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Combining ability analysis for yield and yield contributing traits in winter and spring wheat combinations

Eisha Kapoor, SK Mondal and Tuhina Dey

Abstract

The present investigation was undertaken to study the combining ability and nature of gene action for yield and yield contributing traits in crosses involving winter and spring wheat (Triticum aestivum L.) genotypes. Ten winter wheat lines used as females were crossed with three elite spring wheat genotypes used as male in Line x Tester fashion and grown in randomised block design with three replications. Four winter wheat lines viz., Drina NS 720, China 84-40022, WW-7 and Nordresprez were good general combiners for grain yield and three other yield contributing traits. Among the testers, PBW 343 and Raj 3765 were the best general combiners for grain yield and other yield contributing traits. The sca variance was observed to be more important for all the traits studied. Cross combinations WW-7 x Raj 3765, Drina NS 720 x PBW 343, Nordresprez x PBW 343, China 84-40022 x PBW 343 and Vir 453-47 x PBW 343 were found to show significant positive sca effect for grain yield and yield contributing traits.

KeyWords: Winter and spring wheat, gene effects, yield components.

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Introduction

Wheat (*Triticum* spp.), is the most important cereal crop and occupies prominent position in Indian agriculture after rice. India is now the second largest producer of wheat in the world with the production hovering around 75 million tonnes during the last decade. Wheat is a major contributor to the food security system in India as well, occupying nearly 27.54 million hectares and producing 80.58 million tonnes (Anonymous, 2009). National Commission on Agriculture estimated that India needs 110 million tonnes of wheat by 2020 A.D. This goal can be achieved by enhancing the genetic yield potential of the varieties. Winter wheats act as a promising source of genes for enhancing yield and resistance to biotic and abiotic stresses. The importance of winter wheats for improvement of spring wheat was highlighted as early as 1949 by Akerman and Mackey. Subsequently several workers have explored the potential of winter wheats in spring wheat improvement programme (Hraska and Petrovic, 1976; Kant and Gupta 2002; Kumar *et al*., 2003; Baric *et al*., 2004; Sharma and Chaudhary, 2009) Thus, winter x spring wheat hybridization appears to be important for achieving quantum jump in wheat production. A great interest has been generated in the inter crossing of spring wheat with winter wheat with the hope that this will help in surpassing the existing yield plateau of spring wheat by generating additional variability. The success of winter x spring hybridization depends upon the ability of these two physiologically different ecotypes to combine well with each other. Further, the winter wheat when facultative in nature, flower under condusive environmental conditions and can be utilised in hybridization programme. To evolve an effective hybridization programme, combining ability analysis can be used to test the performance of parents in different cross combinations and to characterise the nature and magnitude of gene effects in the expression of various agronomic characters. Such information is useful for the selection of parental lines having superior performance and isolation of potential combinations for their use in breeding programmes. Line x Tester analysis provides the detailed genetic analysis and identifies superior parents and cross combinations on the basis of combining ability. Therefore, the present study was undertaken with the objective to estimate the general and specific combining ability effects for grain yield and other yield contributing traits in winter and spring wheat crosses and to study the gene effects.

Division of Plant Breeding and Genetics, Sher E Kashmir University of Agricultural Sciences and Technology, FOA Main campus Chatha- Jammu (J&K) 180009, India

Materials and Methods

Ten winter wheat lines *viz*., Golden valley, Nordresprez, China 84-40022, Drina, Vir 453-47, WW7, WW12, WW21, WW26 and Drina NS 720 were used as females and three spring wheat varieties viz., Raj 3765, UP 2425 and PBW 343 were crossed in line x tester fashion. 30 F_1s along with thirteen parents (ten females and three males) were grown in randomized block design with three replications during Rabi(winter season) at research Farm of Sher E Kashmir University of Agricultural Sciences and Technology, Main Campus, Chatha, Jammu, India (32°40' N, 74° 54' E and 330 m above mean sea level). Parents and F_1s were raised in single row plots of 1.5 m and at a distance 5 cm apart with a row spacing of 25 cm. The ten winter wheat lines were facultative in nature and flower naturally under the photoperiodic conditions of Jammu. Ten competitive plants in parents and F_1s were selected randomly for recording observations on eleven characters *viz*, days to 50% flowering, flag leaf area, days to maturity, plant height, spike length, effective tillers per plant, grains per spike, grain yield per plant, 1000 grain weight, biological yield per plant and harvest index. Grain yield per plant and 1000 grain weight were recorded after threshing.

The mean of each plot was used for statistical analysis. The analysis of variance for all the traits was done as suggested by Panse and Sukhatme (1967). Mean of cross combinations (mean of ten plants per replicate) for all the characters were subjected to combining ability analysis (Kempthorne, 1957). Statistical software package SPAR 1 of Indian Agricultural Research Institute, New Delhi was used for statistical analysis.

Results and Discussion

Combining ability studies are useful in selection of parents and classifying them in terms of hybrid performance and to determine the nature and magnitude of gene effects involved in the expression of quantitative traits. Analysis of variance (Table 1) revealed significant differences among the progenies, parents, parents vs crosses, crosses for all the traits under study. This indicated the presence of diversity in the material. Analysis of variance for combining ability (Table 2) further reflected that variations due to line x tester interaction were significant for all the traits. This finding is in conformity to the earlier report of Kant and Gupta (2002) who observed that mean squares due to female x male interaction were significant for all the characters under study except for days to heading, biological yield and grain yield.

The variance component of combining ability for females was significant for spike length and 1000 grain weight. In case of males, significant differences were observed for days to 50 % flowering, days to maturity, spike length and effective tillers per plant (Table 2). The variance due to sca was found to be considerably higher than that of gca for all characters except for days to 50 % flowering and spike length indicating the preponderance of non additive gene action (Table 2). Similar findings have been reported by Li *et al.* (1991) and Muhammad Iqbal *et al.* (1991). Additive gene action for spike length observed in present investigation is in complete agreement with the findings of Nanda *et al.* (1974) and Hraska and Petrovic (1976). The predominance of additive gene action for spike length indicated the importance of this trait in conventional breeding and selection techniques for the improvement of this trait in wheat. However in case of days to 50 % flowering, there is an indication of both additive and non additive components of variance, which is in agreement with the results of Kassem (1978) and Rajara and Maheshwari (1996).

The estimates of gca effects of ten female and three male parents are presented in Table 3. General combining ability effects for almost all the female lines were found to be significant for days to 50 % flowering, whereas in males UP 2425 was the best general combiner for this trait. Among female parents Drina NS 720 was found to be the best and showed positive significant gca effect for grain yield per plant, number of grains per spike, 1000 grain weight and biological yield per plant. It was followed by WW 21, which exhibited significant positive gca effects for grain yield per plant, spike length, 1000 grain weight and biological yield per plant. Kumar *et al.* (2003) also reported WW21 as good general combiner for grain yield and some other traits. WW-7 also exhibited positive and significant gca effects for grain yield per plant, number of grains per spike and harvest index. Nordresprez exhibited positive and significant gca effects for grain yield per plant, 100 grain weight and biological yield per plant (Table 3).

Among males PBW 343 was found to be the best and showed significant positive gca effects for grain yield and other yield contributing traits *viz*, number of grains per spike, biological yield per plant and harvest index. It was followed by Raj 3765, which showed positive and significant gca effects for grain yield per plant, number of effective tillers per plant and biological yield per plant. It can be comprehended that four parents viz., Drina NS 720, WW 21, WW7 and Nordresprez among the lines and Two parents PBW 343 and Raj 3765 among testers were good general combiners. The estimates of sca effects are presented in Table 4 which could be used for identifying better cross combinations and to obtain transgressive segregants. Perusal of the table reveal seven good specific combinations for grain yield and other component traits. Among these three cross combinations *viz*, WW-7 x Raj 3765, Drina NS 720 x PBW 343 and Nordresprez x PBW 343 performed best with both parents involved in the cross having good general combining ability effects. This is highly desirable for effective selection. Singh and Chaudhary (1977) also reported good specific combinations in bread wheat with good gca effects of both the parents. Further, two cross combinations *viz*, China 84-40022 x PBW 343 and Vir 453-47 x PBW 343 with one parent having good gca exhibited superior specific combining ability effect. This is in conformity with the results obtained by Kant *et al.* (2001). On contrary, two other cross combinations *viz*., WW 12 x UP 2425 and Golden valley x UP 2425 were identified as performing good although with parents involved having poor gca for grain yield and component traits.

The overall findings reveal that variety PBW 343 and Raj 3765 should be utilised further in breeding programmes for developing superior varieties. The cross combination WW 7 x Raj 3765, Diana NS 720 x PBW 343, Nordresprez x PBW 343, China 84- 40022 x PBW 343 and Vir 453- 47 x PBW 343 could be the desirable choice for exercising single plant selection for seed yield per plant in advanced generations as all these crosses exhibited highly positive sca effects. In these crosses, additive gene effects were involved in the genetic control, especially for seed yield per plant and two to three yield contributing traits. It is likely that desirable recombinations of fixable nature can be obtained from these cross combinations having high seed yield per plant and other yield components.

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Table 1 Analysis of variance (mean sum of squares) for the design of experiment

Source	df	Days to 50% flowering	Flag leaf area (cm2)	Days to maturity	Plant height (cm)	Spike length (cm)	Effective tillers/ Plant	Grains /spike	Grain yield/ plant (g)	1000-grain weight (g)	Biological yield/ plant(g)	Harvest index (%)
Replications	2	89.59	2.16	1.98	0.69	0.77	13.54	0.98	45.79	1.41	162.62	0.26
Progenies	42	612.76**	429.6**	66.04**	199.36**	15.53**	62.39**	179.66**	657.73**	129.24**	2329.34**	55.97**
Parents	12	736.63**	386.4**	203.64**	349.32**	12.63**	21.56**	156.15**	429.80**	205.84**	2396.60**	111.69**
	1	9489.61**	1141.19**	177.23**	190.87**	317.44**	67.73**	607.19**	3995.88**	587.53**	6044.34**	495.46**
Crosses	29	255.41**	422.95**	5.26**	137.60**	6.32**	79.10**	174.65**	636.94**	81.74**	2173.41**	17.75**
Error	84	1.35	18.97	0.70	3.99	0.22	4.22**	7.81	37.50	0.78	160.14	0.58

*, ** significant at 5 and 1 percent levels, respectively

Table 2 Analysis of variance for combining ability for grain yield and yield contributing characters in wheat

Source	df	Days to 50% flowering	Flag leaf area (cm^2)	Days to maturity	Plant height (cm)	Spike length (cm)	Effective tillers/ Plant	Grains/ spike	Grain yield/ plant(g)	1000-grain weight(g)	Biological yield/plant (g)	Harvest index (%)
Lines	9	179.46	357.29	3.80	142.72	6.35**	39.60	182.80	395.39	146.58*	1775.29	9.97
Testers	2	1716.60*	197.65	16.88*	78.04	43.24**	247.08*	164.81	1271.56	20.33	4023.10	34.03
Line x Tester	18	131.03**	480.81**	4.70**	141.66**	2.20**	80.19**	171.68**	687.20**	56.14**	2166.94**	19.83**
Error	84	1.35	18.97	0.70	3.99	0.22	4.22	7.81	37.50	0.78	160.14	0.58
σ^2 gca (lines)		5.40	-13.72	-0.10	0.12	0.46	-4.51	1.24	-32.42	10.00	-42.52	-1.10
σ^2 gca (testers)		52.85	-9.44	0.41	-2.12	1.37	5.56	-0.23	19.48	-1.20	61.87	0.47
σ^2 sca (lines x tester)		43.23	153.95	1.33	45.89	0.66	25.32	54.62	216.57	18.45	668.93	6.42
σ^2 gca (parents)		41.90	-10.43	0.29	-1.60	1.16	1.38	0.11	7.50	1.38	37.55	0.11
σ^2 gca / σ^2 sca		0.97	-0.07	0.22	-0.03	1.76	0.05	0.002	0.03	0.07	0.06	0.02

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

Table 3 Estimates of general combining ability effects for grain yield and yield contributing characters in wheat

Parents Females	Days to 50% flowering	Flag leaf area (cm^2)	Days to maturity	Plant height (cm)	Spike length (cm)	Effective tillers/ Plant	Grains/ spike	Grain yield/ plant (g)	1000-grain weight(g)	Biological yield/plant (g)	Harvest index (%)
Golden valley	4.33**	7.76**	-0.42	-6.08**	-0.37*	2.53**	-1.43	2.49	-2.73**	7.35	-0.56*
Nordresprez	-4.78**	-1.13	0.24	2.16**	-0.66**	-0.02	1.34	4.40*	1.23**	13.74**	-1.30**
WW-26	3.56**	-8.24**	0.13	4.42**	0.08	0.76	-5.43**	-7.75**	-3.01**	-17.54**	0.82**
WW- 12	6.67**	4.69**	0.47	-0.96	1.69**	-3.58**	2.57**	-13.84**	-2.64**	-26.98**	-1.27**
WW-21	-4.22**	2.78	-0.87**	2.20**	0.61**	1.36	1.12	6.51**	6.96**	13.31**	0.42
China84-40022	-2.00**	1.65	0.58*	4.28	-0.53	1.76*	-6.54**	0.41	3.89**	-4.22	2.10**
Drina	6.89**	5.51**	-0.42	-0.32	-0.10	2.98**	-0.32	-3.20	-7.04**	-6.50	-0.11
WW-7	0.56	-7.45**	0.24	-7.28	-0.69	-2.36**	7.79**	4.42*	-0.61	4.78	0.82**
Vir453-47	0.89*	4.09**	-0.98**	2.02	0.88**	-0.22	-3.88**	-0.22	2.37**	0.68	-0.51*
DrainNS-720	-3.22**	-9.64**	1.02**	-0.43	-1.00**	-0.69	4.79**	6.79**	1.57**	15.37**	-0.42
S.E.(Females)	0.39	1.45	0.28	0.67	0.16	0.68	0.93	2.04	0.29	4.22	0.25
CD at 5%	0.78	2.89	0.56**	1.33	0.32	1.35	1.85	4.06	0.58	8.40	0.50
CD at 1%	1.01	3.76	0.73*	1.74	0.41	1.76	2.41	5.28	0.75	10.93	0.65
Males											
Raj-3765	-2.56**	0.87	-0.59**	-0.95**	0.08	2.79**	-0.61	3.26**	-0.20	7.79**	-0.18
UP-2425	-5.96**	2.02*	0.84**	-0.91*	1.16**	-2.94	-1.98**	-7.50**	0.90**	-13.31**	-0.96**
PBW-343	8.51**	-2.89**	-0.26	1.86**	-1.24**	0.16	2.59**	4.23**	-0.71**	5.52*	1.14**
S.E.(males)	0.21	0.80	0.15	0.37	0.9	037	0.51	1.12	0.16	2.31	0.14
CD at 5%	0.42	1.60	0.30	0.74	0.18	0.74	1.01	2.23	0.32	4.60	0.28
CD at 1%	0.54	2.07	0.39	0.96	0.23	0.96	1.32	2.90	0.41	5.98	0.36

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

Table 4 Estimates of specific combining ability (sca) effects for grain yield and yield contributing characters

Crosses	Days to 50% flowering	Flag leaf area (cm2)	Days to maturity	Plant height (cm)	Spike length (cm)	Effective tillers/ Plant	Grains/ spike	Grain yield/ plant (g)	1000-grain weight (g)	Biological yield/plant (g)	Harvest index (%)
Golden valley											
X Raj-3765	12.33*	2.81	0.92	8.29**	-0.57*	3..1**	-5.17**	4.80	3.07**	12.46	-0.54
X UP-2425	0.07	9.88*	-0.18	-2.26	0.49	1.83	10.87**	13.10**	-3.60**	19.92**	3.07**
X PBW-343	-12.40*	-12.68**	-0.74	-6.03**	0.08	-4.9**	-5.7**	17.90**	0.54	-32.38**	-2.52**
Nord Desprez											
X Raj-3765	0.44	-2.32	1.92**	-4.89**	-1.32**	-2.3	9.89**	1.60	-4.12**	14.10	-2.93**
X UP-2425	1.51*	8.51**	-0.84	3.16**	1.31**	-1.94	-4.91**	-9.51**	0.84	-21.47	-034
X PBW-343	-1.96*	-6.43*	-1.08	1.73	0.006	4.29**	-4.48**	7.92*	3.28**	7.37	3.28**
WW-26											
X Raj-3765	2.11*	12.17**	0.37	-0.11	0.65*	-7.46**	8.83**	1.87	5.91**	6.48	-1.26**
X UP-2425	2.84*	-12.82**	0.60	0.11	-0.06	5.61**	-5.80**	2.53	-2.73**	1.14	1.68**
X PBW-343	-4.96*	0.65	-0.97*	0.004	-0.59*	1.84	-3.03	-4.40	-3.18**	-7.62	-0.42
WW-12											
X Raj-3765	-1.33	5.53*	-0.63	-1.60	0.57*	1.88	6.83**	-0.77	0.58	-3.31	0.83
X UP-2425	-7.93*	5.20*	-1.07*	-6.85**	-0.17	0.94	3.87*	16.09**	4.64**	31.22**	1.61**
X PBW-343	9.27*	-10.72**	1.70**	8.45**	-0.40	-2.82*	-10.70**	-15.31**	-5.22**	-27.91**	-2.45**
WW-21											
X Raj-3765	-2.11*	-3.51	0.03	-9.57**	-0.08	1.66	-7.39**	-4.32	-1.96**	-12.63	1.29**
X UP-2425	0.62	4.20	0.93	15.52**	0.84**	-0.94	2.64	-0.56	0.11	4.40	-2.06**
X PBW-343	1.49	-0.69	-0.97*	-5.95**	-0.76**	-0.71	4.74**	4.88	1.85**	8.23	0.77

Contd......

China 84-40022											
X Raj-3765	-3.00*	6.99**	-1.74**	-4.65**	0.29	-1.79	-11.72**	-14.15**	2.84*	-28.37**	-0.36
X UP-2425	1.73*	-13.08**	-0.18	4.71**	-1.01**	-4.06**	1.98	-3.53	3.41**	-6.48	-0.32
X PBW-343	1.27	6.09*	1.92**	-0.06	0.72**	5.84**	9.74**	17.68**	-6.25**	34.86**	0.68
Diana											
X Raj-3765	-3.89*	-11.62**	-0.08	7.65**	-0.53	5.32**	-0.94	2.69	-5.59**	1.48	1.17**
X UP-2425	-2.49*	-18.00**	-0.84	-4.96**	0.23	1.72	0.76	6.29	-0.09	12.57	0.46
X PBW-343	6.38*	29.62**	0.92	-2.70*	0.30	-7.04**	0.19	-8.98*	5.68**	-14.06	-1.63**
WW-7											
X Raj-3765	0.44	-1.60	-1.41**	-0.81	0.68*	7.99**	2.28	31.77**	3.08**	51.33**	5.03**
X UP-2425	5.84*	-0.80	1.15*	-0.69	-0.49	-4.28**	-6.02**	-20.34**	-2.76**	-37.38**	-2.44**
X PBW-343	-6.29*	2.39	0.26	1.50	-0.19	-3.71**	3.74*	-11.43**	-0.32	-13.94	-2.59**
Vir453-47											
X Raj-3765	-5.22*	-5.47*	0.81	0.42	1.11*	-3.34**	-3.06	-9.79**	-0.13	-17.91*	-1.25*
X UP-2425	-3.82*	15.36**	-0.29	-3.09*	-1.00**	2.06	-2.36	-1.83	-2.67**	-3.01	-0.45
X PBW-343	9.04*	-9.90**	-0.52	2.67*	-0.10	1.29	5.41**	11.61**	2.81**	20.92**	1.70*
Diana NS-720											
X Raj-3765	0.22	-2.98	-0.19	5.27**	-0.81**	-5.01**	0.94	13.7**	-3.67**	-23.63**	-1.98*
X UP-2425	1.62*	1.31	0.71	-5.65**	-0.15	-0.94	-1.02	-2.24	2.86**	-0.90	-1.21*
X PBW-343	-1.84*	1.67	-0.52	0.38	0.95**	5.96**	0.08	15.93**	0.81	24.53**	3.19*
SE	0.67	2.51	0.48	1.15	0.27	1.19	1.61	3.54	0.51	7.31	0.44
CD at 5%	1.33	4.99	0.96	2.29	0.54	2.37	3.20	7.04	1.01	14.55	0.88
CD at 1%	1.74	6.50	1.24	3.00	0.70	3.10	4.17	9.17	1.32	18.93	1.14

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

References

1. Akerman A A and Mackey J. 1949. Attempt to improve yield of spring wheat. II cross between spring and winter wheat. *Sysriges Utandastoraanings Tidskrift* **19**: 105-117

2. Anonymous (2009). DWR Prog Rep. 2009 Crop Improvement. Vol 1, pp 1.1

3. Baric M, Sarcevic H and Keresa S. (2004). Analysis of yield components of F1 hybrids of crosses between spring and winter wheat types (*Triticum aestivum* L.). *Agriculturae Conspectus Scientificus* **69(1)**: 11-15

4. Hraska S and Petrovic, J 1976. The inheritance of quantitative characters in winter wheat in F_1 generation. *Pol' Pol nohospodarstva* **22**: 385-395.

5. Kant L, Mani V P and Gupta H S. (2001). Winter x spring wheat hybridization. A promising avenue for yield enhancement. *Plant Breeding* **120(3)**: 255 – 258

6. Kant L and Gupta H S. 2002 Potential yield enhancement by combining winter and spring wheat gene pools. *SABRAO J of Breeding and Genet* **34(2)**: 95-106

7. Kassem A A. (1978) Genetic analysis and interrelationships of quantitative characters in spring wheat. *Alaxandria J of Agric Res* **26**: 333-342

8. Kempthorne O. 1957. An introduction to genetical statistics. John Wiley and sons, New York, pp 545

9. Kumar A, Thakur K S, Sethi G S and Bhandari J S 2003. Combining ability analysis for grain yield and some other morpho-physiological traits in winter x spring wheat hybrids. *Crops Res* **26(2)**: 334-338

10. Li L Z, Lu D B and Cui D Q. (1991) Study on the combining ability for grain yield and quality characters in winter wheat. *Acta Agriculturae Universitatis Henanensis* **25**: 370-37

11. Muhammed Iqbal, Khurshid Alam and Chowdhary M A. 1991. Genetic analysis of plant height and the traits above flag leaf node in bread wheat. *Sarhad J of agric* **7**: 131-134

12. Nanda G S, Gill K S and Sharma S K. (1974) Combining ability in wheat. *Genetica aqraria* **28**: 307-316

13. Panse V G and Sukhatme P V. 1967. Statistical methods of agricultural workers. ICAR Publications. New Delhi.

14. Rajara M P and Maheshwari R V. (1996) Combining ability in wheat using line x tester analysis. *Madras Agric J* **83(2)**: 107-110

15. Sharma S and Chaudhary, H K. (2009) Combining ability and gene action studies for yield and yield contributing traits in crosses involving winter and spring wheat genotypes. *Acta Agronomica Hungarica* **57(4)**: 417-423

16. Singh V P and Choudhary R K. (1977) Line x Tester analysis for combining ability in triticale. *Crop Improvement* **4**: 74-80