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Combining ability and heterosis for yield and grain quality in durum wheat *(Triticum turgidum* var. *durum)*

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Abstract : Forty hybrids involving ten lines and four testers were evaluated for combining ability and heterosis. Among the parents HD 4672, HD 4694, HI 8498, HD 4676 and PDW 233 were found best for yield as well as quality traits based on the mean and *gca* effects. Considering the mean performance, *sca* effects and heterosis, five hybrids *viz.*, HI 8596 x Trinakaria, HD 4692 x WH 896, HD 4694 x PDW233, HI 8653 x PDW 233 and HD 4695 x Trinakaria were superior for grain yield, five hybrids *viz.*, HI 8381 x Trinakaria, HD 4694 x WH 896, HD 4694 x HD 4676, HI 8651 x HD 4676 and HI 8653 x HD 4676 for quality traits and two hybrids HD 4694 x HD 4676 and HI 8498 x HD 4676 were found best for yield and quality traits both. Hence, these hybrids were suitable for generating good segregants for yield along with quality traits.

Key words: Durum wheat, combining ability, heterosis, Line x Tester

Introduction

Wheat is one of the world's most important food crops, which provides over 20 % of the calories and protein in human nutrition. In India, about five percent of the total wheat area is under durum wheat *(Triticum turgidum* var. *durum)* cultivation and approximately 2.5 million tons of durum wheat is produced annually. Durum wheat is unique in that it is generally considered the hardest of all wheats and has high protein content and especially suited for production of pasta products with high yellow pigment content required for attractive appearance of pasta in dry and cooked form. With changing consumer demands, improvement in processing quality of durum wheat is receiving attention.

Choice of the best parent is a pre-requisite in any crop improvement programme. Evaluation of parents for their transmission potential for yield and yield components will pave a way for better selection. The proper selection of parents could lead to identification of general combiner through which the available additive genetic variance could be fixed by way of befitting breeding procedure. Present study was made to know the general combining ability of parents, specific combining ability of hybrids for grain yield and quality traits and to study the nature and magnitude of gene action involved in the expression of these traits by adopting L x T design.

Materials and methods

The material of the present study consisted of fourteen durum varieties. Out of these, four varieties were used as testers / quality donors, of which two are established cultivars *i.e.* PDW 233 and WH 896, and two are

Table 1. Estimates of components of genetic variation for different traits in *durum* wheat.

Character	σ^2A	σ^2D	σ^2D/σ^2A
Days to 50% flowering	8.50	1.35	0.16
Days to maturity	3.49	0.23	0.07
Biomass / plant (g)	14.02	11.20	0.80
Plant height (cm)	59.58	6.08	0.10
Number of tillers per plant	0.46	0.98	2.13
Spike length (cm)	0.32	0.49	1.53
Spikelets per spike	0.59	0.13	0.22
Grain number per spike	144.65	3.49	0.02
Grain yield per spike (g)	0.12	0.02	0.17
Grain yield per plant (g)	4.09	4.46	1.09
1000-grain weight (g)	22.80	35.97	1.58
Sedimentation value (ml)	8.46	5.07	0.60
β - carotene (ppm)	0.74	0.78	1.05
Protein content (%)	0.43	0.75	1.74
Hectolitre wt. (kg)	2.25	2.07	0.92

established sources for quality *i.e.*, HD 4676 and Trinakaria. Remaining 10 genotypes, including 3 released varieties *i.e.*, HI 8498, HI 8381 and HD 4672 and seven elite lines *i.e.* HD 4694, HI 8596, HD 4692, HI 8591, HD 4695, HI 8651 and HI 8653 were used as lines. All the 54 genotypes *i.e.* lines, testers and their hybrids were raised at IARI, Regional Station, Indore in a randomized block design with three replications adopting a spacing of 30 x 10 cm. Standard agronomic practices were followed to raise a good crop. The observations were recorded on ten yield component traits *viz.*, days to 50% flowering, days to maturity, biomass / plant, plant height, number of tillers / plant, spike length, number of spikelets / spike, grain number / spike, grain yield / spike and grain yield / plant, and on five quality traits *viz.*, 1000 grain weight, sedimentation value, β-carotene, protein content and hectolitre weight. Standard statistical procedures were followed for analysis of variance (Panse and Sukhatme, 1967) and combining ability (Kempthrone, 1957)

Results and Discussion

Analysis for combining ability for fifteen characters revealed significant differences among the genotypes. The variances due to lines, testers and line x tester interaction were highly significant for most of the traits. In the present investigation, high additive variance (σ^2A) than dominance variance (σ^2D) was obtained (Table 1) for the traits *i.e.*, days to 50% flowering, days to maturity, biomass / plant, plant height, spikelets / spike, grain number / spike, grain yield / spike, sedimentation value and hectolitre weight, indicating the pre-dominance of additive gene action (Subhani and Chowdhary, 2000, Singh *et al.*, 2002 and Meena and Shastri, 2003). Traits like number of tillers /plant, spike length, grain yield / plant, 1000 grain weight, β carotene and protein content were highly influenced by non-additive gene action as evidenced from the very low σ^2A/σ^2D ratio (Singh *et al.*, 2002 and Sameena *et al.*, 2000).

So, improvement of these traits can be done by breeding procedures involving selection, inter-mating the selects and reselection among the superior segregants.

The success of plant breeding programmes largely depends on the appropriate choice of the parents. Among the parents HD 4672, HD 4694, HI 8498, HD 4676 and PDW 233 were found best for yield as well as quality traits. The estimate of *gca* effects (Table 2) revealed that the line HD 4694 had significant and desirable effects for eight characters *viz.*, days to maturity, biomass / plant, number of tillers / plant, spikelets /spike, 1000 grain weight, hectoliter weight, sedimentation value and β carotene. Among the testers, HD 4676 had good *gca* for 8 traits *viz.*, days to maturity, spike length, spikelets / spike, number of grains / spike, grain yield / spike, 1000 grain weight, grain yield / plant and sedimentation value (Desai *et al.*, 2005), followed by PDW 233 which had shown good *gca* effects for five traits.

The *sca* effect is a useful index to determine the usefulness of a particular cross combination for exploitation of heterosis. Among the 40 hybrids, the cross combination HI 8596 x Trinakaria showed desirable *sca* effect (Table 3) for seven yield traits *viz.*, biomass / plant, spike length, number of grains / spike, grain yield / spike, 1000 grain weight, hectolitre weight and grain yield (Yadav *et al.*, 1998). The hybrids HD 4692 x WH 896, HD 4694 x PDW 233, HI 8653 x PDW 233 and HD 4695 x Trinakaria performed equally good and showed best *sca* effects for different yield attributing traits. For the quality traits, the hybrids HI 8381 x Trinakaria, HD 4694 x WH 896 and HD 4695 x HD 4676 could be utilized for improving protein content, sedimentation value and β- carotene, whereas, hybrids HD 4694 x PDW 233 and HI 8651 x HD 4676 performed well both for yield as well as quality traits. Hybrid, HD 4694 x PDW 233 showed desirable *sca* effect for yield along with protein, test weight and hectoliter weight, and HI 8651 x HD 4676 showed desirable *sca* effect for grain yield along with β carotene, test weight and hectoliter weight.

Significant heterosis over the better parent PDW 233 was observed in the hybrid HD 4694 x PDW 233 for 8 traits *viz.*, days to 50% flowering, biomass /plant, number of tillers / plant, grain yield / spike, grain yield / plant, 1000 grain weight, protein content and hectolitre weight (Khan and Sher, 1999). Two hybrids *viz.*, HD 4694 x HD 4676 and HI 8498 x HD 4676 had recorded significant standard heterosis for seven traits each including yield and quality parameters. Among the parents used, the lines HI 8498 and HD 4694 exhibited superior mean and good *gca* effects and hence, should be exploited more in crosses to develop genotypes having good yield and desirable quality. Among the testers, PDW 233 appeared to be the best for combining most of the yield and quality traits. Considering the mean performance, *sca* effects and heterosis, five hybrids *viz.*, HI 8596 x Trinakaria, HD 4692 x WH 896, HD 4694 x PDW233, HI 8653 x PDW 233 and HD 4695 x Trinakaria were superior for grain yield, five hybrids *viz.*, HI 8381 x Trinakaria, HD 4694 x WH 896, HD 4694 x HD 4676, HI 8651 x HD 4676 and HI 8653 x HD 4676 for quality traits and two hybrids, HD 4694 x HD 4676 and HI 8498 x HD 4676 were found best for yield and quality traits both. Hence, these hybrids were suitable for generating good segregants for yield along with quality traits.

Table 2 Mean performance and estimates of general combining ability (gi or gj) effects of 14 parents in *durum* wheat.

Parents		Characters														
		Days to 50% flowering	Days to maturity	Biomass/ plant (g)	Plant height (cm)	No.of tillers /plant	Spike length (cm)	Spike-lets/ spike	No.of grains/ spike	Grain yield/ spike(g)	Grain yield/ plant(g)	1000-grain wt.(g)	Sedi-mentation (ml)	β-carotene (ppm)	Protein (%)	Hectolitre wt. (kg)
Lines (Females)																
HI 8381	M	77.33	114.67	52.47	92.33	8.80	7.83	20.07	64.27	2.73	18.13	47.10	24.33	5.50	12.50	74.67
	G	0.88*	0.17	-2.21	0.19	-0.08	0.08	0.03	1.42	-0.05	-0.03	-1.40**	0.09	-0.67**	-0.47**	-2.23**
HI 8498	M	74.0	112.33	46.07	91.30	8.13	7.87	20.33	55.13	2.70	17.07	51.00	36.00	4.77	12.33	78.00
	G	-2.54**	-1.08*	-9.15**	-1.64	-0.28	-0.42**	-0.39	-4.00**	-0.05	1.42*	5.25**	4.43**	-0.13	-0.18**	1.44**
HD 4672	M	77.67	113.33	53.80	104.00	12.13	8.77	20.27	68.13	2.57	20.07	42.70	29.00	5.13	12.60	74.33
	G	-0.71	-0.58	3.47	3.81**	0.22	0.86**	-0.14	-1.82	-0.05	2.94**	1.41**	-1.66**	0.14	0.78**	0.69**
HI 8596	M	77.67	116.33	44.87	97.00	9.73	7.10	19.27	52.13	2.20	14.97	38.90	32.00	8.20	13.60	74.67
	G	-0.54	-0.33	0.51	3.98**	-0.67	0.28*	-0.64**	-3.62**	-0.01	-0.23	0.85*	0.68*	0.50**	-0.69**	0.69**
HI 8591	M	81.67	118.00	46.43	89.40	11.20	7.87	21.27	63.67	2.17	17.47	35.27	22.67	7.03	13.23	72.33
	G	0.38	0.09	-2.11	-0.88	-0.68	0.10	0.33	2.05	-0.02	-1.51*	0.48	-3.82**	-0.72**	-0.04	-0.39**
HD 4694	M	80.67	115.00	40.73	95.20	10.47	7.60	21.13	57.73	2.07	14.57	36.87	27.33	7.97	13.73	74.67
	G	-2.79**	-1.91**	5.88**	2.91*	1.36**	-0.22	0.73**	-1.83	-0.04	1.90**	1.88**	-5.07**	0.14	0.80**	1.19**
HD 4695	M	74.67	113.00	42.73	90.10	10.53	7.13	19.87	55.20	2.03	14.90	39.60	42.33	7.17	12.97	75.67
	G	-0.54	-0.66	-7.20**	-4.45**	-1.63**	-1.11**	-1.19**	-3.11*	0.19**	-4.33**	-0.65	1.43**	0.77**	0.13	-0.39**
HI 8651	M	74.33	112.33	69.13	95.10	10.73	8.80	23.00	62.47	2.77	19.70	44.43	37.67	4.60	12.93	74.00
	G	-0.04	0.51	2.29	-1.50	-0.25	0.73**	1.26**	4.51**	-0.31**	-0.51	-3.70**	-0.16	0.10	-0.54**	-0.81*
HI 8653	M	85.33	121.00	34.80	90.43	10.01	8.00	20.33	64.33	2.07	16.57	34.10	40.67	7.07	15.37	73.33
	G	4.29**	2.84**	1.26	-4.46**	1.55**	0.01	-0.12	2.99*	0.22**	-0.68	-3.85**	3.76**	-0.08	0.77**	-1.31**
HD 4692	M	83.33	118.67	50.17	99.70	9.33	7.27	20.07	65.73	2.60	18.17	32.83	40.67	5.63	13.30	76.00
	G	1.62**	0.92*	7.27**	2.02	0.44	-0.29*	0.11	3.42*	-0.10	1.03	-0.30	0.34	-0.05	-0.56**	1.11**
SE(gi)±	G	0.43	0.43	2.07	1.13	0.46	0.13	0.24	1.39	0.07	0.66	0.38	0.30	0.10	0.08	0.14
Testers (Males)																
PDW 233	M	85.67	119.67	45.68	93.07	11.80	8.43	22.27	66.67	2.27	15.83	38.87	39.33	7.50	13.67	72.67
	G	0.61*	0.51*	-0.60	-4.78**	0.70**	-0.16*	0.36*	5.05**	0.01	0.67	-3.75**	1.83**	0.26**	0.01	0.09
WH896	M	81.00	116.33	51.27	94.47	9.33	8.67	21.40	67.33	2.40	17.80	39.87	38.67	8.53	12.77	73.33
	G	-0.79**	-0.33	-3.22**	-4.47**	-0.32	0.37**	-0.13	4.29**	-0.07	-0.81*	-3.51**	0.19	0.87**	0.10*	-0.34**
HD 4676	M	76.00	113.33	48.33	102.00	7.60	6.90	20.87	59.73	2.80	16.80	48.07	39.67	4.93	12.90	71.33
	G	-2.49**	-1.79**	1.64	0.39	0.32	0.38**	0.50**	5.65**	0.38**	1.91**	1.53**	0.59**	-0.15*	-0.74**	-1.31**
Trinakaria	M	87.67	120.01	78.07	127.43	10.40	8.13	20.00	49.33	2.63	16.53	53.50	39.00	5.03	14.87	76.67
	G	2.61**	1.61**	2.18*	8.87**	-0.71**	-0.58**	-0.74**	-14.9**	-0.32**	-1.77**	5.71**	-2.61**	-0.98**	0.63**	1.56**
S.E.((gj)±	G	0.25	0.25	1.20	0.65	0.26	0.07	0.14	0.80	0.04	0.38	0.22	0.17	0.06	0.05	0.08

* Significant at 5% level, and ** Significant at 1% level, respectively   M = Mean performance, G = *gca* effect

Table 3. Mean performance, estimates of specific combining ability and heterosis for superior cross combinations in *durum* wheat.

Parents		Characters														
		Days to 50% flowering	Days to maturity	Biomass/ plant (g)	Plant height (cm)	No.of tillers /plant	Spike length (cm)	Spike-lets/ spike	No.of grains/ spike	Grain yield/ spike(g)	Grain yield/ plant(g)	1000-grain wt.(g)	Sedi-mentation (ml)	β-carotene (ppm)	Protein (%)	Hectolitre wt. (kg)
For grain yield																
HI 8596 x Trinakaria	M	84.00	119.33	63.10	115.10	10.13	10.43	19.73	48.00	2.47	22.17	54.53	33.00	4.20	13.33	77.33
	S	-0.59	0.06	10.41**	2.08	0.77	2.37**	0.16	6.77**	0.37**	6.00**	4.29**	-2.31**	-1.48**	-0.66**	0.94**
	H	8.15**	2.58	-19.2**	18.66**	4.11**	46.9**	-1.33*	-7.93	-6.33**	34.0**	1.93	-15.4**	-48.8**	-10.3**	0.87
HD4692 x WH896	M	84.00	118.00	62.90	95.60	14.40	8.63	21.93	68.27	2.67	23.50	39.43	36.67	6.97	13.70	75.00
	S	0.71	-0.59	8.85*	-2.13	3.52**	0.20	1.00*	0.72	0.14	5.12**	-0.44	-1.11*	-0.01	0.10	0.09
	H	3.00*	1.43	22.69**	1.2	54.29**	-0.38	2.49**	1.39	2.56**	29.36**	-1.09	-9.84**	-18.4**	3.01**	-1.32**
HI 8653 x PDW233	M	85.33	120.67	57.80	93.97	14.07	8.17	21.27	64.97	2.33	21.43	40.00	40.67	5.70	14.57	73.67
	S	-2.02**	-0.68	7.14*	3.02	1.08	-0.03	0.07	-2.90	0.01	3.28**	3.91*	-2.16**	-0.64**	-0.26	0.74**
	H	0.01	0.84	26.75**	3.91	19.21**	-3.16**	-4.49**	-2.55	2.94**	29.38**	2.92*	0.01	-24.0**	-5.21**	0.45
HD4695 x Trinakaria	M	84.33	119.67	48.77	101.57	9.97	7.13	20.20	43.47	2.10	14.90	52.80	35.67	5.37	14.00	76.67
	S	-0.26	0.72	3.79	-3.03	1.34	0.46*	1.17**	1.73	0.30*	2.84*	4.05**	-0.39	-0.58**	-0.81**	1.36**
	H	12.95**	5.90**	-37.5**	12.73**	-7.59**	0.01	1.00	-21.3**	-20.2**	-9.88**	-1.31	-15.8**	-25.1**	-5.83**	0.01
For quality																
HI 8381 x Trinakaria	M	86.67	119.00	51.43	105.90	11.20	8.07	20.53	50.40	1.97	16.07	39.23	38.67	5.83	14.80	72.33
	S	0.66	-0.77	1.47	-3.34	1.26	-0.39	0.29	4.14	-0.10	-0.30	-8.76**	3.94**	1.32**	0.58**	-1.14**
	H	12.07**	3.78**	-34.1**	14.69**	7.69**	-4.68**	2.33**	-21.6**	-28.3**	-11.4**	-26.7**	-0.85	6.06**	-0.45	-5.65**
HD 4694 x WH 896	M	77.67	116.00	41.73	98.83	9.67	8.07	21.27	67.33	2.60	15.33	35.30	35.00	8.30	15.57	73.00
	S	-1.21	0.24	-10.9**	0.21	-2.1**	-0.43*	-0.29	5.04*	0.05	-3.92**	-6.75**	2.64**	1.13**	0.61**	-1.99**
	H	-.372*	0.87	-18.6**	4.62	-7.64**	-6.92**	-0.62	0.01	8.33**	-13.9**	-11.5**	-9.50**	-2.73**	13.35**	-2.23**
HD4695 x HD4676	M	80.33	115.67	45.50	96.93	9.80	7.73	19.40	59.50	2.23	15.80	42.63	40.67	7.83	15.60	70.67
	S	0.91	0.12	1.06	0.81	0.38	0.10	-0.87*	-2.87	-0.26*	0.06	-1.93*	1.41**	1.06**	2.15**	-1.78**
	H	7.59**	2.36	-5.86	7.58*	-6.96**	-10.8**	-7.03**	-0.39	-20.2**	-5.95*	-11.3**	-3.94**	9.30**	20.31**	-6.61**
For grain yield and quality																
HD4694 x PDW233	M	78.00	114.33	60.93	94.97	14.80	8.33	21.00	61.73	2.73	24.40	44.50	31.67	5.87	16.27	77.67
Grain yield along with	S	-2.27**	-2.26**	5.66	-3.35	2.01*	0.36	-1.04*	-1.13	0.12	3.66**	2.69**	-2.33**	-0.69**	1.41**	2.24**
protein, test weight and hectoliter weight	H	-3.31*	-0.58	33.63**	2.04	25.42**	-1.19**	-5.69**	-7.40	20.5**	54.1**	14.5**	-19.5**	-26.4**	18.45**	4.02**
HI 8651 xHD 4676	M	77.67	115.67	53.37	95.60	11.87	9.50	22.53	71.33	3.47	21.63	44.53	40.00	5.63	12.50	74.00
Grain yield along with	S	-2.26**	-1.04	-0.55	-3.47	1.06	0.04	-0.19	1.34	0.44**	2.07	3.02**	2.33**	-0.47**	-0.28	1.97**
β-carotene, test weight and hectoliter weight	H	4.48**	2.97*	-22.8**	0.53	10.56**	7.95**	-2.03*	14.2**	23.8**	9.81**	-7.35**	0.84	14.2**	-3.35**	0.01

* Significant at 5% level, and ** Significant at 1% level, respectively   M = Mean performance   S = *sca* effect   H = Heterosis

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