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Genetic advance, heritability, correlation, heterosis and heterobeltiosis for morphological traits of maize (*Zea mays* L)

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Abstract:

The present study was carried out to access the vigor of F_1 hybrids for drought tolerance. Higher heritability and genetic advance were found for dry root weigh and total dry weight, strong genotypic correlation was found for dry root weight, dry shoot weight and total dry weight. Higher dry root and shoot weight and dry root-to shoot weight ratio was found for B-336 and Sh-139 × EV-347, B-336 × EV-347, EV-1097 × EV-340, EV-1097Q × B-316 and B-327 × EV-340. Higher heterosis and heterobeltiosis were found for F_1 hybrids for dry root weight EV-1097 × EV-340 (190.476, 154.167), EV-1097 × Pop/209 (112.121, 94.444), dry shoot weight EV-1097 × Pop/209 (130.769, 114.286), dry root-to-shoot weight ratio EV-1097 × B-316 (115.519, 52.985) and B-27 × EV-340 (138.657, 102.344) and for total dry weight EV-1097 × Pop/209 (175.391, 108.333), EV-1097 × EV-340 (133.846, 85.366) respectively. The higher heterosis and heterobeltiosis for all traits indicated that hybrid vigor was higher due to which hybrids may be used for drought tolerance and to improve grain yield of maize.

Keywords: heterosis, heterobeltiosis, correlation, heritability, genetic advance, *Zea mays*

1. Introduction

Maize is an important cereal crop in world after wheat and rice. It was grown in Pakistan as under the area of 1083 thousand hectares with production of 3990 thousand tones during the year of 2011-12 [8]. Maize is used as a food for human and as feed for livestock. Maize is used as a raw material in food, medicine and textile industries. It contains 72 % starch, 10 % protein, 4.80 % oil, 9.50 % fiber, 3.0 % sugar, and 1.70 % ash [11]. Maize is a cross pollinated crop. It is much affected by drought at siliking and anthesis stage due to which seed setting of maize is effected badly [18]. Drought is one of the most limiting factors in the production of maize. Morphological traits in maize are much helpful to improve drought tolerance in maize while selecting genotypes against drought [2, 3, 5]. The present study was carried out to evaluate parents and F_1 hybrids of maize for seedling traits and to study genetic variability, correlation, heterosis and heterobeltiosis.

2. Materials and methods

The experiment was conducted in the glasshouse of Department of Plant Breeding and Genetics, University of Agriculture Faisalabad, Pakistan during crop season of 2012. The genetic material was comprises of twelve parents and including their 36 F_1 hybrids. The parents and F_1 hybrids were sown in polythene bags (6×8inch) filled with water washed river sand in three replications following completely randomized design. The bags were filled 500g sand and 250ml water was applied to produce 50% water stress. The moisture contents were maintained by using ΔT-NH2, Cambridge, England moisture meter. The data was recorded for dry root weight, dry shoot weight, dry root-to-shoot weight ratio and total dry weight by using electronic balance.

Table 1. Detailed information of parents and F_1 hybrids

Pop/209 (Variety, NARC Islamabad)
B-316 (Inbred, PBG, UAF)
EV-340(Inbred, PBG, UAF)
E-322(Inbred, PBG, UAF)
F-96(Inbred, PBG, UAF)
EV-347(Inbred, PBG, UAF)
B-11(Inbred, PBG, UAF)
B-336(Inbred, PBG, UAF)
EV-1097(Variety, NARC Islamabad)
B-327(Inbred, PBG, UAF)
Raka-poshi(Variety, NARC Islamabad)
Sh-139(Inbred, PBG, UAF)

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2.1. Statistical Analysis Formulae:

Phenotypic and genotypic coefficients of variation were calculated according to the formula given below:- GCV =Genotypic coefficient of variation (%), PCV = Phenotypic coefficient of variation (%), $\overline{X}$ = Grand mean of the trait, $\hat{\sigma}^2 p$ = phenotypic variance, $\hat{\sigma}^2 g$ = genotypic variance

$$GCV = \frac{\sqrt{\hat{\sigma}^2 g}}{\overline{X}} \times 100$$

$$PCV = \frac{\sqrt{\hat{\sigma}^2 p}}{\overline{X}} \times 100$$

Broad sense heritability for each recorded trait was calculated as a ratio of the genotypic variances to phenotypic variances. Phenotypic (r_p) and genotypic (r_g) correlation coefficient was calculated as outlined by Kwon and Torrie [15].

$$r_p = \frac{M_{ij}}{\sqrt{(M_{ii})(M_{jj})}}$$

$$r_G = \frac{Cov_{gij}}{\sqrt{(Var_{gi})(Var_{gj})}}$$

Where

r_p = the estimate of phenotypic correlation coefficient, Mij = the mean product of genotypes for the ith and jth traits, Mii and Mjj = Variety mean squares for ith and jth traits, respectively.

r_G = Genotypic correlation coefficient, CoV gij =Genotypic covariance of ith and jth traits

Var gi = Genotypic variance of ith traits, Var gj = Genotypic variance of jth traits

Standard error of genotypic correlation coefficients (SE of rg) were calculated according to Reeve [20]. Genotypic correlation coefficient was considered significant if their absolute value exceeded twice their standard error.

$$S.E. \text{ of } r_G = \frac{1 - r_G^2}{\sqrt{2}} \sqrt{\frac{\sqrt{h_i^2}\sqrt{h_j^2}}{h_i^2 . h_j^2}}$$

Where,

r^2_G = The genotypic correlation coefficient between the traits I and j, h^2_i = The heritability of ith trait., h^2_j = The heritability of jth trait.

The estimates of heritability and genotypic correlation coefficient were considered significant if their absolute value exceeded twice of their standard error. Phenotypic correlation coefficients were tested using t-test as given below [19].

$$t = \frac{r}{\sqrt{(1 - r^2)/n-2}}$$

Where, r = the phenotypic correlation coefficient, n-2 = correlation error degree of freedom

The genetic advance was calculated by using Falconer formula [13].

GA = σ_p x h^2 x i

Where, σ_p = the phenotypic standard deviation, h^2 = Estimate of broad sense heritability, i = constant value (1.755) that reflects selection intensity (10%)

Relative heterosis [17]:

$$Relative\ heterosis = \frac{F_1 - MP\ (Mid\ Parent)}{MP} x\ 100$$

Heterobeltiosis [17]:

$$Heterobeltiosis = \frac{F_1 - BP\ (Better\ Parent)}{BP} x\ 100$$

Significance test for heterosis [17]:

$$t\ value\ for\ Relative\ heterosis = \frac{F_1 - MP\ (Mid\ Parent)}{SE\ (standard\ error)} x\ 100$$

$$t\ value\ for\ heterosis = \frac{F_1 - BP\ (BetterParent)}{SE\ (standard\ error)} x\ 100$$

3. Results and discussions

It was suggested from table 2 that higher heritability was found for dry root weight (89.5645%) and total dry weight (91.8694%) while higher genetic advance was recorded for dry root-to-shoot weight ratio (48.8286%) and total dry weight (18.6504%). Higher heritability and genetic advance indicated that selection on the basis of dry root weight, dry root-to-shoot weight ratio and total dry weight traits may be helpful to improve grain yield under drought condition [5, 6, 7, 14].

Table 2. Genetic components for morphological traits of maize seedlings

Traits	*M.S*	*G.M*	*GV*	*GCV %*	*PV*	*PCV %*	*EV*	*ECV %*	*h^2bs%*	*GA%*
Dry root weight	0.0074**	0.1375	0.0024	13.1503	0.0027	13.8953	0.00027	4.4887	89.5645	17.4212
Dry shoot weight	0.0012**	0.0663	0.0004	7.4209	0.0005	8.5051	0.00011	4.1552	76.1311	9.8309
Dry root-to-shoot weight ratio	1.1020*	2.1414	0.2909	36.8583	0.5201	49.2847	0.22922	32.717	55.9301	48.8286
Total dry weight	0.0126*	0.2059	0.0041	14.0783	0.0044	14.6880	0.00036	4.1881	91.8694	18.6504

* = significant at 1% level, ** = Significant at 5% level, MS = Mean sum of square, GM = Grand mean, GV = Genotypic variance, PV = Phenotypic variance, EV = Environmental Variance, PCV = Phenotypic coefficient of variance, GCV = Genotypic coefficient of variance, ECV = Environmental coefficient of variance, GA = Genetic advance, h^2_{bs} = Broad sense heritability

3.1. Correlation

It was conceived from table 3 that higher and significant genotypic and phenotypic correlation was found for dry root weight with dry shoot weight, total dry weight, dry root-to-shoot weight ratio while dry shoot weight was positively and significantly correlated with dry root weight and total dry weight but negatively and significantly correlated with dry root-to-shoot weight ratio at genotypic and phenotypic levels. A strong and significant genotypic and phenotypic correlation of total dry weight was found for dry root weight and dry shoot weight. Higher and significant genotypic correlations indicated that selection may be useful to improve drought tolerance in maize [3, 4, 5, 6, 9, 16].

Table 3. Genotypic and phenotypic correlation of morphological traits of maize seedlings

Traits	*r*	*Dry root-to-shoot weight ratio*	*Dry root weight*	*Dry shoot weight*
Dry root weight	**g**	0.3878**		
	p	0.3964**		
Dry shoot weight	**g**	-0.5996*	0.3808**	
	p	-0.4455**	0.4903*	
Total dry weight	**g**	0.0644	0.9303*	0.6934*
	p	-0.1008	0.8213*	0.7453*

3.2. Heterosis and heterobeltiosis

It was persuaded from table 4 that higher heterosis and heterobeltiosis was recorded for EV-1097 × EV-340 (190.476, 154.167), EV-1097 × Pop/209 (112.121, 94.444), EV-1097 × E-322 (64.912, 20.513), B-11 × Pop/209 (75.00, 40.00), Sh-139 × EV-347 (74.419, 70.455) and B-327 × EV-340 (106.897, 76.471) respectively, while lower for B-336 x E-322 (-35.886, -50.887), B-327 x B-316 (-32.394, -35.135), Sh-139 × B-316 (-53.086, -56.818) and Raka-poshi × EV-340 (-20.00, -33.333) respectively [1, 7, 9, 10, 12, 14, 21]. It was cleared from figure 1 that higher dry root weight was found for B-336 and Sh-139 × EV-347 while lower for Pop/209 and EV-1097 [3, 4, 6]. It is persuaded from table 5 that higher heterosis and heterobeltiosis was recorded for B-11 x EV-340 (44.828, 23.529), EV-1097 × Pop/209 (130.769, 114.286), Raka-poshi × Pop/209 (43.590, 21.739), B-11 × Pop/209 (78.947, 41.667), Sh-139 × Pop/209 (84.00, 27.778) and B-11 × EV-347 (42.857, 8.696) respectively, while lower for B-336 × E-322 (-56.923, -57.576), EV-1097 × B-316 (-46.667, -66.667) and Raka-poshi × F-96 (-46.429, -50.00) respectively [1, 12, 14, 16, 21]. It was indicated from figure 2 that higher dry shoot weight was recorded for E-322, B-336 and B-336 × EV-347 while lower was found for Pop/209 and EV-1097 [3, 4, 6,7, 10]. It is swayed from table 6 that higher heterosis and heterobeltiosis was recorded for Raka-poshi × F-96 (76.132, 65.351), EV-1097 × B-316 (115.519, 52.985), Raka-poshi × B-316 (73.468, 63.590), Sh-139 × EV-347 (67.825, 45.257) and B-27 × EV-340 (138.657, 102.344) respectively, while lower for B-11 × EV-340 (-45.409, -54.056), Sh-139 × B-316 (-46.932, -56.883) and Raka-poshi × Pop/209 (-39.765, -50.641) respectively [1, 12, 14, 16, 21]. It was suggested from figure 3 that higher dry root-to-shoot weight ratio was found for EV-1097 × EV-340, EV-1097Q × B-316 and B-327 × EV-340. Higher value of dry root-to-shoot weight ratio indicated that selection of drought tolerance genotypes may be useful on the basis of dry root-to-shoot weight ratio. It is convinced from table 7 that higher heterosis and heterobeltiosis was recorded for EV-1097 × Pop/209 (175.391, 108.333), EV-1097 × EV-340 (133.846, 85.366), Sh-139 × EV-347 (51.181, 47.692) and B-11 × Pop/209 (76.271, 40.541) respectively, while lower for B-336 × E-322 (-43.598, -52.517) and Sh-139 × B-316 (-39.837, -40.323) respectively [1, 10, 12, 14, 16, 21]. It was indicated from figure 4 that higher total dry weight was found for B-336 and Sh-139 × EV-347 while lower for Pop/209 and EV-1097 [3, 4, 6, 7, 9]. Higher value of total dry weight indicated that selection of drought tolerance genotypes may be useful on the basis of total dry weight.

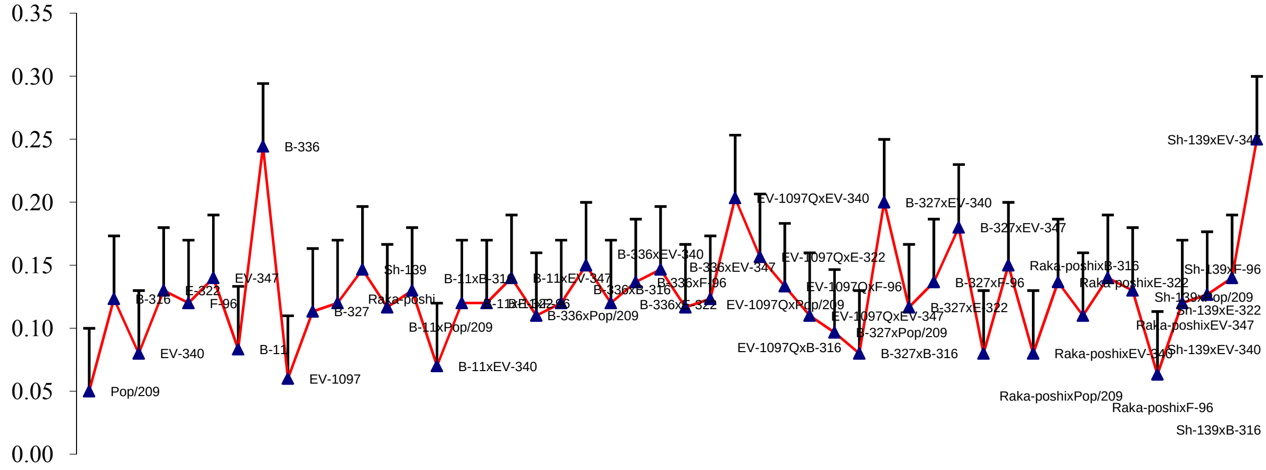

Figure 1: Dry root weight (g)

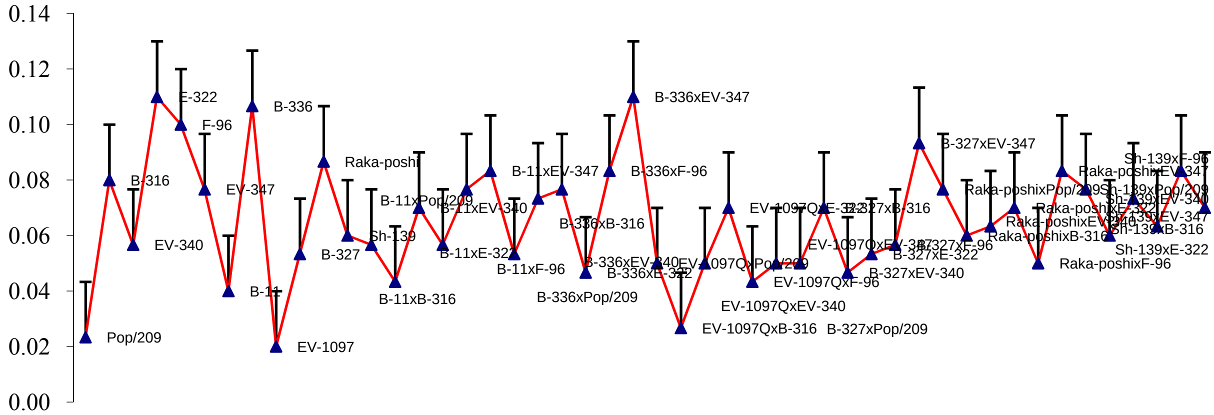

Figure 2: Dry shoot weight (g)

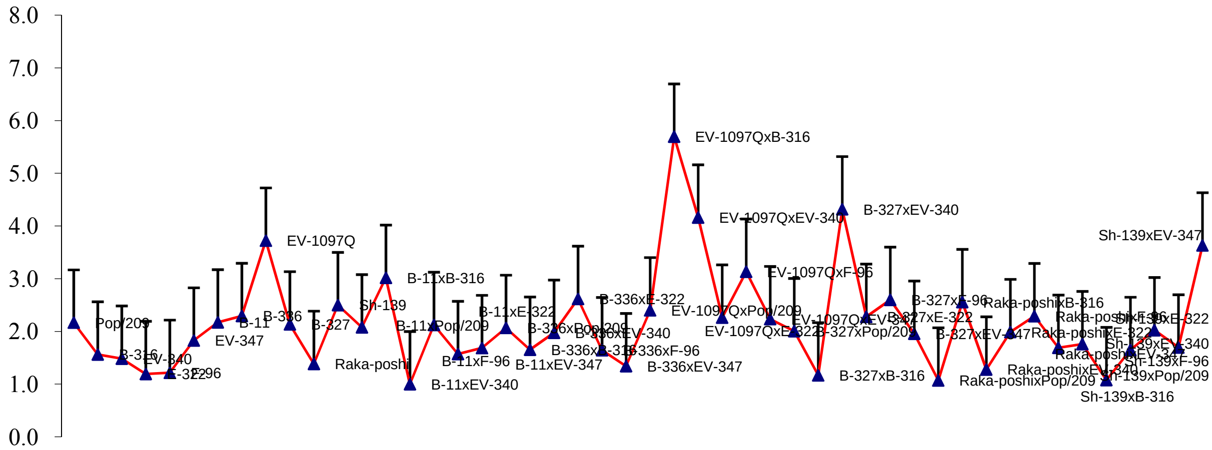

Figure 3: Dry root-to-shoot weight ratio

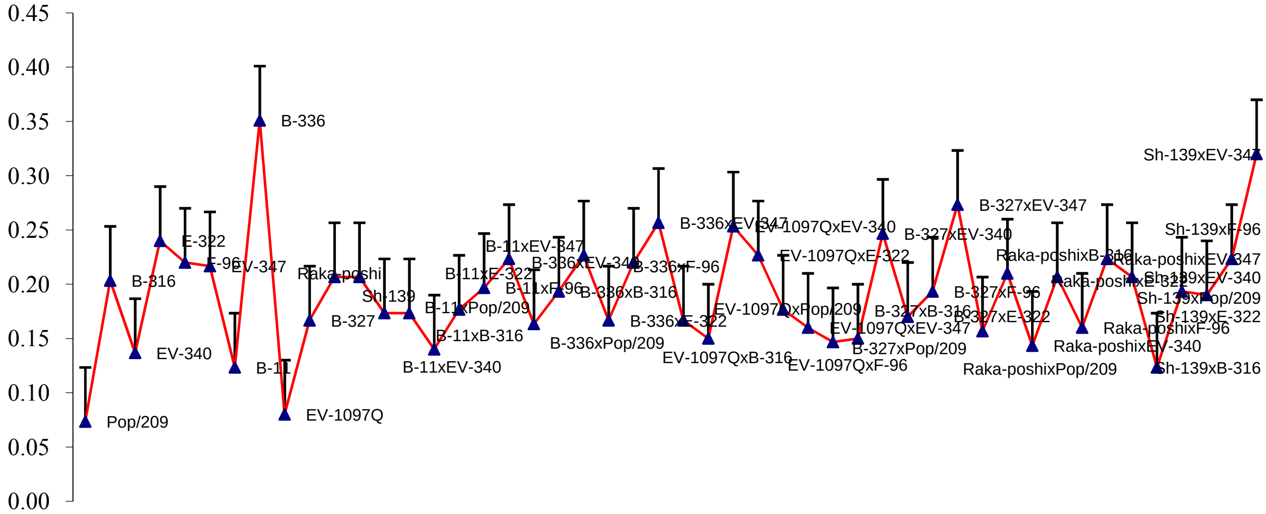

Figure 4: Total dry weight (g)

Table 4. Heterosis and heterobeltiosis for dry root weight of maize seedlings

Parents/Crosses	Mean	Mid	Better	Heterosis	Heterobeltiosis	t_Hetr	t_Hetrb	Potence ratio
Pop/209	0.050	0.050	0.050	-	-	-	-	-
B-316	0.123	0.123	0.123	-	-	-	-	-
EV-340	0.080	0.080	0.080	-	-	-	-	-
E-322	0.130	0.130	0.130	-	-	-	-	-
F-96	0.120	0.120	0.120	-	-	-	-	-
EV-347	0.140	0.140	0.140	-	-	-	-	-
B-11	0.083	0.083	0.083	-	-	-	-	-
B-336	0.244	0.244	0.244	-	-	-	-	-
EV-1097	0.060	0.060	0.060	-	-	-	-	-
B-327	0.113	0.113	0.113	-	-	-	-	-
Raka-poshi	0.120	0.120	0.120	-	-	-	-	-
Sh-139	0.147	0.147	0.147	-	-	-	-	-
B-11xPop/209	0.117	0.067	0.083	75	40	6.9109	3.99	3
B-11xB-316	0.130	0.103	0.123	25.806	5.405	3.6858	0.798	1.3333
B-11xEV-340	0.070	0.082	0.083	-14.286	-16	-1.6126	-1.596	-7
B-11xE-322	0.120	0.107	0.130	12.5	-7.692	1.8429	-1.197	0.5714
B-11xF-96	0.120	0.102	0.120	18.033	0	2.534	0	1
B-11xEV-347	0.140	0.112	0.140	25.373	0	3.9162	0	1
B-336xPop/209	0.110	0.147	0.244	-25.255	-54.98	-5.1371	-16.079	-0.3825
B-336xB-316	0.120	0.184	0.244	-34.723	-50.887	-8.823	-14.882	-1.0551
B-336xEV-340	0.150	0.162	0.244	-7.503	-38.608	-1.6817	-11.291	-0.1481
B-336xE-322	0.120	0.187	0.244	-35.886	-50.887	-9.2837	-14.882	-1.1749
B-336xF-96	0.137	0.182	0.244	-24.977	-44.065	-6.289	-12.887	-0.7319
B-336xEV-347	0.147	0.192	0.244	-23.677	-39.973	-6.289	-11.690	-0.8722
EV-1097xPop/209	0.117	0.055	0.060	112.121	94.444	8.5235	6.7831	12.3333
EV-1097xB-316	0.123	0.092	0.123	34.545	0	4.3769	0	1
EV-1097xEV-340	0.203	0.070	0.080	190.476	154.167	18.4292	14.7631	13.3333
EV-1097xE-322	0.157	0.095	0.130	64.912	20.513	8.5235	3.192	1.7619

EV-1097xF-96	0.133	0.090	0.120	48.148	11.111	5.9895	1.596	1.4444
EV-1097xEV-347	0.110	0.100	0.140	10	-21.429	1.3822	-3.591	0.25
B-327xPop/209	0.097	0.082	0.113	18.367	-14.706	2.0733	-1.995	0.4737
B-327xB-316	0.080	0.118	0.123	-32.394	-35.135	-5.2984	-5.187	-7.6667
B-327xEV-340	0.200	0.097	0.113	106.897	76.471	14.2826	10.3741	6.2
B-327xE-322	0.117	0.122	0.130	-4.11	-10.256	-0.6911	-1.596	-0.6
B-327xF-96	0.137	0.117	0.120	17.143	13.889	2.7644	1.995	6
B-327xEV-347	0.180	0.127	0.140	42.105	28.571	7.3717	4.788	4
Raka-poshixPop/209	0.080	0.085	0.120	-5.882	-33.333	-0.6911	-4.788	-0.1429
Raka-poshixB-316	0.150	0.122	0.123	23.288	21.622	3.9162	3.192	17
Raka-poshixEV-340	0.080	0.100	0.120	-20	-33.333	-2.7644	-4.788	-1
Raka-poshixE-322	0.137	0.125	0.130	9.333	5.128	1.6126	0.798	2.3333
Raka-poshixF-96	0.110	0.120	0.120	-8.333	-8.333	-1.3822	-1.197	-1
Raka-poshixEV-347	0.140	0.130	0.140	7.692	0	1.3822	0	1
Sh-139xPop/209	0.130	0.098	0.147	32.203	-11.364	4.3769	-1.995	0.6552
Sh-139xB-316	0.063	0.135	0.147	-53.086	-56.818	-9.9057	-9.9751	-6.1429
Sh-139xEV-340	0.120	0.113	0.147	5.882	-18.182	0.9215	-3.192	0.2
Sh-139xE-322	0.127	0.138	0.147	-8.434	-13.636	-1.6126	-2.394	-1.4
Sh-139xF-96	0.140	0.133	0.147	5	-4.545	0.9215	-0.798	0.5
Sh-139xEV-347	0.250	0.143	0.147	74.419	70.455	14.7433	12.3691	32

Table 5. Heterosis and heterobeltiosis for dry shoot weight of maize seedlings

Parents/Crosses	Mean	Mid	Better	Heterosis	Heterobeltiosis	t_Hetr	t_Hetrb	Potence ratio
Pop/209	0.023	0.023	0.023	-	-	-	-	-
B-316	0.080	0.080	0.080	-	-	-	-	-
EV-340	0.057	0.057	0.057	-	-	-	-	-
E-322	0.110	0.110	0.110	-	-	-	-	-
F-96	0.100	0.100	0.100	-	-	-	-	-
EV-347	0.077	0.077	0.077	-	-	-	-	-
B-11	0.040	0.040	0.040	-	-	-	-	-
B-336	0.107	0.107	0.107	-	-	-	-	-
EV-1097	0.020	0.020	0.020	-	-	-	-	-
B-327	0.053	0.053	0.053	-	-	-	-	-
Raka-poshi	0.087	0.087	0.087	-	-	-	-	-
Sh-139	0.060	0.060	0.060	-	-	-	-	-
B-11xPop/209	0.057	0.032	0.040	78.947	41.667	4.2531	2.45551	3
B-11xB-316	0.043	0.060	0.080	-27.778	-45.833	-2.8354	-5.4021	-0.8333
B-11xEV-340	0.070	0.048	0.057	44.828	23.529	3.686	1.9644	2.6
B-11xE-322	0.057	0.075	0.110	-24.444	-48.485	-3.1189	-7.8576	-0.5238
B-11xF-96	0.077	0.070	0.100	9.524	-23.333	1.1341	-3.4377	0.2222
B-11xEV-347	0.083	0.058	0.077	42.857	8.696	4.2531	0.9822	1.3636
B-336xPop/209	0.053	0.065	0.107	-17.949	-50	-1.9848	-7.8576	-0.28
B-336xB-316	0.073	0.093	0.107	-21.429	-31.25	-3.4024	-4.9110	-1.5
B-336xEV-340	0.077	0.082	0.107	-6.122	-28.125	-0.8506	-4.4199	-0.2
B-336xE-322	0.047	0.108	0.110	-56.923	-57.576	-10.491	-9.3309	-37
B-336xF-96	0.083	0.103	0.107	-19.355	-21.875	-3.4024	-3.4377	-6
B-336xEV-347	0.110	0.092	0.107	20	3.125	3.1189	0.4911	1.2222
EV-1097xPop/209	0.050	0.022	0.023	130.769	114.286	4.8201	3.92881	17
EV-1097xB-316	0.027	0.050	0.080	-46.667	-66.667	-3.9695	-7.8576	-0.7778
EV-1097xEV-340	0.050	0.038	0.057	30.435	-11.765	1.9848	-0.9822	0.6364

EV-1097xE-322	0.070	0.065	0.110	7.692	-36.364	0.8506	-5.8932	0.1111
EV-1097xF-96	0.043	0.060	0.100	-27.778	-56.667	-2.8354	-8.3487	-0.4167
EV-1097xEV-347	0.050	0.048	0.077	3.448	-34.783	0.2835	-3.9288	0.0588
B-327xPop/209	0.050	0.038	0.053	30.435	-6.25	1.9848	-0.4911	0.7778
B-327xB-316	0.070	0.067	0.080	5	-12.5	0.5671	-1.4733	0.25
B-327xEV-340	0.047	0.055	0.057	-15.152	-17.647	-1.4177	-1.4733	-5
B-327xE-322	0.053	0.082	0.110	-34.694	-51.515	-4.8201	-8.3487	-1
B-327xF-96	0.057	0.077	0.100	-26.087	-43.333	-3.4024	-6.3843	-0.8571
B-327xEV-347	0.093	0.065	0.077	43.59	21.739	4.8201	2.45551	2.4286
Raka-poshixPop/209	0.077	0.055	0.087	39.394	-11.538	3.686	-1.4733	0.6842
Raka-poshixB-316	0.060	0.083	0.087	-28	-30.769	-3.9695	-3.9288	-7
Raka-poshixEV-340	0.063	0.072	0.087	-11.628	-26.923	-1.4177	-3.4377	-0.5556
Raka-poshixE-322	0.070	0.098	0.110	-28.814	-36.364	-4.8201	-5.8932	-2.4286
Raka-poshixF-96	0.050	0.093	0.100	-46.429	-50	-7.372	-7.3665	-6.5
Raka-poshixEV-347	0.083	0.082	0.087	2.041	-3.846	0.2835	-0.4911	0.3333
Sh-139xPop/209	0.077	0.042	0.060	84	27.778	5.9543	2.45551	1.9091
Sh-139xB-316	0.060	0.070	0.080	-14.286	-25	-1.7012	-2.9466	-1
Sh-139xEV-340	0.073	0.058	0.060	25.714	22.222	2.5518	1.9644	9
Sh-139xE-322	0.063	0.085	0.110	-25.49	-42.424	-3.686	-6.8754	-0.8667
Sh-139xF-96	0.083	0.080	0.100	4.167	-16.667	0.5671	-2.4555	0.1667
Sh-139xEV-347	0.070	0.068	0.077	2.439	-8.696	0.2835	-0.9822	0.2

Table 6. Heterosis and heterobeltiosis for dry root-to-shoot weight ratio of maize seedlings

Parents/Crosses	*Mean*	*Mid*	*Better*	*Heterosis*	*Heterobeltiosis*	*t_Hetr*	*t_Hetrb*	*Potence ratio*
Pop/209	2.167	2.167	2.167	-	-	-	-	-
B-316	1.562	1.562	1.562	-	-	-	-	-
EV-340	1.484	1.484	1.484	-	-	-	-	-
E-322	1.192	1.192	1.192	-	-	-	-	-
F-96	1.215	1.215	1.215	-	-	-	-	-
EV-347	1.827	1.827	1.827	-	-	-	-	-
B-11	2.172	2.172	2.172	-	-	-	-	-
B-336	2.293	2.293	2.293	-	-	-	-	-
EV-1097	3.722	3.722	3.722	-	-	-	-	-
B-327	2.133	2.133	2.133	-	-	-	-	-
Raka-poshi	1.384	1.384	1.384	-	-	-	-	-
Sh-139	2.500	2.500	2.500	-	-	-	-	-
B-11xPop/209	2.078	2.169	2.172	-4.225	-4.348	-0.3364	-0.3002	-33
B-11xB-316	3.017	1.867	2.172	61.561	38.875	4.2187	2.68401	3.7684
B-11xEV-340	0.998	1.828	2.172	-45.409	-54.056	-3.0468	-3.7321	-2.4129
B-11xE-322	2.122	1.682	2.172	26.158	-2.302	1.615	-0.1589	0.898
B-11xF-96	1.571	1.694	2.172	-7.209	-27.658	-0.4481	-1.9096	-0.255
B-11xEV-347	1.685	2.000	2.172	-15.732	-22.421	-1.1547	-1.5480	-1.8247
B-336xPop/209	2.067	2.230	2.293	-7.324	-9.884	-0.5995	-0.7204	-2.5789
B-336xB-316	1.653	1.928	2.293	-14.264	-27.931	-1.0092	-2.0359	-0.7522
B-336xEV-340	1.974	1.889	2.293	4.491	-13.944	0.3113	-1.0164	0.2096
B-336xE-322	2.617	1.743	2.293	50.146	14.099	3.2074	1.02769	1.5873
B-336xF-96	1.644	1.754	2.293	-6.303	-28.335	-0.4058	-2.0654	-0.205
B-336xEV-347	1.341	2.060	2.293	-34.919	-41.53	-2.6405	-3.0272	-3.0881
EV-1097xPop/209	2.400	2.944	3.722	-18.491	-35.523	-1.9982	-4.2026	-0.7
EV-1097xB-316	5.694	2.642	3.722	115.519	52.985	11.2022	6.26855	2.8261
EV-1097xEV-340	4.161	2.603	3.722	59.847	11.791	5.7178	1.39495	1.3922
EV-1097xE-322	2.262	2.457	3.722	-7.948	-39.233	-0.7168	-4.6415	-0.1544
EV-1097xF-96	3.133	2.469	3.722	26.931	-15.821	2.4399	-1.8717	0.5303
EV-1097xEV-347	2.233	2.775	3.722	-19.514	-40	-1.9873	-4.7323	-0.5715
B-327xPop/209	2.006	2.150	2.167	-6.718	-7.436	-0.5301	-0.5120	-8.6667
B-327xB-316	1.167	1.848	2.133	-36.86	-45.312	-2.4997	-3.0724	-2.3849
B-327xEV-340	4.317	1.809	2.133	138.657	102.344	9.2045	6.93959	7.7262
B-327xE-322	2.278	1.663	2.133	36.988	6.771	2.2572	0.45911	1.3069

B-327xF-96	2.599	1.674	2.133	55.262	21.838	3.3954	1.48075	2.0144
B-327xEV-347	1.955	1.980	2.133	-1.261	-8.341	-0.0916	-0.5655	-0.1632
Raka-poshixPop/209	1.069	1.775	2.167	-39.765	-50.641	-2.5912	-3.4874	-1.8047
Raka-poshixB-316	2.556	1.473	1.562	73.468	63.59	3.9723	3.15742	12.1673
Raka-poshixEV-340	1.278	1.434	1.484	-10.906	-13.904	-0.5741	-0.6558	-3.1325
Raka-poshixE-322	1.988	1.288	1.384	54.329	43.622	2.5687	1.91926	7.2871
Raka-poshixF-96	2.289	1.300	1.384	76.131	65.351	3.6311	2.87531	11.6776
Raka-poshixEV-347	1.690	1.606	1.827	5.231	-7.528	0.3083	-0.4372	0.3791
Sh-139xPop/209	1.759	2.333	2.500	-24.598	-29.621	-2.1064	-2.3533	-3.4468
Sh-139xB-316	1.078	2.031	2.500	-46.932	-56.883	-3.4982	-4.5194	-2.0334
Sh-139xEV-340	1.649	1.992	2.500	-17.224	-34.039	-1.2592	-2.7044	-0.6757
Sh-139xE-322	2.024	1.846	2.500	9.636	-19.037	0.6529	-1.5125	0.2721
Sh-139xF-96	1.694	1.857	2.500	-8.766	-32.214	-0.5975	-2.5594	-0.2534
Sh-139xEV-347	3.631	2.164	2.500	67.825	45.257	5.3856	3.59567	4.3654

Table 7. Heterosis and heterobeltiosis for total dry weight of maize seedlings

Parents/Crosses	Mean	Mid	Better	Heterosis	Heterobeltiosis	t_Hetr	t_Hetrb	Potence ratio
Pop/209	0.073	0.073	0.073	-	-	-	-	-
B-316	0.203	0.203	0.203	-	-	-	-	-
EV-340	0.137	0.137	0.137	-	-	-	-	-
E-322	0.240	0.240	0.240	-	-	-	-	-
F-96	0.220	0.220	0.220	-	-	-	-	-
EV-347	0.217	0.217	0.217	-	-	-	-	-
B-11	0.123	0.123	0.123	-	-	-	-	-
B-336	0.351	0.351	0.351	-	-	-	-	-
EV-1097	0.080	0.080	0.080	-	-	-	-	-
B-327	0.167	0.167	0.167	-	-	-	-	-
Raka-poshi	0.207	0.207	0.207	-	-	-	-	-
Sh-139	0.207	0.207	0.207	-	-	-	-	-
B-11xPop/209	0.173	0.098	0.123	76.271	40.541	8.4722	4.8915	3
B-11xB-316	0.173	0.163	0.203	6.122	-14.754	1.1296	-2.9349	0.25
B-11xEV-340	0.140	0.130	0.137	7.692	2.439	1.1296	0.3261	1.5
B-11xE-322	0.177	0.182	0.240	-2.752	-26.389	-0.5648	-6.1958	-0.0857
B-11xF-96	0.197	0.172	0.220	14.563	-10.606	2.8241	-2.2827	0.5172
B-11xEV-347	0.223	0.170	0.217	31.373	3.077	6.0247	0.6522	1.1429
B-336xPop/209	0.163	0.212	0.351	-23.016	-53.466	-5.5164	-18.359	-0.3517
B-336xB-316	0.193	0.277	0.351	-30.247	-44.919	-9.4701	-15.424	-1.1354
B-336xEV-340	0.227	0.244	0.351	-7.04	-35.423	-1.9392	-12.163	-0.1602
B-336xE-322	0.167	0.296	0.351	-43.598	-52.517	-14.553	-18.033	-2.3213
B-336xF-96	0.220	0.286	0.351	-22.942	-37.322	-7.3991	-12.815	-1
B-336xEV-347	0.257	0.284	0.351	-9.571	-26.876	-3.0688	-9.2285	-0.4045
EV-1097xPop/209	0.167	0.077	0.080	117.391	108.333	10.1667	8.4785	27
EV-1097xB-316	0.150	0.142	0.203	5.882	-26.23	0.9414	-5.2175	0.1351
EV-1097xEV-340	0.253	0.108	0.137	133.846	85.366	16.3797	11.4134	5.1176
EV-1097xE-322	0.227	0.160	0.240	41.667	-5.556	7.5309	-1.3044	0.8333
EV-1097xF-96	0.177	0.150	0.220	17.778	-19.697	3.0124	-4.2393	0.381
EV-1097xEV-347	0.160	0.148	0.217	7.865	-26.154	1.3179	-5.5436	0.1707
B-327xPop/209	0.147	0.120	0.167	22.222	-12	3.0124	-1.9566	0.5714
B-327xB-316	0.150	0.185	0.203	-18.919	-26.23	-3.9537	-5.2175	-1.9091
B-327xEV-340	0.247	0.152	0.167	62.637	48	10.7315	7.8263	6.3333
B-327xE-322	0.170	0.203	0.240	-16.393	-29.167	-3.7654	-6.848	-0.9091
B-327xF-96	0.193	0.193	0.220	0	-12.121	0	-2.6088	0
B-327xEV-347	0.273	0.192	0.217	42.609	26.154	9.2253	5.5436	3.2667

Raka-poshixPop/209	0.157	0.140	0.207	11.905	-24.194	1.8827	-4.8915	0.25
Raka-poshixB-316	0.210	0.205	0.207	2.439	1.613	0.5648	0.3261	3
Raka-poshixEV-340	0.143	0.172	0.207	-16.505	-30.645	-3.2006	-6.1958	-0.8095
Raka-poshixE-322	0.207	0.223	0.240	-7.463	-13.889	-1.8827	-3.261	-1
Raka-poshixF-96	0.160	0.213	0.220	-25	-27.273	-6.0247	-5.8697	-8
Raka-poshixEV-347	0.223	0.212	0.217	5.512	3.077	1.3179	0.6522	2.3333
Sh-139xPop/209	0.207	0.140	0.207	47.619	0	7.5309	0	1
Sh-139xB-316	0.123	0.205	0.207	-39.837	-40.323	-9.2253	-8.1524	-49
Sh-139xEV-340	0.193	0.172	0.207	12.621	-6.452	2.4475	-1.3044	0.619
Sh-139xE-322	0.190	0.223	0.240	-14.925	-20.833	-3.7654	-4.8915	-2
Sh-139xF-96	0.223	0.213	0.220	4.687	1.515	1.1296	0.3261	1.5
Sh-139xEV-347	0.320	0.212	0.217	51.181	47.692	12.2377	10.109	21.6667

4. Conclusions

It was concluded from present study that higher heritability and genetic advance was found for dry root weigh and total dry weight, strong genotypic correlation was found for dry root weight, dry shoot weight and total dry weight. The higher heterosis and heterobeltiosis for all traits indicated that hybrid vigor was higher due to which hybrids may be used for drought tolerance and to improve grain yield of maize.

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6. Reference

1. Akhtar N: **Heterosis and genetic analysis of seedling traits in maize**. AGRIS. 2002, Pp: 93.
2. Ahsan M, Farooq A, Khaliq I, Ali Q, Aslam M, Kashif M: **Inheritance of various yield contributing traits in maize (*Zea mays* L.) at low moisture condition**. African J. Agri. Res. 2013, 8(4): 413-420.
3. Ali Q, Elahi M**,** Ahsan M, Tahir MHN, Basra SMA: **Genetic evaluation of maize (*Zea mays* L.) genotypes at seedling stage under moisture stress.** IJAVMS. 2011a, 5 (2): 184-193.
4. Ali Q, Elahi M**,** Ahsan M, Tahir MHN, Elahi M, Farooq J, Waseem M, Sadique M: **Genetic variability for grain yield and quality traits in chickpea** (Cicer arietinum **L.).** IJAVMS, 2011b, 5(2): 201-208.
5. Ali Q., M. Ahsan M, Tahir MHN, Basra SMA: **Genetic evaluation of maize (*Zea mays* L.) accessions for growth related seedling traits**. IJAVMS, 2012, 6(3): 164-172.
6. Ali Q, Ahsan M: **Estimation of Variability and correlation analysis for quantitative traits in chickpea** (*Cicer arietinum* **L**.). IJAVMS, 2011, 5(2): 194-200.
7. Alvi MB, Rafique M, Tariq MS, Hussain A: **Hybris vigour of some quantitative characters in maize.** Pak. J. Bio. Sci. 2003, 6(2):139-141.
8. Anonymous: **Economic Survey of Pakistan.** Govt. of Pakistan, Finance and Economic Affairs Division, Islamabad 2011-12.
9. Beck DL, Vasal SK, Crossa J: **Heterosis and combining ability of CIMMYT's tropical early and intermediate maturity maize germplasm**. Maydica, 1990, 35(35):279-285.
10. Bhatnagar S, Betran FJ, Rooney LW: **Combining abilities of quality protein maize inbreds**. Crop Sci. 2004, 44: 1997-2005.
11. Chaudhry AR: **Maize in Pakistan**. Punjab Agri. Res. Coordination Board, Uni. Agri. Faisalabad 1983.
12. Desai SA, Singh RD: **Combining ability studies for some morpho-physiological and biochemical traits related to drought tolerance in maize**. Indian J. Genet. Pl. Br. 2001, 60(1): 203-215.
13. Falconer DS: **Introduction to Quantitative Genetics**. 3rd Ed. Logman Scientific & Technical, Logman House, Burnt Mill, Harlow, Essex, England 1989.
14. Khan MB, Hussain N, Iqbal M**: Effect of water stress on growth and yield components of maize variety YHS 202**. J. Res. 2001, 12(1): 15-18.
15. Kwon SH, Torrie TH: **Heritability and interrelationship of two soybean** (*Glycine max* **L.) populations**. Crop Sci. 1964, 4: 196-198.
16. Malik HN, Malik SJ, Chughtai SR, Javed HI: **Estimates of heterosis among temperate,**

subtropical and tropical maize germplasm. Asian J. Pl. Sci. Pak. 2004, 3(1):23-29.

17. Meredith WR, Bridge RR: **Heterosis and gene action in cotton (***Gossypium hirsutum* **L)**. Crop. Sci. 1972, 12:304-310.
18. Poehlman JM, Selper DA: **Breeding field crops**. Lowa State Press. ISBN 0-8138-2427-3. 1995.
19. Reeve ECR: **The variance of the genetic correlation coefficients.** Biometrics 1955, 11: 351-374.
20. Steel RGD, Torrie JH, Dicky DA: **Principles and procedures of Statistics**. A Biometrical Approach 3rd Ed. McGraw Hill Book Co. Inc. New Yark, 1997, pp: 400-428.
21. Vafias BN, Ipsilandis CG: **Combining ability, gene action and yielding performance in maize**. Asian J. Pl. Sci. Pak. 2005, 4(1):50-55.