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Heritability, heterosis and heterobeltiosis studies for morphological traits of maize (Zea maysL.) seedlings

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Key words: Heterosis, Heterobeltiosis, Heritability, Genetic advance, Zea mays

Abstract

Background: Maize is one of most important cereal crop in world after wheat and rice. It is grown in Pakistan as a major cash crop cultivation in the area of 1083 thousand hectares producing 3990 thousand tones. Maize is dual propose crop it is used as feed for livestock and food for human. It is also used as a raw material in textile, food and medicine industries. The present study was conducted to evaluate parents and F_1 hybrids of maize for seedling traits including heritability, heterosis and heterobelteiosis.

Methodology: The genetic material was comprises of twelve parents and including their 36 F_1 hybrids. The parents and F_1 hybrids were sown in the iron treys filled with sand in three replications following completely randomized design. The data was recorded for fresh root length, fresh shoot length, fresh root-to-shoot length ratio, fresh root weight, fresh shoot weight and fresh root-to-shoot weight ratio. The data was subjected for analysis genotypic and phenotypic coefficients of variance. The genetic advance was calculated by using Falconer (1989) formula.

Results: The average batter performance was given by B-336, EV-347, EV-1097Q and B-327. The F_1 hybrids, EV-1097Q × EV-347, EV-1097Q × EV-340, Raka-poshi × EV-347, B-327 × B-316 and Sh-139 × EV-347 showed higher values of heterosis and heterobeltiosis for respected studied traits of maize seedlings.

Conclusion: In this study, it is concluded that the F_1 hybrids, EV-1097Q x EV-347, EV-1097Q x EV-340, Raka-poshi x EV-347, B-327 x B-316 and Sh-139 x EV-347 may be used as higher yield maize hybrids and parents EV-347, EV-1097Q, B-327 and B-316 may be used to develop higher yield maize hybrids following heterosis breeding scheme.

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Introduction

Maize is one of most important cereal crop in world after wheat and rice. It is grown in Pakistan as a major cash crop cultivation in the area of 1083 thousand hectares producing 3990 thousand tones. Maize is dual propose crop it is used as feed for livestock and food for human. It is also used as a raw material in textile, food and medicine industries. It contains 9.50% fiber, 72%, 3.0% sugar, starch, 4.80% oil, 10% protein and 1.70% ash [1]. The present study was conducted to evaluate parents and F_1 hybrids of maize for seedling traits. In the selection of maize genotypes with higher yield, higher heritability and genetic advance help are important which in turn increase the grains production of maize.

The major objective of this current study was to asses the potential of different varities of maize crop on account of their seedling characteristics.

Methods

The present study was carried out 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 F1 hybrids. The parents and F1 hybrids were sown in the iron treys filled with sand in three replications following completely randomized design. The data was recorded fresh shoot length, for fresh root length, fresh root weight, fresh shoot weight, fresh root-to-shoot weight ratio and fresh root-to-shoot length ratio. The data was subjected for analysis of variance [2]. The genotypic and phenotypic coefficients of variance were calculated by Kwon and Torrie (1964) technique [3]. The genetic advance was calculated by using Falconer (1989) formula [4].

Parents and F_1 hybrids

Pop/209	B-11×Pop/209	EV-1097Q×Pop/209	Raka-poshi×Pop/209
B-316	B-11×B-316	EV-1097Q×B-316	Raka-poshi×B-316
EV-340	B-11×EV-340	EV-1097Q×EV-340	Raka-poshi×EV-340
E-322	B-11×E-322	EV-1097Q×E-322	Raka-poshi×E-322
F-96	B-11×F-96	EV-1097Q×F-96	Raka-poshi×F-96
EV-347	B-11×EV-347	EV-1097Q×EV-347	Raka-poshi×EV-347
B-11	B-336×Pop/209	B-327×Pop/209	Sh-139×Pop/209
B-336	B-336×B-316	B-327×B-316	Sh-139×B-316
EV-1097Q	B-336×EV-340	B-327×EV-340	Sh-139×EV-340
B-327	B-336×E-322	B-327×E-322	Sh-139×E-322
Raka-poshi	B-336×F-96	B-327×F-96	Sh-139×F-96
Sh-139	B-336×EV-347	B-327×EV-347	Sh-139×EV-347

Results

It is cleared from table 1 that higher heritability was recorded for fresh root and shoot length and fresh shoot weight while higher genetic advance was recorded for fresh root and shoot length, fresh shoot weight and fresh root-to-shoot weight ratio. Selection of higher yielding maize genotypes on the basis of higher heritability and genetic advance may be helpful to increase grain production of maize [5,6]. The higher fresh root length was recorded for B-336 (19.693cm), B-316 (16.073cm), EV-1097Q×EV-340 (14.457cm) and Raka-poshi×Pop/209 (14.413cm) as shown from table 2 and figure 1.

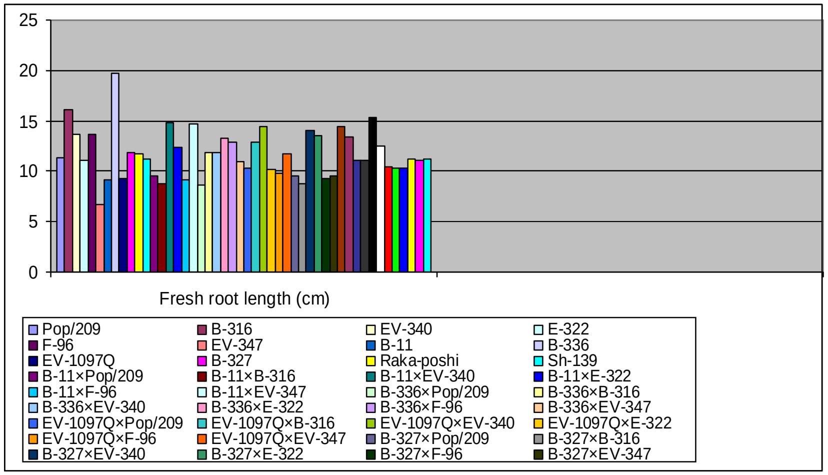

Figure 1: Fresh root length of different varieties

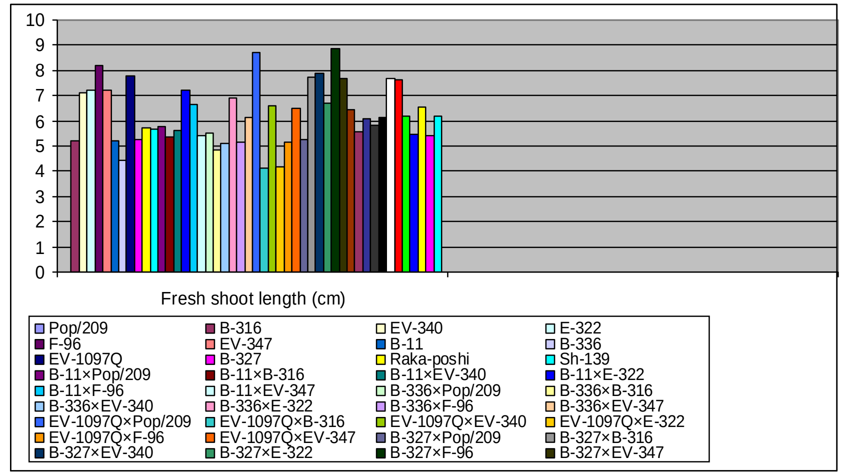

Figure 2: Fresh shoot length of different varieties

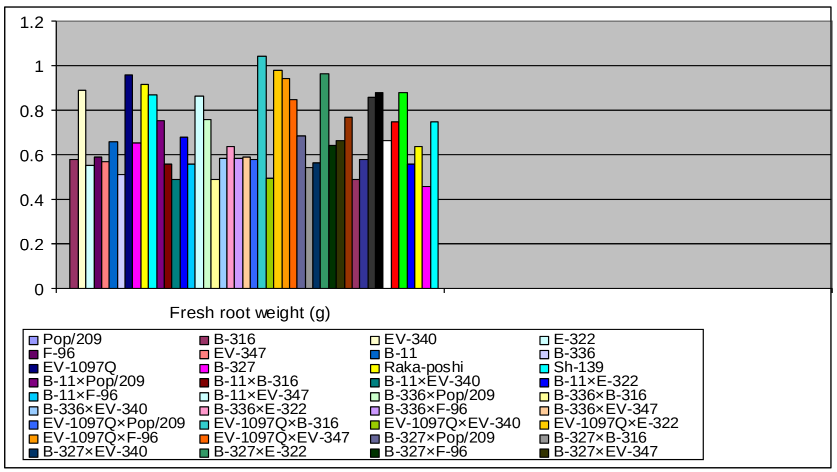

Figure 3: Fresh root weight of different varieties

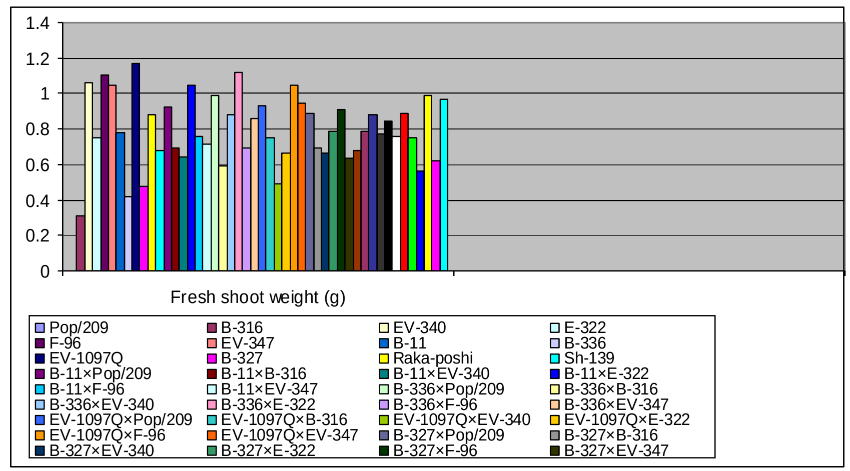

Figure 4: Fresh shoot weight of different varieties

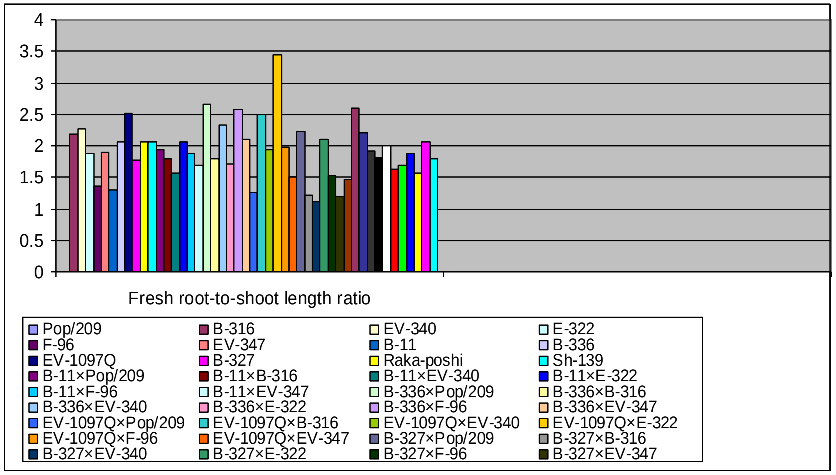

Figure 5: Fresh root to shoot length ratio of different varieties

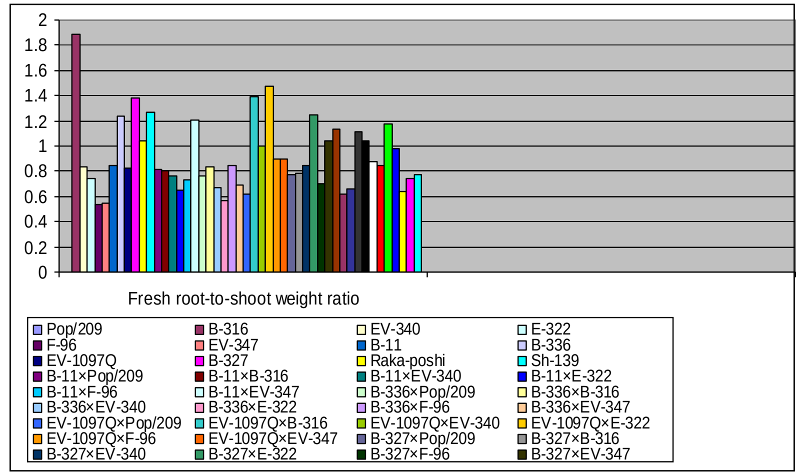

Figure 6: Fresh root to shoot weight ratio of different varieties

Traits	Mean sum of square	Grand mean	Genotypic variance	Genotypic coefficient of variance%	Phenotypic variance	Phenotypic coefficient of variance%	Environmental variance	Environmental coefficient of variance%	Heritability h2bs%	Genetic advance%
Fresh root length (cm)	6.408*	11.677	1.098	30.666	4.212	60.057	3.114	51.637	26.074	40.626
Fresh shoot length (cm)	1.538*	6.263	0.266	20.601	1.006	40.084	0.741	34.386	26.413	27.291
Fresh root-to-shoot length ratio	0.197*	1.909	0.002	3.395	0.192	31.736	0.190	31.554	1.145	4.498
Fresh root weight (g)	0.027**	0.693	0.003	6.285	0.022	17.687	0.019	16.533	12.625	8.326
Fresh shoot weight (g)	0.044**	0.799	0.011	11.695	0.023	16.797	0.012	12.056	48.478	15.493
Fresh root-to-shoot weight ratio	0.082*	0.909	0.009	9.787	0.065	26.670	0.056	24.810	13.466	12.965

* Significant at 1% level, ** Significant at 5% level

Table 1: Genetic components for morphological traits of maize

Parents and crosses	Mean of fresh root length	Heterosis of fresh root length	Heterobeltiosis of fresh root length	Mean of fresh shoot length	Heterosis of fresh shoot length	Heterobeltiosis of fresh shoot length
Pop/209	11.357	-	-	5.207	-	-
B-316	16.073	-	-	7.103	-	-
EV-340	13.627	-	-	7.230	-	-
E-322	11.143	-	-	8.180	-	-
F-96	13.653	-	-	7.210	-	-
EV-347	6.733	-	-	5.210	-	-
B-11	9.110	-	-	4.433	-	-
B-336	19.693	-	-	7.807	-	-
EV-1097Q	9.317	-	-	5.277	-	-
B-327	11.893	-	-	5.743	-	-
Raka-poshi	11.760	-	-	5.683	-	-
Sh-139	11.237	-	-	5.787	-	-
B-11×Pop/209	9.600	-6.189	-15.468	5.373	11.480	3.201
B-11×B-316	8.750	-30.510	-45.562	5.637	-2.283	-20.648
B-11×EV-340	14.770	29.922	8.390	7.197	23.407	-0.461
B-11×E-322	12.367	22.120	10.978	6.627	5.074	-18.989
B-11×F-96	9.100	-20.047	-33.350	5.390	-7.415	-25.243
B-11×EV-347	14.650	84.936	60.812	5.513	14.345	5.822
B-336×Pop/209	8.697	-43.983	-55.840	4.823	-25.871	-38.215
B-336×B-316	11.893	-33.495	-39.607	5.113	-31.411	-34.500
B-336×EV-340	11.883	-28.672	-39.658	6.907	-8.136	-11.529
B-336×E-322	13.213	-14.301	-32.905	5.147	-35.613	-37.082
B-336×F-96	12.883	-22.731	-34.580	6.153	-18.047	-21.179
B-336×EV-347	10.987	-16.852	-44.211	8.733	34.187	11.870
EV-1097Q×Pop/209	10.280	-0.548	-9.481	4.130	-21.208	-21.731
EV-1097Q×B-316	12.870	1.379	-19.930	6.607	6.731	-6.992
EV-1097Q×EV-340	14.457	26.021	6.091	4.197	-32.889	-41.955
EV-1097Q×E-322	10.197	-0.326	-8.495	5.137	-23.656	-37.205
EV-1097Q×F-96	9.787	-14.787	-28.320	6.520	4.431	-9.570
EV-1097Q×EV-347	11.717	46.002	25.760	5.260	0.318	-0.316
B-327×Pop/209	9.483	-18.423	-20.264	7.743	41.431	34.823
B-327×B-316	8.757	-37.378	-45.521	7.863	22.418	10.699

B-327×EV-340	14.090	10.423	3.400	6.690	3.135	-7.469
B-327×E-322	13.483	17.060	13.369	8.860	27.268	8.313
B-327×F-96	9.273	-27.401	-32.080	7.693	18.785	6.704
B-327×EV-347	9.513	2.148	-20.011	6.467	18.077	12.594
Raka-poshi×Pop/209	14.413	24.701	22.562	5.567	2.235	-2.053
Raka-poshi×B-316	13.417	-3.593	-16.528	6.100	-4.588	-14.125
Raka-poshi×EV-340	11.100	-12.553	-18.542	5.813	-9.964	-19.594
Raka-poshi×E-322	11.033	-3.653	-6.179	6.110	-11.854	-25.306
Raka-poshi×F-96	15.363	20.908	12.524	7.657	18.769	6.195
Raka-poshi×EV-347	12.453	34.679	5.896	7.623	39.963	34.135
Sh-139×Pop/209	10.473	-7.288	-7.778	6.170	12.250	6.624
Sh-139×B-316	10.277	-24.741	-36.064	5.473	-15.076	-22.947
Sh-139×EV-340	10.277	-17.335	-24.584	6.527	0.282	-9.728
Sh-139×E-322	11.167	-0.209	-0.623	5.437	-22.148	-33.537
Sh-139×F-96	11.080	-10.968	-18.848	6.190	-4.745	-14.147
Sh-139×EV-347	11.163	24.244	-0.653	7.310	32.949	26.325

Table 2: Mean, heterosis and heterobeltiosis for morphological traits of maize seedlings

Parents and crosses	Mean fresh root-to-shoot length ratio	Heterosis of fresh root-to-shoot length ratio	Heterobeltiosis of fresh root-to-shoot length ratio	Mean of fresh root weight	Heterosis of fresh root weight	Heterobeltiosis of fresh root weight
Pop/209	2.181	-	-	0.578	-	-
B-316	2.263	-	-	0.889	-	-
EV-340	1.885	-	-	0.555	-	-
E-322	1.362	-	-	0.589	-	-
F-96	1.894	-	-	0.570	-	-
EV-347	1.292	-	-	0.659	-	-
B-11	2.057	-	-	0.513	-	-
B-336	2.523	-	-	0.957	-	-
EV-1097Q	1.766	-	-	0.652	-	-
B-327	2.071	-	-	0.916	-	-
Raka-poshi	2.069	-	-	0.867	-	-
Sh-139	1.942	-	-	0.751	-	-
B-11×Pop/209	1.787	-15.677	-18.085	0.557	2.077	-3.689

B-11×B-316	1.558	-27.881	-31.168	0.489	-30.243	-44.994
B-11×EV-340	2.052	4.145	-0.203	0.679	27.193	22.416
B-11×E-322	1.866	9.173	-9.253	0.559	1.543	-4.983
B-11×F-96	1.689	-14.508	-17.893	0.863	59.385	51.374
B-11×EV-347	2.657	58.694	29.210	0.757	29.181	14.871
B-336×Pop/209	1.803	-23.334	-28.527	0.491	-36.040	-48.694
B-336×B-316	2.326	-2.795	-7.806	0.586	-36.475	-38.732
B-336×EV-340	1.721	-21.925	-31.798	0.638	-15.590	-33.333
B-336×E-322	2.569	32.261	1.840	0.586	-24.132	-38.732
B-336×F-96	2.094	-5.187	-17.011	0.589	-22.829	-38.419
B-336×EV-347	1.259	-34.013	-50.105	0.577	-28.548	-39.673
EV-1097Q×Pop/209	2.489	26.139	14.128	1.040	69.014	59.428
EV-1097Q×B-316	1.948	-3.284	-13.907	0.493	-36.073	-44.582
EV-1097Q×EV-340	3.445	88.737	82.776	0.977	61.944	49.821
EV-1097Q×E-322	1.985	26.919	12.421	0.940	51.545	44.149
EV-1097Q×F-96	1.501	-17.952	-20.723	0.849	38.877	30.148
EV-1097Q×EV-347	2.230	45.813	26.267	0.684	4.271	3.743
B-327×Pop/209	1.225	-42.397	-43.848	0.540	-27.682	-41.012
B-327×B-316	1.114	-48.594	-50.769	0.563	-37.581	-38.501
B-327×EV-340	2.109	6.644	1.845	0.962	30.825	5.022
B-327×E-322	1.522	-11.366	-26.534	0.640	-14.976	-30.167
B-327×F-96	1.205	-39.197	-41.804	0.662	-10.877	-27.693
B-327×EV-347	1.472	-12.454	-28.915	0.770	-2.222	-15.939
Raka-poshi×Pop/209	2.590	21.852	18.727	0.490	-32.149	-43.445
Raka-poshi×B-316	2.199	1.542	-2.801	0.579	-34.093	-34.908
Raka-poshi×EV-340	1.910	-3.410	-7.715	0.858	20.750	-1.000
Raka-poshi×E-322	1.806	5.246	-12.731	0.881	20.998	1.576
Raka-poshi×F-96	2.009	1.391	-2.911	0.663	-7.746	-23.529
Raka-poshi×EV-347	1.636	-2.671	-20.942	0.749	-1.835	-13.610

Sh-139×Pop/209	1.697	-17.673	-22.186	0.879	32.230	17.052
Sh-139×B-316	1.881	-10.542	-16.884	0.556	-32.222	-37.495
Sh-139×EV-340	1.575	-17.678	-18.890	0.635	-2.707	-15.409
Sh-139×E-322	2.054	24.328	5.773	0.460	-31.259	-38.677
Sh-139×F-96	1.790	-6.664	-7.826	0.746	12.945	-0.622
Sh-139×EV-347	1.529	-5.441	-21.257	0.776	10.050	3.330

Table 3: Mean, heterosis and heterobeltiosis for morphological traits of maize seedlings

Parents and crosses	Mean fresh shoot weight	Heterosis of fresh shoot weight	Heterobeltiosis of fresh shoot weight	Mean of fresh root-to-shoot weight ratio	Heterosis of fresh root-to-shoot weight ratio	Heterobeltiosis of fresh root-to-shoot weight ratio
Pop/209	0.307	-	-	1.884	-	-
B-316	1.060	-	-	0.839	-	-
EV-340	0.748	-	-	0.743	-	-
E-322	1.107	-	-	0.532	-	-
F-96	1.050	-	-	0.543	-	-
EV-347	0.779	-	-	0.847	-	-
B-11	0.416	-	-	1.232	-	-
B-336	1.166	-	-	0.821	-	-
EV-1097Q	0.474	-	-	1.379	-	-
B-327	0.877	-	-	1.045	-	-
Raka-poshi	0.681	-	-	1.273	-	-
Sh-139	0.927	-	-	0.810	-	-
B-11×Pop/209	0.693	91.613	66.453	0.804	-48.403	-57.329
B-11×B-316	0.643	-12.938	-39.371	0.761	-26.521	-38.242
B-11×EV-340	1.047	79.840	39.991	0.649	-34.298	-47.338
B-11×E-322	0.760	-0.153	-31.295	0.736	-16.581	-40.285
B-11×F-96	0.718	-2.114	-31.651	1.203	35.508	-2.381
B-11×EV-347	0.992	66.025	27.397	0.763	-26.582	-38.075
B-336×Pop/209	0.589	-19.982	-49.457	0.833	-38.415	-55.784
B-336×B-316	0.879	-20.994	-24.586	0.667	-19.693	-20.543
B-336×EV-340	1.120	17.053	-3.945	0.570	-27.180	-30.648
B-336×E-322	0.691	-39.190	-40.738	0.849	25.396	3.305
B-336×F-96	0.859	-22.473	-26.329	0.686	0.550	-16.478
B-336×EV-347	0.932	-4.182	-20.097	0.621	-25.589	-26.692

EV-1097Q×Pop/209	0.750	91.980	58.117	1.387	-15.005	-26.403
EV-1097Q×B-316	0.491	-36.042	-53.711	1.004	-9.461	-27.179
EV-1097Q×EV-340	0.661	8.129	-11.636	1.479	39.433	7.292
EV-1097Q×E-322	1.050	32.827	-5.121	0.896	-6.262	-35.048
EV-1097Q×F-96	0.944	23.857	-10.095	0.899	-6.416	-34.775
EV-1097Q×EV-347	0.889	41.846	14.127	0.769	-30.855	-44.203
B-327×Pop/209	0.691	16.812	-21.141	0.782	-46.639	-58.518
B-327×B-316	0.664	-31.429	-37.359	0.848	-9.964	-18.841
B-327×EV-340	0.788	-3.017	-10.152	1.249	39.707	19.516
B-327×E-322	0.908	-8.437	-17.952	0.704	-10.672	-32.605
B-327×F-96	0.633	-34.256	-39.683	1.046	31.681	0.055
B-327×EV-347	0.679	-18.002	-22.586	1.135	19.973	8.566
Raka-poshi×Pop/209	0.788	59.460	15.656	0.622	-60.582	-66.977
Raka-poshi×B-316	0.879	0.919	-17.107	0.659	-37.590	-48.223
Raka-poshi×EV-340	0.769	7.581	2.809	1.117	10.800	-12.256
Raka-poshi×E-322	0.843	-5.667	-23.795	1.044	15.715	-17.963
Raka-poshi×F-96	0.759	-12.360	-27.746	0.874	-3.755	-31.343
Raka-poshi×EV-347	0.889	21.781	14.170	0.843	-20.496	-33.812
Sh-139×Pop/209	0.750	21.643	-19.029	1.171	-13.078	-37.853
Sh-139×B-316	0.566	-42.987	-46.572	0.981	19.009	16.950
Sh-139×EV-340	0.988	17.977	6.583	0.643	-17.205	-20.627
Sh-139×E-322	0.622	-38.853	-43.825	0.743	10.729	-8.280
Sh-139×F-96	0.966	-2.293	-8.032	0.773	14.277	-4.550
Sh-139×EV-347	0.888	4.144	-4.173	0.874	5.478	3.212

Table 4: Mean, heterosis and heterobeltiosis for morphological traits maize seedlings

Higher fresh shoot length was recorded for E-322 (8.180cm), B-336×EV-347 (8.733cm), B-327×E-322 (8.860cm) and B-327×B-316 (7.763cm) as shown from table 12 and figure 2. Higher fresh root-to-shoot length ratio was found for EV-1097Q×EV-340 (3.445) and Raka-poshi×Pop/209 (2.590) as shown in Table 2 and Figure 3. Higher fresh root and shoot weight was recorded for B-316 (0.889g, 1.060g), B-336 (0.957g, 1.166g), EV-1097Q×Pop/209 (1.040g, 0.750g) and B-327×EV-340 (0.962g, 0.388g) EV-1097Q×E-322 (0.940g, 1.050g) respectively as shown in table 3 and figure 4 and 5. Higher fresh root-to-shoot weight ratio was found for Pop/209 (1.884), EV-1097Q×EV-340 (1.479) and EV-1097Q×Pop/209 (1.387) as shown in table 3 and figure 6. Higher mean performance indicated that these parents and F_1 hybrids may be used to develop higher yielding maize genotypes [6]. It is persuaded from table 2 that higher heterosis for fresh root length was recorded for B-11 x EV-347 (84.936), Raka-poshi x EV-347 (34.679), EV-1097Q x EV-347 (46.002), B-11 x EV-340 (29.922), EV-1097Q x EV-340 (26.021) and Sh-139 x EV-347 (24.244) while lower heterosis was recorded for B-11 x B-316 (-30.509), B-336 x Pop/209 (-43.983), B-336 x B-316 (-33.495) and B-336 x EV-340 (-28.672). The higher value of heterobeltiosis for fresh root length was recorded for B-11 x EV-347 (60.812), Raka-poshi x EV-347 (5.896), EV-1097Q x EV-347 (25.760), B-11 x E-322 (10.978), Raka-poshi x Pop/209 (22.562), B-327 x E-322 (13.369) and Raka-poshi x F-96 (12.524.

Discussion

Results similar with this study are also reported in different research reports [7-10]. It is persuaded from table 2 that higher heterosis and heterobeltiosis for fresh shoot length was recorded for B-327 x Pop/209 (41.430, 34.823), Raka-poshi x EV-347 (39.963, 34.134), B-327 x B-316 (22.418, 10.699) and Sh-139 x EV-347 (32.949, 26.324) respectively, while lower for EV-1097Q x EV-340 (-32.889, -41.954), B-336 x E-322 (-35.613, -37.082), B-336 x Pop/209 (-25.870, -38.215) and B-336 x B-316 (-31.410, -34.50) respectively. Similar results were found in other studies [6,7,10]. It is persuaded from table 3 that higher heterosis and heterobeltiosis for fresh root-to-shoot length ratio was recorded for EV-1097Q x EV-340 (88.737, 82.776), B-11 x EV-347 (58.694, 29.210), EV-1097Q x EV-347 (45.812, 26.267) and Sh-139 x E-322 (24.327, 5.772) respectively, while lower for B-336 x EV-347 (-34.012, -50.105), B-327 x Pop/209 (-42.396, -43.847) and B-327 x B-316 (-48.539, -50.769) respectively. Similar results were found by others in different studies [3,6,7,10]. It is persuaded from table 3 that higher heterosis and heterobeltiosis for fresh root weight was recorded for EV-1097Q x Pop/209 (69.014, 59.427), EV-1097Q x EV-340 (61.944, 49.821), B-11 x F-96 (59.384, 51.373) and EV-1097Q x E-322 (51.544, 44.149) respectively, while lower for B-336 x Pop/209 (-36.039, -48.693), B-336 x B-316 (-36.475, -38.732) and EV-1097Q x B-316 (-36.072, -44.581) respectively. These results are consistent with studies too [3,6,7,10]. It is persuaded from table 4 that higher heterosis and heterobeltiosis was recorded for for fresh shoot weight of B-11 x Pop/209 (91.612, 66.453), B-11 x EV-340 (79.839, 39.991), B-11 x EV-347 (66.025, 27.397) and Raka-poshi x Pop/209 (59.460, 15.655) respectively, while lower for Sh-139 x E-322 (-38.852, -43.825), Sh-139 x B-316 (-42.986, -46.527) and B-336 x B-316 (-39.190, -40.737) respectively. Similar results were found in previous [3,6,7,10]. It is persuaded from table 4 that higher heterosis and heterobeltiosis was recorded for fresh root-to-shoot weight ratio of B-327 x B-316 (144.467, 116.951), EV-1097Q x B-316 (110.151, 91.287), B-327 x F-96 (77.250, 48.293) and Sh-139 x F-322 (88.775, 55.920) respectively, while lower for B-336 x EV-340 (-45.254, -54.098), B-336 x Pop/209 (-32.896, -51.339) and B-336 x B-316 (-31.806, -47.098). Similar results were found in studies on maize before this one [3,6,7,10,11]. Higher values of heterosis and heterobeltiosis of F_1 hybrids indicated that selection of respective parents may be helpful to develop higher yielding maize hybrids under drought conditions.

It was concluded that the F_1 hybrids, EV-1097Q x EV-347, EV-1097Q x EV-340, Raka-poshi x EV-347, B-327 x B-316 and Sh-139 x EV-347 may be used as higher yield maize hybrids and parents EV-347, EV-1097Q, B-327 and B-316 may be used to develop higher yield maize hybrids following heterosis breeding scheme.

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