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A STUDY OF COMPONENTS OF GENETIC VARIATION AND GENOTYPE x ENVIRONMENT INTERACTION IN SELFED WHEAT TRIPLE TEST-CROSS FAMILIES

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ABSTRACT

Ninety progenies produced by crossing 30 wheat varieties/lines with three testers in a triple test-cross fashion were selfed and grown together with parents to detect various components of genetic variation and interaction of these components with sowing date for seven metric traits. The testers were adequate for days to heading, grain number, 1000-grain weight and grain yield per plant. Epistasis was observed for plant height, tiller number and spike length in both sowings. The nonfixable epistasis was more important and sensitive to environment than fixable epistasis. Generally, the additive component was equally or more important than the dominance component. Both the components were equally sensitive to the change in environment. In all cases, dominance was directional.

Key words: Genetic variation, genotype x environment interaction, triple test-cross, wheat.

Among the presently available biometrical genetic procedures, the triple test-cross method, first suggested by [1] and later modified by others [2–6], has several advantages over the other multiple mating designs. The method provides unambiguous detection of additive, dominance and epistatic components of genetic variation and their interaction with environment, is independent of allelic frequencies, gene correlation and mating system, and requires relatively less experimental efforts. The present investigation aims to determine the components of genetic variation and their interaction with date of sowing in 90 selfed triple-test cross progenies of spring wheat.

MATERIALS AND METHODS

Thirty varieties/lines of spring wheat, namely Redpoll 's', WH 147, WH 337, HD 1925, HD 1981, HD 2122, HD 2177, HD 2236, UP 215, UP 262, UP 301, UP 1109, Raj 1482, Raj 1579, Kharchia 65, P 1200, Chat, HD 135, HW 517, NP 846, NP 852, CPAN 1676, CPAN 1830, CPAN

1907, HP 1102, HP 1209, HUW 12, CBS 80 and PBW 65, were crossed to three testers, i.e. varieties WH 283, Kalyan Sona Awnless (KSAL), and their F_1 (WH 283 x KSAL) in a triple test-cross fashion. Ninety families thus produced were raised and selfed. These selfed families together with 32 varieties/lines were sown in randomized block design with three replications on 15.11.1987 (normal sowing) and 15.12.1987 (late sowing). Each progeny family was grown in a 3 m long row with row-to-row distance of 25 cm and plant-to-plant 10 cm. Ten competitive plants from each row were scored for seven quantitative traits.

The presence of epistasis and inadequacy of testers were tested, as mean squares, by the methods of [1, 2]. If the testers were adequate, the estimates of D (additive, genetic), H (dominance) and F (based on covariance between sums and differences) components were obtained according to [2]. But if the testers were not adequate, the method of [5] was followed to estimate these components. The interaction between the sowing date and the additive and dominance gene effects was detected as per the method given by [4].

RESULTS AND DISCUSSION

The mean squares due to epistasis were significant for plant height, number of effective tillers per plant, and spike length in both sowings; and for days to heading and 1000-grain weight in normal sowing (Table 1). This indicates complete absence of epistasis for grains

Table 1. Mean squares from analysis of variance for testing the adequacy of testers, the presence of epistasis and its interaction with environment for seven metric traits in spring wheat

Source	d.f.	Sowing time	Days to heading	Plant height	Tiller number	Spike length	Grain number	1000-grain weight	Yield per plant
Adequacy of testers	29	Normal	13.8	42.3**	2.7**	3.2**	10.4	2.1	3.4
$\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$	29	Late	23.5	25.2**	1.0**	4.8**	25.7	2.2	17.7
Epistasis	30	Normal	16.3**	70.3**	2.3*	3.4**	18.7	1.8**	7.1
$\bar{L}_{1i} + \bar{L}_{2i} - 2\bar{L}_{3i}$	30	Late	17.3	35.4**	1.7*	5.0**	9.3	1.1	15.1
Fixable epistasis	1	Normal	74.3*	109.3*	1.2	0.2	55.9	0.1	7.1
	1	Late	39.4	22.9	0.2	0.1	48.7	0.1	12.1
Nonfixable epistasis	29	Normal	14.3**	69.0**	2.4**	3.5**	17.5	1.9**	7.1
		Late	16.6	35.8**	1.8*	5.1**	8.0	1.1	15.2
Fixable epistasis x environments	1		1.05	85.12*	1.24	0.98	10.15	1.0	5.2
Nonfixable epistasis x environments	29		3.20*	20.15*	3.01*	4.65**	9.35	2.35**	9.98*

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

per spike and grain yield per plant, as well as presence of a weak epistasis for days to heading and 1000-grain weight. The mean squares due to adequacy of testers were significant for plant height, number of effective tillers and spike length. But no trend could be detected about the adequacy of testers for these three traits since epistasis was present for all the three traits in both sowings. However, the testers seemed to be the two phenotypic extremes for days to heading, number of grains per spike, 1000-grain weight, and grain yield per plant.

Further partitioning of epistasis into fixable and nonfixable components indicated that the nonfixable components was more important than fixable, since the mean squares due to the former component were significant for 8 out of 14 characters (for days to heading and 1000-grain weight in normal sowing; and for plant height, number of effective tillers and spike length in both sowings), whereas mean squares due to the latter component were marginally significant for two characters only (days to heading and plant height) in normal sowing. Thus, epistasis in the present material may be mainly attributed to the presence of nonfixable component. However, in a highly self-fertilized crop like wheat, the nonfixable component of epistasis cannot be easily exploited. A greater importance of nonfixable epistasis was also reported in wheat earlier [7, 8].

The fixable epistasis x environment interaction was significant only for plant height, whereas nonfixable epistasis x environment interaction was significant for 6 out of 7 traits (except number of grains per spike). This indicates that the nonfixable component of epistasis was more sensitive to environmental change than the fixable component. Higher sensitivity of the nonfixable component of epistasis was also reported earlier in barley [9] and wheat [10].

The sums (measuring additive genetic variance) and differences (measuring dominance variance) were significant for all the seven traits except number of tillers in late sowing and spike length in both sowings for which the differences were nonsignificant (Table 2). This shows that additive genetic variance was more important in the control of all the traits.

The estimates of additive (D) and dominance (H) components were, in general, different in the two sowings. However, the estimates of F parameter (based on covariance of sums and differences) in the two sowings showed generally similar magnitudes. Out of the total 11 cases showing presence of dominance, overdominance was indicated in three cases (tiller number in the normal sowing and grains per spike in both sowings). In the remaining cases, dominance was partial to complete. Tiller number in the late sowing and spike length in both sowings seemed to be controlled solely by additive and epistatic genes. The value of F indicated presence of directional dominance in all cases. Dominant increasing genes

Table 2. Mean squares from analysis of variance for sums and differences and estimates of D, H and F for seven metric traits in spring wheat

Source	d.f.	Sowing time	Days to heading	Plant height	Tiller number	Spike length	Grains per spike	1000-grain weight	Grain yield per plant
Sums ($\bar{L}_{1i} + \bar{L}_{2i}$)	29	Normal	57.3**	305.7**	3.2**	5.7**	32.1**	1.4**	8.1**
	29	Late	40.1**	198.9**	3.1**	4.8**	35.2**	3.7**	25.4**
Differences ($\bar{L}_{1i} - \bar{L}_{2i}$)	29	Normal	15.7**	57.4**	2.7**	1.9	17.1**	0.6*	4.0*
	29	Late	13.2*	39.4**	1.3	4.7	22.4**	0.4*	9.1*
D		Normal	34.7	191.8	1.3	3.0	17.2	0.9	3.3
		Late	16.5	127.5	1.5	1.0	18.0	2.2	12.0
H		Normal	35.6	94.0	4.0	—	40.0	0.8	4.2
		Late	14.0	79.3	—	—	48.5	0.4	10.5
F		Normal	51.3*	146.3*	- 87.3*	—	47.5*	66.1**	- 90.1**
		Late	53.5*	155.3**	—	—	56.1**	85.1**	- 105.1**

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

occurred more frequently than dominant reducers for days to heading, plant height, grains per spike and 1000-grain weight, since the values of F in all these cases were positive. A reverse situation was observed for tiller number in normal sowing and grain yield per plant in both sowings.

Both the interactions sums x environment (additive gene effects x environment) and differences x environment (dominance gene effects x environment) were significant for 6 out of 7 characters (sums x environment was nonsignificant for days to heading and differences x environment nonsignificant for spike length) (Table 3). This indicates that both additive and dominance gene effects were equally sensitive to the change in environment. However, higher sensitivity of additive gene effects to the environment than the dominance gene effects was also reported earlier [10, 11].

The estimates of D and H components of variation indicate that dominance gene effects did not have any role in the control of tiller number and spike length. On the contrary, the estimates of H were higher than those of D for the remaining characters, indicating that the dominance gene effects play a greater role in the control of these traits. Also, the magnitude of G_{2H} (dominance gene effects x environment interaction) was higher than that of G_{2D} (additive gene effects x environment interaction) for 6 out of 7 traits.

Table 3. Mean squares from analysis of variance for sums and differences and their interaction with environment for seven metric traits in wheat grown in two environments

Source	d.f.	Days to heading	Plant height	Tiller number	Spike length	Number of grains per spike	1000-grain weight	Grain yield per plant
Sums	29	18.5*	109.4**	7.2**	17.3**	42.2**	3.4**	22.1**
Sums x environments	29	14.7	30.6**	2.1**	3.8**	18.4**	1.4**	9.7*
Differences	29	35.4*	55.1*	2.5	1.4	60.4**	10.1**	52.5**
Differences x environments	29	16.4**	28.1*	1.4**	1.4	21.3**	3.1**	17.3**
D		1.3	26.3	1.7	4.5	7.9	0.7	4.1
G_{2D}		3.1	10.0	1.2	1.9	7.0	0.4	2.7
H		25.3	36.0	1.5	0.0	52.1	9.4	47.0
G_{2H}		21.8	27.8	1.8	1.2	37.5	5.5	24.8

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

The relative sensitivity of the additive and dominance gene effects to environment in the parent study leads to the conclusion about the kind of variety to be developed, that is, a pure line variety or a hybrid. The results of the present study indicate that pure line varieties are as good as the hybrids from this viewpoint. Such finding has special significance in a highly self-fertilized crop like wheat where the varieties released are exclusively pure lines.

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