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ANALYSIS OF GENOTYPE–ENVIRONMENT INTERACTION IN PEARL MILLET GENERATIONS

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ABSTRACT

Six generations (parents, F_1, F_2, BC_1 and BC_2) of three crosses, i.e. 78/614 x 77/144, 77/273 x 78/705 and 77/170 x 78/791 between two inbred lines of pearl millet were studied for estimation of gene effects. The material was grown at two locations : at Hisar under irrigated and at Bawal under rainfed conditions. The performance of the generations of the crosses was better at Hisar than at Bawal. The crosses and their generations showed significant interaction with environment. The least square estimates of the parameters of m, (d), (h), e_1, (gd_1) and (gh_1) revealed inadequacy of the additive–dominance model for plant height, ear length, ear weight, grain and dry fodder yield, indicating the role of genotype–environment interaction, epistasis and/or linkage.

Key words: Pearl millet, generation, genotype–environment interaction.

Of the various assumptions underlying quantitative genetics theory, besides epistasis, the linkage and genotype–environment interactions also cause considerable bias in the estimation of genetic parameters. Comstock and Moll [1] have statistically demonstrated a significant effect of genotype–environment interactions in reducing selection efficiency. Little information is available on the influence of environment on generations means in pearl millet. Gupta and Phul [2] showed that genotype–environment interactions influenced the estimates of gene effects for tiller number and ear length in pearl millet although their magnitude was negligible, Bucio Alanis et al. [3] gave a model for the estimation of genetic, environmental and genotype–environment interaction components of variation observed for quantitative traits from the generation means of a cross between two inbred lines. The present study presents results of six generations (parents, F_1, F_2, BC_1, BC_2) of three crosses of pearl millet (*Pennisetum typhoides* (Burm) S & H.) grown at two locations under different moisture regimes.

MATERIALS AND METHODS

The material for the present study comprised six generations, namely, the two parents, F_1, F_2, BC_1 and BC_2 of three pearl millet crosses, viz., 78/614 x 77/144, 77/273 x 78/705, and 77/170 x 78/791. The parents used in the crosses were advanced inbreds selected on the basis of their good agronomic performance and combining ability. The six generations of each cross were grown in randomized block design with three replications at two locations: Haryana Agricultural University research farm at Hisar (irrigated), and H.A.U. Regional Research Station, Bawal (unirrigated, rainfed). The 21 rows comprising a replication represented two rows of each both parents, three of each F_1 and the two back crosses (BC_1, BC_2), and eight rows of F_2. The rows were 4 m long, placed 45 cm apart, with plant-to-plant distance 20 cm. Observations were recorded on five competitive plants in each row on six quantitative traits, namely, plant height (cm), number of effective tillers, ear length (cm), ear weight (g), grain and dry fodder yield (g), all per plant. The significance of generation means and the genotype–environment interaction components was tested from the analysis of variance. The generation means were subjected to test a biometrical model with m, (d), (h) and e_1 parameters to obtain least square estimates of these parameters as per Cavalli [4]. If the value for goodness of fit was significant, the model was extended to include the genotype–environment interaction components, (gd_1) and (gh_1), as suggested by Bucio Alanis et al. [3].

RESULTS AND DISCUSSION

The performance of six generations of three crosses of pearl millet for the six characters was generally better at Hisar than at Bawal. The analysis of variance (Table 1) revealed that

Table 1. Analysis of variance (M.S.S.) of generation means at two locations for quantitative characters in pearl millet

Source	d.f.	Plant height	Effective tillers per plant	Ear length	Ear weight per plant	Grain yield per plant	Dry fodder yield per plant
Replications in locations	4	72.0	0.45*	0.26	31.4	10.9	44.3
Locations	1	130316.0**	32.94*	122.05	44895.9**	13207.0**	153673.5**
Crosses	2	2638.8*	1.20*	47.51*	354.7**	151.5**	163.8*
Generations in crosses	15	1763.4*	2.14*	31.38*	626.4**	269.4**	494.5*
Locations x crosses	2	601.0*	2.16*	53.75*	484.8**	181.7**	347.2**
Locations x generations in crosses	15	289.9*	0.54*	10.00*	418.3*	188.1**	301.1**
Error	68	96.0	0.13	1.38	21.3	6.2	70.7

*P = 0.05–0.01; **P = 0.01

the crosses, their generations, and locations differed significantly. The performance of the F_1 hybrids and their generations was affected significantly as a components locations x crosses and locations x crosses in generations exhibited significant variation for all the characters, underlying the need for studying the influence of genotype–environment interaction on gene effects.

The least square estimates of the four-parameter with model m, (d), (h) and e_1 and the six-parameters model including these four and two genotypes–environment interaction parameter (gd_1) and (gh_1) are presented in Table 2. The inadequacy of the four- and six-parameter models was noticed in the crosses 78/614 x 77/144 and 77/273 x 78/705 for ear weight and grain yield and in 78/614 x 77/144 for plant height, indicating that besides genotype–environment interaction, linkage and/or epistasis of higher order interactions might be present. Higher order interactions in the inheritance of plant height, ear length, tiller number and ear girth were also reported by [5]. Significant deviation of the four-parameters model from goodness of fit but high level of fitness of the six-parameters model in the cross 77/170 x 78/791 for plant height, ear weight, grain yield, fodder yield and the cross 77/273 x 78/705 for dry fodder yield indicates that inclusion of the genotype–environment interaction parameters model explained better the genetic variability for the characters in these crosses. The substantial decrease in values of goodness of fit when the six-parameters model with two genotype–environment interaction parameters (gd_1 and gh_1) was fitted and significant values of only the (gh_1) parameter indicated that genotype–environment interactions did not play a major or direct role in the inheritance of the characters in question, and therefore, epistasis could be the main cause of the failure of the additive–dominance model. Nonsignificant χ^2 values in both the four- and six-parameter models for tiller number showed that the nonallelic interactions may have affected the performance of tiller number in the two environments differently. Singh [6] also reported the prevalence of epistasis for tiller number individually in the two environments, while Gupta and Phul [2] believed the deviation of additive–dominance model for this character to be material specific.

The nonsignificant d and (gd_1) effects in majority of cases, but predominantly significant values of h and (gh_1) indicated that the nonadditive genetic variation was in greater preponderance in this material. Also, the magnitude of the latter was higher than the former. The preponderance of non-additive gene effects for yield and other quantitative characters in pearl millet supports the previous findings [7, 8]. Almost similar estimates of h and (gh_1) in a number of cases was an indication that the environment did not cause any bias in the estimates of h.

Preponderance of epistasis in majority of cases in this material itself was observed by Singh [6]. The role of epistasis in the inheritance of quantitative characters in pearl millet

Table 2. Additive, dominance, environmental and genotype environmental components of means of six generations of pearl millet grown at two locations

Character	Cross	m	d	h	e_l	gd_l	gh_l	χ^2	d.f.
Plant height	78/614 x 77/144	155.8**	- 4.61	24.7**	33.1**	21.3**	8		
		155.0**	- 5.73	26.8**	35.4**	3.21	- 6.35	21.4**	6
	77/273 x 78/105	162.9**	- 2.86	40.1**	36.7**	4.9	8		
		163.0**	- 2.71	39.3**	38.0**	1.76	- 4.89	3.5	6
	77/170 x 78/791	159.1**	- 13.41**	43.3**	37.1**	19.5*	8		
		157.1**	- 13.89**	48.5**	31.5**	0.73	16.77*	2.9	6
Effective tillers per plant	78/614 x 77/144	1.8**	- 0.08	0.7	0.3	0.5	8		
		1.8**	- 0.09	0.7	0.3	- 0.06	0.16	0.4	6
	77/273 x 78/705	2.1**	- 0.32	1.4	0.5	2.0	8		
		2.1**	- 0.28	1.4	0.5	0.15	0.31	1.7	6
	77/170 x 78/791	2.1**	- 0.54	1.31*	0.6*	0.4	8		
		2.0**	- 0.54	1.4*	0.7	- 0.32	- 0.18	1.5	6
Ear length	78/614 x 77/144	18.3**	- 1.10	4.3*	0.6	6.9	8		
		18.1**	- 0.98*	5.1*	1.1*	- 0.33	- 1.78	3.0	6
	77/273 x 78/705	16.9**	- 1.44*	4.5**	2.0**	12.5	8		
		16.9**	- 1.38*	4.3**	1.8*	- 0.43	0.85	13.9	6
	77/170 x 78/791	15.1**	- 1.40*	5.88**	0.5	3.0*			
		15.0**	- 1.35*	6.4*	0.8	-0.08			
Ear weight per plant	78/614 x 77/144	13.0**	- 0.43	11.9**	17.2	95.0**	8		
		17.0**	- 0.59	26.5**	8.7**	0.15	22.66**	27.1**	6
	77/273 x 78/705	30.4**	- 0.83	9.2**	26.6**	52.4**	8		
		23.9**	- 2.20	26.9**	18.8**	- 1.40	21.86	28.1**	6
	77/170 x 78/791	18.5**	- 1.41	11.3**	16.8**	59.9**	8		
		15.9**	- 0.67	21.4**	12.4**	0.22	16.79**	5.0	6
Grain yield per plant	78/614 x 77/144	11.3**	- 0.78	5.2**	7.6**	17.0**	8		
		8.7**	- 0.67	15.2**	4.6**	- 0.02	11.69	15.5**	6
	77/273 x 78/705	23.5**	- 0.70	13.3**	22.8**	88.0**	8		
		13.7**	- 3.75*	21.8**	10.9**	- 3.35	18.06**	21.5*	
	677/170 x 78/791	10.0**	- 0.13	8.1**	8.0**	20.3**	8		
		9.1**	- 0.47	9.5**	6.4**	- 0.06	6.35**	3.2	6
Dry fodder yield per plant	78/614 x 77/144	44.0**	0.13	9.6	35.4**	8.4	8		
		42.8**	0.13	13.5*	3.3**	- 0.36	11.36**	4.1	6
	77/273 x 78/705	37.5**	- 2.05	3.1	28.6**	17.5*	8		
		36.9**	- 15.54	16.3	28.0**	- 14.39*	13.22	7.9	6
	77/170 x 78/791	49.5**	- 1.89	15.2**	43.3**	17.2*	8		
		45.5**	- 2.51	31.9**	38.8**	- 0.87	19.63**	12.6	6

*P = 0.05–0.01. **P = 0.01.

has also been reported by many other workers [2, 7, 9, 10]. As the role of epistasis and linkage is due to genetic reasons, which may be material specific, the environment causing bias in the gene effects necessitates the study of more number of generations and testing over an array of environments.

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