2 X WH 1059	33.60	K 9906(G) X KRL 213(A)	2.88**
Number of Grains Per Main Spike	WR 885	57.00	WH 1059	3.28**	K 9906 X WR 885	59.78	DL 788-2(P) X WH 1059(G)	9.41**
	WH 1059	54.89	HD 2932	2.54**	HD 2932 X WH 1059	57.67	LOK 1(P) X KRL 213(G)	8.67**
	HD 2932	54.11	KRL 213	2.35**	DL 788-2 X WH 1059	57.11	K 9906 (G)X WR 885(G)	8.03**
1000-Grain Weight (g)	HD 2932	50.11	K 9906	1.69**	GW 173 XWH 1059	51.15	GW 173(G) XWH 1059(G)	5.37**
	LOK 1	49.20	GW 173	1.54**	GW 173 X DL 788-2	49.76	GW 173(G) X KRL 213(P)	5.24**
	GW 366	49.09	HD 2932	1.12**	GW 173 X KRL 213	49.66	DL 788-2(P) X WH 1059(G)	5.07**
Biological Yield Per Plant (g)	GW 366	49.32	GW 366	6.38**	K 9906 X WR 885	62.57	K 9906(G) X WR 885(G)	18.91**
	WR 885	44.20	RAJ 3765	2.23**	GW 366 X K 9906	62.20	LOK 1(P) X RAJ 3765(G)	15.94**
	HD 2932	42.39	K 9906	1.70**	GW 366 X GW 173	57.53	GW 173(P) X DL 788-2(P)	14.71**
Harvest Index (%)	GW 173	46.84	HD 2932	1.92**	HD 2932 X DL 788	47.03	DL 788-2(G) X WR 885(G)	4.61**
	LOK 1	45.57	GW 173	1.22**	DL 788-2 X WR 885	46.92	LOK 1(A) X DL 788-2(G)	4.51**
	DL 788-2	44.98	DL 788-2	1.02**	LOK 1 X DL 788-2	46.47	GW 366(P) X RAJ 3765(P)	3.98**
Protein Content (%)	DL 788-2	14.29	DL 788-2	0.37**	DL 788-2 X K 9906	14.74	WH 1059(P) X K 9906(G)	1.16**
	K 9906	13.83	WR 885	0.21**	WH 1059 X K 9906	14.51	GW 366(A) X KRL 213(A)	1.14**
	GW 173	13.70	K 9906	0.16**	GW 366 X KRL 213	14.39	DL 788-2(G) X K 9906(G)	0.93**
Wet Gluten Content (%)	GW 173	36.42	WR 885	0.37**	GW 173 X WH 1059	37.43	LOK 1(G) X GW 366(A)	2.57**
	RAJ 3765	36.39	LOK 1	0.30**	GW 173 X WR 885	37.24	HD 2932(P) X WH 1059(P)	2.48**
	WR 885	36.23	DL 788-2	0.23**	DL 788-2 X K 9906	37.07	HD 2932(P) X WR 885(G)	1.74**
Water Absorption (ml)	GW 173	47.44	WR 885	1.33**	GW 366 X WR 885	49.78	GW 366(P) X WR 885(G)	5.02**
	K 9906	46.22	WH 1059	0.62**	HD 2932 X WH 1059	47.56	DL 788-2(A) X KRL 213(P)	3.03**
	WR 885	45.67	HD 2932	0.36**	GW 173 X RAJ 3765	47.33	GW 173(G) X RAJ 3765(A)	2.96**

G, A and P in parenthesis indicates good, average and poor combining parents, respectively.

*, ** significant at 5 per cent and 1 per cent levels of significance, respectively.

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