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Epistatic, Additive and Dominance Variation in a Triple Test Cross of Bread Wheat (*Triticum aestivum* L.)

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Summary. Triple test cross progenies resulting from the crossing of three testers ('Kloka', 'UP 368' and an F_1 intermediate between them) and 24 varieties of bread wheat have been studied for plant height (cm), peduncle length (cm), ear length (cm), number of spikelets per spike and harvest index (ratio between economic and total yield). Epistasis was not significant for any of the characters studied. The testers were inadequate for plant height and for peduncle length although the testers varied considerably for these traits. Additive variance played a significant role in the inheritance of all the characters except number of spikelets per spike. The dominance variance was important for plant height, ear length and harvest index. The degree of dominance was in the over-dominance range for plant height. Complete dominance was operative for ear length, number of spikelets per spike and harvest index whereas for peduncle length only partial dominance was observed. The possibility of the isolation of the recombinants with high harvest index has been stressed.

Key words: Epistasis – Triple test cross – *Triticum aestivum* L.

Introduction

From their studies involving variable genetic materials in triple test cross of wheat, Ketata et al. (1976), Singh and Singh (1976) and Nanda et al. (1980) concluded a widespread occurrence of epistatic effects. This may not be the case for all the characters, however, and therefore detection and estimation of epistasis for individual traits in a given material would have to be made before reliance can be placed on the unbiasedness of additive and dominance components. In the present investigation a study was conducted to detect epistasis for some of the metric traits in wheat.

Materials and Methods

The three testers included varieties 'Kloka', 'UP368' and an F_1 intermediate in characters between these two. 'Kloka' is a tall winter wheat variety with a long peduncle. It has small ears, small seeds and a poor yielding ability. In contrast, 'UP368' is a triple-dwarf variety of spring wheat with a relatively small peduncle and profuse tillering. It has bold seeds and a good yielding ability. These three testers were crossed as male parents to a set of 24 varieties selected on the basis of genetic diversity. These were: 'C591', 'Kalyansona', 'Sonalika', 'WL711', 'WL903', 'WL2193', 'WL2232', 'WG357', 'WG377', 'WH147', 'WH157', 'HD1941', 'HD2009', 'HD2160', 'HD2204', 'HD2258', 'CPAN1538', 'CPAN1687', 'IWP72', 'Girija', 'HB117-107', 'Nacozari', 'Abugharib' and 'Cocoraque 75'. Forty-eight single crosses, 24 three-way crosses, 24 parental varieties and three testers were grown in a randomised complete block design with two replications. For each progeny the plot size was one row, 1.5 m long. The row to row distance was 30 cm. The seeds were sown at 10 cm distance within a row. Each row was treated as a separate unit for the purpose of randomisation. Observations were recorded on five randomly chosen plants in each row for plant height (cm), peduncle length (cm), ear length (cm), number of spikelets per spike and harvest index (ratio between economic and total yield). The statistical analysis was conducted as suggested by Kearsey and Jinks (1968), Jinks et al. (1969), Jinks and Virk (1977) and Virk and Jinks (1977).

Results

The analysis of variance (Table 1) indicated significant differences among progenies for all the characters studied. When total variation was divided into some of its components, an interesting situation was observed for ear length. Whereas for rest of the characters all the components into which variation was divided were significant, for ear length the contrast (Lines × 'Kloka') vs (Lines × 'UP 368') was of a rather low magnitude. In addition, lines, when crossed to F_1, did not vary significantly among themselves.

The mean performance and range of the 24 parental lines, these lines crossed with 'Kloka', crossed with

'UP 368' and crossed with the F_1 between 'Kloka' and 'UP 368', are given in Table 2. The differences in the plant height of various groups were marked. The pattern of variation for peduncle length of the progenies of different sets was almost similar to that of the plant height. The variation for ear length of different groups was not large, being 12.20, 12.77, 12.76 and 12.39 cm respectively in the four groups. The pattern of variation for the number of spikelets indicated the lowest manifestation in case of the lines themselves (21.79) followed by the progenies of the third, fourth and second group. There was almost no variation for

Table 1. The analysis of variance for the five characters studied

Source	d.f.	Plant height	Peduncle length	Ear length	Number of spikelets per spike	Harvest index
Progenies	98	233.56**	59.48**	1.30**	3.35**	0.0039**
Pi lines	23	320.65**	40.63**	2.44**	6.05**	0.0062**
Lines × 'Kloka' (L_1)	23	153.19**	27.87**	1.76*	4.21**	0.0014*
Lines × 'UP 368' (L_2)	23	135.11**	36.22**	1.14**	2.08**	0.0016*
Lines ('Kloka' × 'UP 368') (L_3)	23	111.90**	31.46**	1.04	2.71**	0.0045**
Lines × 'Kloka' vs Lines × 'UP 368'	1	9531.41**	3481.73**	0.06	27.76**	0.0220**
Error	98	16.67	12.72	0.78	0.74	0.0005

*, ** Significant at 5 and 1 per cent levels, respectively

Table 2. Mean values and the ranges of the varieties and the crosses for the five characters studied

Variety/Progenies	Plant height	Peduncle length	Ear length	Number of spikelets per spike	Harvest index
Lines	97.20 (67.8 – 128.8)	37.44 (28.8 – 46.2)	12.20 (9.67 – 13.77)	21.79 (18.6 – 25.0)	0.44 (0.37 – 0.48)
Lines × 'Kloka'	114.08 (92.4 – 137.0)	45.48 (38.6 – 56.5)	12.77 (11.37 – 14.25)	24.08 (21.6 – 26.1)	0.43 (0.33 – 0.55)
Lines × 'UP 368'	94.56 (78.0 – 122.6)	33.23 (24.7 – 42.8)	12.76 (11.20 – 13.85)	22.98 (21.2 – 25.0)	0.45 (0.37 – 0.57)
Lines × ('Kloka' × 'UP 168')	107.93 (95.5 – 130.2)	40.81 (36.0 – 51.6)	12.39 (10.83 – 14.06)	23.12 (21.0 – 25.6)	0.47 (0.39 – 0.60)
Overall mean	103.46 (67.8 – 137.0)	39.24 (24.7 – 56.5)	12.58 (9.67 – 14.25)	22.99 (18.6 – 26.1)	0.44 (0.33 – 0.60)

Values in the brackets are ranges values

Table 3. The analysis of variance to detect the presence of epistasis (I test) for the five characters studied

Source	d.f.	Plant height	Peduncle length	Ear length	Number of spikelets per spike	Harvest index
Epistasis	24	59.81	18.57	1.43	1.85	0.0047
a, (i) type	1	79.09**	87.22**	3.22*	4.90	0.0176*
b, (j) and (l) type	23	58.97	16.06	1.35**	1.71	0.0041
Replicates × epistasis	24	66.52**	10.28**	0.93*	2.08*	0.0021
a, Replicated × (i) type epistasis	1	2.30	3.92	2.15	4.67	0.0001
b, Replicated × (j) and (l) type epistasis	23	69.32**	10.55**	0.87	1.97	0.0021
Within families	576	12.14	5.37	0.60	1.35	0.0036

*, ** Significant at 5 and 1 per cent levels, respectively

Table 4. The analysis of variance to detect the presence of epistasis (II test) for the five characters studied

Source	d.f.	Plant height	Peduncle length	Ear Length	Number of Spikelets per spike	Harvest index
Epistasis (L1 + L2i − Pi)	23	110.14*	12.91*	1.34	2.97	0.0028
Replication	1	20.81	9.56	0.01	0.12	0.0160
Error	23	54.54	5.87	0.72	2.04	0.0019

* Significant at 5 per cent level

Table 5. Estimates of additive and dominance components, degree of dominance, F value and correlation coefficient sums and differences for the five characters studied

Parameters	Plant height	Peduncle length	Ear length	Number of spikelets per spike	Harvest index
Additive (D)	84.92**	45.19**	1.27**	0.28	0.0045*
Dominance (H)	139.71**	6.08	1.15**	0.18	0.0030**
Degree of dominance	1.28	0.37	0.95	0.80	0.82
F value	− 19.27	1.34	− 0.20	− 0.003	− 0.0045**
Correlation coefficient	0.14	− 0.04	0.13	0.0014	0.90**

*, ** Significant at 5 and 1 per cent levels, respectively

harvest index when groups were compared. However, large variation could be detected when progenies within groups were examined.

Two tests were conducted to detect the presence of the epistasis in the material under study. The first of the tests is based on the variance due to the term ($\bar{L}1i+\bar{L}2i-2\bar{L}3i$) and the second test is based on the variance due to the term ($\bar{L}1i+\bar{L}2i-\bar{P}i$). Results are given in Tables 3 and 4. For plant height the first test of epistasis was found to be non-significant. However, when it was partitioned into its components the (i) type was indicated to be important. The situation for peduncle length was similar to the one operating for plant height. For ear length and harvest index both tests of epistasis were non-significant. However, partitioning of the epistasis indicated (i) type to be of importance. For number of spikelets per spike both the tests for epistasis were also non-significant.

The estimates of additive and dominance variance, the degree of dominance, F value and the correlation coefficients are given in Table 5. It may be noted from this table that additive variance was significant for all characters except number of spikelets per spike. The dominance component played a significant role in the inheritance of plant height, ear length and harvest index. The relative magnitude of the dominance and additive components was measured by the degree of dominance. It was in the over-dominance range for plant height only. Complete dominance was operative in the case of ear length, number of spikelets per spike and harvest index whereas only partial dominance was observed for peduncle length. The estimate of F was significant only in case of harvest index, where it was negative. The correlation coefficient was significant only in case of harvest index, where it had a positive value. The estimates of HD, DK and FK for plant height were 130.2, 142.0 and 120.4 respectively and for peduncle length these estimates were 12.6, 15.5 and 7.9 after allowing for the common alleles. The variation in the estimates under two situations may be observed.

Discussion

For two of the characters studied, viz. plant height and peduncle length the first test of epistasis was non-significant whereas the second test indicated significant values. The results implied that epistasis was absent. However, the testers were inadequate due to some common alleles. This may be an important observation in view of the fact that the testers involved in the present study had significantly different plant heights: 128.0 cm in the case of 'Kloka' and 87.0 in the case of 'UP 368'. The peduncle length in the two parents was 41 and 28 cm respectively. Although the two tester parents are diverse, as they belong to winter and spring wheats, they appear to have some loci for which they carry the same alleles. In fact they may not have common genes but only carry some loci which do not segregate in the population, or alternately they may not carry all those genes that are available in the Pi lines. Results of Ketata et al. (1976) are in agreement with the present study as they also found epistasis to be of no consequence in the inheritance of plant height. However, Singh and Singh (1976) noted a significant role of epistasis, the homozygote × homozygote type being more important. In the present study also, partitioning indicated (i) type to be larger in magnitude. For ear length, the number of spikelets per spike and harvest index, both tests were non-significant. The genetic consequence of such a situation would be that unbiased estimation of D and H components would be possible. Ketata et al. (1976) also reported similar results.

For plant height, though the estimates of both D and H were significant, the magnitude of the former was much larger (Table 5). However, when estimation was done, after allowing for the common alleles which the parents shared, the situation was significantly different. Under this situation the two components had almost a similar magnitude. The earlier studies on triple test cross in wheat presented a variable trend for plant height. Singh and Singh (1976) observed results which are in agreement with the present study. However, Ketata et al. (1976) found almost the same magnitude of the two components in one of the crosses whereas the additive component was larger in another cross. There are a number of studies on the inheritance of plant height where one or the other components of variance has been found to be important. However, the results of these studies are not directly comparable with the present one as the estimates in the earlier studies may have been based on effects due to the presence of epistasis. In the present study the results indicated that peduncle length was controlled by additive gene effects and dominance had only a limited role to play when analysis was conducted without allowing for the common alleles that the two parents share. However, when analysis was done after allowing for the common alleles, the magnitude of D and H was almost same. It is thus very important that unbiased estimates of various genetic parameters are obtained. This would facilitate the right decisions in breeding programmes. The two methods have a significant resolving power and have been indicated in the present study. Virk and Aulakh (1975) and Reddy (1976) reported additive gene effects to be important in the inheritance of peduncle length in wheat. For ear length the present study has indicated both additive and dominance components to be important in the inheritance, additive component being slightly larger in magnitude. These results are in agreement with those of Singh and Singh (1976) obtained from a triple test cross in wheat. In other earlier studies also stress has been more on additive variance with only a few emphasizing the importance of dominance variance. It is probable that the results of the earlier studies are based due to the presence of epistasis. For harvest index the unbiased estimates from the present study have indicated that though both additive and dominance components were significant, the former was larger in magnitude. This is of importance especially because very high per se values for harvest index have been observed in some of the crosses. With additive variance being significant it should be possible to select for higher harvest index. Role of additive variance in the inheritance of harvest index has earlier been stressed by Bhatt (1976).

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