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Inheritance of grain yield and tillers per plant in wheat (*Triticum aestivum* L.)

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Abstract

Inheritance of grain yield and tillers per plant in wheat (*Triticum aestivum* L.) was studied from twelve generations *viz.*, both parents, F_1, F_2, first backcross generations (BC_1 arid BC_2), second backcross generations (BC_{11}, BC_{12}, BC_{21} and BC_{22}) along with BC_{1S} and BC_{2S} derived by selfing of BC_1 and BC_2 populations of two crosses involving four diverse cultivars. Since the studies have been based on trigenic model, therefore, the 10-parameter modal was considered more adequate to explain the results however, significant χ^2 values indicated even higher order interactions. In cross UP 301 × HD 2009, dominance and epistatic effects were found predominant for both the traits while in the cross RS-31-1 × RAJ 1482 only epistatic effects were observed to be more important-for these traits. To utilize non-fixable gene effects (non-additive) which were higher in magnitude than fixable (additive), breeding methods involving reciprocal recurrent selection or biparental mating are suggested for further improvement in grain yield and tillers per plant in wheat.

Key words: Wheat, generation mean analysis, gene effects, grain yield, tillers per plant

Introduction

Research on biometrical genetics has shown that yield is a complex character. It is an ultimate result of its component character for which direct selection is not effective. Early breeders suggested selection for yield components as a possible method for yield improvement. This approach did not prove effective as Watson [1] and Stoskopf and Reinbergs [2] established that none of the yield components could be used to predict the yield and their simultaneous improvement. Thus, the choice of breeding procedure will depend upon the knowledge of inheritance of the character under improvement, nature of gene action and the relative magnitude of components of genetic variance *viz.*, additive and non additive. These form the guidelines for handling the material in designing the breeding methods of bio-metrical and quantitative genetics which may help in evaluation of breeding materials on a large scale with more accuracy and at the same time to generate information on inheritance of different traits in wheat. Number of tillers per plant is one of the important contributing attributes of grain yield. Therefore, the present study was planned to investigate genetics of number of tillers per-plant alongwith grain yield by using generation mean analysis of 12 generations of two wheat crosses.

Materials and methods

The experimental material generated from four diverse parents, comprised two crosses namely, UP 301 × HD 2009 and RS-31-1 × Raj 1482. Twelve-basic generations *viz.* two parents, F_1 and F_2, first backcross generations with both parents (BC_1 and BC_2), where BC_1 was the cross between F_1 × female parent and BC_2 was F_1 × male parent, their selfed progenies (BC_1F_2, BC_2F_2) and second backcross generations i.e., the BC_1 and BC_2 plants again crossed with both original parents (BC_1 × female parent, BC_1 × male parent, BC_2 × female parent and BC_2 × male parent) were raised together in randomized block design with three replications at 30 cm × 10 cm spacing at Agricultural Research Station, Sriganganagar, Rajasthan. Each parent and F_1 generation was sown in 2 rows, each backcross generation in 4 rows and F_2, the second cycle of backcrosses and selfed progenies of first back cross generations in 6 rows of 5 m length. Grain yield per plant and number of tillers-per-plant was recorded on 15 random plants in each parent and F_1, 30 plants in each back cross generation and 60 plants in each F_2, second backcross generations and selfed backcross generation.

Individual scaling test A, B and C of Mather [3] X and Y of Ven der veen [4] and B_{11}, B_{12}, B_{21}, B_{22}, B_1S of Hill [5] alongwith joint scaling test of Cavalli [6] were used to determine the presence of epistasis. The estimates of gene effects were obtained by weighted least square techniques using trigenic epistatic model by joint scaling test of Cavalli [6]. In the trigenic epistatic model the parameters estimated were m = mean of all possible homozygous lines; (d) = additive gene effects pooled over all loci; (h) = dominance gene effects pooled over all loci; (i) = over all additive × dominance epistatic gene effects; (j) = over all additive × dominance epistatic gene effects; (1) = over all dominance × dominance epistatic gene effects; (w) = additive × additive × additive gene interaction effects; (x) = additive × additive × dominance gene interaction effects; (y) = additive × dominance × dominance gene interaction effects; (z) = dominance × dominance × dominance gene interaction effects. Components of heterosis (over better parent) in the presence of trigenic interactions were calculated as suggested by Hill [5].

Results and discussion

Individual and joint scaling tests indicated the presence of epistasis in both the crosses for grain yield and tillers per plant. Since the studies have been based on trigenic model, therefore, the 10-parameter model was considered adequate to explain the results. However, the significant χ^2 values in both the cross for grain yield and in RS-31-1 × RAJ 1482 for tiller per plant suggest involvement of even higher order interaction or linkage between sets of genes in these crosses (Table 1).

The analysis of gene effects revealed that interactions played major role in the inheritance of grain yield and tillers per plant. The additive gene effect was not observed in any of the traits. However, significant dominance (h) gene effect was observed in the cross UP 301 × HD 2009 for both the traits. The digenic interaction additive × additive (i) and dominance x dominance (j) had an important role in controlling the inheritance of grain yield. One or more of the trigenic interactions were also involved in interitance of these traits (Table 2).

The absolute totals of epistatic effects further revealed that first order interactions [(i), (j), (l)] and second order interactions [(w), (x), (y), (z)] were more important in controlling the inheritance of these traits than the main effects in all the cases [7, 8]. The parameters (h), (l) and (z) were significant and different in signs, indicated duplicate type of epistasis at trigenic level in UP-301 × HD-2009 for grain yield (Table 3). The absolute totals of non fixable gene effects [(h), (i), (l), (x), (y), (z)] were many times higher than the fixable [(d), (i), (w)] in both the crosses for grain yield and tillers per plant, indicating greater role of non additive effects in the inheritance of these triats [9, 10, 11].

Significant heterosis over better parent was generally observed. Analysis of components of heterosis revealed that dominance (h) was the major contributor of heterosis. However, significant heterosis was observed only for grain yield in the cross UP 301 × HD 2009 (Table 4). Absence of significant heterosis in remaining cases could be explained due to internal cancellation of heterosis components. Significant inbreedirtg depression was also observed due to the dissipation of non-additive dominance effects of epistatic effects involving dominance in F_2 generation.

In conclusion, results of this study show that as a consequence of higher magnitude of interactions, the non-fixable gene effects were higher than the fixable indicating the major role of non-additive gene effects. In view of high magnitude of inter allelic interactions for grain yield and tillers per plant the successful breeding methods will be the ones, which can mop-up the genes to form superior gene constellations interacting in a favorable manner. Some forms of recurrent selection namely, dialer selective mating [12] or biparental mating in early segregating generations [13] might prove to be effective alternative approach.

Table 1. Individual and joint scaling test for grain yield and tiller per plant in two crosses of wheat

Scaling tests	Grain yield		Tillers per plant	
	UP-301 × HD-2009	RS-31-1 × RAJ-1482	UP-301 × HD-2009	RS-31-I × RAJ-1482
A	5.00**±1.67	–4.47**±1.54	–1.60±0.94	2.13±1.25
B	3.73*±1.69	–1.40±1.60	–2.53*±1.15	–2.53*±1.06
C	12.40**±3.14	12.07**±2.46	–11.60**±1.57	1.80±2.03
B_{11}	–8.81**±3.24	–12.48**±2.94	2.87±2.25	2.00±2.47
B_{12}	–4.24±3.80	–5.19±3.59	7.53**±2.28	5.51*±2.53
B_{21}	15.89*±8.07	–1.52±3.30	7.01**±2.00	4.52*±2.44
B_{22}	–27.44**±3.53	1.71±3.29	1.27±2.35	7.01**±2.18
B_1S	–12.95*±6.41	20.09**±6.42	–1.46±4.32	–8.49*±4.16
B_2S	44.35**±7.24	35.01**±5.06	–0.26±3.78	8.03*±3.87
X	–0.38±1.46	–4.47**±1.38	0.53±0.93	2.01*±0.99
Y	11.98**±1.61	1.02**±1.53	2.60*±1.01	1.26±1.10
Joint Scaling test χ^2 value	29.84**(2)	28.26**(2)	2.81(2)	6.60*(2)

*,** Significant at 5% and 1% level, respectively; Note: Degree of freedom for γ^2 is given in parenthesis.

Table 2. Gene effects for grain yield and tiller per plant in two wheat crosses

Effects	Grain yield		Tillers per plant	
	UP-301 × HD-2009	RS-31-1 × RAJ-1482	UP-301 × HD-2009	RS-31-1 × RAJ-1482
m	23.55**±4.59	21.40**±3.92	25.71**±2.53	12.71**±2.82
(d)	–1.35±3.51	–2.08±3.17	1.68±2.09	–0.96±2.09
(h)	96.46**±23.67	33.73±19.90	–45.99**±12.74	21.31±14.88
(i)	9.00*±4.60	12.76**±3.93	–9.25**±2.54	2.54±2.8
(j)	6.85±9.49	11.18±8.91	–2.17±5.99	6.27±6.14
(l)	–162.02**±36.53	–27.58±3.20	56.25**±19.94	–36.84±23.44
(w)	6.60±3.49	–0.61±3.15	–0.75±2.08	–1.54±2.07
(x)	–26.55*±13.32	–1.20±10.57	31.53**±6.66	–14.27±8.27
(y)	–4.46±9.44	–23.45**±9.04	3.12±6.04	–9.38±6.42
(z)	87.36**±17.79	10.36±15.58	17.66±9.95	19.55±11.6*

*,**Significant at 0.05 and 0.01 levels, respectively

Table 3. Absolute totals of epistatic, fixable and non-fixable gene effects for grain yield and tillers pre plant in two wheat crosses

Gene effects	Grain yield		Tillers per plant	
	UP-301 × HD-2009	RS-31-1 × RAJ-1482	UP-301 × HD-2009	RS-31-1 × RAJ-1482
Main effects				
(d)	–1.35	–2.08	1.68	–0.96
(h)	96.46	33.73	–45.99	21.31
Epistatic effects				
I order	177.87	51.52	67.67	45.65
II order	124.97	35.62	53.06	44.74
Total gene effects				
Fixable	16.95	15.45	11.68	5.04
Non-fixable	383.70	107.50	156.72	107.62

First order interactions : (i), (j) and (l); Second order interactions : (w), (x), (y) and (z); *,** Significant at 5% and 1% level, respectively; Fixable components : (d), (i) and (w); Non-fixable components : (h), (j), (l), (x), (y) and (z)

Table 4. Components of heterosis for gain yield and tillers per plant in two wheat crosses

Effects	Grain yield		Tillers per plant	
	UP-301 × HD-2009	RS-31-l × RAJ-1482	UP-301 × HD-2009	RS-31-l × RAJ-1482
(h)	96.46	33.73	–45.99	21.31
-(i)	–9.00	–12.76	9.25	–2.54
1/2 (x)	13.27	–0.60	15.77	–7.14
1/4 (z)	21.84	2.59	–4.42	4.89
-(d)	1.35	2.08	–1.68	0.96
1/2 (j)	3.42	5.59	–1.09	3.14
-(w)	–6.60	0.61	0.75	1.54
-1/4 (y)	1.11	5.86	–0.78	2.35
Heterosis (%)	7.07**	0.67	0.87	–0.87
Inbreeding depression	3.27**	4.73**	3.83**	0.33

*,** Significant at 0.05 and 0.01 levels, respectively

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