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Inheritance of tillers-per-plant in durum wheat (*Triticum durum* Desf.)

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Abstract

Gene effects were analyzed using means of number of tillers-per-plant of 12 generations *viz.*, both parents, F_1, F_2, first backcross generations (BC_1 and 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 three crosses involving six diverse cultivars of durum wheat (*Triticum durum* Desf.). To determine the nature of gene actions governing number of tillers-per-plant, generation mean analysis was used under normal and late sown environments. The ten-parameter model was adequate in all the cases except in the cross Cocorit 71 × A-9-30-1 under late sown condition where the 3 parameter model was adequate. Epistatic effects, particularly trigenic types were predominant over additive and dominance effects under both normal and late sown environments. Duplicate epistasis was observed in two crosses under normal sown environment. Epistatic interactions particularly non-fixable types were the contributors to the significant and positive heterosis.

Key words : Durum wheat, non-allelic interaction, duplicate epistasis, heterosis

Introduction

Earlier workers suggested that there would be no separate gene system for yield *per se* and that yield is the end product of the multiplicative interaction between the yield components. Number of tillers-per-plant is one of the important contributing attributes of grain yield and its significance has been reported by number of biometrical studies. The use of generation mean analysis has been very limited in durum wheat (*Triticum durum* Desf.). However, previously a number of studies have been carried out to examine the inheritance of such quantitative traits following diallel analysis [1-5]. Diallel analysis does not provide the estimates of different non-allelic gene actions operating in the inheritance, which can be obtained by generation mean analysis. The non-allelic interactions could inflate the measure of additive and dominance components. It is, therefore, important to identify and estimate the components of epistasis along with the additive and dominance compoents, so that the fixable components could be exploited by using suitable breeding techniques. Keeping in vierw, these facts, the present study was planned to investigate genetics of number of tillers-per-plant by using 12 generations of the three crosses under normal and late sown conditions. Such information will be useful for the improvement of grain yield in durum wheat.

Materials and methods

The experimental material comprised three crosses namely, Cocorit71 × A-9-30-1, HI8062 × JNK-4W-128 and Raj911 × DWL5002, generated from six diverse parents. Twelve 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). All these populations were raised together in randomized block design with three replications at 30 cm × 10 cm spacing under normal (20th November) and late sown (20th December) environments in the same cropping season at research farm of Rajasthan Agricultural University, Durgapura, Jaipur. Each parent and F_1 generation was sown in 2 rows, each backcross generation in 4 rows and F_2 and the second cycle of backcrosses in 6 rows of 5 m length. Number of tillers-per-plant was recorded on 15 random plants in each parent and F_1, 30 plants in each backcross generation and 60 plants in each F_2 and second backcross generations in both environments.

The data on each population in both environments were analyzed separately by joint scaling test of Cavelli [7] to determine the nature of gene action. Components of heterosis (over better-parent) in the presence of trigenic interactions were calculated as suggested by Hill [8].

Results and discussion

Results of joint scaling tests indicated that the inheritance of this trait could be explained on the basis of 10 parameter model in all the cases except in the cross Cocorit71 × A-9-30-1 under late sown condition where the 3-parameter model was adequate (Table 1). In the cross Raj911 × DWL5002 the differences among the generation means were not significant under late sown condition, indicating that environments played greater role in the expression of different non-allelic interactions in such a way that significant contribution for trait changed drastically in changing the favourable environment. As a matter of fact, when sowing is delayed, the genotypic expression is afected, hence the possibility is that the true phenotypic differences are not resolved leading to observation of non significant differences between the different genetic parameters estimated in normal and delayed sowings. In such situations the estimates made in late sowings are expected to be found non significant to less significant ones in comparison to the normal environments, unless the parents involved are specially selected for the targeted environment. These results confirmed that epistatic interaction had a significant contribution in the controlling the inheritance of this trait in durum wheat. Dominance (h) gene effects were more important and had higher magnitude than additive (d) gene effects in most of the cases. However, its relative role changed with the cross as well as with the sowing time. In delayed sowing, the character expression is affected, such that the difference in the mean values between different generations is reduced. This ultimately affects the estimates of genetic components. This can further be observed from the digenic interactions, where only additive × additive (i) in the cross HI8062 × JNK-4W-128; dominance × dominance (l) interaction in Cocorit71 × A-9-30-1 and Raj911 × DWL5002 were significant in normal sowing whereas, in late sown condition none of the digenic interactions were significant in the cross HI8062 × JNK-4W-128. One or the other of the trigenic effects was also significant in all the three crosses where 10-parameter model was employed.

Table 1. Gene effects for number of tillers-per-plant under two sowing dates in three crosses of durum wheat

Effects	Cocorit71 × A-9-30-1		HI 8062 × JNK-4W-128		Raj911 × DWL 5002
	Normal sown	Late sown	Normal sown	Late sown	Normal sown
m	9.56** ±0.82	6.62** ±0.15	6.39** ±0.74	7.17** ±0.74	8.89** ±0.33
(d)	0.42 ±0.59	−0.20 ±0.15	−1.41 ±0.69	−2.36** ±0.57	1.33** ±0.21
(h)	4.45* ±1.18	1.32** ±0.34	3.72* ±1.39	1.19 ±1.15	−1.71** ±0.42
(i)	−4.38 ±2.46		6.25** ±1.59	3.26 ±2.00	1.26 ±1.14
(j)	−4.39 ±3.05		−1.60 ±3.89	−3.34 ±2.65	−1.26 ±1.15
(l)	−37.71** ±7.87		7.18 ±4.97	−0.89± 6.98	9.74** ±3.43
(w)	0.01 ±1.77		−2.83 ±1.52	−2.03 ±2.01	−1.82** ±0.63
(x)	48.14** ±10.28		10.90 ±6.90	2.58 ±4.44	9.24* ±4.51
(y)	−12.60* ±4.93		11.60* ±5.14	9.77* ±4.44	2.06 ±2.53
(z)	69.61** ±12.39		−4.23 ±11.74	9.42 ±10.90	−6.26 ±5.50
χ^2 for 10 parameter model	1.93(2)	12.66(9)	5.08(2)	6.84(2)	1.18(2)

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

Note: Degrees of freedom for χ^2 is given in parentheses

The absolute totals revealed that first order interactions [(i), (j), (l)] and second order interactions [(w), (x), (y), (z)] were more important in controlling the inheritance of this trait than the main effects in all the cases except in the cross Cocorit71 × A-9-30-1 in late sowing where dominance (h) had higher value than additive (d) gene effect (Table 2). However, the epistatic effects were higher in the normal sowing date. Delaying sowing has minimized the epistatic effects in this cross. The parameters (h), (l) and (z) were significant and differed in signs, indicating duplicate epistasis, at three gene levels in the cross Cocorit71 × A-9-30-1 and at two gene levels in the cross Raj911 × DWL5002 in normal sown condition. No conclusion regarding type

Table 2. Main effects, total of the first and second order epistatic effects, fixable and non-fixable gene effects for number of tillers-per-plant under different sowing dates in three crosses of durum wheat

Cross	Sowing time	Main effects		Epistatic effects		Total gene effects	
		(d)	(h)	I order	II order	Fixable	Non fixable
Cocorit71 × A-9-30-1	Normal	0.41	4.45	46.48	130.36	4.80	176.92
	Late	−0.20	1.32			0.20	1.32
HI8062 × JNK-4W-128	Normal	−1.41	3.72	15.03	29.56	10.50	39.22
	Late	−2.36	1.19	7.49	23.79	7.65	27.18
Raj911 × DWL5002	Normal	1.33	−1.71	12.27	19.37	4.41	30.27

First order interactions: [(i), (j), (l)]; Second order interactions: [(w), (x), (y), (z)]; Fixable components: [(d), (i), (w)]; Non-fixable components: [(h), (j), (l), (x), (y), (z)] of epistasis could be drawn in remaining cases as either (h), (i) or both were non-significant. Patel [9] also observed duplicate epistasis in *aestivum* wheat. Non-fixable gene effects (absolute totals) were high in all the croses in both the environments (Table 2), indicating their greater role in the inheritance of this trait [10-15].

Significant heterosis over better parent was generally observed. Analysis of components of heterosis revealed that epistatic interactions were the contributors to the significant heterosis except in the cross Cocorit 71 × A-9-30-1 under late sown condition, where dominance (h) was the major contributor of heterosis (Table 3). Additive × additive × dominance (x) trigenic interaction was the major contributor of heterosis in all three crosses in normal sowing (Table 3). Significant heterosis is generally reported in wheat [3, 5 and 6]. Inbreeding depression was also observed in most of the cases due to the dissipation of epistatic effects involving dominance in F_2 generation. Thus, the study revealed that higher magnitude of interactions particularly of trigenic type the absolute totals of non-fixable effects were invariably higher than the fixable effects. Thus methods, which will exploit non-additive gene action, such as restricted recurrent selection by the way of intermating the most desirable segregates followed by selection [16] or multiple crosses or biparental mating in early segregating generations [17] could held promising for genetic improvement of the trait. In the crosses where duplicate type of epistasis was observed, the selection intensity should be mild in the earlier and intense in the later generations because it hinders the progress through selection. The study also showed that the inheritance is highly affected by environment, hence estimates of the components of inheritance should be done in optimum environment.

Table 3. Components of heterosis for number of tillers-per-plant

Effects	Cocorit71 × A-9-30-1		HI8062 × JNK-4W-128		Raj911 × DWL 5002
	Normal sown	Late sown	Normal sown	Late sown	Normal sown
(h)	4.45	1.32	3.72	1.19	−1.71
−(i)	4.38	-	−6.25	−3.26	−1.26
1/2(x)	−24.07	-	5.45	1.29	−1.26
1/4(z)	17.40	-	−1.06	2.36	−1.57
−(d)	−0.42	0.20	1.41	2.36	−1.33
1/2(j)	−2.20	-	−0.80	−1.67	−0.63
−(w)	−0.01	-	2.83	2.03	1.82
−1/4(y)	3.15	-	−2.90	−2.44	−0.52
F_1-BP	1.69	1.30	1.40	1.22	−0.57
S.E.	0.39	0.64	0.43	0.87	0.24
Heterosis (%)	14.10**	18.93*	13.91**	14.30	−6.06*
F_1-F_2	1.48	0.88	3.22	1.98	0.80
S.E.	0.62	0.69	0.48	0.74	0.28
Inbreeding depression (%)	11.16*	10.78	28.08**	20.31**	9.058**

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

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