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CORRELATION AND PATH COEFFICIENT ANALYSIS IN MAIZE GENOTYPES

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ABSTRACT

A study was conducted to assess the genetic variability, characters association for the direct and indirect effects of 16 morpho-physiological traits in 24 maize inbred lines. A trial was conducted during kharif, 2012 following a randomized block design with three replications. Analysis of variance revealed that there were a significant differences among the genotypes for all the traits studied. Highest PCV and GCV were observed for leaf area/plant, preceded by cobs/plant and kernels/row. Correlation coefficient revealed that cob length (0.54, 0.55), leaf area/plant (0.52, 0.53), grain rows/cob (0.38, 0.40), 100 seed weight (0.38, 0.39), cobs/plant (0.36, 0.37) and leaf relative water content (0.32, 0.35) had significant positive correlation with grain yield/plant at the phenotypic (r_p) and genotypic levels (r_g), respectively. However, days to maturity and plant height showed negative correlation with grain yield/plant at the genotypic level.Path coefficient analysis reflected that days to 50 % silking (0.153), cob height (0.003), cobs/plant (0.087), cob length (0.213), number of grain rows/cob (0.354), kernels/row (1.282), 100 seed weight (1.165), plant height (0.024), cob girth (0.074) and chlorophyll content (0.034) showed positive direct effect on grain yield at the genotypic levels. While, days to 50% tasselling (-0.132), anthesis-silking interval (-0.036) and days to maturity (-0.096) showed negative direct effect on grain yield at the genotypic level. Positive but indirect effects were shown by days to 50% tasselling (0.109), days to 50% silking (0.066), cob length (0.555), cob girth (0.366), grain rows/cob (0.404), kernels/row (0.232), 100 seed weight (0.394), chlorophyll content (0.120), leaf area/plant (0.532) and leaf relative water content (0.358) at the genotypic level. Thus, the selection of such characters would help to improve the grain yield of maize in further breeding program.

Key words: Maize, physiological traits, correlation coefficients, path analysis

INTRODUCTION

Maize (*Zea mays* L.; 2n=20) is the third most widely distributed crop of the world, being grown in diverse seasons and ecologies with highest production and productivity among food cereals. Among the cereals, maize is rich in starch, oil, sucrose and carotene. Maize serves as a source of basic raw material for a number of industries *viz*., starch, protein, oil, alcoholic beverages, food, sweeteners, cosmetics and bio-fuels (Khan and Dubey 2015). Globally 67 percent of maize is used for livestock feed, 25% human consumption, industrial purposes and balance is used as seed and the demand for grain is increasing worldwide (Reddy *et al.* 2013). Yield of corn (*Zea mays* L.) is considered as a complex inherited character therefore, direct selection for yield *per se* may not be the most efficient method for its improvement, but indirect selection for other yield related characters, which are closely associated with yield and high heritability estimates will be more effective. Genetic correlation analysis is a handy technique which elaborates the degree of association among important quantitative traits. In order to develop promising genotypes with high yielding potential, it is essential to know the associations among different traits, especially with grain yield, which is the most important and ultimate objective in any breeding programme (Rafiq *et al.* 2010). Association studies could lead plant breeders in the selection of traits contributing towards the character(s) of concern, and ultimately their improvement through hybridization. With increased industrial demand, it is necessary to maximize maize production at a much faster pace than at current. Knowing the correlations between traits is of great importance for success of selections in breeding programmes (Alake *et al.* 2008). The analysis of correlation coefficient is one of the most widely used tool among numerous methods that can be used. A path coefficient analysis permits the separation of correlation coefficient into direct and indirect effects (effects exerted through other variables) and effectively measuring the relative importance of causal factors. The study of characters association along with the path coefficient analysis has been applied in many

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crops like, rice (Allam *et al.* 2015), wheat (Singh *et al.* 2014), barley (Singh *et al.* 2014), sorghum (Kumar 2013). It is therefore, necessary to analyze the cause and effect relationship between dependent and independent variables to untangle nature of relationship between variables. Keeping these points in view, an effort was made to measure genetic variability among the characters in maize and to study the relationship between yield and its component characters in maize.

MATERIALS AND METHODS

The experimental materials consisted of 24 diverse maize genotypes, obtained from the Department of Genetics and Plant Breeding, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad (U.P.). Field trials were laids out in a randomized block design with three replications with a spacing of 60 cm x 20 cm (3.0 m row length for each entry) The recommended cultural practices were followed to raise healthy plants. Five plants from the middle row of each entry in each replication were randomly taken for recording observations on days to 50% silking, days to 50 % tasselling, anthesis-silking interval, days to maturity, plant height, cob height, number of cobs/plant, ear length, ear girth, grain rows/ cob, kernels/row, 100 grains weight, chlorophyll content, leaf area/plant, leaf relative water content and grain yield/plant. The data were analyzed by using analysis of variance suggested by Panse and Sukhatme (1964), and genetic parameters such as PCV and GCV were calculated by the formula given by Burton (1952), heritability in broad sense (h^2) by Lush (1949), genetic advance in percent of mean (genetic gain) were work out as suggested by Johnson *et al.* (1955), correlation coefficient by Al-jibouri *et al.* (1958) and path coefficient analysis by Dewey and Lu (1959).

RESULTS AND DISCUSSIONS

Analysis of variance

The analysis of variance (Table 1) revealed that there were significant differences among the characters which indicated that sufficient genetic variability were present among the different genotypes. These results are in accordance with findings of Alake *et al.* (2008), Krupakar *et al.* (2013) and Agrawal *et al.* (2014) who observed significant variability for yield and its contributing traits in maize inbred lines.

Table 1: Analysis of variance for yield and yield related characters in 24 inbred lines

Source of Variations	Replication (df=2)	Treatment (df=23)	Error (df=46)
Days to 50 % tasselling	0.01	4.60**	0.09
Days to 50 % silking	0.00	4.52**	0.05
Anthesis-silking interval	0.00	0.51**	0.00
Days to maturity	0.00	31.65**	0.13
Plant height	15.79	1287.57**	8.51
Cob height	29.32	175.94**	45.72
Cobs/plant	0.00	0.51**	0.00
Cob length	0.00	11.13**	0.00
Cob girth	0.61	2.74**	0.91
Grain rows/cob	0.14	2.47**	0.16
Kernels/row	0.14	82.51**	0.57
Grain yield/plant	0.48	275.75**	2.61
100 seed weight	0.55	30.44**	0.36
Chlorophyll content (SPAD)	0.85	128.53**	1.94
Leaf area/plant	9286.92	6751197.00**	16344.39
Leaf relative water content	7.61	150.46**	6.06

*** Significant at 0.01 level of significance; * Significant at 0.05 level of significance*

Genetic variability

The highest GCV and PCV values (Table 2) were recorded for leaf area/plant (36.21, 36.29) followed by cobs/plant (32.97, 33.06), kernel/row (23.67, 23.84) and anthesis-silking interval (20.02, 20.03), respectively. The differences between PCV and GCV values were low for most of the characters studied indicating low environmental influence in the characters expression. However, cob height (3.27) and cob girth (3.92) showed high difference in the PCV and GCV values reflecting considerably high environmental influence. These characters also had medium heritability (between 0.50 and 0.59) coupled with low genetic gain. These results were well supported by Langade *et al.* (2013) and Reddy *et al.* (2013). Except cob height and cob girth, all other characters studied have high heritability's indicating that the selection is effective for the improvement of grain yield and associated characters. These results were well supported by Sharma *et al.* (2014). Hepziba *et al.* (2013) revealed high broad-sense heritability for cobs/plant and 100 grains weight in maize. Direct selection can be done for enhancing grain yield since it has high heritability (0.98) and genetic gain (23.85). Agrawal *et al.* (2014) reported moderate heritability and genetic advance for grain yield, ear height, plant height and ear length. Ali *et al.* (2013) and Mustafa *et al.* (2014) recorded higher magnitude of heritability and genetic advance for most of the characters.

Table 2: Estimates of genetic components for maize inbred lines

Characters	GCV	PCV	Genotypic variance	Phenotypic variance	h^2 (broad sense)	Genetic gain	Genetic advance as % of mean
Days to 50 % tasselling	3.01	3.07	2.26	2.35	0.96	3.03	6.07
Days to 50 % silking	2.85	2.88	2.23	2.29	0.98	3.04	5.80
Anthesis-silking interval	20.02	20.03	0.26	0.26	1.00	1.05	41.21
Days to maturity	4.05	4.07	15.76	15.90	0.99	8.14	8.31
Plant height	16.34	16.45	639.53	648.04	0.99	51.75	33.43
Cob height	10.72	13.99	65.11	110.84	0.59	12.74	16.93
Cobs/plant	32.97	33.06	0.26	0.26	0.99	1.04	67.71
Cob length	18.89	18.90	5.56	5.57	1.00	4.86	38.90
Cob girth	9.44	13.36	0.91	1.83	0.50	1.39	13.74
Grain rows/cob	8.79	9.38	1.16	1.32	0.88	2.08	16.97
Kernels/row	23.67	23.84	40.97	41.55	0.99	13.09	48.42
Grain yield/plant	17.91	18.08	136.57	139.18	0.98	23.85	36.54
100 seed weight	19.00	19.23	15.04	15.40	0.98	7.89	38.67
Chlorophyll (SPAD)	18.91	19.20	63.30	65.24	0.97	16.14	38.38
Leaf area/plant	36.21	36.29	3367426.25	3383770.75	1.00	3771.07	74.40
Leaf relative water content	14.83	15.44	72.20	78.27	0.92	16.81	29.34

Correlation coefficient analysis

The genotypic (r_g) and phenotypic (r_p) correlation coefficients for all the traits (Table 3) revealed that genotypic correlation was at a higher magnitude than phenotypic correlation in most of the cases indicating a high degree of association among the characters. Therefore, selection based on phenotypic traits would be effective in achieving genetic gain. Results revealed that the cob length (0.54**, 0.55**), leaf area/plant (0.52**, 0.53**), grain rows/cob (0.38**, 0.40**), 100 seed weight (0.38**, 0.39**), cobs/plant (0.36*, 0.37*) and leaf relative water content (0.32*, 0.35*) showed significant positive correlation with grain yield/plant at the phenotypic(r_p) and genotypic levels (r_g),respectively. As the genotypic relationship among traits affecting grain yield elucidate true association as they exclude environmental influences. This was well supported by Malik *et al.* (2005), Saleem *et al.* (2007) and Kanagarasu *et al.* (2012) where cob height and leaf area were positively significantly correlated with grain yield. Days to maturity (-0.33*), however, showed negative but significant correlation with grain yield/plant. Nzuve *et al.* (2014) and Nataraj *et al.* (2014) found that several characters showed positive significant correlation with grain yield at the genotypic and phenotypic levels. Kote *et al.* (2014) also reported significant association in desirable direction with seed yield/plant at both genotypic and phenotypic levels.

Days to 50 % tasselling showed significant and positive correlation with days to 50 % silking (0.92**). Anthesis-silking interval showed significant negative correlation with plant height (-0.45**) and cob height (-0.29*). Days to maturity had significant negative correlation with cob length (-0.33*), grain rows/cob (-0.36*) and chlorophyll content (-0.55**). There was a significant positive correlation between plant

Table 3: Genotypic (r_g) and phenotypic (r_p) correlation coefficients for quantitative and physiological characters in maize (*Zea mays* L.)

Characters		Days to 50 % silking	Anthesis silking Interval	Days to maturity	Plant height (cm)	Cob height (cm)	Cobs/ plant	Cob length (cm)	Cob girth (cm)	Grain rows/ Cob	Kernels per row	100 seed wt (g)	Chlorophyll content (Spad)	Leaf area per plant (cm²)	LRWC (%)	Grain yield/ plant (g)
Days to 50 % tasselling	r_p	0.92**	-0.19	-0.11	0.07	0.12	-0.08	-0.13	-0.11	0.20	0.15	-0.15	0.08	-0.19	-0.21	0.10
	r_g	0.95	-0.19	-0.11	0.06	0.09	-0.08	-0.13	-0.16	0.22	0.15	-0.16	0.09	-0.19	-0.23	0.10
Days to 50 % silking	r_p		0.14	-0.15	-0.08	-0.001	-0.08	-0.18	-0.19	0.15	0.14	-0.14	0.11	-0.16	-0.21	0.06
	r_g		0.14	-0.16	-0.08	0.005	-0.08	-0.18	-0.30	0.15	0.14	-0.14	0.11	-0.16	-0.23	0.06
Anthesis-silkinginterval	r_p			-0.12	-0.45**	-0.29*	-0.006	-0.13	-0.24	-0.16	-0.04	0.04	0.06	0.09	0.00	-0.12
	r_g			-0.12	-0.46	-0.38	-0.007	-0.13	-0.34	-0.17	-0.04	0.04	0.06	0.09	-0.002	-0.12
Days to maturity	r_p				0.10	0.16	0.17	-0.33*	-0.004	-0.36*	0.03	-0.07	-0.55**	-0.11	-0.10	-0.33*
	r_g				0.11	0.26	0.17	-0.33	0.02	-0.40	0.03	-0.07	-0.56	-0.11	-0.10	-0.33*
Plant height	r_p					0.75**	0.21	0.10	0.41**	0.20	-0.13	-0.11	0.20	0.03	0.18	-0.14
	r_g					0.96	0.21	0.10	0.61	0.22	-0.13	-0.12	0.21	0.03	0.19	-0.14
Cob height	r_p						0.23	0.16	0.27	0.04	-0.13	-0.12	0.21	-0.10	0.08	-0.17
	r_g						0.30	0.21	0.48	0.10	-0.19	-0.14	0.32	-0.13	0.06	-0.24
Cobs/plant	r_p							-0.22	0.14	0.06	-0.35*	-0.02	0.10	-0.26	-0.04	0.36 *
	r_g							-0.22	0.20	0.05	-0.35	-0.02	0.10	-0.26	-0.04	0.37*
Cob length	r_p								0.22	0.35*	-0.11	0.31*	0.38 **	0.37 **	0.24	0.54 **
	r_g								0.32	0.38	-0.11	0.31	0.39	0.37	0.24	0.55**
Cob girth	r_p									0.24	-0.16	0.31 *	0.04	0.44 **	0.40 **	0.26
	r_g									0.35	-0.28	0.47	0.05	0.64	0.59	0.36
Grain rows/cob	r_p										-0.37 **	0.33 *	0.28	0.26	0.44 **	0.38 **
	r_g										-0.39	0.37	0.31	0.28	0.51	0.40**
Kernels/row	r_p											-0.70 **	-0.29 *	-0.09	-0.35 *	0.22
	r_g											-0.72	-0.30	-0.09	-0.37	0.23
100 seed weight	r_p												0.17	0.51 **	0.54 **	0.38 **
	r_g												0.17	0.51	0.58	0.39**
Chlorophyll content (SPAD)	r_p													-0.07	0.07	0.11
	r_g													-0.06	0.06	0.12
Leaf area/plant	r_p														0.65 **	0.52 **
	r_g														0.68	0.53**
Leaf relative water content	r_p															0.32 *
	r_g															0.35*

Table 4: Direct (diagonal) and indirect (off diagonal) effect of quantitative and physiological characters to yield in maize (*Zea mays* L.) at phenotypic level

Characters	Level	Days to 50% tasseling	Days to 50% silking	Anthesis-silking interval	Days to maturity	Plant height	Cob height	Cobs/plant	Cob length	Cob girth	Grain rows/ cob	Kernels /row	100 seed weight	Chlorophyll content (SPAD)	Leaf area /plant	Leaf relative water content
Days to 50% tasseling	r_p	-0.2431	-0.2260	0.0468	0.0290	-0.0173	-0.0304	0.0199	0.0329	0.0286	-0.0496	-0.0383	0.0386	-0.0213	0.0477	0.0524
Days to 50% silking	r_p	0.2436	0.2620	0.0371	-0.0416	-0.0221	-0.0003	-0.0221	-0.0482	-0.0499	0.0414	0.0372	-0.0389	0.0301	-0.0432	-0.0575
Anthesis-silking interval	r_p	0.0231	-0.0170	-0.1202	0.0155	0.0550	0.0350	0.0008	0.0168	0.0298	0.0201	0.0056	-0.0057	-0.0079	-0.0114	0.0000
Days to maturity	r_p	0.0159	0.0212	0.0172	-0.1336	-0.0145	-0.0217	-0.0229	0.0446	0.0006	0.0489	-0.0047	0.0101	0.0743	0.0152	0.0140
Plant height	r_p	-0.0006	0.0007	0.0039	-0.0009	-0.0084	-0.0063	-0.0018	-0.0009	-0.0035	-0.0017	0.0011	0.0010	-0.0017	-0.0003	-0.0015
Cob height	r_p	0.0088	-0.0001	-0.0205	0.0115	0.0530	0.0705	0.0166	0.0119	0.0194	0.0034	-0.0094	-0.0091	0.0154	-0.0076	0.0062
Cobs/plant	r_p	-0.0081	-0.0083	-0.0007	0.0169	0.0207	0.0232	0.0985	-0.0217	0.0147	0.0059	-0.0347	-0.0023	0.0105	-0.0259	-0.0044
Cob length	r_p	-0.0298	-0.0406	-0.0308	-0.0736	0.0237	0.0373	-0.0487	0.2206	0.0507	0.0777	-0.0255	0.0696	0.0852	0.0826	0.0531
Cob girth	r_p	0.0036	0.0058	0.0075	0.0001	-0.0127	-0.0083	-0.0045	-0.0070	-0.0303	-0.0076	0.0050	-0.0096	-0.0015	-0.0136	-0.0121
Grain rows/cob	r_p	0.0710	0.0550	-0.0583	-0.1275	0.0699	0.0168	0.0210	0.1227	0.0868	0.3483	-0.1309	0.1165	0.0984	0.0938	0.1547
Kernels/row	r_p	0.1817	0.1635	-0.0536	0.0404	-0.1553	-0.1535	-0.4061	-0.1331	-0.1917	-0.4335	1.1529	-0.8144	-0.3380	-0.1063	-0.4077
100 seed weight	r_p	-0.1675	-0.1568	0.0504	-0.0801	-0.1254	-0.1359	-0.0245	0.3332	0.3339	0.3532	-0.7457	1.0556	0.1820	0.5403	0.5780
Chlorophyll content	r_p	-0.0013	-0.0017	-0.0009	0.0080	-0.0029	-0.0032	-0.0015	-0.0056	-0.0007	-0.0041	0.0042	-0.0025	-0.0144	0.0010	-0.0010
Leaf area/plant	r_p	0.0058	0.0049	-0.0028	0.0034	-0.0010	0.0032	0.0078	-0.0111	-0.0134	-0.0080	0.0027	-0.0152	0.0021	-0.0297	-0.0195
LRWC	r_p	0.0053	0.0054	0.0000	0.0026	-0.0045	-0.0022	0.0011	-0.0060	-0.0099	-0.0110	0.0088	-0.0136	-0.0017	-0.0163	-0.0248
Grain yield/plant	r_p	0.1086	0.0681	-0.1251	-0.3300	-0.1417	-0.1758	-0.3662	0.5490	0.2651	0.3836	0.2284	0.3802	0.1114	0.5262	0.3297
Partial R^2	r_p	-0.0264	0.0178	0.0150	0.0441	0.0012	-0.0124	-0.0361	0.1211	-0.0080	0.1336	0.2634	0.4014	-0.0016	-0.0156	-0.0082

Table 5: Direct (diagonal) and indirect (off diagonal) effect of quantitative and physiological characters to yield in maize at genotypic level

Characters	Level	Days to 50% tasseling	Days to 50% silking	Anthesis-silking interval	Days to maturity	Plant height	Cob height	Cobs/plant	Cob length	Cob girth	Grain rows/ cob	Kernels /row	100 seed weight	Chlorophyll content (SPAD)	Leaf area/plant	Leaf relative water content
Days to 50% tasselling	r_g	-0.1321	-0.1265	0.0260	0.0147	-0.0089	-0.0127	0.0109	0.0183	0.0218	-0.0293	-0.0205	0.0217	-0.0131	0.0260	0.0306
Days to 50% silking	r_g	0.1463	0.1528	0.0218	-0.0246	-0.0133	0.0008	-0.0132	-0.0285	-0.0461	0.0235	0.0217	-0.0221	0.0180	-0.0256	-0.0355
Anthesis silking interval	r_g	0.0070	-0.0051	-0.0355	0.0046	0.0164	0.0137	0.0003	0.0050	0.0123	0.0063	0.0017	-0.0017	-0.0023	-0.0034	0.0001
Days to maturity	r_g	0.0107	0.0155	0.0124	-0.0961	-0.0109	-0.0255	-0.0166	0.0322	-0.0027	0.0386	-0.0038	0.0075	0.0548	0.0111	0.0105
Plant height	r_g	0.0016	-0.0021	-0.0110	0.0027	0.0237	0.0228	0.0050	0.0025	0.0146	0.0052	-0.0032	-0.0030	0.0052	0.0008	0.0045
Cob height	r_g	0.0003	0.0000	-0.0011	0.0008	0.0027	0.0028	0.0009	0.0006	0.0014	0.0003	-0.0005	-0.0004	0.0009	-0.0004	0.0002
Cobs/plant	r_g	-0.0071	-0.0075	-0.0006	0.0149	0.0184	0.0262	0.0867	-0.0191	0.0182	0.0047	-0.0307	-0.0019	0.0095	-0.0230	-0.0038
Cob length	r_g	-0.0294	-0.0397	-0.0298	-0.0713	0.0228	0.0464	-0.0470	0.2130	0.0692	0.0812	-0.0248	0.0678	0.0835	0.0801	0.0528
Cob girth	r_g	-0.0123	-0.0224	-0.0258	0.0021	0.0456	0.0361	0.0156	0.0242	0.0744	0.0261	-0.0212	0.0352	0.0040	0.0477	0.0441
Grain rows/cob	r_g	0.0784	0.0544	-0.0632	-0.1420	0.0782	0.0364	0.0193	0.1349	0.1241	0.3539	-0.1395	0.1341	0.1121	0.1011	0.1813
Kernels/row	r_g	0.1987	0.1818	-0.0612	0.0511	-0.1739	-0.2475	-0.4535	-0.1495	-0.3647	-0.5054	1.2821	-0.9240	-0.3957	-0.1157	-0.4821
100 seed weight	r_g	-0.1912	-0.1687	0.0554	-0.0914	-0.1450	-0.1715	-0.0257	0.3708	0.5514	0.4414	-0.8397	1.1651	0.2002	0.6024	0.6763
Chlorophyll content	r_g	0.0033	0.0039	0.0022	-0.0191	0.0073	0.0109	0.0037	0.0132	0.0018	0.0106	-0.0104	0.0058	0.0335	-0.0023	0.0021
Leaf area/plant	r_g	0.0306	0.0260	-0.0148	0.0180	-0.0053	0.0212	0.0412	-0.0584	-0.0996	-0.0444	0.0140	-0.0803	0.0108	-0.1554	-0.1065
LRWC	r_g	0.0039	0.0039	0.0000	0.0018	-0.0032	-0.0011	0.0007	-0.0042	-0.0100	-0.0087	0.0064	-0.0098	-0.0011	-0.0116	-0.0169
Grain yield/plant	r_g	0.1087	0.0664	-0.1249	-0.3338	-0.1452	-0.2410	-0.3717	0.5548	0.3660	0.4041	0.2315	0.3939	0.1202	0.5319	0.3577
Partial R^2	r_g	-0.0144	0.0102	0.0044	0.0321	-0.0034	-0.0007	-0.0322	0.1182	0.0272	0.1430	0.2967	0.4589	0.0040	-0.0826	-0.0061

Where, r_p = Phenotypic level and r_g= Genotypic level ,Genotypic path (R^2 =0.9554 , Residual effect =0.2113) and Phenotypic path (R^2 = 0.8893, Residual effect =0.3327 height and cob height (0.75**), cob girth (0.41**). Cobs/plant showed significant negative correlation with kernels/row (-0.35*). Cob length had significant and positive correlation with grain rows/cob (0.35*), 100 seed weight (0.31*), chlorophyll content (0.38**) and leaf area/plant (0.37**). Cob girth showed significant and positive correlation with 100 seed weight (0.31*), leaf area/plant (0.44**) and leaf relative water content (0.40**). Similar results were reported by Niyokwizigirwa *et al.* (2014). Grain row/cob showed significant and positive correlation with 100 seed weight (0.40**) and leaf relative water content (0.44**), but it showed negative but significant correlation with kernels/row (-0.37**). Kernels/row showed negative significant correlation with 100 seed weight (-0.70**), chlorophyll content (-0.29*) and leaf relative water content (-0.35*). 100 seed weight showed significant and positive correlation with leaf area/plant (0.51**) and leaf relative water content (0.54**). Leaf area/plant showed significant and positive correlation with leaf relative water content (0.65**). Such results could help the breeder to select high grain yield through selection for one or more of these characters. The findings indicates that selection for long cob, more number of grain rows/cob, high 100 seed weight and more number of cobs/plant may be given company to increase grain yield of maize. Langade *et al.* (2013) and Dhutmal *et al.* (2015) reported similar results.

Path analysis

Path analysis reveals the direct and indirect effects of characters on grain yield (Table 4 and 5) The characters days to 50 % silking (r_p=0.262, r_g=0.153), cob height (r_p=0.071, r_g=0.003), cobs/plant (r_p=0.099, r_g=0.087), cob length (r_p=0.221, r_g=0.213), number of grain rows/cob (r_p=0.348, r_g=0.354), kernels/row (r_p=1.153, r_g=1.282), and 100 seed weight (r_p=1.056,r_g=1.165), showed positive direct effect on grain yield at both the phenotypic (r_p) and genotypic (r_g) levels. However, plant height (0.024), cob girth (0.074) and chlorophyll content (0.034) showed positive direct effect on grain yieldonly at the genotypic (r_g) level. These showed that selection is effective for increasing grain yield/plant through selecting the traits having direct effect on grain yield/plant. The experimental results were in accordance with earlier findings of Muhammad *et al.* (2008), Bello *et al.* (2010) and Kumar *et al.* (2014). While, days to 50% tasselling (-0.132), anthesis-silking interval (-0.036) and days to maturity (-0.096) showed negative direct effect on grain yield at the genotypic level. Positive but indirect effect was shown by days to 50% tasseling (0.109), days to 50% silking (0.066), cob length (0.555), cob girth (0.366), grain rows/cob (0.404), kernels/row (0.232), 100 seed weight (0.394), chlorophyll content (0.120), leaf area/plant (0.532) and leaf relative water content (0.358) at the genotypic level. Similar findings were reported by Zarei *et al.* (2012) and Kumar *et al.* (2013).

Thus, the present study indicated the characters namelydays to 50 % silking, cob height, cobs per plant, cob length, number of grain rows/cob, kernels/row, and 100 seed weight would help to improvemaize yield since these characters recorded significant genotypic and phenotypic correlation with high direct effect on grain yield.

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