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Gene Action for Various Grain and Fodder Quality Traits in *Zea Mays*

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Abstract *A Zea may is* an important cereal crop. To nourish human and livestock, it is very important that the quality of maize grain and fodder must be higher. A study was conducted to evaluate maize accessions for grain and fodder quality traits. Results indicated that higher heritability was found for nutrient detergent fiber, fodder cellulose, fodder crude fiber, fodder crude and fodder moisture percentage while genetic advance was higher for fodder cellulose, fodder crude protein and fodder ash percentage. High significant genotypic and phenotypic correlation was found among grain protein, oil and starch percentage, nutrient detergent fiber, fodder cellulose, fodder crude fiber & protein and fodder moisture percentage. The higher cumulative additive effect was recorded for acid detergent fiber, fodder crude fiber; nutrient detergent fiber and fodder cellulose suggested that selections may be made to develop synthetic varieties for better quality. Higher dominance effect and degree of dominance indicated that selection may be useful for the development of good quality maize hybrids through heterosis breeding programme. Principle component bi-plot analysis indicated that B-11×EV-347, B-11, Sh-139, EV-1097×E-322, Sh-139×B-316, B-327×E-322, B-316, Raka-poshi, B-11×Pop/209, B-336×EV-340, B-327×E-322, B-327×F-96, EV-1097×E-322, Raka-poshi×EV-347, EV-1097×Pop/209 and EV-1097×EV-340 performed better for grain and fodder quality and may be used for improvement of grain and fodder quality of maize.

Keywords: *zea mays, additive, dominance, degree of dominance, genetic advance, quality*

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1. Introduction

Maize (*Zea mays* L.) plant has a remarkable productive potential and world's leading cereal food crop with added importance for countries like Pakistan where quickly increasing population has already facing less availability of food supplies. Maize is the third important cereal crop in Pakistan than wheat and rice. Maize accounts for 5.67% of the value of agriculture output. It accounts for 1083 thousands hectares of total cropped area in Pakistan with annual production of 4271 thousand tons. Maize is the dual purpose cereal crop as used in human food, livestock feed and industrial raw material for the manufacturing of various by-products. It has highest crude protein 9.9% at early and at full bloom stages which decreases to 7% at milk stage and to 6% at maturity. Maize has highly nutritive value as it contains 72% starch, 10% protein, 4.80% oil, 9.50% fiber, 3.0% sugar, 1.70% ash, 82% endosperm, 12% embryo, 5% bran testa and 1% tip cap [1].

Pakistan have livestock population of 154.7 million heads which produce about 43.562 million tons of milk, 1.601 million tons of beef and 0.590 million tons of mutton. The livestock sector of Pakistan contributes about 53.2% of the agriculture outputs and 11.4% to national GDP of Pakistan. Green fodder is the most cheapest and precious source for livestock food. It is rich an important source of 35-40% cellulose, 25.28% hemicelluloses, 0.30% fat, 28.70% crude fiber, 37.22% acid detergent fiber, 70.85% neutral detergent fiber, 40.6% dry matter, 4% ash, 48.86% carbohydrates, 9.22% moisture, 2.84% ether extract and 11% crude proteins [1]. The milk production of livestock animals may be increased up to 100% by using good quality and highly nutritive fodder [1,2]. Around 80-90 % of nutrient requirements of livestock are met from the fodder crops but the present fodder supply is 1/3 times less than the actual needs and the majority of the animals remain under fed especially during June-July (extremely hot season) and December-January (extremely cold season).

In Pakistan out of total cropped area of 23.51 million ha only 2.46 million ha was under fodder crops with total fodder production of 55.06 million tons [3] that is not sufficient enough to fulfill the requirements of nutrition for the existing livestock. The livestock feed pool in Pakistan is deficient by 21 % of total dry matter (DM), and by 33 % of crude protein requirements [2]. The poor yield is due to growing pressure of human population, less and irregular rainfalls, scarcity of irrigation water, less priorities for fodder crop production and imbalance use of fertilizers [4,5,6]. Present study was conducted to evaluate maize inbred lines and F_1 hybrids for various grain and fodder quality traits. Gene action provides plant breeder a plate form to select genotypes with better grain yield and quality [1,7-15].

2. Materials and methods

The present study was carried out in the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad Pakistan to evaluate the selected maize parents and F_1 hybrids for grain and fodder quality traits at maturity during crop growing season 2012. The samples were collected from the field at anthesis stage and various quality traits were recorded (AOAC, 1996) in the Animal Nutrition Laboratory, Institute of Animal Nutrition University of Agriculture Faisalabad.

Parents and F_1 crosses used in evaluation experiment

Sr. No.	Genotypes	Sr. No.	Genotypes	Sr. No.	Genotypes
1	Pop/209	17	B-11×F-96	33	B-327×EV-340
2	B-316	18	B-11×EV-347	34	B-327×E-322
3	EV-340	19	B-336×Pop/209	35	B-327×F-96
4	E-322	20	B-336×B-316	36	B-327×EV-347
5	F-96	21	B-336×EV-340	37	Raka-poshi×Pop/209
6	EV-347	22	B-336×E-322	38	Raka-poshi×B-316
7	B-11	23	B-336×F-96	39	Raka-poshi×EV-340
8	B-336	24	B-336×EV-347	40	Raka-poshi×E-322
9	EV-1097	25	EV-1097×Pop/209	41	Raka-poshi×F-96
10	B-327	26	EV-1097×B-316	42	Raka-poshi×EV-347
11	Raka-poshi	27	EV-1097×EV-340	43	Sh-139×Pop/209
12	Sh-139	28	EV-1097×E-322	44	Sh-139×B-316
13	B-11×Pop/209	29	EV-1097×F-96	45	Sh-139×EV-340
14	B-11×B-316	30	EV-1097×EV-347	46	Sh-139×E-322
15	B-11×EV-340	31	B-327×Pop/209	47	Sh-139×F-96
16	B-11×E-322	32	B-327×B-316	48	Sh-139×EV-347

The seed of F_1 hybrids along with their parents were sown in field following a triplicated randomized complete block design. The plant to plant and row to row distances were maintained as 25 and 75 cm, respectively.

2.1. Quality Parameters

The grain and plant samples containing leaves and stem will be collected and grounded into fine powder and the following quality traits including grain protein percentage, grain oil percentage, grain starch percentage, grain crude fibre percentage, nutrient detergent fibre, acid detergent fibre, fodder cellulose, carbohydrates, fodder crude fibre, fodder crude protein and fodder moisture percentage were estimated using (Proximate analysis, AOAC (Association of Official Analytical Chemists) 1996).

The percentage of the embryo was recorded by using following formula:

Embryo % = [Embryo weight/Seed weight] × 100

The fresh weight of the sample was recorded with the help of electronic balance (OHAUS-GT4000, USA). The sample was dried out in oven at 106°C for 24hours. The dried sample was again weighed with the help of electronic balance. The difference in the weight was recorded that was the estimation of dry matter in the sample.

Dry matter % = [Fresh sample weight – dry sample weight] × 100

The moisture percentage was calculated was using following formula.

Moisture % = [Sample amount of water (FW-DW)/Sample weight (FW)] × 100

FW = Fresh sample weight, DW = Dry sample weight

2.2. Statistical Analysis

The data were analyzed statistically using analysis of variance technique (Steel *et al.* 1997) and Duncan Multiple Range (DMR) test at 5 % significance probability level and it was used to compare the treatments means. Significantly varying genotypes were subjected to North Carolina Design II matting scheme (Comstock and Robinson, 1948, 1952) to estimate their gene action. Phenotypic ($\mathbf{r_p}$) and genotypic ($\mathbf{r_g}$) correlation coefficient was calculated as outlined by Kwon and Torrie (1964).

3. Results and Discussion

It was suggested that significant differences were recorded for grain protein percentage. The mean performance of parents and F_1 hybrids indicated that average grain protein percentage was recorded as 9.7396±0.0712% (Table 1). It was also persuaded from Table 1 that higher heritability (96.70%) and lower genetic advance (3.619%) was recorded for grain protein percentage. It was suggested from Table 4 that higher grain protein percentage was recorded for EV-1097×EV-347 (10.77%), EV-1097×F-96 (10.67%), B-327×Pop/209 (10.33%) and EV-1097×EV-340 (10.33%) while lower grain protein percentage was recorded for Sh-139×B-316 (9.267%), Sh-139×E-322 (9.200%), Sh-139×EV-340 (9.200%) and Raka-posh×Pop/209 (9.167%). The higher values of grain protein percentage for F_1 hybrids EV-1097×EV-347, EV-1097×F-96, B-327×Pop/209 and EV-1097×EV-340 indicated that selection of EV-1097, B-327, EV-347, F-96 and EV-340 may be used for developing higher grain protein percentage hybrids. It was found from Table 1 that significant differences were recorded for grain oil percentage. The mean performance of parents and F_1 hybrids indicated that average grain oil percentage was recorded as 4.85±0.0619%.

Table 1. Genetic components for various grain and fodder quality traits in maize

Source of variation	Grain protein %	Grain oil %	Grain crude fiber %	Grain starch %	Embryo %	Acid detergent fiber %	Neutrient detergent fiber %	Fodder Cellulose %	Fodder dry matter %	fodder crude fiber %	Fodder crude protein %	Fodder moisture %
M.S.S	0.463**	0.313**	0.115**	1.332*	0.165*	5.532*	38.761*	36.316*	2.058*	5.500**	4.980*	0.083*
G.M±SE	9.7396± 0.0712	4.85± 0.0619	9.4392 ± 0.0579	71.966 ± 0.1313	11.77± 0.1120	22.899± 0.2528	51.696± 0.3078	28.797± 0.2755	40.178± 0.2442	26.845 ± 0.1080	10.353± 0.1072	9.0951± 0.0142
G.V	0.510	0.101	o.o35	0.427	0.043	1.780	12.826	11.996	0.627	1.822	1.649	0.028
GCV	3.971	6.542	1.987	0.908	1.756	5.826	6.928	12.027	1.970	5.028	12.402	1.830
PV	0.155	0.104	0.039	0.444	0.055	1.844	12.920	12.072	0.686	1.833	1.660	0.028
PCV	4.038	6.665	2.080	0.926	1.997	5.930	6.953	12.065	2.062	5.044	12.445	1.837
EV	0.005	0.004	0.003	0.017	0.013	0.064	0.095	0.076	0.060	0.012	0.011	0.0001
ECV	0.731	1.277	0.614	0.182	0.951	1.104	0.595	0.957	0.608	0.402	1.035	0.157
$h^2_{bs\,\%}$	96.70	96.30	91.30	96.10	77.30	96.50	99.30	99.40	91.30	99.40	99.30	99.30
S.E h^2_{bs}	0.299	0.364	0.607	0.177	0.524	0.087	0.033	0.034	0.144	0.086	0.091	0.700
GA %	3.619	8.98	2.66	1.25	2.16	8.01	9.66	16.79	2.64	7.02	17.30	2.55

Source of variation	Ether extractable fat %	Nitrogen free extract %	Fodder ash %
Mean Sum of Squares (M.S.S)	0.025**	10.760*	1.148**
Grand mean (G.M)	2.9055	41.861	8.9026
Standard error (S.E)	0.0262	0.3720	0.100
Genotypic variance (GV)	0.008	5.183	0.559
Genotypic coefficient of variance (GCV %)	3.049	5.439	6.282
Phenotypic variance (PV)	0.009	5.649	0.589
Phenotypic coefficient of variance (PCV %)	3.179	5.678	6.619
Environmental Variance (EV)	0.001	0.466	0.029
Environmental coefficient of variance (ECV %)	0.900	1.113	0.337
Broad sense heritability ($h^2_{bs\,\%}$)	92.00	91.70	94.90
Standard error for broad sense heritability (S.E h^2_{bs})	1.289	1.453	0.789
Genetic advance (GA %)	9.09	9.143	14.362

It was also persuaded from Table 1 that higher heritability (96.30%) and lower genetic advance (8.98%) was recorded for grain oil percentage. It was indicated from Table 4 that higher grain oil percentage was recorded for B-327×B-316 (5.27%), Raka-poshi×B-316 (5.37%), E-336×Pop/209 (5.40%) and Raka-poshi×EV-340 (5.33%) while lower grain oil percentage was recorded for Sh-139 (4.13%), E-322 (4.20%), B-11×EV-340 (4.27%) and F-96 (4.03%). The higher values of grain oil percentage for F_1 hybrids B-327×B-316, Raka-poshi×B-316, E-336×Pop/209 and Raka-poshi×EV-340 indicated that selection of Raka-poshi, B-327, Pop/209, B-316 and EV-340 may be used for developing higher grain oil percentage hybrids. Findings were reported similar to Yousaf and Saleem, 2001. It was indicated from Table 1 that significant differences were recorded for grain crude fiber percentage. The mean performance of parents and F_1 hybrids indicated that average grain crude fiber percentage was recorded as 9.4392±0.0579%. It was also persuaded from Table 1 that higher heritability (91.30%) and lower genetic advance (2.66%) was recorded for grain crude fiber percentage. It was suggested from Table 4 that higher grain crude fiber percentage was recorded for E-336 × B-316 (9.87%), E-336 × E-322 (9.80%), EV-1097 (9.80%) and E-336×EV-340 (9.77%) while lower grain crude fiber percentage was recorded for Sh-139 (9.13%), B-316 (9.12%), E-336×EV-347 (9.10%) and B-11 (9.10%). The higher values of grain crude fiber percentage for F_1 hybrids E-336 × B-316, E-336 × E-322 and E-336×EV-340 indicated that selection of EV-1097, E-336, B-316, E-322 and EV-340 may be used for developing higher grain crude fiber percentage hybrids[4,17,18,19,20].

It was shown from Table 1 that significant differences were recorded for grain starch percentage. The mean performance of parents and F_1 hybrids indicated that average grain starch percentage was recorded as 71.966±0.1313%. It was also persuaded from Table 1 that higher heritability (91.10%) and lower genetic advance (1.25%) was recorded for grain starch percentage. It was suggested from Table 4 that higher grain starch percentage was recorded for B-11×B-316 (74.20%), B-11×Pop/209 (73.17%), Sh-139 (73.63%) and Raka-poshi (73.20%) while lower grain starch percentage was recorded for Raka-poshi×EV-347 (71.17%), E-336 (71.20%), Raka-poshi×E-322 (71.20%) and B-11×F-96 (71.17%). The higher values of grain starch percentage for F_1 hybrids B-11×B-316 and B-11×Pop/209 indicated that selection of B-11, B-316, Raka-poshi and Sh-139 may be used for developing higher grain starch percentage hybrids. Findings were reported similar to [6,18,20].

It was found from Table 1 that significant differences were recorded for grain embryo percentage. The mean performance of parents and F_1 hybrids indicated that average grain embryo percentage was recorded as 11.77±0.1120%. It was also indicated from Table 1 that higher heritability (77.30%) and lower genetic advance (2.16%) was recorded for grain embryo percentage. It was suggested from Table 4 that higher grain embryo percentage was recorded for B-11×EV-347 (12.60%), E-336×Pop/209 (12.20%), E-336 (12.13%) and EV-1097 (12.20%) while lower grain embryo percentage was recorded for Raka-poshi×F-96 (11.50%), Sh-139×EV-347 (11.20%), Raka-poshi×E-322 (11.57%) and Sh-139×F-96 (11.37%). The higher values of grain embryo percentage for F_1 hybrids B-11×EV-347 and E-336×Pop/209 indicated that selection of B-11, E-336, EV-347 and EV-1097 may be used for developing higher grain embryo percentage hybrids with greater hybrid vigor. Greater embryo percentage indicated the health of the seed and seedlings. Similar results were reported by

[4,11,17,18,19,21]. It was indicated from Table 1 that significant differences were recorded for fodder acid detergent fiber percentage.

The mean performance of parents and F_1 hybrids indicated that average fodder acid detergent fiber percentage was recorded as 22.899±0.2528%. It was also persuaded from Table 1 that higher heritability (96.50%) and lower genetic advance (8.01%) was recorded for fodder acid detergent fiber percentage. It was suggested from Table 4a that higher fodder acid detergent fiber percentage was recorded for E-336×EV-347 (26.10%), B-11×EV-340 (25.03%), B-11 (25.03%) and E-336 (24.87%) while lower fodder acid detergent fiber percentage was recorded for Raka-poshi×F-96 (19.97%), E-336 (20.80%), Raka-poshi×Pop/209 (20.37%) and B-327×F-96 (20.63%). The higher values of fodder acid detergent fiber percentage for F_1 hybrids E-336×EV-347 and B-11×EV-340 indicated that selection of E-336, B-11, EV-347 and EV-340 may be used for developing good quality fodder acid detergent fiber percentage hybrids. Higher fodder acid detergent fiber indicated better quality of maize fodder [1,4,11,18,21,22].

It was suggested from Table 1 that significant differences were recorded for fodder nutrient detergent fiber percentage. The mean performance of parents and F_1 hybrids indicated that average fodder nutrient detergent fiber percentage was recorded as 51.696±0.3078%. It was also persuaded from Table 1 that higher heritability (99.30%) and lower genetic advance (9.66%) was recorded for fodder nutrient detergent fiber percentage. It was indicated from Table 4a that higher fodder nutrient detergent fiber percentage was recorded for EV-1097×EV-340 (56.83%), EV-1097×E-322 (58.87%), EV-1097×F-96 (57.97%), Sh-139×EV-340 (55.76%) and B-327×EV-340 (55.67%) while lower fodder nutrient detergent fiber percentage was recorded for B-327×E-322 (40.10%), B-327×F-96 (43.60%), Raka-poshi×Pop/209 (45.03%) and B-327×EV-347 (45.40%). The lower values of fodder nutrient detergent fiber percentage for F_1 hybrids B-327×E-322, B-327×F-96, Raka-poshi×Pop/209 and B-327×EV-347 indicated that selection of B-327, E-322, EV-347, Raka-poshi and F-96 may be used for developing good quality fodder nutrient detergent fiber percentage hybrids. Lower fodder nutrient detergent fiber percentage indicated better quality of maize fodder [23-27].

It was shown from Table 1 that significant differences were recorded for fodder cellulose percentage. The mean performance of parents and F_1 hybrids indicated that average fodder cellulose percentage was recorded as 28.797±0.2755%. It was also persuaded from Table 1 that higher heritability (99.40%) and moderate genetic advance (16.79%) was recorded for fodder cellulose percentage. It was suggested from Table 4a that higher fodder cellulose percentage was recorded for EV-1097×EV-340 (33.97%), EV-1097×E-322 (36.43%), EV-1097×F-96 (34.33%) and B-327×EV-340 (33.53%) while lower fodder cellulose percentage was recorded for B-327×E-322 (17.20%), B-327×F-96 (22.97%), EV-1097 (24.47%) and B-327×EV-347 (24.40%). The lower values of fodder cellulose percentage for F_1 hybrids B-327×E-322, B-327×F-96 and B-327×EV-347 indicated that selection of B-327, E-322, EV-347, EV-1097 and F-96 may be used for developing good quality fodder cellulose percentage hybrids. Lower fodder cellulose percentage indicated better quality of maize fodder [26,28,29].

It was indicated from Table 1 that significant differences were recorded for fodder dry matter percentage. The mean performance of parents and F_1 hybrids indicated that average fodder dry matter percentage was recorded as 40.178±0.2442%. It was also persuaded from Table 1 that higher heritability (91.30%) and lower genetic advance (2.64%) was recorded for fodder dry matter percentage. It was suggested from Table 4a that higher fodder dry matter percentage was recorded for EV-1097×Pop/209 (41.67%), EV-1097×EV-347 (41.33%), EV-1097×E-322 (41.40%), E-336×F-96 (41.57%) and Sh-139×Pop/209 (41.40%) while lower fodder dry matter percentage was recorded for Raka-poshi×B-316 (39.10%), EV-340 (38.93%), EV-347 (38.13%) and E-322 (38.03%). The higher values of fodder dry matter percentage for F_1 hybrids EV-1097×Pop/209, EV-1097×EV-347, EV-1097×E-322, E-336×F-96 and Sh-139×Pop/209 indicated that selection of E-336, E-322, Sh-139, EV-1097 and F-96 may be used for developing good quality fodder dry matter percentage hybrids.

Higher fodder dry matter percentage indicated better quality of maize fodder. Findings were reported similar to [30,31,32] . It was found from Table 1 that significant differences were recorded for fodder crude fiber percentage. The mean performance of parents and F_1 hybrids indicated that average fodder crude fiber percentage was recorded as 26.845±0.1080%. It was also persuaded from Table 1 that higher heritability (99.40%) and lower genetic advance (7.02%) was recorded for fodder crude fiber percentage. It was suggested from Table 4a that higher fodder crude fiber percentage was recorded for EV-1097 (28.50%), B-327 (29.31%), Raka-poshi (28.99%), EV-1097×F-96 (28.40%) and Sh-139×EV-347 (28.50%) while lower fodder crude fiber percentage was recorded for E-336 × EV-340 (24.30%), B-11 (24.31%) and E-336 (24.10%). The higher values of fodder crude fiber percentage for F_1 hybrids EV-1097 × F-96 and Sh-139 × EV-347 indicated that selection of B-327, EV-347, Raka-poshi, Sh-139, EV-1097 and F-96 may be used for developing good quality fodder crude fiber percentage hybrids. Higher fodder crude fiber percentage indicated better quality of maize fodder [29,33,34].

It was suggested from Table 1 that significant differences were recorded for fodder crude protein percentage. The mean performance of parents and F_1 hybrids indicated that average fodder crude protein percentage was recorded as 10.353±0.1072%. It was also persuaded from Table 1b that higher heritability (99.30%) and moderate genetic advance (17.30%) was recorded for fodder crude protein percentage. It was suggested from Table 4b that higher fodder crude protein percentage was recorded for Sh-139 (12.69%), Raka-poshi (13.20%), E-336×Pop/209 (12.69%), B-11×B-316 (11.81%) and E-336×E-322 (11.96%) while lower fodder crude protein percentage was recorded for B-11×Pop/209 (8.82%), B-327×EV-340 (8.53%), B-327×F-96 (7.81%) and EV-1097×EV-347 (7.73%). The higher values of fodder crude protein percentage for F_1 hybrids E-336×Pop/209, B-11×B-316, and E-336×E-322 indicated that selection of E-336, Raka-poshi, Sh-139, EV-1097 and Pop/209 may be used for developing good quality fodder crude protein percentage hybrids. Higher fodder crude protein percentage indicated better quality of maize fodder [20]. It was found from Table 1 that significant differences were recorded for fodder moisture percentage.

The mean performance of parents and F_1 hybrids indicated that average fodder moisture percentage was recorded as 9.0951±0.0142%. It was also persuaded from Table 1 that higher heritability (99.30%) and lower genetic advance (2.55%) was recorded for fodder moisture percentage. It was suggested from Table 4b that higher fodder moisture percentage was recorded for B-327 (9.24%), E-336 (9.24%), E-336 × E-322 (9.22%), E-336×F-96 (9.24%) and B-327×EV-340 (9.21%) while lower fodder moisture percentage was recorded for B-11×Pop/209 (8.79%), B-11×B-316 (8.92%), B-316 (8.15%) and EV-1097×Pop/209 (8.91%). The higher values of fodder moisture percentage for F_1 hybrids E-336×E-322, E-336×F-96 and B-327×EV-340 indicated that selection of E-336 and B-327 may be used for developing good quality fodder moisture percentage hybrids. Higher fodder moisture percentage indicated better quality of maize fodder (Khalil *et al*., 2000; Awan *et al*. 2001; Yousaf and Saleem. 2001; Mazur et al. 2001; Dubey et al., 2001; Rai et al. 2004 and Xiang *et al*. 2010).

It was revealed from Table 1 that significant differences were recorded for fodder ether extractable fat percentage. The mean performance of parents and F_1 hybrids indicated that average fodder ether extractable fat percentage was recorded as 2.9055±0.0262%. It was also persuaded from Table 1 that higher heritability (92.00%) and lower genetic advance (9.09%) was recorded for fodder ether extractable fat percentage. It was suggested from Table 4b that higher fodder ether extractable fat percentage was recorded for F-96 (3.103%), B-327×EV-347 (3.027%), B-327×F-96 (3.017%) and Sh-139×B-316 (3.007%) while lower fodder ether extractable fat percentage was recorded for B-11×F-96 (2.727%), Raka-poshi (2.753%), B-327 (2.710%) and EV-1097 (2.747%). The higher values of fodder ether extractable fat percentage for F_1 hybrids B-327×EV-347, B-327×F-96 and Sh-139×B-316 indicated that selection of E-336, F-96, B-316 and B-327 may be used for developing good quality fodder ether extractable fat percentage hybrids. Higher fodder ether extractable fat percentage indicated better quality of maize fodder. Findings were found similar to [11,25].

It was shown from Table 1 that significant differences were recorded for fodder nitrogen free extract percentage. The mean performance of parents and F_1 hybrids indicated that average fodder nitrogen free extract percentage was recorded as 41.861±0.3720%. It was also persuaded from Table 1 that higher heritability (91.75%) and lower genetic advance (9.143%) was recorded for fodder nitrogen free extract percentage. It was suggested from Table 4b that higher fodder ether extractable fat percentage was recorded for E-336 (46.11%), B-11×Pop/209 (46.28%), B-327×F-96 (46.28%) and E-336×E-322 (46.18%) while lower fodder nitrogen free extract percentage was recorded for B-327 × Pop/209 (39.11%), Raka-poshi (37.84%), EV-347 (39.56%) and Sh-139 (38.84%). The higher values of fodder nitrogen free extract percentage for F_1 hybrids B-11×Pop/209, B-327×F-96 and E-336×E-322 indicated that selection of E-336, F-96, B-11 and B-327 may be used for developing good quality fodder nitrogen free extract percentage hybrids. Higher fodder nitrogen free extract percentage indicated better quality of maize fodder [20,24,25].

It was indicated from Table 1 that significant differences were recorded for fodder ash percentage. The mean performance of parents and F_1 hybrids indicated that average fodder ash percentage was recorded as 8.9026±0.100%. It was also persuaded from Table 1 that higher heritability (94.91%) and moderate genetic advance (14.362%) was recorded for fodder ash percentage. It was suggested from Table 4b that higher fodder ash percentage was recorded for EV-1097×F-96 (9.69%), EV-1097×E-322 (9.80%), B-11×EV-340 (9.91%) and B-11×E-322 (11.17%) while lower fodder ash percentage was recorded for B-11 × F-96 (8.14%), Raka-poshi (8.06%), B-11×EV-347 (8.05%) and Sh-139 (8.11%). The higher values of fodder ash percentage for F_1 hybrids EV-1097×F-96, EV-1097×E-322, B-11×EV-340 and B-11×E-322 indicated that selection of EV-1097, F-96, B-11 and EV-340 may be used for developing good quality fodder ash percentage hybrids. Higher fodder ash percentage indicated better quality of maize fodder [20,35].

3.1. Correlation Analysis

It was found that a positive significant genotypic and phenotypic correlation was found between grain protein percentage and grain oil percentage, embryo percentage, nutrient detergent fiber, cellulose percentage and dry matter percentage while a significant and negative correlation was found for fodder crude protein and ether extractable fat percentage at both genotypic and phenotypic levels (Table 2 and 2a). Significant correlations indicated that selection of good grain and fodder quality may be helpful for improving maize germplasm (Xiang et al. 2010; Ali et al. 2011b and Ali et al. 2012a). It was suggested that a positive significant genotypic and phenotypic correlation was found between grain oil percentage and grain protein percentage, embryo percentage and nitrogen free extract percentage while a significant and negative correlation was found for grain starch percentage, fodder crude protein and ether extractable fat percentage at both genotypic and phenotypic levels. Significant correlations indicated that selection of good grain and fodder quality may be helpful for improving maize breeding material (Table 2 and 2a). Findings were found similar to Ali et al [7].

It was revealed from Table 2 and 2a that a positive significant genotypic and phenotypic correlation was found between grain crude fiber percentage and embryo percentage and fodder moisture percentage. It was suggested that a negative significant genotypic and phenotypic correlation was found between grain starch percentage and grain oil percentage, nutrient detergent fiber, cellulose percentage, fodder moisture percentage and nitrogen free extract percentage (Table 2 and 2a). The quality of fodder may be enhanced by selecting genotypes on the basis of nutrient detergent fiber percentage [15,36]. It was persuaded from Table 2 and 2a that a positive significant genotypic and phenotypic correlation was found between embryo percentage and grain oil and protein percentage, grain crude fiber percentage, acid detergent fiber and fodder moisture percentage while a significant and negative correlation was found for nutrient detergent fiber, cellulose percentage, fodder ash percentage and ether extractable fat percentage at both genotypic and phenotypic levels.

Table 2. Genotypic correlations of various grain and fodder quality traits in maize

Traits	Grain oil %	Grain crude fiber %	Grain starch %	Embryo %	Acid detergent fiber %	Neutrient detergent fiber %	Fodder cellulose %	Fodder dry matter %	Fodder crude fiber %	Fodder crude protein%	Fodder moisture %	Ether free extractable fat %	Nitrogen free extract %	Fodder ash %
Grain protein %	0.2720*	-0.0697ns	-0.0935 ns	0.3933*	0.0290 ns	0.2508*	0.2496*	0.2275*	0.0209 ns	-0.1758*	-0.1148 ns	-0.4623*	0.1425 ns	0.0603 ns
Grain oil %		0.1297ns	-0.4201*	0.4926*	-0.1297 ns	-0.0526 ns	-0.0039 ns	0.1213 ns	-0.1118 ns	-0.2289*	0.1293 ns	-0.2092*	0.2744*	-0.1114 ns
Grain crude fiber %			-0.0361ns	0.2656*	0.0444 ns	-0.0094 ns	-0.0269 ns	0.1711 ns	0.0265 ns	0.0546 ns	0.3566*	0.0119 ns	-0.1296 ns	0.1279 ns
Grain starch %				-0.0585	0.0432 ns	-0.2298*	-0.2574*	-0.1118 ns	-0.0226 ns	0.0546 ns	-0.1845*	-0.2160*	0.0094 ns	0.1049 ns
Embryo %					0.2031*	-0.2479*	-0.3396*	-0.0089 ns	-0.0974 ns	0.0430 ns	0.2589*	-0.2803*	0.1019 ns	-0.1814*
Acid detergent fiber %						0.2812*	-0.1050 ns	-0.0442 ns	-0.0037 ns	0.2892*	0.2204*	-0.0784 ns	-0.1912*	0.0280 ns
Neutrient detergent fiber %							0.9316*	0.2118*	0.2973*	-0.0203 ns	-0.1344 ns	-0.1152 ns	-0.2055*	0.0242 ns
Fodder cellulose %								0.2373*	0.3100*	-0.1324 ns	-0.2229*	-0.0860 ns	-0.1379 ns	0.0155 ns
fodder dry matter %									0.1075 ns	0.0594 ns	-0.1092 ns	-0.2512*	-0.1293 ns	0.2077*
fodder crude fiber %										0.0069 ns	0.0743 ns	-0.4358*	-0.6903*	-0.1061 ns
Fodder crude protein %											0.0809 ns	0.0898 ns	-0.6668*	-0.1366 ns
Fodder moisture %												-0.0809 ns	-0.1449 ns	-0.1829*
Ether free extractable fat %													0.1664 ns	0.1029 ns
Nitrogen free extract %														-0.1232 ns

** = Significant at 5% significance level, * = Significant at 1% significance level, ns = Non-significant

It was found that a positive significant genotypic and phenotypic correlation was found between acid detergent fiber and embryo percentage, nutrient detergent fiber, fodder crude protein percentage and fodder moisture percentage while a significant and negative correlation was found for nitrogen free extract percentage at both genotypic and phenotypic levels (Table 2 and 2a). It was revealed that a positive significant genotypic and phenotypic correlation was found between nutrient detergent fiber and grain protein percentage, acid detergent fiber, fodder crude fiber percentage, cellulose percentage and fodder dry matter percentage while a significant and negative correlation was found for embryo percentage, grain starch percentage and nitrogen free extract percentage at both genotypic and phenotypic levels (Table 2 and 2a). Positive and significant correlations suggested that grain and fodder quality may be improved by selecting genotypes on the basis of grain protein and starch maize germplasm [37,38]. It was suggested that a positive significant genotypic and phenotypic correlation was found between cellulose percentage and nutrient detergent fiber, grain protein percentage, fodder crude fiber percentage and fodder dry matter percentage while a significant and negative correlation was found for embryo percentage, grain starch percentage and fodder moisture percentage at both genotypic and phenotypic levels (Table 2 and 2a). It was revealed that a positive significant genotypic and phenotypic correlation was found between fodder dry matter percentage and cellulose percentage, nutrient detergent fiber, grain protein percentage and fodder ash percentage while a significant and negative correlation was found for nitrogen free extract percentage at both genotypic and phenotypic levels (Table 2 and 2a). Good grain and fodder quality may be improved for maize germplasm [7,15,31,38]. It was suggested from Table 2 and 2a that a positive significant genotypic and phenotypic correlation was found between fodder crude fiber percentage and cellulose percentage and nutrient detergent fiber while a significant and negative correlation was found for ether extractable fat percentage and nitrogen free extract percentage at both genotypic and phenotypic levels.

Table 2a. Phenotypic correlations among various grain and fodder quality traits in maize

Traits	Grain oil %	Grain crude fiber %	Grain starch %	Embryo %	Acid detergent fiber %	Neutrient detergent fiber %	Fodder cellulose %	Fodder dry matter %	Fodder crude fiber %	Fodder crude protein%	Fodder moisture %	Ether free extractable fat %	Nitrogen free extract %	Fodder ash %
Grain protein %	0.2690**	-0.0603 ns	-0.0918 ns	0.3456**	0.0270 ns	0.2464**	0.2448**	0.2170**	0.0183 ns	-0.1747*	-0.1137 ns	0.4333**	0.1425 ns	0.0544 ns
Grain oil %		0.1220 ns	-0.4013**	0.4389**	-0.1290 ns	-0.0520 ns	-0.0030 ns	0.1128 ns	-0.1102 ns	-0.2276**	0.1266 ns	-0.1883*	0.2648**	-0.1036 ns
Grain crude fiber %			-0.0530 ns	0.2056*	0.0371 ns	-0.0131 ns	-0.0280 ns	0.1548 ns	0.0248 ns	0.0516 ns	0.3327**	0.0226 ns	-0.1190 ns	0.1178 ns
Grain starch %				-0.0584 ns	0.0427 ns	-0.2225**	-0.2469**	-0.1035 ns	-0.0218 ns	0.0533 ns	-0.1766*	-0.1985*	0.0085 ns	0.1012 ns
Embryo %					0.1722*	-0.2259**	-0.3008**	-0.0219 ns	-0.0888 ns	0.0400 ns	0.2235**	-0.2487**	0.0849 ns	-0.1642*
Acid detergent fiber %						-0.2765**	-0.1050 ns	-0.0421 ns	-0.0032 ns	0.2822**	0.2148**	-0.0701 ns	-0.1792 ns	0.0255 ns
Neutrient detergent fiber %							0.9267**	0.2058*	0.2961**	-0.0209 ns	-0.1315 ns	-0.1096 ns	-0.1971*	0.0241 ns
Fodder cellulose %								0.2301**	0.3077**	-0.1324 ns	-0.2200**	-0.0864 ns	0.1338 ns	0.0152 ns
Fodder dry matter %									0.1023 ns	-0.0579 ns	-0.1092 ns	-0.2257**	-0.1182 ns	0.1948*
Fodder crude fiber %										0.0072 ns	0.0743 ns	-0.4149**	-0.6648**	-0.1044 ns
Fodder crude protein %											0.0793 ns	0.0840 ns	-0.6559**	-0.1332 ns
Fodder moisture %												-0.0783	-0.1409 ns	-0.1798 ns
Ether free extractable fat %													0.1599 ns	0.0932 ns
Nitrogen free extract %														-0.1284 ns

** = Significant at 5% significance level, * = Significant at 1% significance level, ns = Non-significant

It was shown from results that a positive significant genotypic and phenotypic correlation was found between fodder crude protein percentage and acid detergent fiber while a significant and negative correlation was found for grain protein and oil percentage and nitrogen free extract percentage at both genotypic and phenotypic levels (Table 2 and 2a). It was indicated from results that a positive significant genotypic and phenotypic correlation was found between fodder moisture percentage and grain crude fiber percentage, embryo percentage and acid detergent fiber while a significant and negative correlation was found for grain starch percentage, cellulose percentage and fodder ash percentage at both genotypic and phenotypic levels (Table 2 and 2a). Significant correlations higher grain and fodder quality maize germplasm may be developed [18,24,28,38,39].

It was persuaded from Table 2 and 2a that a negative significant genotypic and phenotypic correlation was found between fodder ether extractable fat percentage and fodder moisture percentage and grain protein, oil, starch, embryo percentage, fodder dry matter percentage and fodder crude fithat a positive significant genotypic and phenotypic correber percentage. It was suggested from Table 2 and 2a lation was found between fodder nitrogen free extract percentage and grain oil percentage while a significant and negative correlation was found for acid detergent fiber, nutrient detergent fiber, fodder crude fiber percentage and fodder crude protein percentage at both genotypic and phenotypic levels. It was suggested from Table 2 and 2a that a positive significant genotypic and phenotypic correlation was found between fodder ash percentage and fodder dry matter percentage while a significant and negative correlation was found for embryo percentage and fodder moisture percentage [3,7,15,21,36].

3.2. North Carolina Mating Design-II

Table 3(a). Analysis of variance for grain and fodder quality traits in maize (North Carolina matting design-II)

SOV/Traits	Grain protein %	Grain oil %	Grain crude fiber %	Grain starch %	Embryo %	Acid detergent fiber %	Neutrient detergent fiber %	Fodder cellulose %
Replication	0.0056ns	0.0403ns	0.0192ns	0.0604ns	0.0278ns	0.2973ns	0.111ns	0.022ns
Males	0.1714**	0.1474**	0.1340*	1.1781*	0.1363**	4.1819*	35.281*	18.827*
Females	2.1185*	0.4896*	0.1185*	3.0277*	0.3305*	18.3353*	162.591*	158.548*
M × F	0.2161*	0.2011*	0.0993*	0.9400**	0.1536**	3.2882*	25.672*	22.520**
Error	0.01317	0.0101	0.0095	0.0482	0.0433	0.2369	0.239	0.255

(b). various genetic components for grain and fodder quality traits in maize (North Carolina matting design-II)

SOV/Traits	Grain protein %	Grain oil %	Grain crude fiber %	Grain starch %	Embryo %	Acid detergent fiber %	Neutrient detergent fiber %	Fodder cellulose %
σ^2_m	-0.002	-0.003	0.002	0.013	-0.001	0.049	0.534	-0.205
σ^2_f	0.106	0.016	0.001	0.116	0.009	0.836	7.607	7.557
$\sigma^2_{m\times f}$	0.068	0.064	0.029	0.297	0.037	1.017	8.478	7.422
σ^2_D	0.138	0.017	0.004	0.172	0.012	1.181	10.854	9.803
σ^2_H	0.271	0.255	0.119	1.189	0.147	4.068	33.911	29.688
$[\sigma^2_H/\sigma^2_D]^{1/2}$	1.403	3.827	5.479	2.627	3.350	1.856	1.768	1.740

* = Significant at 1 % significance level, ** = Significant at 5 % significance level, ns = Non-significant σ^2_m = male additive variance, σ^2_f = Female additive variance, $\sigma^2_{m\times f}$ = m×f interaction additive variance, σ^2_H = Dominance variance, σ^2_D = cumulative additive variance, $[\sigma^2_H/\sigma^2_D]^{1/2}$ = Degree of dominance

Table 3a. (a). Analysis of variance for fodder quality traits of maize (North Carolina matting design-II)

SOV/Traits	Fodder dry matter %	Fodder crude fiber %	Fodder crude protein %	Fodder moisture %	Fodder ether extractable fat %	Fodder nitrogen free extract (Carbohydrate %)	Fodder ash (%)
Replication	0.4504ns	0.0306ns	0.0263ns	0.0002ns	0.0016ns	0.5738ns	0.0370ns
Males	0.8319*	1.8399*	2.0761**	0.0501**	0.0041**	4.1020*	1.5453*
Females	4.6045*	16.4070*	9.2478*	0.0572**	0.0521*	12.4019*	1.7604*
M × F	1.0589**	2.4384*	4.2583*	0.0195**	0.0181*	9.4472*	1.2101*
Error	0.0797	0.0403	0.0304	0.0002	0.0020	0.5298	0.0381

(b). various genetic components for fodder quality traits of maize (North Carolina matting design-II)

SOV/Traits	Fodder dry matter %	Fodder crude fiber %	Fodder crude protein %	Fodder moisture %	Fodder ether extractable fat %	Fodder nitrogen free extract (Carbohydrate %)	Fodder ash (%)
σ^2_m	-0.013	-0.033	-0.121	0.002	-0.001	-0.297	0.019
σ^2_f	0.197	0.776	0.277	0.002	0.002	0.164	0.031
$\sigma^2_{m\times f}$	0.326	0.799	1.409	0.006	0.005	2.973	0.391
σ^2_D	0.246	0.990	0.208	0.005	0.001	-0.177	0.066
σ^2_H	1.306	3.197	5.637	0.026	0.021	11.889	1.563
$[\sigma^2_H/\sigma^2_D]^{1/2}$	2.305	1.797	5.206	2.251	3.786	-8.194	4.881

* = Significant at 1 % significance level, ** = Significant at 5 % significance level ns = Non-significant, σ^2_m = male additive variance, σ^2_f = Female additive variance, $\sigma^2_{m\times f}$ = m×f interaction additive variance, σ^2_H = Dominance variance, σ^2_D = cumulative additive variance, $[\sigma^2_H/\sigma^2_D]^{1/2}$ = Degree of dominance

Table 4.Statistical significance of parents and F_1 hybrids of maize for various grain quality traits

Genotypes	Grain protein %	Grain oil %	Grain crude fiber %	Grain starch %	Embryo %
Pop/209	10.20 BC	5.200ABCD	9.490DEFGHI	71.53JKLMNO	11.77CDEFGH
B-316	10.07 CD	4.800FGH	9.120 NO	71.77HIJKL	11.60 FGHI
EV-340	9.800 EFG	4.770FGHI	9.350HIJKLM	72.27 DEF	11.60 FGHI
E-322	9.400LMNOPQ	4.200 MN	9.430 FGHIJ	72.33 DE	11.57 GHI
F-96	9.433KLMNOP	4.030 N	9.520DEFGH	72.17DEFGH	11.60 FGHI
EV-347	9.433KLMNOP	4.730FGHIJ	9.310IJKLMN	71.50JKLMNO	11.67DEFGHI
B-11	10.27 BC	5.070 DE	9.100 O	71.50JKLMNO	12.03 BCD
E-336	10.30 BC	5.230ABCD	9.270 JKLMNO	71.20 O	12.13 BC
EV-1097Q	9.367MNOPQ	5.100 D	9.800 AB	72.20DEFGH	12.20 B
B-327	9.333MNOPQ	4.730FGHIJ	9.600 CDEF	72.20DEFGH	11.80CDEFGH
Raka-poshi	9.400LMNOPQ	4.570 IJK	9.330HIJKLM	73.20 C	11.77CDEFGH
Sh-139	9.633FGHIJKL	4.130 MN	9.130 NO	73.63 B	11.67DEFGHI
B-11×Pop/209	9.633FGHIJKL	4.830 FGH	9.230 KLMNO	73.17 C	11.57 GHI
B-11×B-316	9.633FGHIJKL	4.730FGHIJ	9.400FGHIJK	74.20 A	11.67DEFGHI
B-11×EV-340	9.800 EFG	4.270 LM	9.500 DEFGHI	73.17 C	11.77CDEFGH
B-11×E-322	9.300 NOPQ	5.130 CD	9.670 BCD	72.23 DEFG	11.63 EFGHI
B-11×F-96	10.07 CD	5.130 CD	9.470 EFGHI	71.17 O	11.67DEFGHI
B-11×EV-347	10.13 BC	5.230ABCD	9.370 GHIJKL	71.23 NO	12.60 A
E-336×Pop/209	10.10 BCD	5.400 A	9.670 BCD	71.37 LMNO	12.20 B
E-336×B-316	9.900 DE	5.100 D	9.870 A	71.43KLMNO	12.03 BCD
E-336×EV-340	9.700EFGHIJ	4.830FGH	9.770 ABC	71.67JKLMN	11.67DEFGHI
E-336×E-322	9.467JKLMNO	4.900 EF	9.800 AB	71.43KLMNO	11.60 FGHI
E-336×F-96	9.567GHIJKLM	4.770FGHI	9.370GHIJKL	71.30 MNO	11.70DEFGHI
E-336×EV-347	9.700EFGHIJ	4.700FGHIJ	9.100 O	71.60JKLMNO	11.73DEFGHI
EV-1097Q×Pop/209	9.733 EFGHI	4.630 HIJ	9.200 LMNO	71.30 MNO	11.70DEFGHI
EV-1097Q×B-316	10.17 BC	4.670 GHIJ	9.670 BCD	71.53JKLMNO	11.73DEFGHI
EV-1097Q×EV-340	10.33 B	4.770 FGHI	9.470 EFGHI	71.73IJKLM	11.60 FGHI
EV-1097Q×E-322	10.13 BC	4.830 FGH	9.470 EFGHI	72.17DEFGH	11.73DEFGHI
EV-1097Q×F-96	10.67 A	4.830 FGH	9.630 BCDE	72.27 DEF	11.80CDEFGH
EV-1097Q×EV-347	10.77 A	5.130 CD	9.500DEFGHI	72.13DEFGHI	11.83BCDEFGH
B-327×Pop/209	10.33 B	5.230 ABCD	9.400FGHIJK	72.40 D	12.00 BCDE
B-327×B-316	9.800 EFG	5.270 ABCD	9.530DEFGH	72.23DEFG	12.13 BC
B-327×EV-340	10.10 BCD	4.700FGHIJ	9.430FGHIJ	72.37 D	11.93BCDEFG
B-327×E-322	9.767EFGH	4.770 FGHI	9.570 DEFG	72.37 D	11.87BCDEFGH
B-327×F-96	9.833 EF	4.670 GHIJ	9.170 MNO	72.43 D	11.83BCDEFGH
B-327×EV-347	9.533HIJKLMN	4.530 JK	9.670 BCD	71.90EFGHIJ	11.97 BCDEF
Raka-poshi×Pop/209	9.167 Q	5.200ABCD	9.470EFGHI	72.33 DE	11.97 BCDEF
Raka-poshi×B-316	9.400 LMNOPQ	5.370 AB	9.430 FGHIJ	71.83FGHIJK	11.73DEFGHI
Raka-poshi×EV-340	9.500IJKLMNO	5.330 ABC	9.170 MNO	71.77HIJKL	11.77CDEFGH
Raka-poshi×E-322	9.667EFGHIJK	5.170 BCD	9.200 LMNO	71.20 O	11.57 GHI
Raka-poshi×F-96	9.567GHIJKLM	5.130 CD	9.370GHIJKL	71.37LMNO	11.50 HIJ
Raka-poshi×EV-347	9.433KLMNOP	4.870 FG	9.430 FGHIJ	71.17 O	11.77CDEFGH
Sh-139×Pop/209	9.467 JKLMNO	4.630 HIJ	9.500DEFGHI	72.27 DEF	11.67DEFGHI
Sh-139×B-316	9.267 OPQ	4.770FGHI	9.630 BCDE	71.80GHIJKL	11.60 FGHI
Sh-139×EV-340	9.200 PQ	4.670 GHIJ	9.500DEFGHI	71.77HIJKL	11.73DEFGHI
Sh-139×E-322	9.200 PQ	4.770 FGHI	9.500DEFGHI	71.70IJKLM	11.73DEFGHI
Sh-139×F-96	9.500IJKLMNO	4.400 KL	9.170 MNO	71.50JKLMNO	11.37 IJ
Sh-139×EV-347	9.333MNOPQ	4.870 FG	9.370GHIJKL	71.37LMNO	11.20 J

Table 4a. Statistical significance of parents and F_1 hybrids of maize for various fodder quality traits

Genotypes	Acid detergent fiber %	Neutrient detergent fiber %	Fodder cellulose %	Fodder dry matter %	Fodder crude fiber %
Pop/209	21.50RST	51.57MNOP	30.07 FG	39.33OPQ	28.35 CD
B-316	20.80TUV	53.43GHIJ	32.63 C	40.27GHIJKLM	27.37 F
EV-340	24.00DEFGH	53.77 GHI	29.77 GH	38.93 Q	27.39 F
E-322	24.27BCDE	55.43 D	31.13 DE	38.03 R	27.27 F
F-96	22.60KLMNOPQ	53.27 HIJ	30.67 EF	39.47MNOPQ	26.26 JK
EV-347	23.23GHIJKLM	51.47MNOP	28.23 I	38.13 R	27.89 E
B-11	25.03 B	49.83 RST	24.80 LM	39.40NOPQ	24.31 QR
E-336	24.87 BC	55.50 D	30.63 EF	40.00IJKLMNO	24.10 R
EV-1097Q	24.37 BCDE	48.83 UV	24.47 M	40.87ABCDEFGH	28.58 C
B-327	23.37FGHIJKL	50.77 OPQ	27.40 IJK	40.27GHIJKLM	29.31 A
Raka-poshi	23.20HIJKLMN	49.90 QRS	26.70 K	40.00IJKLMNO	28.99 B
Sh-139	23.40FGHIJKL	48.63 UV	25.23 LM	39.90JKLMNOP	28.38 CD
B-11×Pop/209	22.20 PQR	48.90TUV	26.70 K	40.63DEFGHIJ	24.37 QR
B-11×B-316	23.40FGHIJKL	50.57 PQR	27.17 JK	39.93JKLMNO	24.45 Q
B-11×EV-340	25.03 B	51.83 LMN	26.80 K	40.10HIJKLMNO	25.31 O
B-11×E-322	22.70KLMNOPQ	49.43 STU	26.73 K	39.93 JKLMNO	25.39 NO
B-11×F-96	22.37 NOPQ	49.57 STU	27.20 JK	39.53 LMNOPQ	27.12 FG
B-11×EV-347	24.07 CDEFG	51.37MNOP	27.30 JK	39.33 OPQ	27.31 F
E-336×Pop/209	24.20 CDEF	51.60 MNO	27.40 IJK	40.33 GHIJKL	27.88 E
E-336×B-316	24.60 BCD	54.03 GH	29.43 GH	40.53 EFGHIJK	24.82 P
E-336×EV-340	22.07 PQRS	48.73 UV	26.67 K	40.00 IJKLMNO	24.30 QR
E-336×E-322	22.30 OPQR	49.83 RST	27.53 IJK	41.00 ABCDEFG	25.66 MN
E-336×F-96	24.33 BCDE	49.80 RST	25.47 L	41.57 AB	25.89 LM
E-336×EV-347	26.10 A	51.00 NOP	24.90 LM	41.20 ABCDEF	26.28 J
EV-1097Q×Pop/209	20.83 TUV	52.27KLM	31.43 DE	41.67 A	27.42 F
EV-1097Q×B-316	22.10 PQRS	53.53GHIJ	31.43 DE	40.87ABCDEFGH	27.36 F
EV-1097Q×EV-340	22.87JKLMNOPQ	56.83 C	33.97 B	40.63DEFGHIJ	27.36 F
EV-1097Q×E-322	22.47 MNOPQ	58.87 A	36.43 A	41.40ABCD	28.33 CD
EV-1097Q×F-96	23.63 EFGHIJ	57.97 B	34.33 B	41.33 ABCDE	28.40 CD
EV-1097Q×EV-347	22.37 NOPQ	55.00 DEF	32.63 C	41.33 ABCDE	28.12 DE
B-327×Pop/209	21.50 RST	48.30 V	26.80 K	40.70CDEFGHIJ	27.30 F
B-327×B-316	23.13IJKLMNO	51.03 NOP	27.90 IJ	40.30GHIJKLM	27.35 F
B-327×EV-340	22.13 PQRS	55.67 D	33.53 B	40.00 IJKLMNO	27.27 F
B-327×E-322	22.90 JKLMNOP	40.10 Y	17.20 O	39.97 JKLMNO	26.89 GH
B-327×F-96	20.63 UVW	43.60 X	22.97 N	39.33 OPQ	25.42 NO
B-327×EV-347	21.00 TUV	45.40 W	24.40 M	39.47 MNOPQ	25.31 O
Raka-poshi×Pop/209	20.37 VW	45.03 W	24.67 LM	39.47 MNOPQ	25.95 KLM
Raka-poshi×B-316	22.03 QRS	52.07 KLM	30.03 FG	39.10 PQ	26.19 JKL
Raka-poshi×EV-340	22.57 LMNOPQ	53.63 GHI	31.07 DE	40.00 IJKLMNO	26.41 IJ
Raka-poshi×E-322	22.03 QRS	52.97 IJK	30.93 DE	40.30 GHIJKLM	26.43 IJ
Raka-poshi×F-96	19.97 W	51.43 MNOP	31.47 DE	40.83BCDEFGHI	26.69 HI
Raka-poshi×EV-347	21.33 STU	52.60 JKL	31.27 DE	41.33ABCDE	26.46 IJ
Sh-139×Pop/209	23.43 FGHIJK	54.27 FG	30.83 EF	41.47 ABC	27.91 E
Sh-139×B-316	24.20 CDEF	55.30 DE	31.10 DE	40.47FGHIJK	27.21 F
Sh-139×EV-340	23.87 DEFGHI	55.67 D	31.80 D	39.90JKLMNOP	27.36 F
Sh-139×E-322	22.40 MNOPQ	51.47 MNOP	29.07 H	40.20GHIJKLMN	27.84 E
Sh-139×F-96	23.40 FGHIJKL	54.37 EFG	30.97 DE	39.70KLMNOPQ	28.13 DE
Sh-139×EV-347	24.00 DEFGH	54.97 DEF	30.97 DE	40.10HIJKLMNO	28.50 C

Table 4b.Statistical significance of parents and F_1 hybrids of maize for various fodder quality traits

Genotypes	Fodder crude protein %	Fodder moisture %	Fodder ether extractable fat %	Fodder nitrogen free extract (Carbohydrate %)	Fodder ash %
Pop/209	9.630OPQ	9.190BCDE	2.867IJKL	41.36JKLMNO	8.600MNOPQ
B-316	8.970 S	8.150 P	2.903EFGHIJK	43.46 BC	9.130HIJK
EV-340	9.770NOP	9.120GHIJ	2.950BCDEFGHI	41.63HIJKLMN	9.140GHIJK
E-322	11.81 CD	9.090 IJ	3.000 BCD	39.89 QRS	8.930JKLM
F-96	11.01 IJ	9.090 IJ	3.103 A	41.78GHIJKLM	8.760 LMNO
EV-347	11.81 CD	9.120GHIJ	2.917DEFGHIJK	39.56 RS	8.700 MNO
B-11	11.01 IJ	9.160DEFG	2.940BCDEFGHI	43.31 BCDE	9.270 FGHI
E-336	9.480 PQ	9.240A	2.810 LMNO	46.11 A	8.270QRSTU
EV-1097Q	9.630OPQ	9.200ABCD	2.747 OP	40.69MNOPQR	9.170FGHIJ
B-327	9.770NOP	9.240 A	2.710 P	40.34 OPQR	8.630 MNOP
Raka-poshi	13.20 A	9.170CDEF	2.753 NOP	37.84 T	8.060 U
Sh-139	12.69 B	9.140FGH	2.840 KLM	38.84 ST	8.110 TU
B-11×Pop/209	8.820 ST	8.790 O	2.880 GHIJKL	46.28 A	8.850 KLMN
B-11×B-316	11.81 CD	8.920 N	2.877 HIJKL	43.18BCDEF	8.770 LMNO
B-11×EV-340	11.31FGHI	8.950 MN	2.933CDEFGHIJ	41.59HIJKLMNO	9.910 B
B-11×E-322	10.87JK	9.160DEFG	2.963BCDEFGH	40.46 NOPQR	11.17 A
B-11×F-96	11.66CDE	9.200ABCD	2.727 OP	41.15 KLMNOP	8.140 TU
B-11×EV-347	11.01 IJ	9.200ABCD	2.870 IJKL	41.55IJKLMNO	8.050 U
E-336×Pop/209	12.69 B	9.150EFGH	3.000 BCD	39.11 S	8.170 STU
E-336×B-316	11.23GHI	9.090IJ	2.980 BCDE	43.70 B	8.190 RSTU
E-336×EV-340	8.820 ST	9.200ABCD	2.980 BCDE	46.18 A	8.510 OPQR
E-336×E-322	11.96 C	9.220 AB	2.957BCDEFGHI	41.60HIJKLMNO	8.610 MNOP
E-336×F-96	11.09HIJ	9.240 A	2.933CDEFGHIJ	41.18KLMNOP	9.660 BCD
E-336×EV-347	11.52DEFG	8.970 M	2.930CDEFGHIJ	40.68 MNOPQR	9.630BCDE
EV-1097Q×Pop/209	11.74 CD	8.910 N	2.943BCDEFGHI	39.66 RS	9.330EFGHI
EV-1097Q×B-316	11.38EFGH	9.030 L	2.887 FGHIJKL	39.96 PQRS	9.400DEFGH
EV-1097Q×EV-340	11.59 DEF	9.040 KL	2.810 LMNO	39.71 RS	9.490 CDEF
EV-1097Q×E-322	8.970 S	9.030 L	2.837 KLMN	41.04LMNOPQ	9.800 BC
EV-1097Q×F-96	9.340 QR	9.080 JK	2.847 JKL	40.65MNOPQR	9.690 BCD
EV-1097Q×EV-347	7.730 U	9.110 HIJ	2.757 MNOP	43.00BCDEFG	9.270 FGHI
B-327×Pop/209	9.630 OPQ	9.120GHIJ	2.763 MNOP	42.63BCDEFGHI	8.570 NOPQ
B-327×B-316	10.06 MN	9.130FGHI	2.763 MNOP	42.34CDEFGHIJK	8.350PQRSTU
B-327×EV-340	8.530 T	9.210 ABC	2.757 MNOP	42.83BCDEFGH	9.410DEFGH
B-327×E-322	8.830 ST	9.190BCDE	2.940BCDEFGHI	42.72BCDEFGHI	9.440DEFGH
B-327×F-96	7.810 U	9.160DEFG	3.017 BC	46.28 A	8.330PQRSTU
B-327×EV-347	11.01 IJ	9.170CDEF	3.027 B	42.01FGHIJKL	9.470 DEFG
Raka-poshi×Pop/209	9.630 OPQ	9.040 KL	2.990 BCDE	43.03BCDEFG	9.370DEFGHI
Raka-poshi×B-316	9.700 OP	9.040 KL	2.980 BCDE	43.34 BCD	8.750LMNO
Raka-poshi×EV-340	9.840 MNO	9.120GHIJ	2.980 BCDE	43.04BCDEFG	8.610 MNOP
Raka-poshi×E-322	9.910 MNO	9.110 HIJ	2.973 BCDEF	42.94BCDEFG	8.630 MNOP
Raka-poshi×F-96	10.65 KL	9.130FGHI	2.950BCDEFGHI	42.08DEFGHIJKL	8.500OPQRS
Raka-poshi×EV-347	10.53 L	9.140 FGH	2.930CDEFGHIJ	39.79 RS	8.480 OPQRS
Sh-139×Pop/209	11.01 IJ	9.120GHIJ	2.950BCDEFGHI	40.57 MNOPQR	8.430OPQRST
Sh-139×B-316	10.13 M	9.130FGHI	3.007 BCD	42.05EFGHIJKL	8.470 OPQRS
Sh-139×EV-340	9.700 OP	9.140 FGH	2.993 BCDE	42.22CDEFGHIJKL	8.600 MNOPQ
Sh-139×E-322	9.630 OPQ	9.160DEFG	2.953BCDEFGHI	41.36 JKLMNO	9.060 IJKL
Sh-139×F-96	9.040 RS	9.130FGHI	2.870 IJKL	42.55BCDEFGHIJ	8.180 RSTU
Sh-139×EV-347	8.970 S	9.150EFGH	2.970 BCDEFG	41.14 KLMNOP	9.270 FGHI

It was suggested from results given in Table 3 that significant differences were found for grain protein percentage. The results also indicated that higher additive variance for male × female interaction was found for fodder crude fiber, fodder nitrogen free extract (carbohydrates), acid detergent fiber, nutrient detergent fiber and fodder cellulose while lowest for fodder moisture percentage and ether extractable fat. Higher female additive variance as reported for acid detergent fiber, fodder crude fiber, nutrient detergent fiber and fodder cellulose while lowest for grain crude fiber, fodder moisture percentage and ether extractable fat. Higher male additive variance was found for acid detergent fiber, nutrient detergent fiber and fodder ash percentage. The higher cumulative additive effect was recorded for acid detergent fiber, fodder crude fiber, nutrient detergent fiber and fodder cellulose while lowest for grain crude fiber, fodder moisture percentage and ether extractable fat but higher dominance effect was recorded for grain starch percentage, acid detergent fiber, fodder crude fiber, nutrient detergent fiber, fodder dry matter, fodder ash, fodder crude fiber and fodder cellulose while lowest was recorded for fodder moisture percentage and ether extractable fat. The highest degree of dominance was recorded for grain crude fiber, fodder crude fiber and fodder ash percentage while lowest was for fodder nitrogen free extract. Higher values of dominance effect and degree of dominance indicated that over type of dominance gene action was shown for grain and fodder quality traits. The over dominance and higher degree of dominance indicated that selection on the basis of grain and fodder quality may be helpful for the development of hybrid seed with better grain and fodder quality [39-42].

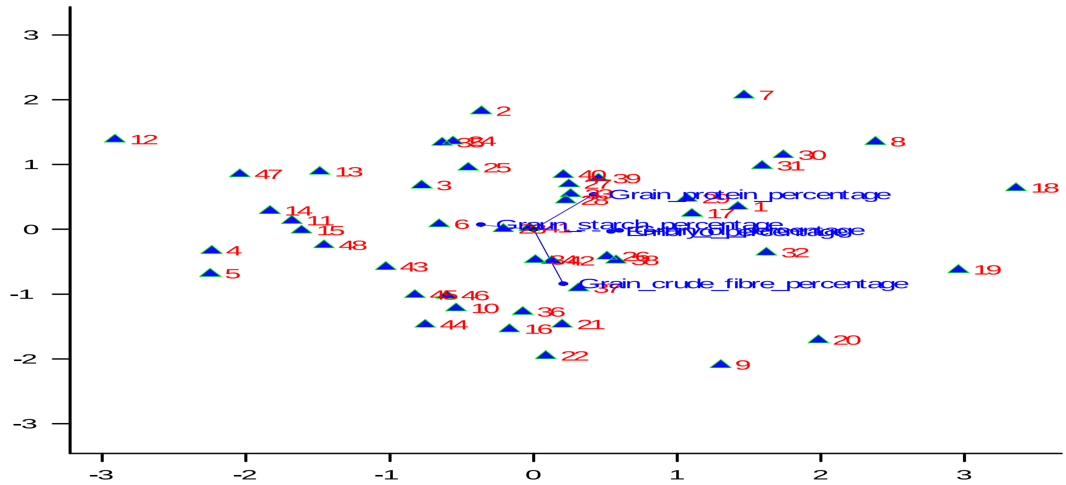
3.3. Principle Component Bi-plot Analysis

It was suggested from principle component bi-plot 1 that the inbred lines B-11, B-336, Sh-139 and EV-1097 and F_1 hybrids B-11×EV-347, B-336×Pop/209, B-336×B-316, B-336×E-322 and Sh-139×F-96 performed well for grain oil percentage, grain crude protein percentage, grain starch percentage and embryo percentage. The performance of B-11, B-11×EV-347, EV-1097×E-322, Sh-139×B-316, B-327×E-322 and Sh-139×F-96 was higher for ether extractable fat percentage, ash percentage, fodder cellulose percentage, fodder crude fiber percentage and acid detergent percentage (principle component bi-plot 2) while B-316, Raka-poshi, B-11×Pop/209, B-336×EV-340, B-327×E-322, B-327×F-96, EV-1097×E-322, Raka-poshi×EV-347, EV-1097×Pop/209 and EV-1097×EV-340 performed better for fodder moisture percentage, nitrogen free extract percentage (carbohydrates %), nutrient detergent fiber percentage, fodder crude protein percentage and fodder dry matter percentage (principle component bi-plot 3). It was concluded from principle component bi-plot analysis that the accessions that performed better for all grain and fodder quality traits may be used for the development of good quality maize hybrids and synthetic varieties to improve maize yield and production. Results were in favor of the finds reported by [11,20,21,43].

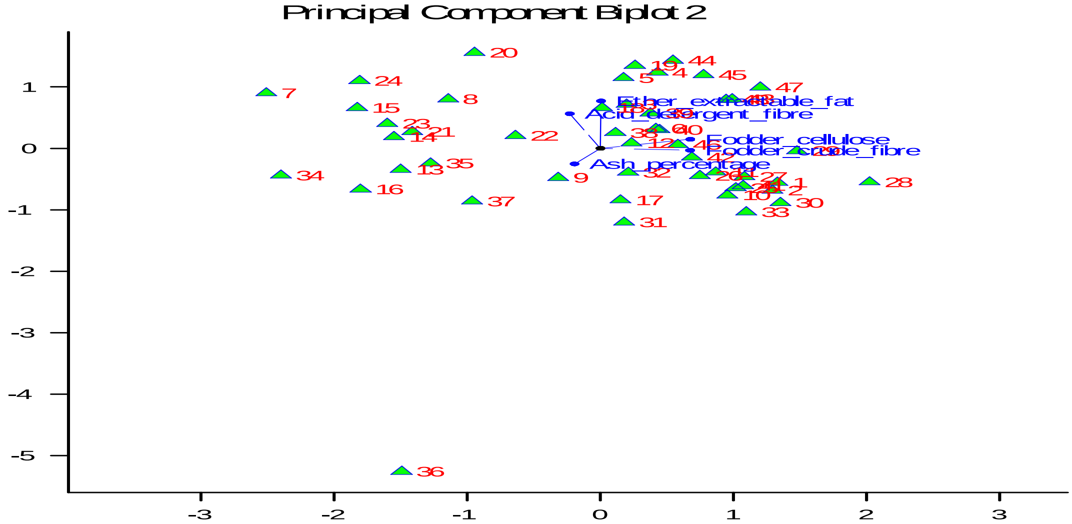
4. Conclusions

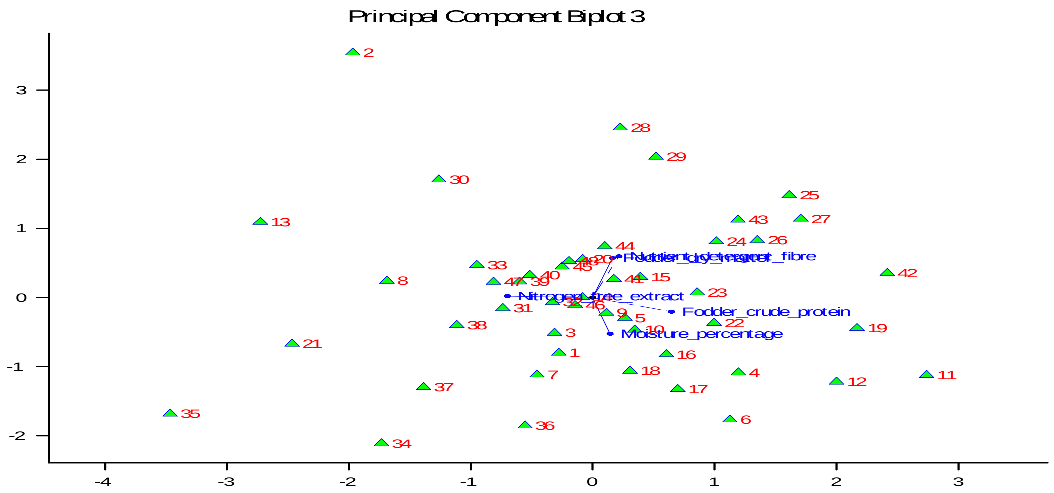
From prescribed study, it was reported from results that higher heritability, genetic advance, significant genotypic and phenotypic correlation and cumulative additive effect for grain protein percentage, grain oil percentage, grain starch percentage, nutrient detergent fiber, fodder cellulose, fodder crude fiber, fodder crude protein and fodder moisture percentage suggested that selections may be made to develop synthetic varieties for better quality but higher dominance effect and degree of dominance indicated that selection may be useful for the development of good quality maize hybrids through heterosis breeding program. Principle component bi-plot analysis indicated that B-11×EV-347, B-11, Sh-139, EV-1097×E-322, Sh-139×B-316, B-327×E-322, B-316, Raka-poshi, B-11×Pop/209, B-336×EV-340, B-327×E-322, B-327×F-96, EV-1097×E-322, Raka-poshi×EV-347, EV-1097×Pop/209 and EV-1097×EV-340 performed better for grain and fodder quality and may be used for improvement of grain and fodder quality of maize .

Principal Component Biplot 1



Principal Component Biplot 2





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Conflict of Interest

Authors have shown no conflict of interest.

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