*Indian J. Genet.*, **54** (2): 120–124 (1994)

# RELATIVE USEFULNESS OF TRIPLE TEST CROSS METHODS FOR ESTIMATING ADDITIVE AND DOMINANCE IN BREADWHEAT

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**(Received: May 25, 1992; accepted: November 3, 1993)**

## ABSTRACT

**Forty-five triple test cross progenies of wheat were produced by crossing 15 true breeding lines/varieties with three testers and grown in normal and stress environments. The data on parents and $F_1$s were analysed for days to heading, plant height, tillers/plant, total biomass, grains/ear, 1000-grain weight and grain yield/plant to determine the relative usefulness of three methods for estimation of additive and dominance components of genetic variation. The variance of parents ($\sigma^2_p$) estimated the additive component better than the two other methods ($\bar{L}_{1i} + \bar{L}_{2i}$ and $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$). The methods $4\sigma^2_d + 9\sigma^2(\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ and $25[\sigma^2(2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2(2\bar{L}_{2i} - \bar{P}_i)]$ provided better estimates of dominance component than $\bar{L}_{1i} - \bar{L}_{2i}$ method in the presence of epistasis. These two methods also gave similar estimates of dominance component.**

**Key words:** *Triticum aestivum*, relative usefulness, triple test cross, additive and dominance components.

Different methods have been proposed to estimate additive and dominance components in triple test cross (TTC) progenies [1–4]. However, to obtain the most reliable estimates of these two components, it is essential to know their relative merits. The present study has been undertaken to compare different TTC methods presently available for the estimation of additive and dominance components in a set of varieties/lines of breadwheat.

## MATERIALS AND METHODS

Fifteen homozygous breadwheat (*Triticum aestivum* L. em. Thell) varieties/lines ($P_i$), namely, WL 711, Red Poll, UP 215, UP 262, UP 1109, HD 2009, HD 2122, HD 2236, HD 2270, Sonalika, Raj 1579, CPAN 1796, CPAN 1907, HUW 12 and WH 147 were crossed with three

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testers *viz.*, HD 2428 ($L_1$), NP 846 ($L_2$) and their $F_1$ ($L_3$) to produce 45 TTC families. All these families along with 17 parents were grown in randomized block design with three replications in normal (timely sowing) and stress (late sowing) environments. Each family was grown in 3 m long row with the spacing of 25 x 10 cm. Ten competitive plants from each row were used to record observations on days to heading, plant height, tillers/plant, total biomass, grains/ear, 1000- grain weight and grain yield/plant.

Two tests, $\bar{L}_{1i} + \bar{L}_{2i} - 2\bar{L}_{3i}$ and $\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$ given by Kearsey and Jinks [1] and Jinks et al. [5], respectively, were simultaneously applied to detect the presence of epistasis and test the adequacy of testers. The additive component was estimated by three methods, namely, $\bar{L}_{1i} + \bar{L}_{2i}$ [1]. $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ [2], and $\sigma^2_p$ (variance of parents). The estimates of additive component were obtained as $\sigma^2_s$ (sums) = 1/4D in the first two methods and $\sigma^2_p$ = D in the third method. The dominance component was also estimated by three methods: $\bar{L}_{1i} - \bar{L}_{2i}$ [1], $4\sigma^2_d + 9\sigma^2(\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ [3], and $\sigma^2(2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2(2\bar{L}_{2i} - P_i)$ [4]. The estimates of dominance component were obtained as $\sigma^2_d$ (differences) = ¼H, $4\sigma^2_d + 9\sigma^2(\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_1)$ = H and 25 [$\sigma^2(2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2(2\bar{L}_{2i} - \bar{P}_i)$] = H in first, second and third methods, respectively.

## RESULTS AND DISCUSSION

The test $\bar{L}_{1i} + \bar{L}_{2i} - 2\bar{L}_{3i}$ indicated absence of epistasis for plant height in both environments and for total biomass only in the stress environment (late sowing). The test $\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$ revealed that the testers were adequate only for plant height in normal environment but inadequate for plant height and total biomass under stress (Table 1).

**Table 1. Mean squares for the adequacy of testers and the test of epistasis for seven metric traits in wheat grown in two environments**

| Parameter | d.f. | Environ-ment | Days to heading | Plant height | Tillers per plant | Total biomass | Grains per ear | 1000-grain weight | Yield per plant |
|---|---|---|---|---|---|---|---|---|---|
| Adequacy of testers | 14 | Normal | 12.4** | 10.5 | 15.8** | 972.6** | 217.9** | 13.0** | 75.5** |
| ($\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$) | 14 | Stress | 9.9** | 115.3** | 11.7** | 250.8** | 105.0** | 11.3** | 75.8** |
| Error | 28 | Normal | 0.5 | 5.1 | 0.4 | 7.3 | 3.3 | 2.4 | 3.2 |
| | 28 | Stress | 1.4 | 5.8 | 1.0 | 22.4 | 4.3 | 3.2 | 5.4 |
| Epistasis | 15 | Normal | 11.7** | 5.4 | 7.2** | 405.7** | 99.1** | 7.4** | 39.5** |
| ($\bar{L}_{1i} + \bar{L}_{2i} - 2\bar{L}_{3i}$) | 15 | Stress | 15.7** | 7.9 | 7.3** | 11.3 | 99.1** | 17.3** | 87.8** |
| Error | 30 | Normal | 1.4 | 3.3 | 0.9 | 5.7 | 7.3 | 1.8 | 2.4 |
| | 30 | Stress | 3.1 | 5.4 | 0.9 | 7.2 | 3.5 | 3.0 | 4.4 |

**Significant at p = 0.01 level.

For estimating additive component, the variance of parents was taken as standard as it is not affected by inadequacy of testers and least affected by epistasis (only homozygote x homozygote type epistasis can affect this variance). Since epistasis was present in 11 out of 14 cases in the present investigation, this method is expected to give better estimates of additive component than the other two methods. The estimates were significant for all the characters in both environments. The estimates obtained by the methods $\bar{L}_{1i} + \bar{L}_{2i}$ and $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ did not differ in estimating the additive component (Table 2). The estimates of additive component obtained from the variance of parents ($\sigma^2_p$) significantly differed from

**Table 2. Estimates of additive component obtained by three methods in wheat grown in two environments**

| Character | Environment | Estimates from different methods | | | Difference between comparisons | | |
|---|---|---|---|---|---|---|---|
| | | $\bar{L}_{1i} + \bar{L}_{2i}$ | $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ | $\sigma_{p2}$ | $\bar{L}_{1i} + \bar{L}_{2i}$ vs. $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ | $\bar{L}_{1i} + \bar{L}_{2i}$ vs. $\sigma_{p2}$ | $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ vs $\sigma_{p2}$ |
| Days to heading | Normal | 33.6 | 15.2 | 6.4 | NS | S | S |
| | Stress | 33.4 | 20.4 | 7.8 | NS | S | S |
| Plant height | Normal | 325.9 | 301.4 | 290.6 | NS | NS | NS |
| | Stress | 299.6 | 240.1 | 151.6 | NS | NS | NS |
| Tillers/plant | Normal | 25.4 | 13.5 | 4.8 | NS | S | S |
| | Stress | 23.0 | 11.3 | 3.3 | NS | S | S |
| Total biomass | Normal | 742.9 | 1092.5 | 442.1 | NS | NS | S |
| | Stress | 452.9 | 432.9 | 395.1 | NS | NS | NS |
| Grains/ear | Normal | 95.1 | 105.8 | 39.5 | NS | NS | S |
| | Stress | 48.6 | 42.3 | 15.7 | NS | S | S |
| 1000-grain wt. | Normal | 25.3 | 17.1 | 9.1 | NS | S | NS |
| | Stress | 14.9 | 12.3 | 10.7 | NS | NS | NS |
| Grain yield per plant | Normal | 18.7 | 15.1 | 4.1 | NS | S | S |
| | Stress | 35.2 | 32.3 | 11.8 | NS | S | S |

NS—nonsignificant, S—significant.

those of $\bar{L}_{1i} + \bar{L}_{2i}$ and $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ methods in 8 and 9 cases out of 14 cases, respectively, indicating the superiority of the method of estimating variance of the parents over the other two methods. However, the three methods gave similar results in respect of additive component for plant height in both environments and total biomass only in stress environment because of the absence of epistasis and adequacy of testers for plant height in normal environment and absence of epistasis for plant height and total biomass in stress environment. Similarly, the inadequacy of testers and/or the presence of epistasis for 1000-grain weight in stress environment could not influence the estimates obtained by $\bar{L}_{1i} + \bar{L}_{2i}$ and $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ methods to a great extent. Also, the estimates obtained by the $\bar{L}_{1i} +$

$\bar{L}_{2i}$ method for total biomass and grains/ear and by $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$ for 1000-grain weight in normal environment were, apparently, not influenced by the presence of epistasis and the inadequacy of testers.

**Table 3. Estimates of dominance component obtained by three methods in wheat grown in two environments**

| Character | Environ-ment | Estimates from different methods | | | Difference between comparisons | | |
|---|---|---|---|---|---|---|---|
| | | $\bar{L}_{1i} - \bar{L}_{2i}$ | $4\sigma^2_d + 9\sigma^2 (\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ | $25\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2 (2\bar{L}_{2i} - \bar{P}_i)$ | $\bar{L}_{1i} - \bar{L}_{2i}$ vs. $4\sigma^2_d + 9\sigma^2 (\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ | $\bar{L}_{1i} - \bar{L}_{2i}$ vs. $\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2 (2\bar{L}_{2i} - \bar{P}_i)$ | $4\sigma^2_d + 9\sigma^2 (\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ vs. $\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ |
| Days to heading | Normal | 9.1 | 25.2 | 25.2 | S | S | NS |
| | Stress | 3.6 | 7.8 | 7.8 | S | S | NS |
| Plant height | Normal | 152.3 | 151.7 | 151.7 | NS | NS | NS |
| | Stress | 85.9 | 107.6 | 107.6 | NS | NS | NS |
| Tillers/plant | Normal | 21.6 | 47.4 | 47.4 | S | S | NS |
| | Stress | 17.5 | 35.7 | 35.7 | S | S | NS |
| Total biomass | Normal | 517.4 | 1175.2 | 1175.2 | S | S | NS |
| | Stress | 185.5 | 217.6 | 217.6 | NS | NS | NS |
| Grains/ear | Normal | 47.9 | 195.9 | 195.9 | S | S | NS |
| | Stress | 51.5 | 111.3 | 111.2 | S | S | NS |
| 1000-grain weight | Normal | 3.3 | 7.9 | 7.9 | S | S | NS |
| | Stress | 3.8 | 9.2 | 9.2 | S | S | NS |
| Grain yield/plant | Normal | 25.9 | 85.9 | 85.9 | S | S | NS |
| | Stress | 30.2 | 65.1 | 65.1 | S | S | NS |

NS—nonsignificant, S—significant.

The estimates of dominance component given in Table 3 were significant for all the seven characters in both environments. The methods $4\sigma^2_d + 9\sigma^2 (\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ and 25 $\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2 (2\bar{L}_{2i} - \bar{P}_i)$) provided similar estimates for all the characters in both environments, showing their equal efficiency in estimating the dominance component. On the other hand, the estimates obtained by these two methods were higher and differed significantly from those obtained by the $\bar{L}_{1i} - \bar{L}_{2i}$ method for all the characters except plant height in normal environment, where epistasis was absent and the testers were adequate, and for plant height and total biomass in stress environment, where epistasis was absent. Since the method $\bar{L}_{1i} - \bar{L}_{2i}$ provides a better estimate of dominance component than the other two methods when the testers are adequate and takes into account only the segregating loci between the two testers and not all loci controlling a particular character, the estimation of dominance component in this method may be affected by both the presence of epistasis and the inadequacy of testers. Therefore, the deflation of values of dominance component in this method may be attributed to these two factors (epistasis and inadequacy of testers) except in case of plant height in normal environment in which there was no indication of either epistasis or inadequacy of testers. The reason for the estimates of dominance component being slightly higher in the $\bar{L}_{1i}-\bar{L}_{2i}$ method than in other methods for plant height in normal environment was the absence of epistasis and adequacy of testers. The inadequacy of testers for plant height and total biomass under stress did not influence the estimates of dominance component to a great extent. Singh et al. [6] also reported almost similar results for estimating additive and dominance components in wheat.

Based on the results of the present study, variance of parents provided better estimates of additive component than the methods $\bar{L}_{1i} + \bar{L}_{2i}$ and $\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$. The dominance component was obtained more precisely by the methods $4\sigma_d^2 + 9\sigma^2 (\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ and $25\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2 (2\bar{L}_{2i} - \bar{P}_i))$ than that of $\bar{L}_{1i}-\bar{L}_{2i}$ in the presence of epistasis. In triple test cross if the testers are inadequate, the additive component is obtained more precisely than the dominance component because the coefficient for calculating dominance compoment by the methods of $4\sigma_d^2 + 9\sigma^2 (\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i)$ and $25\sigma^2 (2\bar{L}_{1i} - \bar{P}_i)$ pooled with $\sigma^2$ $(2\bar{L}_{2i} - \bar{P}_i))$ is lower than that of additive component.

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