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GENETIC ANALYSIS OF DIALLEL CROSS IN BREADWHEAT UNDER DIFFERENT ENVIRONMENTAL CONDITIONS IN EGYPT. 2. F_2 AND PARENTS

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ABSTRACT

Five traits, namely, plant height, spike length, grains/spike, grain yield/plant, and 100-grain weight were studied in 15 F_2 populations obtained from a 6 x 6 half-diallel set in wheat. The parents showed difference for gca depending on their genotype and environment. For sca the 15 F_2 populations differed from location to location. All the traits were influenced by additive as well as dominance gene effects. Unequal allele frequency was observed in the parents with asymmetrical distribution among these parents for the proportion of positive and negative alleles with an excess of dominant over recessive genes. Some traits showed partial dominance, others showed overdominance depending on location. Narrow sense heritability was low for all the traits in F_2 except for grains/spike which was maximum at Ismailia. Data of graphic analysis of F_2 showed variation in the dominance or recessive genes in parents. This agreed with the results of statistical analysis. There were significant phenotypic and genotypic correlation coefficients between grain yield/plant and the four other traits.

For quantitative traits, such as yield, the relative performance of genotypes often changes from one environment to another. Extensive testing is required to identify the genotypes that show maximum desirable interaction with the environment. Among those materials in a set being tested an ideal cultivar would be adapted to a wide range of conditions with above average yield over environments and below average variance across environments.

Singh et al. [1] found that gca components were higher than sca in three environments for spike length and grains/spike, while for grain weight and grain yield/plant sca estimates were higher in F_2. Yadav and Singh [2] found that in F_2 generation, both gca x

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environment as well as sca x environment interactions were significant for plant height, grains/spike and grain yield/plant. The sensitivity of gca of these traits to environments was higher than that of sca.

Bhowmik and Ali [3] showed significant location x variety interaction in F_2 for 100-grain weight. Hassaballa et al. [4] reported that additive gene effect was more than dominance effect in F_2 generation for plant height and 100-grain weight, while Blanco et al. [5] and Hassaballa et al. [4] found that both additive and dominance gene actions affected the inheritance of grains/spike and grain yield/plant. Various degrees of dominant were shown in F_2 [1, 5]. Narrow sense heritability in F_2 varied among locations and varieties [4, 6]. Phenotypic and genotypic correlations between yield and related characters in F_2 were reported by [7–9].

The present investigation extends the analysis of a 6 x 6 half-diallel set of crosses in breadwheat to the F_2 generation to obtain information on the changes in the components of variation that may occur in successive generations at three locations in Egypt.

MATERIALS AND METHODS

Six parents and their F_2 populations obtained by selfing 15 F_1s from 6 x 6 half-diallel crosses were planted at three locations in Egypt, i.e. Ismailia (sandy soil), Nobaria (calcareous), and Gemmeiza (clay soil) in winter 1992. The parents used were Sakha 69, Giza 157, Giza 160 and Sakha 92 (Egyptian varieties) and Agent and Baart (Mexican varieties). Randomized complete block design with 3 replications was followed. Each F_2 was represented by 10 rows per block, and parents were represented by 4 rows in each block. The rows were 3 m long and 30 cm apart, and the plants were spaced at 40 cm. Data were recorded for plant height, spike length, number of grains/spike, grain yield/plant, and 100-grain weight.

The statistical procedures of Griffing [10] for combining ability analysis, Hayman [11], Jinks [12] for genetical and graphic analysis, and Singh and Chaudhary [13] for phenotypic and genotypic correlation coefficients were followed.

RESULTS AND DISCUSSION

ESTIMATION OF COMBINING ABILITY AND GENETIC COMPONENTS

Table 1 shows highly significant effects (mean squares) of genotypes for all five traits in all three locations and also in pooled analysis. Highly significant genotype x location interactions were detected.

Table 1. Analysis of variance (MS) for five traits in F_2 generation of wheat

Source	Location	d.f.	Plant height	Spike length	Grains per spike	Grain yield per plant	100-grain weight
Replications	Ismailia	2	92.687**	8.669**	60.719	0.104	0.916
	Nobaria	2	23.442*	0.183	23.792	94.939**	0.256
	Gemmeiza	2	22.665	0.381	12.052	7.133**	0.481
Genotypes	Ismailia	20	93.935**	2.134**	92.791**	15.269**	0.866**
	Nobaria	20	47.709**	2.759**	46.603**	25.533**	0.794**
	Gemmeiza	20	222.464**	1.245**	202.388**	70.329**	0.785**
Error	Ismailia	40	16.232	0.479	26.158	5.521	0.319
	Nobaria	40	5.966	0.366	19.315	8.182	0.276
	Gemmeiza	40	15.024	0.479	26.350	7.522	0.223
Locations		2	42261.832**	244.741**	1857.913**	3848.433**	40.903**
Replications x locations		6	46.318**	3.734**	32.184	34.058**	0.552*
Genotypes		20	254.844**	2.893**	218.671**	40.214**	0.857**
Locations x genotypes		40	54.639**	2.452**	16.554**	35.459**	0.793**
Error		120	12.404	0.931	23.941	7.075	0.275

Table 2 shows the analysis of variance of gca and sca at the three locations. Plant height and 100-grain weight showed highly significant values of gca and sca at all locations. Number of grains/spike exhibited highly significant gca in all locations. Grain yield/plant showed highly significant gca at Nobaria and Gemmeiza, and sca at Ismailia and Gemmeiza. Most of the gca and sca effects were significant in pooled analysis. Thus the behaviour of different sources of variation was different from one location to another.

Table 3 shows gca values in F_2 at all three locations and for pooled analysis. For plant height the parent variety Agent at Ismailia and in pooled analysis, Giza 160 an Sakha 69 at Gemmeiza exhibited highly significant positive gca effects. For spike length, Sakha 92 and Agent at Ismailia, Giza 160 at Nobaria, Agent and Giza 157 at Gemmeiza and in pooled analysis revealed positive gca effects. The varieties Sakha 92 and Baart were the best general combiners at Ismailia and in the pooled analysis for grains/spike, while Sakha 69 at Nobaria and Baart at Gemmeiza were better combiners for this trait. For grain yield/plant, the parent variety Baart at Nobaria, Sakha 69 and 92 and Agent at Gemmeiza and Sakha 69 in the pooled analysis were good combiners. Giza 160 and Agent showed high gca for 100-grain weight at all three locations and in pooled analysis. These findings were in agreement with those of [2, 14].

Table 2. Analysis of variance (MS) of general combining ability and specific combining ability in F_2 generation of wheat

Source	Location	d.f.	Plant height	Spike length	Grains per spike	Grain yield plant	100-grain weight
Gca	Ismailia	5	109.467**	6.467**	260.704**	1.946	1.291**
	Nobaria	5	32.650**	1.633**	95.767**	56.290**	0.816*
	Gemmeiza	5	124.217**	3.160**	477.900**	118.383**	1.024**
Sca	Ismailia	15	88.760**	0.689	36.819	19.711**	0.722**
	Nobaria	15	52.725**	5.349**	30.214	15.281	0.787**
	Gemmeiza	15	255.211**	0.607	110.549**	54.311**	0.705**
Error	Ismailia	40	5.410	0.159	8.719	1.840	0.107
	Nobaria	40	1.989	0.122	6.438	2.727	0.092
	Gemmeiza	40	5.008	0.159	8.783	2.507	0.074
Gca		5	78.165**	3.476**	643.012**	93.988**	0.440*
Sca		15	313.738**	2.699**	77.224**	22.290**	0.996**
Locations x gca		10	94.142**	3.892**	95.676**	41.315**	1.345**
Locations x sca		30	41.472**	1.973**	50.181**	33.507**	0.609**
Error		40	12.404	0.931	23.941	7.075	0.273

Table 3. General combining ability effects in F_2 generation of wheat

Parent variety		Ismailia					Nobaria				
		plant height	spike length	grains per spike	grain yield per plant	100-grain weight	plant height	spike length	grains per spike	grain yield per plant	100-grain weight
Sakha 69		– 0.930	– 0.138*	– 1.468*	0.075	– 0.148	0.836	– 0.332*	1.681*	0.932	0.123
Giza 157		– 1.356**	0.257	1.1080	– 0.207	– 0.179	0.684	– 0.054	1.373	0.688	– 0.297
Giza 160		– 2.522**	– 0.996**	– 4.814**	– 0.114	0.380**	– 0.814	0.436**	– 3.831**	– 2.516**	– 0.255*
Agent		3.500**	0.330*	– 1.573	– 0.313	– 0.077	0.383	– 0.016	0.084	0.738	– 0.189
Sakha 92		1.219	0.351**	4.496**	0.491	0.192	0.911	– 0.150	– 0.051	– 1.243*	0.003
Baart		0.089	0.196	2.252*	0.069	– 0.167	– 2.001**	0.117	0.745	1.402*	0.128
L.S.D. gi	5%	1.517	0.260	1.926	0.884	0.213	0.919	0.228	1.655	1.077	0.197
	1%	2.029	0.348	2.576	1.183	0.285	1.231	0.305	2.214	1.441	0.264
L.S.D. gi–gj	5%	2.350	0.403	2.983	1.370	0.330	1.425	0.353	2.564	1.668	0.306
	1%	3.144	0.540	3.992	1.834	0.441	1.906	0.472	3.430	2.232	0.410

Table 4 shows results of sca analysis. For plant height, the cross Giza 160 x Sakha 92 showed promising values at all locations except at Ismailia where cross Giza 160 x Agent was the best. These results agree with those of [15].

For spike length, the crosses Sakha 69 x Giza 160 and Sakha 69 x Agent at Nobaria, Giza 157 x Baart at Gemmeiza, and the pooled analysis showed highly significant values. For grains/spike, the F_2 of the cross Sakha 69 x Giza 160 at Ismailia, Sakha 69 x Baart at the other two locations, and in pooled analysis were promising for this trait. These findings are in agreement with those of [10, 17]. For grain yield/plant, the crosses Sakha 92 x Baart at Ismailia and in pooled analysis, Sakha 69 x Baart at Nobaria and in pooled analysis showed significant sca. For 100-grain weight, the cross Sakha 69 x Sakha 92 showed highly significant sca at Ismailia and in pooled analysis, while Giza 157 x Baart showed high sca at Gemmeiza and in pooled analysis. Yadav and Singh [2] and Hassan and Abdel [18] reported similar results for grain yield/plant and 100-grain weight.

The additive components of genetic variance effect (D) (Table 5) was significant at Ismailia for plant height, at Ismailia and Gemmeiza for spike length and grains/spike at Nobaria and Gemmeiza for grain/plant, and at Ismailia and Gemmeiza for 100- grain weight. The dominant effects (H1) were highly significant for plant height and 100-grain weight at all locations. The other traits showed different H1 value at each location. The

at three locations and in pooled analysis

Gemmeiza					Pooled analysis				
plant height	spike length	grains per spike	grain yield per plant	100-grain weight	plant height	spike length	grains per spike	grain yield per plant	100-grain weight
1.763*	0.185	1.094	1.859**	0.107	0.557	– 0.095	0.436	0.955	0.027
0.402	0.341*	0.056	0.303	0.010	– 0.090	0.181*	0.845	0.261	0.008
2.192*	– 0.586**	– 8.229**	– 4.155**	– 0.163	– 0.381	– 0.382**	– 5.625**	– 2.262**	– 0.013
1.231	0.344*	0.033	1.245**	0.203*	1.705**	0.219**	– 0.486	0.556	– 0.021
– 3.381*	– 0.195	1.820	1.380*	0.168	– 0.417	0.002	2.088**	0.209	0.120*
– 2.207*	– 0.089	5.227**	– 0.632	– 0.325**	– 1.373**	0.075	2.741**	0.280	– 0.121*
1.459	0.260	1.933	1.032	0.177	0.744	0.144	1.061	0.576	0.113
3.947	0.348	2.596	1.381	0.237	1.387	0.193	1.421	0.771	0.151
2.261	0.403	2.994	1.600	0.275	0.163	0.223	1.644	0.893	0.175
3.025	0.540	4.006	2.140	0.368	1.556	0.299	2.199	1.194	0.235

Table 4. Specific combining ability effects in F_2 generation of wheat

Cross		Ismailia					Nobaria				
		plant height	spike length	grains per spike	grain yield per plant	100-grains weight	plant height	spike length	grains per spike	grain yield per plant	100-grains weight
Sakha 69 x Giza 157		3.830*	0.269	– 0.756	2.952*	– 0.421*	2.053	0.055	1.455	– 1.199	1.31**
Sakha 69 x Giza 160		0.109	0.336	8.246**	2.799*	– 0.901**	– 0.472	0.846**	1.637	– 1.170	– 0.321
Sakha 69 x Agent		– 2.121	0.527	– 4.082	0.233	0.121	1.659	1.057**	– 3.139	– 1.247	0.134
Sakha 69 x Sakha 92		2.355	0.196	– 5.916**	0.739	0.990**	3.156**	– 0.065	– 3.068	0.544	0.234
Sakha 69 x Baart		1.168	0.350	2.398	0.674	0.171	– 0.379	0.274	5.818**	4.571**	– 0.118
Giza 157 x Giza 160		– 0.856	0.186	0.564	0.660	0.051	4.388**	– 0.019	– 3.844*	– 0.647	– 0.011
Giza 157 x Agent		– 4.472*	– 0.079	2.155	1.000	0.149	1.517	– 0.474	– 2.736	– 1.852	– 0.156
Giza 157 x Sakha 92		5.342**	0.278	2.916	1.044	0.459	2.528*	0.279	– 0.685	– 0.366	– 0.593*
Giza 157 x Baart		2.464	0.502	– 1.012	0.412	– 0.088	0.986	0.138	4.774*	1.043	0.555*
Giza 160 x Agent		13.142**	– 0.541	0.010	0.768	– 0.381	3.871*	– 0.142	– 0.218	0.268	– 0.359
Giza 160 x Sakha 92		2.716	0.388	– 2.353	0.951	0.508*	6.121**	– 0.240	– 0.083	1.511	0.318
Giza 160 x Baart		– 1.940	– 0.164	– 3.879	0.652	0.176	– 2.305*	0.194	– 2.546	– 1.427	– 0.469*
Agent x Sakha 92		– 3.525*	– 0.005	– 1.262	0.484	– 0.189	0.662	0.348	2.332	– 2.971*	– 0.250
Agent x Baart		– 1.198	– 0.335	1.737	1.260	0.339	2.373*	0.001	– 0.233	– 2.996*	0.234
Sakha 92 x Baart		6.814**	0.441	– 0.340	3.890**	– 0.212	1.529	– 0.166	1.394	0.266	0.576*
L.S.D. Sij	5%	3.440	0.591	4.367	1.468	0.483	2.086	0.516	3.753	2.442	0.448
	1%	4.603	0.791	5.844	3.668	0.646	2.791	0.692	5.021	3.268	0.600
L.S.D. Sij–Sik	5%	6.218	3.379	7.894	3.626	0.873	3.770	1.068	6.783	4.415	0.811
	1%	8.320	4.521	10.562	4.852	1.168	5.044	1.429	9.076	5.907	1.085

component of variation due to dominance effects correlated with gene distribution (H2) and were significant in all locations only for plant height. For grains/spike and grain yield/plant, the (H2) values were significant at Gemmeiza. All H2 values were smaller than H1 values, indicating unequal allele frequency. The overall dominance effects of the heterozygous loci (h^2) were significant in all locations for plant height and grains/spike. For

at three locations and in pooled analysis

Gemmeiza					Pooled analysis				
plant height	spike length	grains per spike	grain yield per plant	100-grains weight	plant height	spike length	grains per spike	grain yield per plant	100-grains weight
6.734**	0.190	5.104*	0.181	0.036	4.206**	0.171	1.934	0.645	0.249
2.677	-0.069	-3.610	-3.407**	-0.103	0.772	1.371**	2.091	-0.593	-0.442**
0.917	-0.077	-8.731**	-6.480**	0.012	0.152	0.502**	-5.318**	-2.498**	0.089
3.467*	-0.209	2.207	-2.039	-0.005	2.992**	-0.026	-2.259	-0.252	0.406**
4.706**	-0.091	11.431**	-1.071	-0.595**	1.831*	0.178	6.549**	1.391*	-0.181
6.562**	-0.470	6.650**	1.394	-0.168	3.365**	-0.101	1.123	0.469	-0.043
-0.194	-0.338	5.694*	-1.076	0.239	-0.716	-0.297	1.704	-0.643	0.077
6.165**	0.086	2.684	-0.074	-0.329	4.679**	0.214	1.638	0.202	-0.154
0.194	0.793**	-5.351*	0.295	0.495*	1.214	0.478**	-0.530*	0.583	0.321
19.291**	-0.485	-4.996*	-6.205**	-1.016**	12.101**	-0.389**	-1.735	-1.723*	-0.585**
5.317	0.185	2.216	0.303	0.231	4.718**	0.11	-0.074	0.720**	0.352
-0.731	-0.457	1.687	-0.463	-0.144	-1.659	-0.142	-1.579	-0.413	-0.146
-4.445*	-0.251	-1.378	-3.756**	-0.684**	-2.436**	-0.201	-0.103	-2.081**	-0.374**
-0.951	-0.423	3.638	-0.521	0.183	0.075	-0.252	1.714	-0.752	0.252
7.897**	0.388	2.239	-0.656	-0.119	5.414**	0.185	1.098	1.167*	0.082
3.310	0.590	4.383	2.342	0.403	1.701	0.327	2.406	1.203	0.257
4.429	0.790	5.865	3.133	0.539	2.275	0.437	3.219	1.938	0.343
5.983	1.068	7.923	4.233	0.728	3.074	1.061	3.195	2.362	0.464
8.000	1.429	10.601	5.663	0.975	4.112	1.420	5.819	3.161	0.621

spike length, this value was significant only at Ismailia and Gemmeiza, and for grain yield/plant and 100-grain weight at Gemmeiza. This indicates that the effects of dominance is due to heterozygosity, as was also concluded by previous workers [5, 19]. The covariance of additive and dominance (F) was not significant at all the locations. Values of $(H1/D)^{1/2}$ were higher than unity for some traits at one or more locations, indicating overdominance.

Partial dominance was also detected for some traits at one or more locations. For example, at Ismailia it was 0.88 for plant height and 0.32 for spike length. The (H2/4H1) values for all traits in all locations were less than 0.25, showing asymmetric distribution of positive and negative alleles among the parents. The ratio $KD/KR = (4DH1)^{1/2} + F/(4DH1)^{1/2} - F$ were more than unity for almost all the traits at all locations, confirming the excess of dominant genes governing these traits. The $h^2/H2$ values for all the traits studied at all locations suggest that there was one, two or more pairs of genes affecting the inheritance of these traits. These results are in agreement with those of [6].

Narrow sense heritability was low for all the traits in F_2, except for grains/spike at Ismailia, which was high (63.40). Heritability of grain yield/plant at Gemmeiza was moderate (54.10%). Different values of heritability for this character were reported from previous studies [18, 20].

The correlation coefficients (r) were insignificant for almost all traits in F_2 at all locations, suggesting that none of parental lines was completely dominant or recessive for genes controlling any of these traits. Significant r values were obtained for grain yield/plant (0.86 and 0.91) at Nobaria and Gemmeiza, respectively, and for spike length at Gemmeiza (0.82). The values of r^2 for all the traits at all locations were different from unity, suggesting the possibility of selection for the genes showing dominance. Similar results were reported by Mosaad et al. [19].

GRAPHIC ANALYSIS

The graphic analysis of F_2 data for the five traits given revealed that the regression line intersected the Wr axis to the left of the point of origin, indicating partial dominance controlling plant height at Ismailia ($b = 0.655 \pm 0.347$), spike length at both Ismailia ($b = 0.655 \pm 0.347$) and Gemmeiza ($b = 0.687 \pm 0.174$), grains/spike at Ismailia ($b = 0.259 \pm 0.136$) and Nobaria ($b = 0.421 \pm 0.455$), grain yield/plant at Nobaria ($b = 0.436 \pm 0.286$) and Gemmeiza ($b = 0.545 \pm 0.203$), and 100-grain weight at Ismailia ($b = 0.061 \pm 0.604$). These results correspond to the values of $(H1/D)^{1/2}$ in Table 5 and agree with the findings of Blanco et al. [5] and Mosaad et al. [19]. At Nobaria and Gemmeiza, the regression for plant height intersected Wr axes below of the point of origin, indicating overdominance of plant height at Nobaria ($b = 0.159 \pm 0.83$) and Gemmeiza ($b = 0.182 \pm 0.117$), spike length at Nobaria ($b = 0.019 \pm 0.117$), grains/spike at Gemmeiza ($b = 0.279 \pm 0.465$), grain yield/plant ($b = 0.141 \pm 0.123$) and 100-grain weight ($b = 0.027 \pm 0.511$) at Nobaria and Gemmeiza ($b = 0.19 \pm 0.217$). These results also agree with the $(H1/D)^{1/2}$ values presented in Table 5 and with those reported by [20].

The distribution of parental lines along the regression line showed different results depending on the trait and location. Parents P1 for plant height in all locations, P5 for spike length in all locations, and P3 for the grains/spike at Ismailia and Nobaria displayed more

Table 5. Estimates of genetic components in F_2 generation of a 6 x 6 diallel cross of wheat at three locations

Genetic component	Ismailia					Nobaria		
	plant height	spike length	grains per spike	yield per plant	100-grain weight	plant height	spike length	grains per spike
D	24.64 ± 10.61**	0.80 ± 0.05**	53.55 ± 8.83**	- 1.55 ± 1.07	0.22 ± 0.16*	1.61 ± 5.77	0.03 ± 1.09	4.55 ± 5.45
H1	113.24 ± 107.83**	- 1.38 ± 0.55**	48.21 ± 89.67	40.73 ± 10.95**	2.23 ± 1.70*	179.06 ± 58.59**	16.30 ± 11.14	72.09 ± 55.77**
H2	304.46 ± 96.33**	- 1.29 ± 0.49**	59.80 ± 80.10	44.58 ± 9,78**	1.80 ± 1.51	154.79 ± 52.34**	12.30 ± 9.95	50.42 ± 49.82*
h	214.92 ± 64.83**	16.16 ± 0.33**	- 114.56 ± 53.91**	1221.29 ± 6.58**	0.63 ± 1.02	275.21 ± 35.23**	11.51 ± 6.59	- 48.11 ± 33.53**
F	29.93 ± 51.88	- 0.32 ± 0.26	36.49 ± 43.14	- 3.81 ± 5.27	0.35 ± 0.81	2.28 ± 28.19	0.99 ± 5.36	- 12.53 ± 26.83
E	6.62 ± 4.01	0.29 ± 0.02	9.26 ± 3.33	1.75 ± 0.40	0.11 ± 0.06	2.26 ± 2.18	0.11 ± 0.41	6.51 ± 2.07
$(H/D)^{1/2}$	0.88	0.32	0.23	1.28	0.79	2.63	5.33	0.99
(H2/4H1)	0.24	0.23	0.31	0.27	0.20	0.21	0.18	0.17
KD/KR	2.01	0.53	6.00	0.35	3.02	1.31	- 7.62	0.18
h^2/H2	7.05	- 12.45	- 1.91	27.39	0.35	17.77	0.93	- 1.66
h^2 (n.s.)	21.60	45.30	63.40	0.00	20.90	3.00	0.90	8.30
r	- 0.64	0.11	0.78	- 0.70	0.40	- 0.80	- 0.71	- 0.07
r^2	0.41	0.01	0.62	0.49	0.16	0.64	0.51	0.01

(Contd.)

Table 5 (contd.)

Genetic component	Nobaria		Gemmeiza				
	yield per plant	100-grain weight	plant height	spike length	grains per spike	yield per plant	100-grain weight
D	8.98 ± 2.61**	− 0.08 ± 0.13	11.93 ± 93.74	0.45 ± 0.11**	54.77 ± 17.67**	35.55 ± 8.11**	0.27 ± 0.10**
H1	19.22 ± 26.55	3.05 ± 1.36**	978.02 ± 302.03**	0.93 ± 1.11	454.04 ± 179.52**	227.19 ± 82.42**	2.32 ± 1.09**
H2	10.52 ± 23.73	2.35 ± 1.22*	898.55 ± 269.81**	0.37 ± 0.99	384.03 ± 160.37**	154.17 ± 73.63**	1.99 ± 0.97
h	62.11 ± 13.96	1.75 ± 0.82**	11976.91 ± 181.0**	3.37 ± 0.67**	1263.73 ± 107.9**	2088.61 ± 49.55**	12.97 ± 0.65**
F	8.61 ± 12.77	− 0.19 ± 0.65	14.08 ± 145.32	0.26 ± 0.53	− 27.24 ± 86.38	73.34 ± 39.66	0.51 ± 0.52
E	4.10 ± 0.98	0.09 ± 0.05	5.13 ± 11.24	0.15 ± 0.04	8.55 ± 6.68	2.50 ± 0.06	0.07 ± 0.04
$(H/D)^{1/2}$	0.37	1.48	2.25	0.35	0.72	0.63	0.73
(H2/4H1)	0.13	0.19	0.23	0.09	0.21	0.17	0.21
KD/KR	4.61	0.45	1.30	2.32	0.70	9.87	4.64
h^2/H2	5.90	0.74	13.33	9.04	3.29	13.54	6.51
h^2 (n.s.)	34.40	0.00	4.40	38.20	25.30	54.10	29.90
r	0.86	− 0.24	− 0.24	0.82*	0.35	0.91*	0.77
r^2	0.75	0.06	0.05	0.68	0.12	0.82	0.60

dominant genes. Parent No. 3 for plant height at Ismailia and Gemmeiza, and for spike length at Nobaria, and P6 and P4 for grains/spike at Nobaria seemed to have more recessive genes.

PHENOTYPIC AND GENOTYPIC CORRELATION COEFFICIENTS

Table 6 shows the phenotypic and genotypic correlation coefficients between the five traits. Due to the major importance of grain yield, assessment will be focussed on the relationship of grain yield/plant with plant height, spike length, grains/spike, and 100-grain weight. Grain yield/plant was phenotypically and genotypically correlated with plant height at Ismailia (r = 0.327 and 0.228) and Nobaria (r = 0.225 and 0.153). Positive correlation was obtained with spike length at Gemmeiza (r = 0.443 and – 0.177), grains/spike at Nobaria (r = 0.596 and – 0.593) and at Gemmeiza (r = 0.413 and – 0.188). Grain yield/plant was also positively correlated with 100-grain weight at Nobara (r = 0.347 and 0.253).

Grain yield was also phenotypically correlated with spike length at Ismailia (r = 0.145) and with 100-grain weight at Gemmeiza (r = 0.526). It was genotypically correlated with 100-grain weight at Ismailia (r = 0.162) and with plant height at Gemmeiza (r = 0.162). Similar results were reported by Selim [21] and Oliveiro and Camargo [8].

Table 6. Phenotypic (P) and genotypic (G) correlations in the F_2 generation of wheat at three locations

Character		Ismailia				Nobaria				Gemmeiza			
		spike length	grains per spike	100-grain weight	grain yield per plant	spike length	grains per spike	100-grain weight	grain yield per plant	spike length	grains per spike	100-grain weight	grain yield per plant
Plant height	P	0.557^{**}	0.179^{*}	-0.144^{*}	0.327^{**}	0.041	-0.067	0.152^{*}	0.225^{**}	-0.102	-0.042	-0.383^{**}	-0.388^{**}
	G	0.316^{**}	0.114	-0.104	0.228^{**}	0.011	-0.048	0.096	0.153^{*}	0.282^{**}	0.018	0.207^{**}	0.162
Spike length	P		0.492^{*}	-0.395^{**}	0.145^{*}		-0.100	-0.120	-0.105		0.105	0.450^{**}	0.443^{**}
	G		0.302^{**}	-0.345^{**}	0.079		0.139^{*}	-0.120	-0.132		0.169^{*}	-0.364^{**}	-0.177^{*}
Grains/spike	P			-0.402^{**}	0.023			0.313^{**}	0.596^{**}			-0.103	0.413^{**}
	G			-0.335^{**}	0.018			-0.295^{**}	-0.593^{**}			0.182^{**}	-0.188^{**}
100-grain weight	P				0.014				0.347^{*}				0.526^{**}
	G				0.162^{*}				0.253^{**}				-0.098

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