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GENE EFFECTS FOR GRAINS PER SPIKE, GRAIN WEIGHT AND GRAINS PER SPIKELET IN A SET OF NINETEEN CROSSES OF WHEAT

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ABSTRACT

Generation means analysis involving six basic generations of each of the 19 crosses of wheat (*Triticum aestivum* L.) involving 20 genetically diverse parents was used to elucidate the inheritance of grains per spike, grain weight and grains per spikelet. The additive and additive × additive gene effects were significant in a great majority of cases. However, the magnitude of additive gene effects was quite small as compared with other gene effects. The dominance and dominance × dominance gene effects, though present in about one third of the crosses were of larger magnitude but were unexploitable due to their opposite signs. The detection of both fixable and non fixable gene action and of duplicate epistasis implies the use of biparental approach/intermating in early segregating generations.

Key words: Wheat, *T. aestivum* L. gene effects, yield components, inheritance

Number of grains per spike and grain weight are two important components of grain yield. Grains per spike can be increased by increasing the number of grains per spikelet. Genetic information concerning the nature of gene action for these three characters would be a valuable tool for breeding higher yielding cultivars. Although some studies have already been conducted in the past [1- 4], these are based on basic generations of one or a few crosses. The results from such studies can have only a limited applicability. The present study was, therefore, initiated to investigate the nature of gene effects on a set of 19 crosses involving 20 varieties. The results which would be helpful in generalizations are reported in the present paper.

MATERIALS AND METHODS

Nineteen varieties of bread wheat (*Triticum aestivum* L.), viz., WL 410, WL 1562, WG 357, WG 377, HD 1941, HD 2258, CPAN 1285, CPAN 1360, Tanori 71, Nacozari, UP 301, WH 171, RAJ 1482, Sonalika, Crim, Girija, K 68, IWP 72 and Kalyansona were crossed to WL 711. The parents, F_1, F_2, and two backcrosses, B_1 and B_2 of 19 crosses were grown in a split plot design with three replications. Each replication comprised five rows each of P_1, P_2 and F_1 generations, whereas, the F_2 and backcrosses were represented by 20 and 15 rows, respectively. The plot size was a single one meter long row. The plant to plant and row to row distance was kept 10 and 30 cm., respectively. Data were recorded on five plants in each row on number of grains per spike, 1000- grain weight and number of grains per spikelet. The genetic parameters were estimated by successive model fitting in each cross by weighted least squares analysis [5].

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the generations for all the three characters i.e., grains per spike, grain weight and grains per spikelet, thereby, suggesting the presence of enough genetic variability in the material under study. Significant heterosis over better parent was observed for grains per spike in the crosses of WL 711 with HD 2258, Tanori 71, UP 301, WH 171 and Kalyansona, indicating considerable dominance in these crosses. Inbreeding depression for grains per spike occurred in crosses of WL 711 with WG 377, HD 2258, CPAN 1360, Tanori 71, Nacozari, UP 301, WH 171, IWP 72 and Kalyansona. Heterosis over better parent was observed for grain weight in crosses of WL 711 with WL 1562, WH 171 and Sonalika.

The estimates of gene effects for the best fit model with respect to these three traits in each of the 19 crosses are given in Table 1. The signs of parameter [d] and [j] are dependent upon the mean of two parental generations. Therefore, the higher scoring parent was invariably treated as P_1.

The presence of only additive gene effects was indicated for grains per spike in the crosses of WL 711 with WL 410, WG 357, CPAN 1285, Sonalika, Girija and K 68. Earlier studies [2, 6] have also indicated the preponderance of additive gene effects for grains per spike. The additive and additive × additive gene effects were significant in crosses of WL 711 with WL 1562, HD 1941, RAJ 1482 and Crim. Similar results have earlier been reported [7]. A model with parameteric combination of m, [d], [h], [i] and [1] was the best fit in crosses WL 711 × Tanori 71 and WL 711 × UP 301. All the six parameters were significant in crosses WL 711 × CPAN 1360 and WL 711 × IWP 72. Dominance and epistatic gene effects have been reported to be operating in the inheritance of this trait [3, 8- 9]. The digenic epistatic model was inadequate in crosses of WL 711 with WG 377, HD 2258, and Nacozari indicating the presence of higher order genic interactions or linkage or both.

For grain weight, only the [d] parameter was significant in the crosses of WL 711 with WL 410, WL 1562, CPAN 1285, CPAN 1360, Tanori 71, Nacozari and Kalyansona indicating that only additive type of gene action was responsible for the

Table 1. **Estimates of gene effects for grains per spike, grain weight and grains per spikelet in 19 crosses of wheat**

Cross	m	[d]	[h]	[i]	[j]	[l]	X^2
Grains per spike							
WL711 × WL410	61.11 ± 4.43	$3.02^{**} \pm 0.47$	-	-	-	-	6.12
WL1562	56.90 ± 4.23	$6.52^{**} \pm 0.49$	-	$6.89^{*} \pm 2.98$	-	-	5.38
WG357	58.04 ± 3.48	$6.62^{**} \pm 0.46$	-	-	-	-	5.55
WG377	72.81 ± 4.25	$3.65^{**} \pm 0.46$	-	$-7.62^{*} \pm 3.14$	-	$14.59^{*} \pm 6.72$	7.38^{*}
HD1941	69.82 ± 4.14	$4.31^{**} \pm 0.46$	-	$-6.18^{*} \pm 3.13$	-	-	4.32
HD2258	56.03 ± 3.21	$1.79^{**} \pm 0.49$	$27.37^{*} \pm 11.06$	-	$6.51^{*} \pm 2.70$	$-12.91^{*} \pm 5.58$	5.43^{*}
CPAN1285	67.02 ± 4.67	$4.96^{**} \pm 0.42$	-	-	-	-	1.38
CPAN1360	43.58 ± 3.08	$5.39^{**} \pm 0.41$	$47.72^{**} \pm 12.30$	$18.32^{**} \pm 3.35$	$6.83^{*} \pm 2.18$	$-23.43^{**} \pm 6.48$	-
Tanori71	39.78 ± 3.01	$3.16^{**} \pm 0.39$	$61.82^{**} \pm 10.98$	$25.83^{**} \pm 3.12$	-	$-31.80^{**} \pm 7.12$	3.12
Nacozari	55.95 ± 3.41	$2.85^{**} \pm 0.48$	$25.39^{*} \pm 11.32$	$9.42^{*} \pm 3.98$	-	$-13.51^{*} \pm 6.12$	5.12^{*}
UP301	55.19 ± 3.52	$3.11^{**} \pm 0.42$	$32.29^{**} \pm 9.32$	$9.64^{*} \pm 4.23$	-	$-15.65^{*} \pm 7.12$	2.28
WH171	58.06 ± 3.89	$1.96^{**} \pm 0.58$	$22.67^{*} \pm 11.45$	$8.44^{**} \pm 4.12$	$10.24^{**} \pm 2.53$	-	4.38
RAJ1482	76.58 ± 4.56	$2.72^{**} \pm 0.43$	-	$-12.04^{**} \pm 5.36$	-	-	3.38
Sonalika	63.83 ± 4.87	$7.96^{**} \pm 0.45$	-	-	-	-	5.38
Crim	71.80 ± 4.69	$9.28^{**} \pm 0.54$	-	$-13.80^{**} \pm 4.12$	-	-	4.45
Girija	59.89 ± 3.96	$4.03^{**} \pm 0.95$	-	-	-	-	2.38
K68	63.05 ± 4.12	$7.70^{**} \pm 0.15$	-	-	-	-	4.38
IWP72	44.81 ± 3.98	$2.52^{**} \pm 0.38$	$46.37^{**} \pm 13.98$	$21.18^{**} \pm 3.56$	$7.46^{**} \pm 1.78$	$-26.34^{**} \pm 7.12$	-
Kalyansona	63.98 ± 4.25	-	-	-	$7.93^{**} \pm 1.89$	-	4.42

(Contd. on next page)

Cross		m	[d]	[h]	[i]	[j]	[l]	X^2
Grain weight								
WL 711 ×	WL410	37.63 ± 2.22	$2.95^{**} \pm 0.34$	-	-	-	-	3.12
	WL1562	44.95 ± 3.24	$1.84^{**} \pm 0.39$	-	-	-	-	4.45
	WG357	40.34 ± 2.56	$1.89^{**} \pm 0.28$	$13.35^{**} \pm 5.95$	$5.50^{*} \pm 2.18$	$6.49^{**} \pm 1.72$	-	5.38^{*}
	WG377	39.75 ±2.67	$2.29^{**} \pm 0.36$	-	-	$6.37^{**} \pm 1.77$	-	8.42^{**}
	HD1941	32.88 ± 2.96	$2.77^{**} \pm 0.46$	$16.97^{**} \pm 6.08$	$7.28^{**} \pm 2.91$	-	-	4.12
	HD2258	34.46 ± 2.35	$1.32^{**} \pm 0.37$	$18.01^{**} \pm 5.95$	$7.34^{**} \pm 2.43$	-	-	6.38^{*}
	CPAN1285	40.68 ± 2.69	$2.25^{**} \pm 0.35$	-	-	-	-	3.43
	CPAN1360	35.86 ± 2.65	$1.79^{**} \pm 0.55$	-	-	-	-	5.38
	Tanori171	43.95 ± 2.78	$1.55^{**} \pm 0.36$	-	-	-	-	2.12
	Nacozari	40.69 ± 1.99	$3.25^{**} \pm 0.42$	-	-	-	-	4.45
	UP301	23.97 ± 1.85	$1.83^{**} \pm 0.31$	$37.10^{**} \pm 6.11$	$17.28^{**} \pm 2.22$	$10.30^{**} \pm 1.95$	$-20.72^{**} \pm 4.09$	-
	WH171	49.31 ± 3.25	$0.73^{*} \pm 0.36$	$-22.42^{**} \pm 6.96$	$-6.66^{*} \pm 3.12$	-	$17.29^{**} \pm 4.40$	4.42^{*}
	RAJ1482	49.89 ± 3.02	$1.79^{**} \pm 0.56$	$-22.37^{**} \pm 8.29$	$-8.76^{**} \pm 2.58$	-	$12.97^{**} \pm 5.12$	1.12
	Sonalika	42.71 ± 3.28	$1.14^{**} \pm 0.44$	-	-	$-3.64^{*} \pm 1.69$	-	9.92^{*}
	Crim	34.22 ± 3.40	$2.48^{**} \pm 0.41$	-	$6.74^{**} \pm 2.95$	-	-	2.22
	Girija	34.94 ± 3.67	$1.99^{**} \pm 0.37$	-	$6.46^{*} \pm 3.12$	-	-	2.18
	K68	34.46 ± 3.24	$2.74^{**} \pm 0.54$	$20.03^{**} \pm 7.17$	$11.22^{*} \pm 2.17$	-	-	1.32
	IWP72	29.51 ± 2.99	$1.52^{**} \pm 0.39$	$29.46^{**} \pm 6.32$	$12.42^{**} \pm 2.92$	$14.98^{**} \pm 4.53$	$-16.64^{**} \pm 4.98$	-
	Kalyansona	35 .79 ± 3.28	$3.20^{**} \pm 0.31$	-	-	-		4.38

(Contd. on next page)

Cross	m	[d]	[h]	[i]	[j]	[l]	X^2
Grains per spikelet							
WL711 × WL410	3.29 ± 0.31	0.10* ± 0.04	-	-	-	-	4.32
WL1562	2.73 ± 0.29	0.15** ± 0.03	-	0.54** ± 0.27	-	-	3.12
WG357	3.12 ± 0.32	0.12** ± 0.03	-	-	-	-	2.78
WG377	2.89 ± 0.19	0.08* ± 0.03	1.33* ± 0.57	0.64** ± 0.19	-	-	6.42*
HD1941	2.95 ± 0.30	0.18** ± 0.04	-	-	-	-	3.16
HD2258	3.18 ± 0.23	0.12** ± 0.04	-	-	-	-	4.42
CPAN1258	2.38 ±0.21	0.21** ±0.03	1.72** ± 0.58	0.86**±0.21	-	–0.92* ± 0.39	4.18*
CPAN1360	3.09 ± 0.29	0.15** ± 0.03	-	-	-	-	3.36
Tanori71	2.58 ± 0.18	0.25** ± 0.03	1.79* ± 0.88	0.84* ± 0.38	-	–1.06* ± 0.54	5.46*
Nacozari	2.65 ± 0.24	0.12* ± 0.05	1.77** ± 0.50	0.92** ± 0.16	-	–0.87* ±0.35	2.12
UP301	3.10 ± 0.28	0.08* ± 0.03	-	-	-	-	1.38
WH171	3.17 ± 0.32	015** ± 0.04	-	-	-	-	2.42
RAJ1482	3.33 ± 0.29	0.06* ± 0.03	-	-	-	-	2.12
Sonalika	2.96 ± 0.23	0.25**±0.05	-	-	-	-	3.13
Crim	2.88	± 0.34	0.22** ± 0.03	-	-	-	-
Girija	2.85 ± 0.26	0.08* ± 0.03	-	-	-	-	3.42
K68	2.39 ±0.30	0.33** ± 0.02	1.96** ± 0.64	0.72** ± 0.24	-	–1.20* ± 0.41	2.12
IWP72	2.69 ±0.29	0.28** ± 0.04	-	0.44*±0.22	-	-	1.12
Kalyansona	3.32 ±0.33	0.13** ± 0.03	-	-	-	-	2.48

*, ** Significant at 5% and 1% levels, respectively

genetic control in these crosses. These results corroborated earlier findings [2]. In WL 711 × Crim and WL 711 × Girija, both [d] and [i] were significant. The dominance and/or dominance × dominance interactions were detected in crosses of WL 711 with K 68, HD 1941 and RAJ 1482. The presence of higher order interactions or linkage or both was detected in the crosses of WL 711 with WG 357, WG 377, HD 2258, WH 171 and Sonalika. The complexity of inheritance of this trait has been indicated by the presence of additive, dominance and epistatic effects [4, 6, 8, 10].

With respect to grains per spikelet, the additive gene effects were preponderant in the crosses of WL 711 with WL 410, WG 357, HD 1941, HD 2258, CPAN 1360, UP 301, WH 171, RAJ 1482, Sonalika, Crim, Girija and Kalyansona. Out of the remaining crosses, [d] and [i] were significant in WL 711 × WL 1562 and WL 711 × IWP 72; and the parameters [d], [h], [i] and [l] were significant in WL 711 × Nacozari and WL 711 × K 68. The digenic epistatic model failed in crosses of WL 711 with WG 377, CPAN 1285 and Tanori 71.

The present investigations suggested that the additive gene effects were contributing significantly to the mean performance in all the 19 crosses for all the three characters except for grains per spike in WL 711 × Kalyansona. However, their magnitude in comparison with other gene effects was relatively smaller. The other most prevalent gene effect was the additive × additive epistatic effects. Although the dominance and dominance × dominance gene effects were present in fewer number of cases, their magnitude was considerably high. Inspite of such high magnitude, the dominance property of the genes would not be exploited because of opposite signs of [h] and [l] in all the situations where these coexisted, indicating the presence of duplicate type of epistasis. The additive × dominance type of epistasis was of minor importance. Earlier studies had also indicated the complexity of inheritance of these yield component characters.

Keeping in view the presence of both fixable and non-fixable gene action as well as of the duplicate type of epistasis in the inheritance of grains per spike, grain weight and grains per spikelet, these traits probably have a poor amenability to simple selection procedures. This would warrant the exploitation of both fixable and non-fixable variation through additional cycles of intermating in early segregating generations.

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