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Short Communication

Gene action and heterosis for some quantitative characters in bread wheat [*Triticum aestivum* (L.) Em. Thell.] under different moisture conditions

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Twelve generations namely, P1, P2, F1, F2, BC1, BC2, B11, B12, B11, B22, B1s and B2s of four spring wheat crosses *viz.*, S4 × HPW89, Hindi 62 × HS240, VL421 × HS240 and VL421 × PBW175 generated from three drought tolerant (S4, Hindi 62 and VL421) and three drought susceptible (HPW89, HS240 and PBW175) wheat genotypes were raised together in a compact family block design with 3 replications at 23 × 5 cm spacing under rainfed (E1) and irrigated (E2) conditions in *rabi* 2002-2003 at the Experimental Farm of Department of Plant Breeding and Genetics, CSK HPKV, Palampur. Observations on days to 75 % flowering and maturity, plant height, flag leaf area (FLA) and spike length were recorded on randomly selected 5 plants in each parents and F_1, 20 plants in each back cross generations, 15 plants in each second back cross generations and 40 plants in F_2 generation under both the environments.

The data of each population in both environments were analyzed separately by joint scaling test of Cavalli [1] to determine the nature of gene action. The heterosis over better parent and standard variety (VL 421) were estimated as deviation of F_1 value from the better parent and standard variety value in each environment for all the characters. $[\{\overline{F}_1 - \overline{BP}\}/ \overline{BP} \times 100]$ and $[\{\overline{F}_1 - \overline{SV}\}/ \overline{SV} \times 100]$.

The estimates of genetic parameters w. r. t. five traits of four crosses are given in Table 1. The results of joint scaling tests of 3 and 6 parameter model showed that either additive-dominance model or digenic epistatic model showed its adequacy for days to 75% maturity and spike length, whereas for flag leaf area (FLA) and plant height both the model were found to be inadequate to explain the nature of gene effects in most of the crosses. Inadequacy of both the model indicated the involvement of more complex interactions or linkage in the inheritance of the traits. The role of G × E interactions can also be predicted as one model is fitting well in one environment while not in the other environment in the same cross. However, the various gene effects were estimated on the basis of 6 parameter model.

In general, additive gene effects prevailed over dominance gene effects for both days to 75% flowering and maturity in desirable direction (-ve) under E2 and E1, respectively (Table 1). Among the interactions, dominance × dominance (l) was important for both the traits [2]. Negative sign of significant effects indicated that the genes for earlyness were dominant over genes for the lateness. Dominance gene effects was more pronounced than additive gene effects and among the interactions all three digenic interaction were important for the inheritance for FLA [3]. Dominance gene effects (h) was the most important for spike length, being significantly higher in magnitude and in desirable direction under both the environment and among the interactions, additive × additive (i) was relatively more important by virtue of its higher magnitude and direction [4]. Considering the magnitude and direction, dominance gene effects were relatively more important for the inheritance of plant height [5], whereas, among interactions, additive × dominance (j) and dominance × dominance (l) showed its importance. Duplicate type of epistasis (having h and l opposite sign) was observed for all the traits either in one or both the environments in some crosses.

On over all basis, additive component is more important in the inheritance of days to 75% flowering and maturity, whereas, dominance is important for other traits under study. Among the interactions (l) is more important for days to flowering and maturity, (i) for spike length, (i, j and l) for F_1A and (j and l) for plant height. The inheritance pattern varied with cross, character and environments under consideration. In such situation, diallel selective mating and/or biparental mating could be helpful for improvement of these traits.

None of the crosses showed desirable heterosis for days to 75% flowering and maturity neither in (E1)

Table 1. Estimates of genetic parameters for various traits in bread wheat

	Env.	m	d	h	i	j	l	Epistasis	χ^2 (9d.f.)	χ^2 (6d.f.)
Days to 75% flowering										
S4/HPW89	E1	129.93*±1.15	0.85±1.15	7.18*±2.03	-	-	-		7.28	-
	E2	133.08*±2.31	−0.92±1.01	16.96*±7.89	3.33±2.63	0.04±2.99	−12.16±6.96		25.33*	22.00*
Hindi62/HS 240	E1	127.62*±4.82	0.42±1.31	12.67±12.66	−1.28±4.57	0.99±4.82	−2.34±8.87		44.48*	43.70*
	E2	137.67*±0.28	−0.11±0.28	1.84±1.53	-	-	-		7.47	-
VL421/HS 240	E1	131.50*±1.40	−0.68±1.29	6.91*±2.66	-	-	-		4.60	-
	E2	132.93*±3.10	−2.46*±1.05	14.58±8.37	2.37±3.15	0.93±2.97	6.50±6.51		19.53*	18.48*
VL421/PBW 175	E1	128.24±0.72	1.61*±0.77	2.10±1.38	-	-	-		16.84	-
	E2	125.93*±3.01	−0.11±1.32	25.98*±9.03	6.17±3.04	−1.50±4.79	−18.00*±6.57	D	12.87	4.32
Days to 75% maturity										
S4/HPW 89	E1	155.17*±4.29	1.27±1.92	34.80*±11.40	7.57±4.83	−0.05±5.67	−24.61*	D	24.77*	13.34*
	E2	16.98*±0.62	−1.06±0.62	3.40*±0.92	-	-	-		4.03	-
Hindi62/HS 240	E1	147.47*±8.75	0.56±0.18	46.53*±20.61	-	-	-		16.30	-
	E2	171.83*±0.76	0.80±0.76	0.93±1.21	-	-	-		3.80	-
VL421/HS 240	E1	168.23*±4.94	−3.31*±1.40	−7.13±12.35	−3.42±5.06	12.51*±4.54	10.54±8.86		45.36*	36.92*
	E2	161.83*±2.13	−1.48±0.78	30.71*±7.05	6.38*±2.14	−4.65±2.58	−20.15*±6.16	D	28.97*	13.50
VL421/PBW 175	E1	167.67*±2.64	0.74±1.43	−23.84±10.47	−6.70±2.48	6.24±5.85	18.49*±9.23		18.50*	6.38
	E2	167.01*±0.74	−0.27±0.74	2.47±1.30	-	-	-		9.10	-
Plant height										
S4/HPW 89	E1	68.39*±2.98	−1.14±1.00	2.18±8.61	−0.67±2.97	−1.28±3.33	1.16±6.50		22.82*	22.59*
	E2	78.28*±1.28	−3.89*±1.17	5.51±2.86	-	-	-		10.94	-
Hindi62/HS 240	E1	68.57*±0.96	−7.62*±0.96	14.14*±1.88	-	-	-		12.43	-
	E2	90.13*±3.70	−6.58*±1.35	−28.50*±11.21	−10.15*±4.07	−7.48±5.70	43.95*±9.06	D	67.25*	24.76*
VL421/HS 240	E1	79.77*±4.76	−5.27*±0.95	−19.16±11.13	−12.20*±4.56	9.47*±3.91	10.15±6.91		31.46*	17.16*
	E2	104.00*±3.75	−4.49*±0.66	−62.61*±8.62	−23.02*±3.73	6.70*±1.80	44.79*±6.50	D	98.94*	15.91*
VL421/PBW 175	E1	71.67*±4.75	−0.97±1.44	−4.29±12.31	−7.76±4.73	−12.34*±4.83	5.84±8.85		17.41*	6.33
	E2	91.72*±5.05	−3.08*±1.55	−18.14±13.78	−12.05*±5.34	11.41*±5.58	10.59±10.65		27.94*	11.81
Flag leaf area										
S4/HPW 89	E1	5.74*±0.94	−1.30±0.85	40.81*±4.52	9.33*±0.60	7.87*±3.39	−34.30*±3.94	D	396.67*	19.86*
	E2	6.19±4.64	−0.65±0.76	54.17*±11.46	9.42*±4.67	6.91*±3.65	−46.03*±7.18	D	103.21*	7.08
Hindi62/HS 240	E1	19.22*±4.35	1.09*±0.28	−15.99±12.00	1.66±4.36	−14.48*±2.81	15.76±9.03		76.76*	35.58*
	E2	15.74*±1.94	−1.13±0.69	6.76±5.68	7.46*±2.05	2.49±2.55	5.91±4.50		69.63*	23.58*
VL421/HS 240	E1	19.29*±2.70	−4.06*±0.60	−21.32*±7.78	−3.72±2.50	3.87±3.90	23.63*±6.11	D	59.43*	37.27*
	E2	23.60*±2.27	−2.22±0.44	−2.06±5.87	−3.43±2.24	−2.34±1.97	2.87±3.92		30.57*	45.54*
VL421/PBW 175	E1	14.37*±1.05	−1.84±1.04	4.26*±1.90	-	-	-		8.35	-
	E2	23.17*±1.60	0.48±0.46	−13.14*±4.41	−5.62*±1.61	0.39±1.26	10.88*±4.25	D	22.40*	9.77
Spike length										
S4/HPW 89	E1	9.56*±0.23	0.69±0.20	1.15*±0.41	-	-	-		2.60	-
	E2	8.89*±0.69	−0.54*±0.13	5.98*±1.74	1.99*±0.64	0.84±0.54	−2.99*±1.37	D	22.88*	8.11
Hindi62/HS 240	E1	7.25*±0.82	−2.05*±0.42	8.16*±2.35	2.71*±0.84	1.84±1.11	−3.69*±1.84	D	26.38*	13.56*
	E2	10.57*±0.22	−11.01*±0.21	2.09*±0.63	-	-	-		13.12	-
VL421/HS 240	E1	8.77*±0.90	−0.62*±0.30	5.61*±2.51	1.83*±0.76	−2.29*±1.08	−2.74±1.85		92.71*	65.59*
	E2	10.90*±0.56	−1.80*±0.34	3.93*±1.73	−0.13±0.76	2.01*±0.77	−2.28±1.46		18.97*	9.46
VL421/PBW 175	E1	9.11*±0.26	−0.03±0.24	0.40±0.53	-	-	-		7.28	-
	E2	10.80*±0.14	−1.58*±0.08	−0.80±0.47	-	-	-		14.39	-

nor (E2) environment. For flag leaf area, heterosis was observed over BP in the crosses Hindi 62/ HS240 and V1421/PBW175 under E2 and over SC under both the environments and also in the cross VL421/ HS240 under E2 which is desirable for higher biomass production. For spike length, desirable heterosis was observed in the cross Hindi62/HS240 and V1421/ PBW175 under E2 over SC. None of the crosses showed desirable heterosis (-ve) for plant height under E2, however, positive heterosis was observed both over BP and SC under E1 in all the crosses except S4/HPW89, which would help to screen the cross combinations for drought.

Table 2. Estimates of heterosis under rainfed (E1) and irrigated (E2) conditions

Cross	Percent deviation from (BP)		Percent deviation from (SC)	
	E1	E2	E1	E2
Days to 75% flowering				
S4/HPW 89	3.75	3.17	3.26	5.09*
Hindi 62/HS 240	7.37*	2.57	7.52*	6.65*
VU2I/J1S 240	6.16	5.21	6.16	5.20
VU2I/PBW 175	0.81	0.91	0.79	0.90
Days to 75% maturity				
S4/HPW 80	1.48	2.69*	1.99	–3.77*
Hindi 62/HS 240	2.52	1.40	2.80	–3.08*
VJ42I/HS 240	4.93*	1.86	4.96	3.62*
VU21/PBW 175	2.07	2.33	1.58	1.85*
Flag leaf area				
S4/HPW 89	–15.92	–6.63	14.96	–20.00*
Hindi 62/HS 240	–3.46	11.48*	84.11*	50.00*
VL421/HS 240	–36.74*	–0.66	27.57	33.67*
VL421/PBW 175	18.26	25.00*	53.13*	25.00*
Spike length				
S4/HPW 89	7.28	5.84	4.07	20.30
Hindi 62/HS 240	–5.45	1.11	15.72	27.83*
VL421/HS 240	–7.89	–2.15	12.74	23.72*
VL421/P8W 175	–6.27	0.80	–6.27	0.79
Plant height				
S4/HPW 89	0.01	14.00*	12.06*	13.81*
Hindi 62/HS 240	33.04*	23.76*	32.52*	17.73*
VL21/HS 240	11.17*	4.44	11.17*	4.44
VL21/PBW 175	21.56*	11.98*	21.57*	11.98*

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