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GENETIC CONTROL OF YIELD AND ITS COMPONENTS IN BREADWHEAT

S. C. MISRA, V. S. RAO, R. N. DIXIT, V. D. SURVE
AND V. P. PATIL

Agharkar Research Institute, Agharkar Road, Pune 411004

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ABSTRACT

Genetic control of tillers/plant, grains/spike, 1000-grain weight, grain weight/spike and yield/plant in nine generations (P_1, P_2, F_1, F_2, F_3, BC_1, BC_2, F_2 x P_2, and F_2 biparental crosses) were investigated in an intervarietal cross of breadwheat involving NI 5439 and PH 663, having higher number of spikelets/spike, grains/spike and grain weight/spike. Biparental progeny excelled their corresponding F_3 and F_2 for tiller number, spikelets/spike, grains/spike, grain weight/spike, 1000-grain weight and yield/plant. Considerable additive genetic variance was observed for tillers/plant and grain weight/spike while additive and dominance genetic variance was predominant for 1000-grain weight. The additive–dominance model was adequate for tillers/plant, grain weight/spike and yield/plant. Epistatic effects of additive x additive, additive x dominance and dominance x dominance were observed for 1000-grain weight. The digenic epistatic model was inadequate to explain the nature of gene action for spikelets/spike and 1000-grain weight. Thus, nonallelic interactions should not be ignored in formulating breeding programmes and the biparental approach would be extremely useful for enhancing genetic variability and creation of transgressive segregates.

Key words: Gene action, biparental mating, transgressive segregation, wheat.

Grain yield is a complex character resulting from the interaction of a number of component characters influenced by environmental fluctuations. As such, it is difficult to manipulate yield through recording yield alone. Several workers have suggested use of component traits as selection criteria for yield improvement. However, the compensatory effects and negative correlations between these traits may nullify any improvement based on individual components. It is, therefore, necessary to know the genetic architecture of yield and its component characters.

Previous studies on the inheritance of grain yield and its components were confined to genetic analysis using the six basic generations, i.e. the two parents, F_1, F_2, BC_1 and BC_2 [1–3]. Based on these studies, the use of biparental approach was suggested to create maximum variability and take advantage of the nonallelic interactions. Information on the impact of biparental approach on yield improvement is rather limited [4, 5]. Therefore, the present investigation has been carried out to get further information on the inheritance of grain yield and its components using biparental matings.

MATERIALS AND METHODS

The experimental material was developed from a cross involving two varieties of bread wheat (*T. aestivum* L. em Thell.), NI 5439 and PH 663. Variety PH 663 has higher number of grains/spike and greater grain weight/spike, whereas NI 5439 has good tillering ability and medium grain size. During 1989–90, the F_2 generation of this cross was grown and 50 biparental crosses were made between 100 random F_2 plants. Twelve plants were selected to obtain F_2 x PH 663 generation separately. Seeds of F_1, F_2, F_3, BC_1 and BC_2 were obtained by making fresh crosses and advancing generations. The experiment was conducted during 1990–91 involving both parents, F_1, F_2, F_3, BIPs, BC_1, BC_2 and F_2 x PH 663 generations. Three rows of parents and F_1, 10 rows of F_2, 4 rows each of BC_1 and BC_2, 56 rows of F_3, 28 rows of BIPs, and 12 rows of F_2 x PH 663 generations were sown per replication. The row length was 1 m and intra- and interplant distances 10 and 30 cm, respectively, with two replications.

Data were recorded on five random plants per row for tillers/plant, grains/spike, 1000-grain weight, grain weight/spike and yield/plant. Statistical analysis for generation means was done according to Hayman [6].

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant difference among generations with respect to all the characters studied, indicating the presence of sufficient genetic variability in the material (Table 1). Variety NI 5439 was significantly superior to PH 663 for tillers/plant and numerically superior for 1000-grain weight, while it was reverse for spikelets/spike, grains/spike and grain weight/spike. The yield/plant of both parents was comparable. A perusal of different generation means revealed that the F_1 performance for these characters was midway between the parents, except for 1000-grain weight and yield/plant where it exhibited heterosis over better parent. Similar observation was recorded for BC_1, BC_2 and F_2 x PH 663 progeny for all these characters. However, this limited heterosis may have been caused due to absence of genes with dominance effects at most of the loci while heterosis for 1000-grain weight and yield/plant may be due to additive gene action. Similarly, a low degree of inbreeding depression from F_2 to F_3 for all the characters was also indicative of absence of loci with dominant effects. These results support the findings of partial dominance for grain weight [7, 8], tiller number [9] and grain yield/plant [10, 11].

Table 1. Mean performance of different generations and analysis of variance with respect to certain characters in wheat

Generation or source of variation	Character					
	tillers per plant	spikelets per spike	grains per spike	grain wt. per spike (g)	1000-grain weight (g)	yield per plant (g)
		Character means				
NI 5439	14.2	19.2	44.0	1.2	29.2	11.0
PH 663	6.9	25.6	118.8	2.3	23.7	10.8
F_1	9.8	21.7	54.9	1.7	32.6	13.2
F_2	10.6	22.0	60.4	1.7	28.6	11.2
BC_1	12.5	21.5	50.6	1.3	25.6	11.1
BC_2	9.3	25.3	79.4	2.1	25.7	10.1
F_2 (BIP)	10.8	23.8	62.0	1.8	30.0	12.5
F_3	11.5	22.7	64.4	1.7	26.6	11.8
F_2 x PH 663	9.0	23.8	81.1	2.2	29.6	11.6
		Mean squares				
Replications	36.6	10.2	58.6	0.6	331.0	21.4
Treatments	21.8^{**}	9.9^{*}	538.9^{**}	0.5^{**}	226.6^{**}	10.2^{*}
Error	10.6	6.8	165.4	0.2	101.7	7.4
CD	6.4	5.1	25.5	0.9	14.0	5.3

*,**Significant at P=0.05 and 0.01, respectively.

Mean performance of the biparental progeny excelled their corresponding F_3 and F_2 for tiller number, spikelets/spike, grains/spike, grain weight/spike, 1000-grain weight, and yield/plant. The biparentals were superior to their corresponding F_3s for all the characters except grains/spike. Similarly, considerable increase over F_1s was observed for all these characters except 1000-grain weight and yield/plant. Superior performance of the biparental progenies may be attributed to accumulation of favourable low-frequency genes, thus generating segregates which could be rarely obtained in F_2 generation. Intermating generated tremendous variability through dissociation of undesirable linkages and offered additional opportunity for the creation of rare genetic recombinants. These results are in conformity with earlier reports [4, 7, 11, 12] and suggests that random mating in early segregating generations is an effective mode of creating potentially high yielding transgressive segregates.

Gene action. Generation mean analysis was performed for the additive–dominance model on nine generations for all the characters. The χ^2 value was significant for spikelets/spike, grains/spike and 1000-grain weight (Table 2). The digenic epistatic model was inadequate for spikelets/spike and 1000-grain weight. In order to detect the effect of linked epistatic genes, the F_2, $F_2 \times F_1$ and BIP progenies may be utilized as these provide the same expectations in the absence of linkage [13]. This test also gives an indication of the type of linkage present in the population. In case of predominantly repulsion phase linkage, the mean of BIPs is higher than that of F_2 generation. As such, repulsion phase linkage was evident for all the traits under study. Therefore, inheritance of these attributes may have been complicated by linkage and high order of interactions.

Table 2. Estimates of genetic parameters based on different generation means in wheat

Parameter	Tillers per plant	@Spikelets per spike	@Grains per spike	Grain wt. per spike	1000-grain weight	Yield per plant
m	11.4* + 0.4	23.1* ± 0.9	63.6* ± 2.1	1.8* + 0.1	30.6* ± 0.6	11.2* ± 0.4
[d]	3.8* + 0.5	3.3* ± 0.4	36.8* ± 2.6	0.6* + 0.1	2.8* ± 0.1	0.5 ± 0.5
[h]	- 1.1 + 0.9	- 1.4 ± 1.0	- 8.8 ± 3.5	- 0.1 + 0.1	2.0* ± 0.8	1.2 ± 1.0
[i]	—	- 0.5 ± 0.9	17.0* ± 3.2	—	- 4.1* ± 0.6	—
[j]	—	- 0.3 ± 1.4	- 14.6 ± 9.1	—	- 7.5* ± 1.3	—
[l]	—	0.8 ± 1.9	14.4 ± 6.8	—	- 17.8* ± 1.5	—
χ^2 (6 df)	4.32	—	—	6.58	—	10.54
χ^2 (3 df)	—	14.59*	4.19	—	27.19*	—

*Significant at P = 0.01.

@ χ^2 values for 3-parameter model were significant.

Additive gene action was pronounced for tillers/spike and grain weight/spike. Non-significant additive component (d) for spikelets/spike, grains/spike and yield/plant suggested that genes in the parents were in dispersed form. Predominance of additive gene effects has already been reported for seed weight [14, 15], grain yield [7, 16], and for grains/spike, 1000-grain weight, and yield/plant [5]. Both dominance and additive gene effects for grains/spike have also been reported [17].

The digenic epistatic effects of additive x additive, additive x dominance, and dominance x dominance for 1000-grain weight indicated that epistasis also played an important role in determining the inheritance of grains/spike. Presence of large epistatic effects for different characters has also been reported for grain weight [1, 18] grain yield [2, 16, 18] and for tiller number 1000-grain weight and grain yield [5].

It is evident from the above results that rapid improvement in yield through the conventional breeding method may not produce quick and desirable results. In addition to digenic and high order of interaction, additive and dominance effects are also important for improvement in contributing characters to yield. With respect to important economic traits, it is also apparent that the biparental progenies are superior in performance to their corresponding F_2 and F_3 progenies and their respective F_1s. Thus, the conventional approach may lead to considerable improvement but the variability hidden in heterozygotes shall remain concealed and unexploited. In order to get transgressive segregates it is necessary to break undesirable linkages and simultaneously exploit additive, dominance and nonadditive gene effects. Biparental matings among potentially desirable plants may be resorted to in early segregating generations. Such an approach would provide transgressive segregates for exploitation and further selection. The material so generated could be subjected to population improvement techniques.

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