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DETECTION OF ADDITIVE, DOMINANCE AND EPISTATIC VARIATION IN WHEAT USING TRIPLE TEST CROSS METHOD

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ABSTRACT

Sixty progeny families were produced by crossing 20 wheat varieties with three male testers (WH 147, WH 542 and their F_1) in a triple test cross fashion to detect epistasis and test and estimate additive and dominance components of genetic variation. Epistasis was present for plant height and 1000-grain weight in both environments. Testers were adequate for grain number. Additive component played a greater role in the control of almost all the six characters.

Key words: Wheat, triple test cross, epistasis, genetic variation.

For estimation of components of genetic variation, a number of experimental designs are available. Among these, the triple test cross (TTC) method is the most efficient. Further, in addition to the practical role played by gene action in phenomenally increasing maize production in USA in the early 1950s, the relative role of additive and dominance components has helped in providing proof for the genetic basis of heterosis [1, 2]. Keeping the above points in view, the present study has been undertaken to detect epistasis and estimate additive and dominance components in sixty families of wheat through triple test cross analysis.

MATERIALS AND METHODS

Twenty two homozygous varieties of bread wheat (*Triticum aestivum* L. em. Thell), namely, HD 1925, WH 157, HD 1981, UP 262, 21CMH-77A, WG 357, HD 2009, WI 410, YCN-35, HD 2236, WH 291, Lok 1, Kharchia 65, HD 2135, WL 711, HD 2160, HUW 234, CI 14246, HD 2428, HD 2342A, WH 147 and WH 542 were randomly chosen and used to produce 60 TTC families. Of these, two agronomically superior varieties, namely, WH 147 and WH 542 (which were phenotypically different for most of the yield component traits) and their F_1 (WH 147 x WH 542) were crossed as male testers (L_1, L_2 and L_3 respectively) with each of the remaining 20 varieties/lines in a triple test cross fashion and sixty progeny families were produced during 1991–92 crop season. Sixty TTC families alongwith their 20 parents were evaluated during rabi 1992–93 season in a randomized block design each with three replications at two locations (Hisar and Kaul) of CCS Haryana Agricultural University in 3 m long rows with row to row distance of 25 cm and plant to plant distance of 10 cm. Observations were recorded on five randomly chosen plants in each row for days to heading, plant height, tiller number, grain number per ear, 1000-grain weight and grain yield per plant. The statistical analyses were carried out as suggested by [3–5].

RESULTS AND DISCUSSION

The progeny families differed significantly for all the six characters in both the environments indicating that there was enough genetic variability present in the material under investigation.

EPISTASIS AND ADEQUACY OF TESTERS

Two tests, $\bar{L}_{1i} + \bar{L}_{2i} - 2\bar{L}_{3i}$ and $\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$ were applied simultaneously to determine whether the failure of the simple additive–dominance model was because of the presence of epistatis or attributed to the inadequacy of the testers. The presence of epistasis for days to heading and grain yield at Hisar, tiller number at Kaul and for plant height and 1000 grain weight in both the environments, indicated the important role of epistasis in the control of these characters and in all these cases epistasis is expected to cause bias in the estimates of additive and dominance components (Table 1). Several other investigators [6, 7] also found that epistasis as an important element for several wheat traits including grain yield. The presence of epistasis for days to heading and grain yield at Hisar and its absence for these

Table 1. Mean squares for test of epistasis for six metric traits for wheat TTC families grown at Hisar and Kaul

Source of variation	Environment	d.f.	Days to heading	Plant height	Tiller number	Grains per ear	1000-grain weight	Yield per plant
Epistasis ($\bar{L}_{1i} + \bar{L}_{2i} - \bar{L}_{3i}$)	Hisar	20	38.1**	116.5**	5.6	6.4	18.0**	142.3**
	Kaul	20	12.6	99.3**	25.3**	6.3	28.5**	15.4
i type	Hisar	1	75.2**	1083.0**	9.2	9.8	96.5**	528.5**
	Kaul	1	10.0	449.6**	91.3**	7.3	81.4**	19.3
j and l type	Hisar	19	36.1**	65.6**	5.5	6.2	13.9**	122.0**
	Kaul	19	12.7	80.9**	21.8**	6.3	25.7**	15.2
Within family error	Hisar	720	13.0	18.5	8.6	11.4	6.1	20.6
	Kaul	720	14.4	20.2	6.7	8.9	4.9	16.1

**Significant at 1% level.

traits at Kaul further indicated that the presence or absence of epistasis may depend upon the environment in which the plant material has been grown and thus, it may not always be related to the inherent capacity of a genotype. Such conclusions have also been drawn by other investigators [6, 8]. The two subcomponents of epistasis (i type and j and l type) were significant in all the cases where there was an evidence of epistasis, that is, for days to heading, grain yield at Hisar, tiller number at Kaul and for plant height and 1000-grain weight in both the environments. However, partitioning of epistasis indicated i type to be larger in magnitude. The larger magnitude of i type epistasis than that of j and l type epistasis has a special significance in wheat being a self-fertilized crop where fixable component of genetic variation (additive genetic component and i type epistasis) can be most easily exploited. The i type epistasis has been found to be more important than j and l type epistasis by [9] also.

The testers used were adequate for days to heading and grain yield at Kaul and for grain number in both the environments (Table 2). The absence of epistasis and significant values of $\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$ for tiller number at Hisar clearly indicated the inadequacy of testers in this

Table 2. Mean squares for the adequate of testers for six metric traits for wheat TTC families grown in two environments, Hisar and Kaul

Source of variation	Environment	d.f.	Days to heading	Plant height	Tiller number	Grains per ear	1000-grain weight	Yield per plant
Families ($\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$)	Hisar	19	96.0**	218.5**	8.3**	21.2	63.2**	26.2**
	Kaul	19	11.6	174.6**	63.3**	17.3	48.5**	16.3
Families x replications	Hisar	38	6.0	4.3	3.8	15.5**	14.0**	6.0
	Kaul	38	8.9**	9.6	2.4	12.8**	10.5**	17.4**
Within family error	Hisar	720	6.2	9.4	4.8	6.7	3.7	9.2
	Kaul	720	5.0	10.0	4.0	5.0	3.1	9.5

**Significant at 1% level.

case. In the present study, since epistasis was present in all other cases, it could not be known whether the failure of the additive-dominance model was solely due to the presence of epistasis or due to both the inadequacy of testers and the presence of epistasis.

ESTIMATION OF ADDITIVE AND DOMINANCE COMPONENTS

The significant values of the item sums and differences for all the six characters except 1000 grain weight in both the environments (Tables 3, 4), indicate that both the additive and dominance gene effects played a significant role in controlling these characters in the present material. The results given in Tables 1, 3 and 4 reveal that days to heading and grain yield

Table 3. Mean squares for sums ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)) and ($\bar{L}_{1i} + \bar{L}_{2i}$) for six metric traits for wheat TTC families grown in two environments, Hisar and Kaul

Source of variation	Environment	d.f.	Days to heading	Plant height	Tiller number	Grains per ear	1000-grain weight	Grain yield per plant
Sums ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	Hisar	19	242.9**	430.9**	79.3**	143.1**	88.8**	154.6**
	Kaul	19	173.3**	221.5**	50.7**	104.1**	43.6**	157.7**
Sums x replications	Hisar	38	44.8**	55.0**	8.4	13.8	14.0**	7.0
	Kaul	38	37.5**	49.3**	5.9	6.5	5.5	38.1**
Within family error	Hisar	720	13.0	18.5	8.6	11.4	6.1	20.6
	Kaul	720	14.4	20.2	6.7	8.9	4.9	16.1
Sums ($\bar{L}_{1i} + \bar{L}_{2i}$)	Hisar	19	132.2**	292.4**	57.5**	91.2**	59.1**	97.6**
	Kaul	19	88.5**	123.2**	44.9**	63.7**	35.5**	98.5**
Sums x replications	Hisar	38	17.8**	25.8**	4.7	5.0	4.8	5.2
	Kaul	38	17.7**	19.1**	12.3**	4.8	5.2	24.9**
Within family error	Hisar	480	6.6	8.3	5.1	5.9	4.1	8.9
	Kaul	480	5.4	8.0	4.8	4.1	2.9	7.7

**Significant at 1% level.

at Hisar, tiller number at Kaul and plant height in both the environments were governed by all the three kinds of gene effects (additive, dominance and epistatic), whereas 1000-grain weight (in both the environments) by additive genetic and epistatic effects and tiller number at Hisar, days to heading and grain yield at Kaul and number of grains per ear in both the environments were controlled by additive and dominance gene effects. However, in all the

Table 4. Mean squares for differences ($\bar{L}_{1i} - \bar{L}_{2i}$) for six metric traits for wheat TTC families grown in two environments, Hisar and Kaul

Source of variation	Environment	d.f.	Days to heading	Plant height	Tiller number	Grains per ear	1000-grain weight	Yield per plant
Differences ($\bar{L}_{1i} - \bar{L}_{2i}$)	Hisar	19	89.0**	212.1**	36.4**	30.9**	29.1	43.9**
	Kaul	19	83.1**	201.8**	40.9**	25.6**	24.2	40.7**
Differences x replications	Hisar	38	6.6	4.0	5.0	4.0	16.2**	16.0**
	Kaul	38	9.7**	13.5**	13.5**	3.4	13.9**	9.0
Within family error	Hisar	480	6.6	8.3	5.1	5.9	4.1	8.9
	Kaul	480	5.4	8.8	4.8	4.1	2.9	7.7

**Significant at 1% level.

seven cases (days to heading and grain yield at Hisar, tiller number at Kaul and plant height and 1000 grain weight in both the environments) for which there was evidence of epistasis, the estimates of additive and dominance components of variation were biased to an unknown extent due to the presence of epistasis.

The estimates of D component varied greatly for all the six characters except grain yield for which the estimates of this component in the two environments were comparable (Table 5). On the contrary, the estimates of H components for all the six characters in two environments were comparable.

Table 5. Estimates of additive (D), dominance (H) components and degree of dominance for six metric traits for wheat TTC families grown in two environments, Hisar and Kaul

Component	Environ-ment	Days to heading	Plant height	Tiller number	Grain per ear	1000-grain weight	Yield per plant
D ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	Hisar	88.0**	167.0**	31.4** (32.8)**	58.5**	33.2**	59.6**
	Kaul	60.4**	76.5**	19.5**	42.3**	17.2**	53.2**
D ($\bar{L}_{1i} + \bar{L}_{2i}$)	Hisar	76.3**	177.7**	34.9** (32.8)	56.9**	36.7**	59.2**
	Kaul	47.2**	69.4**	21.8**	39.7**	21.7**	49.0**
H ($\bar{L}_{1i} - \bar{L}_{2i}$)	Hisar	54.9**	135.9**	24.4**	16.7**	8.6	18.6
	Kaul	48.9**	125.6**	18.3**	14.4**	6.9	22.0**
$(H/D)^{1/2}$ ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	Hisar	0.8	0.9	0.9	0.5	0.5	0.6
	Kaul	0.9	1.3	1.0	0.6	0.6	0.6
$(H/D)^{1/2}$ ($\bar{L}_{1i} + \bar{L}_{2i}$)	Hisar	0.8	0.9	0.9	0.5	0.5	0.6
	Kaul	1.0	1.3	0.9	0.6	0.6	0.7

**Significant at 1% level.

Note. Values in parentheses are the variances of parents which is a direct estimate of D components.

The values of the degree of dominance obtained for the two environments for all the characters studied were quite comparable except for plant height where overdominance was indicated at Kaul and dominance at Hisar. As for the two environments, the degree of dominance values obtained by two methods (using D values obtained through the $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ and $\bar{L}_{1i} + \bar{L}_{2i}$ analyses) were also comparable. The low degree of dominance for number of grains per ear, 1000-grain weight and grain yield per plant indicated a considerably higher role played by the additive gene effects in the control of these characters than the dominance gene effects. High estimates of additive component and larger mean squares due to i type epistasis for these three characters further indicate that such characters can be improved by using simple selection procedures.

The estimates of D and H for days to heading and grain yield at Kaul, tiller number at Hisar and grain number per ear in both environments were unbiased as nonallelic interactions were not present in these cases. These results are in agreement with the findings of [10] who had also recorded absence of epistasis for days to heading and number of grains per ear.

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