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GENE EFFECTS FOR SIX METRIC TRAITS IN FOUR SPRING WHEAT CROSSES

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ABSTRACT

To study the nature and magnitude of gene effects for six metric traits in four spring wheat crosses, additive-dominance model and digenic interaction model were chosen. The dominance gene effects were more important than additive gene effects in almost all cases which showed presence of both kinds of gene effects. Epistasis was indicatd in 12 out of 24 cases. The additive × dominance interaction (j) was a minor component of epistasis. Presence of trigenic or higher order interactions or linked digenics was indicated for tillers and grain yield/plant in cross HD 2122 × Sonalika. Epistasis played a big role in the control of plant height, tillers/plant and grain yield than in the control of the remaining three characters. The crosses WL 711 × HD 1981 and WG 377 × HD 1925 can provide better opportunities for improvement through simple selection procedures than the remaining two crosses.

Key words: Gene effects, metric traits, spring wheat, joint scaling test, six-parameter method, epistasis, heterosis.

The knowledge about the nature and magnitude of gene effects may greatly help in formulating plant breeding programmes, since such a knowledge not only tells about the relative importance of different kinds of gene effects (additive, dominance and epistatic) in the control of characters, but also provides information about the cause(s) of heterosis.

In the present study, an attempt has been made to estimate various kinds of gene effects through standard biometrical genetic procedures and to know the relative importance of these gene effects in the control of six important metric traits including grain yield in wheat.

MATERIALS AND METHODS

The material of the present study consisted of four spring wheat crosses, namely, WL 711 × HD 1981, WG 377 × HD 1925, WL 711 × HD 2122, and HD 2122 × Sonalika. Six generations, P_1, P_2, F_1 ($P_1 \times P_2$), F_2, BC_1 ($F_1 \times P_1$) and BC_2 ($F_1 \times P_2$) of each of the four crosses were produced and raised in randomized block design with three replications in 2.5 m long rows with row-to-row distance of 23 cm and plant to plant 10 cm during 1983–84. Each parental and F_1 generation was represented by 1 row, each BC generation by 5 rows, and each F_2 by 20 rows. The data were recorded on five randomly chosen competitive plants in each row for six metric traits, namely, days to heading, plant height, effective tillers/plant, grain/ear, 100-grain weight, and grains yield/plant.

The data were subjected to the joint scaling test of Cavalli [1] to obtain estimates of m, (d) and (h) parameters and to test the adequacy of the additive–dominance model. In cases where the additive–dominance model was adequate but some other parameter was nonsignificant (e.g. parameter (h) was nonsignificant in 8 out of 12 cases, showing adequacy of the additive–dominance model), the best fitting model (two-parameter model) eliminating nonsignificant parameter was applied to obtain more precise estimates of the remaining parameters. The data of the characters showing inadequacy of the additive–dominance model were subjected to the six-parameter model based on the formulae given by Mather and Jinks [2] to obtain estimates of m, (d), (h), (i), (j) and (l) parameters. This model was used as a guide to choose the best suited model in each case. In all cases to which this model was applied, one or more parameters were nonsignificant and thus the best fitting model was applied in each case by excluding the nonsignificant parameter(s).

RESULTS AND DISCUSSION

The estimates of main gene effects and χ^2 values, obtained by applying the best fitting models for characters showing adequacy of the additive–dominance model in four spring wheat crosses, are given in Table 1. Of the total six characters studied, four characters for cross WL 711 × HD 1981, three each for crosses WG 377 × HD 1925 and WL 711 × HD 2122, and two characters for cross HD 2122 × Sonalika showed adequacy of the additive–dominance model. Both (d) and (h) parameters were significant in four cases only (effective tillers and grain yield/plant in cross WL 711 × HD 2122, and days to heading and grains/ear in cross HD 2122 × Sonalika), indicating that the additive as well as dominance gene effects were responsible for the control of these characters. However, higher values of (h) than those of (d) in all these four cases indicated that dominance gene effects were relatively more important. The genes with negative effects were dominant over the genes with positive effect, for days to heading and grains/ear in cross HD 2122 × Sonalika, since the values of (h) parameter in both cases were negative. For number of tillers and grain yield/plant in the cross WL 711 × HD 2122, the genes with positive effect showed dominance over the genes with negative effect. In the remaining eight cases (days to heading, grains/ear, and 100-grain weight in crosses WL 711 × HD 1981 and WG 377 × HD 1925; plant height in cross WL 711 × HD 1981; and 100-grain weight in cross WL 711 × HD 2122), only additive gene effects seemed to exercise control over the characters because the parameter (h) was nonsignificant in all these cases and was thus omitted while obtaining estimates of m and (d) parameters.

The estimates of main and first order interaction gene effects and χ^2 values obtained by applying five-, four- or three-parameter models for characters showing inadequacy of the additive–dominance model are presented in Table 2. The values

Table 1. Estimates of main gene effects and χ^2 values for characters showing adequacy of additive-dominance model in wheat crosses

Cross and character	m	(d)	(h)	χ^2	
				value	d.f.
Cross WL 711 × HD 1981:					
days to heading	106.8**	4.7**	—	5.1	4
plant height	120.0**	11.6**	—	7.2	4
grains/ear	58.1**	6.4**	—	3.0	4
100-grain weight	4.9**	0.3**	—	0.9	4
Cross WG 377 × HD 1925:					
days to heading	93.9**	3.4**	—	6.2	4
grains/ear	53.4**	4.1**	—	2.9	4
100-grain weight	5.0**	0.2**	—	0.7	4
Cross WL 711 × HD 2122:					
tillers/plant	14.0**	2.7**	2.9**	4.6	3
100-grain weight	3.9**	0.2**	—	1.6	4
grain yield	22.8**	2.0**	6.3**	5.2	3
Cross HD 2122 × Sonalika:					
days to heading	97.3**	3.9*	−8.7**	3.9	3
grains/ear	38.3**	2.7**	−5.1**	4.3	3

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

of the interaction parameters, in general, were higher than those of (d) and (h) parameters. This indicates that epistasis played an important role in the control of these characters. Among the interaction parameters, (j) was significant only for tillers and grain yield/plant in cross HD 2122 × Sonalika, indicating least importance of additive × dominance epistasis in the material studied. These two cases (tillers and grain yield/plant in cross HD 2122 × Sonalika) also indicated presence of trigenic or higher order interactions or linked digenics, since the five-parameter models applied to these two cases were inadequate. The parameters (i) and (l) were almost equally important. In all those cases where parameter (h) was significant, its magnitude was higher than that of (d), indicating greater importance of dominance gene effects than for grain yield/plant in cross HD 2122 × Sonalika for which the value of the additive parameter was relatively high. The negative values of (h) for plant height in crosses WG 377 × HD 1925 and WL 711 × HD 2122 indicate that the genes with negative effect were dominant over the genes with positive effect.

The classification of epistasis in such cases largely depends on the significance and sign of (h) and (l) parameters. These two parameters had different signs for tillers and grain yield/plant in cross WL 711 × HD 1981 and plant height in cross WG 377 × HD 1925, indicating predominance of duplicate type of epistasis in these three cases. On the contrary, preponderance of complementary epistasis was indicated for plant height and grain yield/plant in cross HD 2122 × Sonalika, since the signs of (h) and (l) parameters were same in these two cases. Singh and Singh [3], however, noted predominance of complementary type of epistasis in their study.

Table 2. Estimates of main and first order interaction gene effects and χ^2 values for characters showing inadequacy of the additive–dominance model in wheat crosses

Cross and character	*m*	(*d*)	(*h*)	(*i*)	(*j*)	(*l*)	χ^2	
							value	d.f.
Cross WL 711 × HD 1981:								
tillers/plant	11.5**	2.5*	9.4**	13.2**	—	−14.0**	2.6	1
grain yield	22.8**	4.1**	7.4**	12.4**	—	−15.0**	2.8	1
Cross WG 377 × HD 1925:								
plant height	114.9**	5.3**	−9.8**	−12.7**	—	14.6**	0.9	1
tillers/plant	11.4**	2.3**	8.8**	13.8**	—	—	2.9	2
grain yield	22.7**	2.9**	—	9.8**	—	—	2.1	3
Cross WL 711 × HD 2122:								
days to heading	88.4**	8.7**	—	20.5**	—	−18.6**	2.0	2
plant height	116.0**	5.6**	−8.3**	19.7**	—	—	2.3	2
grains/ear	41.7**	7.5**	—	—	—	22.7**	1.1	3
Cross HD 2122 × Sonalika:								
plant height	108.4**	9.7**	14.9**	—	—	43.9**	3.2	2
tillers/plant	11.4**	3.9**	—	−6.1**	5.7**	13.5**	15.2**	1
100-grain weight	5.2**	0.6**	—	1.9**	—	2.1*	0.9	2
grain yield	23.9**	5.1**	3.2*	—	4.0*	11.4**	6.8**	1

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

Epistasis played a significant role in the control of tillers and grain yield/plant in crosses WL 711 × HD 1981, WG 377 × HD 1925, and HD 2122 × Sonalika; and for plant height in crosses WG 377 × HD 1925, WL 711 × HD 2122 and HD 2122 × Sonalika. The remaining three characters, on the other hand, indicated less importance of epistasis. The character 100-grain weight was either under the control of additive genes alone (crosses WL 711 × HD 1981, WG 377 × HD 1925 and WL 711 × HD 2122), or additive genes plus additive × additive and dominance × dominance epistasis, indicating that this character can be easily improved by using simple selection procedures. A similar situation for this character was observed by Paroda and Joshi [4]. For days to heading and number of grains per ear, the situation regarding the relative importance of additive and nonadditive gene effects, varied across the crosses. The characters: number of tillers and grain yield/plant, were controlled by more complex genetic systems. These results indicate that improvement in grain yield/plant through indirect selection for grain weight would be more successful than through direct selection for grain yield itself.

Overall, crosses WL 711 × HD 1981 and WG 377 × HD 1925 can provide better opportunities for improvement through simple selection procedures than crosses WL 711 × HD 2122 and HD 2122 × Sonalika.

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