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Combining ability Analyses for Protein Content and Maturity Traits in Spring Wheat (*Triticum aestivum*)

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Summary

Combining ability analyses were carried out for protein content, days to 50% heading, days to 50% heading in growing0 days (GDD), days to 50% flowering, days to 50% flowering in growing0 days (GDD), days to 50% physiological maturity, days to 50% physiological maturity in growing0 days (GDD), No. of grains/ spike, 1000 grain weight and grain yield/ plant in spring wheat. Additive as well as dominance gene action was responsible for expression of these traits. Most of the genotypes were found to be superior general combiners for protein content and other traits studied. Like wise, crosses involving diverse parents showed significant SCA effects for protein content and other traits. To ensure further increase in protein content with optimum maturity duration, combinations of desirable component traits is advocated. Biparental and/or diallel selective mating design would be useful methods for further improvement of protein content with optimum level of maturity time and grain yield in spring wheat.

Key Words: Protein content, Wheat, Combining ability analysis

Introduction

Wheat is one of the most leading source of vegetable proteins among food crops (1) and protein content in wheat grain governs its end use quality. Therefore, improvement in protein content of wheat kernel has been the most important objective of wheat breeder for a long time owing to its importance in human nutrition (2). Better understanding of inheritance of protein content and maturity traits will be valuable to make breeding strategies for rapid development of wheat varieties having high protein content with early maturity. Combining ability analysis will be helpful in selecting parents that could produce superior segregates in advance generation. Various studies reported involvement of additive, dominance and epistasis gene action in controlling protein content and maturity traits (3-4). In view of above facts, the present investigation was undertaken with the objective to determine combining ability of protein content and maturity traits in some important cultivar of spring wheat.

Experimental

Eleven wheat genotypes of diverse origin namely HP 1633, PBW 343, Bagula, Veery 'S', Pavon 76, HP 1731, HW 1084, HD 2285, HP 1102, K 9107 and KRL-1-4 were selected on the basis of variation present for their protein content and maturity traits from germplasm collection at Banaras Hindu University, Varanasi- India. This center (25.2 ^{0}N and 83.0 ^{0}E) has loam alluvial soil having neutral pH (7.2). Average minimum and maximum temperature was 10.9 ^{0}C and 23.66 ^{0}C during vegetative phase and 25.55 ^{0}C and 32.9 ^{0}C during reproductive phase of the crop, respectively. These genotypes were crossed in all possible combinations to produce F_1 and F_2 generations excluding reciprocals. The parental plants, F_1 and F_2 offspring's were then sown on *Rabi* 2002 in randomized block design with three replications at research farm of this centre. Each entry was sown in three 3-m-long rows at a spacing of 25× 5 cm. Agronomic practices recommended for normal fertility (120 kg N: 60 kg P_2O_5: 40 kg K_2O ha^{-1}) were followed to ensure good crops. Twenty plants each from parents and F_1 as well as 250 plants from F_2 generation were tagged randomly in each replication excluding the border plants prior to heading and observations were made for different traits on these plants only. The observations were recorded for quantitative traits viz. Days to 50% heading (in days), Days to 50% flowering (in days), Days to 50% physiological maturity (in days), No. of grains/ spike, 1000-grain weight (gm) and Grain yield/plant (gm). Protein content (in per cent) in wheat kernel was then calculated by multiplying the total percentage of nitrogen by a factor of 5.7 (5) while Nitrogen content (in per cent) in wheat grain was estimated following the method of Linder (6). The number of days from sowing to 50% heading, sowing to 50% flowering and sowing to 50% physiological maturity was converted to growing^0 days. Degree days for a particular period were calculated as Tn = (Tmax + Tmin)/ 2 – Tb, where Tmax and Tmin are the maximum and minimum daily temperature, respectively and Tb is the base temperature, below which no grain development occur. Data obtained for each trait were subjected to analysis of variance and variances were tested by F- test. Estimates of GCA and SCA were worked out by the method suggested by Griffing (7). The statistical tests were carried out using the INDOSTAT program.

Results and Discussion

Analysis of variance showed significant differences among parents, F_1's and F_2 progenies for all the traits (Table 1) indicating that the material used in the study had significant genetic diversity. The combining ability analyses indicated significant differences for GCA and SCA effects for all the traits (Table 2) studied. This suggested that the parents used in the study differed significantly for general as well as specific combining ability. The magnitude of GCA was larger than SCA effects except No. of grains/ spike and seed yield /plant in F_2 generation revealed preponderance of additive gene effects in the genetic control of most of the traits. Similar finding was also reported by Singh et al (8) and Chandra et al (9) for the expression of the traits studied. The greater magnitude of additive effects compared to non additive effects suggests that selection for high protein content might be effective in the early segregating generations. The general combining ability effects of the parents (Table 3) indicated that Pavon 76, HP1633, HP1731 and HP1102 displayed desirable and significant GCA effects for protein content whereas PBW 343, Bagula and HW1084 had significant negative GCA effects for this trait in both the generations. HP 1731 and K 9107 exhibited significant positive GCA effect for days to 50% heading, days to 50% heading in growing^0 days and days to 50% flowering whereas PBW 343 and HD 2285 showed negative GCA effect for these traits in both generations. HP 1633 showed positive GCA effect for days to 50% heading in growing^0 days, days to 50% flowering and days to 50% flowering in growing^0 days. Pavon 76 reflected positive GCA effect for days to 50% heading, days to 50% heading in growing^0 days, days to 50% flowering whereas Veery 'S' and KRL-1-4 showed negative GCA effect for days to 50% heading in growing^0 days and days to 50% flowering in growing^0 days. PBW343 and Veery 'S' provided a significant positive GCA effect for 1000 seed weight and seed yield per plant in F_1 and F_2 generations while K9107 generated positive significant effect for 1000 seed weight in F_1 and F_2 and seed yield per plant in F_1 generation only. Pavon 76, HW1084, HD2285 and HP1102 showed significant and negative GCA effect for 1000 seed weight and seed yield per plant whereas Bagula had negative and significant GCA effect for 1000 seed weight in F_1 and F_2 and for seed yield in F_2 generation. PBW 343, K 9107 and HP 1102 showed significant and desirable GCA effect for No. of grains/spike. These findings suggested that crossing two parents with the highest GCA should provide the greatest possibility of producing superior progeny.

The most promising crosses displaying significant and desirable SCA effects were listed in table 4. It was observed that out of 55 crosses, significant and desirable SCA effect was noted in 18 crosses for protein content, 15 for days to 50% heading, 20 crosses for No. of grains/ spike, 22 crosses for 1000 seed weight, 14 crosses for seed yield /plant, 17 for days to 50% heading in growing^0 days and days to 50% flowering, 7 for days to 50% flowering in growing^0 days, 1 for days to 50% physiological maturity and 9 for days to 50% physiological maturity in growing^0 days suggesting that non additive gene action also played an important role in expression of these traits. These findings are in agreement with the results of Iqbal et al (3) and Kamaluddin et al (4).

Table 1: Analysis of variance for parents, $F_{1's}$ and $F_{2's}$ for protein content and maturity traits in 11× 11 diallel cross of spring Wheat

Characters	Source of variation					
	Parents (d.f.10)	F_1S (d.f.54)	F_2 S (d.f. 54)	Parents vs F_1S (d. f. 1)	Parents vs F_2S (d. f.1)	Errors (d. f. 130)
Protein content	19.05**	9.03**	5.35**	33.90**	4.38**	1.21
Days to 50% Heading	158.69**	39.20**	73.22**	18.95**	32.71**	0.94
Days to 50% Heading in GDD	36799.01**	10044.44**	8223.22**	220.445**	10584.54**	359.63
Days to 50% flowering	146.60**	36.87**	42.19**	16.97**	24.26**	0.64
Days to 50% flowering in GDD	35805.07**	11854.04**	10439.26**	9375.74**	4068.18**	2091.70
Days to 50% Phy. Maturity	69. 40**	9.09**	31.84**	247.19**	18.36**	0.62
Days to 50% Phy. Maturity in GDD	34531.89**	4599.54**	11347.76**	113447.15**	1599.01**	329.37
No. of grains/spike	131.69**	233.81**	268.19**	191.56**	278.34**	3.48
1000-grain weight	39.89**	48.71**	57.34**	42.18**	300.57**	0.32
Grain yield/ plant	65.24**	45.62**	54.01**	636.47**	134.14**	0.21

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
GDD: Growing^0 days

Table 2: Combining ability analysis for protein content and maturity traits in 11× 11 diallel cross of spring wheat

Characters	Source of variation			
	Generation	GCA (d.f. 10)	SCA (d.f. 55)	Error (d.f. 130)
Protein content	F_1	13.59**	1.85**	0.0037
	F_2	7.60**	1.52**	0.0064
Days to 50% Heading	F_1	31.68**	16.80**	0.31
	F_2	71.06**	20.85**	0.28
Days to 50% Heading in GDD	F_1	7571.09**	4142.25**	119.51
	F_2	8512.68**	3437.85**	41.65
Days to 50% flowering	F_1	30.61**	15.49**	0.21
	F_2	38.58**	15.83**	0.15
Days to 50% flowering in GDD	F_1	7610.84**	4722.54**	697.22

	F_2	9327.19**	3915.56**	100.68
Days to 50% Phy. Maturity	F_1	10.63**	6.75**	0.20
	F_2	21.33**	10.75**	6.12
Days to 50% Phy. Maturity in GDD	F_1	5379.80**	3307.42**	109.59
	F_2	13153.39**	3424.67**	157.55
No. of grains/spike	F_1	95.94**	78.67**	0.79
	F_2	42.36**	104.92**	1.35
1000-grain weight	F_1	39.83**	11.38**	0.17
	F_2	44.31**	14.95**	0.03
Grain yield/ plant	F_1	34.22**	16.52**	0.10
	F_2	17.21**	26.63**	0.07

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
GDD: Growing^0 days

Table 3: Estimates of GCA effects for 11 parents along with their mean performance for protein content and maturity traits in F_1 and F_2 generation in 11× 11 diallel cross of spring wheat

Parents	Protein content			Days to 50% heading			Days to 50% heading in GDD		
	GCA effect		Mean	GCA effect		Mean	GCA effect		Mean
	F_1	F_2		F_1	F_2		F_1	F_2	
HP1633	1.09**	0.65**	13.17	0.60**	-1.31**	83.33	10.43**	6.82**	988.80
PBW343	-0.58**	-0.21**	10.13	-1.47**	-3.67**	66.67	-27.35**	-31.98**	738.83
Bagula	-0.93**	-0.75**	9.40	-1.19**	-2.49**	70.67	-16.75**	-13.35**	793.03
VeeryS	0.01	0.03**	11.17	1.19**	-1.24**	72.33	19.15**	1.59	814.80
	1.00**	1.43**	14.70	1.24**	2.35**	85.33	18.98**	24.74**	1021.20
HP1731	1.14**	0.37**	13.03	2.24**	3.58**	83.33	36.27**	42.48**	988.80
HW1084	-1.02**	-0.58**	8.67	0.40*	1.17**	71.67	5.31	-0.25	805.93
HD2285	-0.59**	0.40**	9.70	-1.76**	-1.57**	65.33	-25.46**	-36.39**	720.10
HP1102	0.77**	0.34**	13.48	-1.83**	-0.08	70.67	-28.84**	-14.94**	793.03
KRL-1-4-7	0.86**	-1.34**	14.34	-1.40**	0.20	71.67	-19.36**	-12.89**	807.10
K9107	-1.75**	13.03**	7.20	1.96**	3.07**	82.33	27.62**	34.17**	971.87
Xp	12.29	11.26	95.37	75.54	75.75		860.90	842.15	
SE(gi)±	0.005	0.006	0.08	0.15	0.14		2.88	1.70	
SE(gi-gj)	0.007	0.009	0.12	0.22	0.20		4.28	2.52	

Parents	Days to 50% flowering			Days to flowering in GDD			Days to 50% physiological maturity		
	GCA effect		Mean	GCA effect		Mean	GCA effect		Mean
	F_1	F_2		F_1	F_2		F_1	F_2	
HP1633	0.46**	0.66**	88.33	5.90	10.27**	1069.53	0.62**	0.17	114.00
PBW343	-2.15**	-2.96**	70.33	-20.73	-39.96**	788.57	-1.05**	-2.26**	105.33
Bagula	-1.13**	0.62**	75.33	-21.06*	-9.42**	853.93	-0.02	-0.34	116.00
VeeryS	1.05**	0.54	78.67	30.41**	9.30**	908.63	-0.53**	-1.70**	111.00
	1.26**	1.48**	90.67	16.58	20.22**	1091.20	0.28	1.12	116.00
HP1731	2.39**	3.07**	90.33	33.25**	46.89**	1085.60	0.60**	1.82**	117.67
HW1084	0.11	-0.21	76.67	-0.36	-4.58	874.10	1.34**	1.33	118.33
HD2285	-0.74**	-2.03**	76.63	-14.12	-35.64**	868.30	-1.76**	0.15	104.00

HP1102	-2.00**	-0.98**	77.00	-35.33**	-16.46**	879.70	0.03	-1.13	110.00
KRL-1-4-7	-1.07**	-0.72	77.67	-21.50*	-11.95**	891.37	-0.45**	0.05	113.67
K9107	1.82**	1.69**	87.00	27.01*	31.33**	1048.33	0.13**	0.79	116.00
Xp	81.41	79.97		957.12	931.60		115.40	112.94	
SE(gi)±	0.12	0.10		6.98	2.65		0.11	0.64	
SE(gi-gj)	0.18	0.15		10.35	3.93		0.18	0.96	

Parents	Days to 50% phy. maturity in GDD			No. of grains/spike			1000 grain weight			Grain yield/plant		
	GCA effect		Mean	GCA effect		Mean	GCA effect		Mean	GCA effect		Mean
	F_1	F_2		F_1	F_2		F_1	F_2		F_1	F_2	
HP1633	13.20**	8.69*	1533.50	1.76**	-1.74**	53.33	0.09	-0.38**	40.10	0.24	-0.08	21.37
PBW343	-22.02**	-44.08**	1348.17	5.04**	1.39**	60.00	2.32**	1.31**	39.03	2.84**	2.79**	27.23
Bagula	-0.28	-2.00	1578.47	-1.50**	-0.20	43.33	-0.35**	-0.16**	32.53	-0.14	-0.36**	20.47
VeeryS	-10.47**	-13.17**	1475.37	-0.06	-1.97**	60.00	0.50**	0.49**	39.17	2.07**	0.47**	28.27
Pavon 76	4.30	28.99**	1578.47	-2.57**	0.44	55.00	-1.06**	-0.38**	33.53	-1.94**	-0.47**	22.30
HP1731	12.66**	44.21**	1614.73	-0.27	0.52	57.00	1.65**	1.43**	40.10	-0.47**	1.07**	28.33
HW1084	32.66**	41.57**	1645.47	-2.86**	-2.31**	54.00	-2.43**	-1.90**	33.10	-0.90**	-0.58**	21.20
HD2285	-40.25**	-26.28**	1310.93	-3.86**	1.87**	46.67	-2.66**	-3.05**	37.47	-1.81**	-0.60**	19.43
HP1102	-0.08	-19.78**	1447.10	1.40**	2.03**	67.67	-0.74**	-1.19**	35.37	-0.86**	-0.61**	20.20
KRL-1-4-7	-9.88**	-27.66**	1526.13	-0.42	-2.28**	59.33	-0.06	-0.10	40.03	-1.03**	-1.63**	28.43
K9107	20.16**	27.53**	1578.47	3.35**	2.26**	56.33	2.75**	3.93**	44.13	2.01**	-0.02	33.43
Xp	156.95	1506.03		62.65	64.08		36.65	34.93		20.59	18.78	
SE(gi)±	2.76	3.31		0.23	0.30		0.10	0.04		0.08	0.07	
SE(gi-gj)	4.10	4.92		0.35	0.44		0.16	0.07		0.12	0.10	

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
GDD: Growing⁰ days

Table 4: Estimates of SCA effects of five most promising crosses for 11 parents along with their mean performance for protein content and maturity traits in F_1 and F_2 generations in 11× 11 diallel cross of spring wheat

Characters	Cross Combinations	SCA effect			
		F_1	F_2	Mean (F_1)	Mean (F_2)
Protein content	PBW343 / HP1731	2.84**	2.24**	15.70	13.67
	VeeryS / HP 1102	2.03**	0.62**	15.10	12.40
	HP1633 / HW 1084	1.23**	0.87**	13.60	12.20
	HD2285 / K 9107	1.19**	0.09**	12.50	10.50
	HP1731 / HW 1084	1.18**	0.24**	13.60	11.30
	$\bar{x}$	12.29	11.27		
	SEij±	0.01	0.02		
	SE (Sij-Sik)±	0.03	0.03		
Days to 50% heading	PBW 343 / K 9107	-6.70**	-8.82**	69.33	66.33
	Bagula / KRL-1-4	-6.62**	-8.79**	66.33	64.67
	Bagula / HP 1731	-5.26**	0.82	71.33	77.67

	HP 1633 / K 9107	-4.44**	- 6.18**	73.67	71.33
	PBW 343 / HP 1731	-3.31**	-5.33**	73.00	70.33
	$\bar{x}$	75.54	75.76		
	SEij±	0.52	0.48		
	SE (Sij-Sik) ±	0.76	0.73		
Days to 50% heading in GDD	PBW 343 / K 9107	-150.68**	-110.28**	710.50	734.07
	Bagula / KRL-1-4	-90.72**	-81.78**	734.07	734.13
	HP 1633 / Pavon 76	-88.61**	-85.05**	801.70	788.67
	HP 1633 / K 9107	-66.79**	-81.41**	832.17	801.73
	PBW 343 / HP 1731	-46.36**	-63.98**	823.47	788.67
	$\bar{x}$	86.90	847.15		
	SEij±	10.13	5.98		
	SE (Sij-Sik) ±	14.85	8.76		
Days to 50% flowering	PBW 343 / K 9107	-6.42**	-7.10**	71.67	69.33
	Bagula / KRL-1-4	-4.88**	-5.97**	72.67	66.33
	HP 1633 / Veery S	-4.27**	-4.51**	76.67	74.67
	HP 1731 / HW 1084	-3.57**	-4.51**	78.33	74.67
	Pavon 76 / HD 2285	-3.26**	-2.43**	77.00	72.67
	$\bar{x}$	81.41	79.97		
	SEij±	0.42	0.36		
	SE (Sij-Sik) ±	0.62	0.53		
Days to 50% flowering in GDD	PBW 343 / K 9107	-118.17**	-50.25**	845.23	872.73
	HP 1633 / Veery S	-84.80**	-77.08**	908.63	874.10
	Bagula / KRL-1-4	-73.78**	-91.10**	840.80	819.13
	Veery S / KRL-1-4	-63.18**	-48.12**	902.87	880.83
	HP 1731 / HW 1084	-52.65**	-71.06**	937.37	902.87
	$\bar{x}$	957.13	931.60		
	SEij±	24.47	9.29		
	SE (Sij-Sik) ±	35.88	13.63		

Continued----

Characters	Cross Combination	SCA effect			
Days to 50% phy. Maturity	KRL-1-4 / K 9107	-1.22**	-5.45**	114.67	108.33
	Veery S / HP 1731	-15.93**	-1.40	116.33	111.67
	Bagula / KRL-1-4	-4.27**	-6.99	110.67	105.67
	Pavon 76 / HD 2285	-2.59**	-0.89	117.33	113.33
	Bagula / Veery S	-2.53**	-3.58	112.33	107.33
	$\bar{x}$	115.40	112.95		
	SEij±	0.41	2.29		
	SE (Sij-Sik) ±	0.62	3.36		
Days to 50% phy. Maturity in GDD	Bagula / KRL-1-4	-94.56**	-121.14**	1461.23	1355.23
	Bagula / Veery S	-58.34**	-82.30**	1496.87	1390.57
	Pavon 76 / K 9107	-49.55**	-36.42**	1592.63	1526.13
	Bagula / HW 1084	-36.77**	-41.37**	1561.57	1504.23
	PBW 343 / Bagula	-24.79*	-62.32**	1518.87	1397.63
	$\bar{x}$	1565.95	1506.03		
	SEij±	9.70	11.63		
	SE (Sij-Sik) ±	14.22	17.05		
No. of grains/spike	PBW 343 / HW 1084	19.50**	16.84**	84.33	80.00
	HP1633 / K9107	16.24**	16.74**	84.00	81.33
	Bagula / Pavon 76	13.09**	5.02**	71.67	69.33
	HP1633 / Bagula	11.76**	10.53**	74.67	72.67
	HP1633 / HD2285	10.78**	3.12**	71.33	67.33
	$\bar{x}$	62.65	64.08		
	SEij±	0.82	1.07		
	SE (Sij– Sik) ±	1.20	1.58		
1000 grain weight	HP 1731 / KRL-1-4	4.96**	2.94**	43.20	39.20
	Bagula/ HP 1102	4.70**	4.61**	40.27	38.20
	Veery S/ HD 2285	3.93**	4.13**	38.43	36.50

	HW 1084/ HP 1102	3.81**	4.49**	37.30	36.33
	HP 1633/ HD 2285	3.25**	2.69**	37.33	34.20
	$\bar{x}$	36.66	34.93		
	SEij±	0.37	0.16		
	SE (Sij-Sik)±	0.56	0.25		
Grain yield/plant	PBW 343/ HP 1102	5.63**	4.63**	28.20	25.60
	HP 1633/ HD 2285	5.41**	2.92**	24.43	21.03
	Bagula/ HP 1731	4.82**	4.96**	24.80	24.47
	HW 1084/ HD 2285	3.84**	2.76**	21.73	20.37
	HP 1633/ Bagula	3.34**	5.15**	24.03	23.50
	$\bar{x}$	20.56	18.78		
	SEij±	0.28	0.24		
	SE (Sij-Sik)±	0.43	0.36		

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
GDD: Growing^0 days

Conclusions

Both additive and non-additive gene action played an important role in expression of these traits, although additive genetic variance was predominant. Therefore, biparental mating and /or diallel selective mating which may allow intermating of the selects in different cycles and utilize both additive and non additive gene effect could be effective in developing wheat cultivar having high protein content with optimum maturity period. Combining ability analyses can also help breeders in selecting those lines which when crossed will result in the highest proportion of desirable segregates. Dominance genetic effect shall be valuable in wheat breeding programmes when hybrid seed production is made economically feasible through an efficient cytoplasmic male sterility system.

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References

[1] D. Patnaik and P. Khurana. 2001. Wheat Biotechnology: A mini review. Electronic J. Biotech. (www .ejb.org/content/vo14/issue2/full/4/-).

[2] C. Groos, N. Robert, E. Bervas, G. Charnet. 2003. Genetic analysis of grain protein content, grain yield and thousand kernel weight in bread wheat. Theo. Appel. Genet. 106: 1032-1040.

[3] M. Iqbal, A. Navabi, D. F. Salmon, R. C. Yang, B. M. Murdoch, S. S. Moore, D. Spaner. 2007. Genetic analysis of flowering and maturity time in high latitude spring wheat. Euphytica 154: 207-218.

[4] Kamaluddin, R. M. Singh, L. C. Prasad, A. K. Joshi. 2007. Combining ability analysis for grain filling duration and yield traits in spring wheat (*Triticum aestivum* L. em. Thell). Genet. Mol. Biol. 30 (2): 411-416

[5] A. O. A. C. 1984. Official Methods of Analysis, 14th Edn Association of Official Agricultural Chemists, Washington D.C.

[6] R. C. Linder. 1944. Rapid analytical method for some of the more common organic substances of plant and soil. Plant Physiol. 19: 76-84.

[7] B. Griffing 1956. Concept of general and specific combining ability in relation to diallel crossing system. Aus. J. Bio Sci. 9: 463-493.

[8] J. Singh, D. K. Garg, R. S. Raje. 2007. Combining ability and gene action for grain yield and its components under high temperature environment in bread wheat [Triticum aestivum (L.) em. Thell]. Indian J. Gen. Plant Breed. 67(2): 215-216.

[9] D. Chandra, M. A. Islam, N. C. D. Barma. 2004. Variability and interrelationship of nine quantitative Characters in F_5 bulks of 5 wheat crosses. Pak J. Bio Sci. 7 (6): 1040-1045.