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Correlation and Path Analysis Studies for Yield and Quality Traits in Quality Protein Maize (*Zea mays* L.)

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A B S T R A C T

Character association was studied in the present investigation, to assess the relationships among yield, its components for enhancing the usefulness of selection. Genotypic correlations reveal the existence of real associations. The study of character association among the yield components revealed the significantly positive association of grain yield with Anthesis silking interval, ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100-kernel weight, shelling percentage, crude protein, tryptophan and lysine while, significantly negative associations were recorded with days to 50 per cent anthesis, days to 50 per cent silking, and days to maturity whereas, positive non-significant associations were registered for plant height, ear height and tryptophan contents. The study of character association among the yield components revealed the significantly positive association of grain yield with Anthesis silking interval, ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100-kernel weight, shelling percentage, crude protein, tryptophan and lysine while, significantly negative associations were recorded with days to 50 per cent anthesis, days to 50 per cent silking, and days to maturity whereas, positive non-significant associations were registered for plant height, ear height and tryptophan contents. Path coefficient analysis revealed that shelling percentage, ear girth and lysine at Adilabad exhibited the highest positive direct effects and hence these traits play an important role in generating the high yielding genotypes in the future breeding programmes.

Introduction

Globally, maize is an important crop belongs to the family, Graminae and tribe, Maydae which is the native of Central America (Mexico). Portuguese traders introduced it into South East Asia in 16th century. It is considered as queen of cereals due to its high genetic potentiality and adaptability. It is delight for the plant breeders to work on this important crop due to the presence of high genetic variability. Several people consume maize as staple food to meet their protein and calories requirement. However, net protein utilization and biological value of normal maize was less as the normal maize has the drawback of deficient in important amino acids like tryptophan and lysine. Mal nutritional problems were observed where maize was the staple food especially in young children, pregnant and lactating mothers, especially in tribal communities. Maize breeders strived hard to improve the nutritional aspects in maize by way of improving the most deficient amino acids i.e. tryptophan and lysine and finally succeeded in incorporating modified *opaque* 2 into normal maize so that the digestibility, biological value has been improved with the enhanced levels of lysine and tryptophan contents. However, main goal of the plant breeders is to develop high yielding hybrids coupled with high tryptophan and lysine contents to combat malnutrition problems especially in developing countries mostly in tribal communities.QPM has balance leucinc: isoleucine ratio with the enhanced niacin levels helps in preventing pellagra. It is a better alternative to animal protein which is costly and plays a major role in meeting infant, lactating mothers food requirements. Character association provides information on the nature and extent of association between pairs of metric traits and helps in selection for the improvement of the character (Srijan *et al.*, 2016). Correlation gives only the relation between two variables whereas path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921). Path analysis is that, it permits the partitioning of the correlation coefficient into its components, one component being the path coefficient that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effect(s) of a predictor variable on the response variable through another predictor variable (Dewey and Lu, 1959).

Materials and Methods

During *Kharif*, 2015, a diallel set of 36 crosses along with 9 parents and two checks *viz*., DHM-117 and Vivek QPM 9 were sown in Randomized Block Design replicated thrice ARS, Adilabad (Adilabad dist.) of Telangana state, India. Each entry was sown in two rows of four meters length with a spacing of 75 cm between rows and 20 cm between the plants. The recommended fertilizers of N, P and K were applied in the ratio of 120: 80: 60 kg ha^{-1}. The entire P and K and half dose of nitrogen was applied as basal, while remaining half dose of N in two equal split doses at knee height and tasseling stages. Weeding operations, necessary plant protection measures were taken up to protect the crop from pests and diseases as per the recommendations along with the timely irrigation schedules to raise a healthy crop. Observations were made on different characters i.e. days to 50 per cent anthesis, days to 50 per cent silking, anthesis silking interval, days to maturity, plant height (cm), ear height (cm), ear length (cm), ear girth (cm), Number of kernel rows per ear, number of kernels per row, 100 kernel weight (g), Shelling percentage, Crude Protein (%), lysine content (%),Tryptophan content (%) and grain yield (g/plant). Genotypic and phenotypic correlations coefficient was worked out by adopting method described by Singh and Chaudhary (1977). Path coefficient analysis was done according to the procedure suggested by Dewey and Lu (1959).

Results and Discussion

Grain yield is a complex character and is dependent on several contributing traits. Hence, character association was studied in the present investigation, to assess the relationships among yield, its components for enhancing the usefulness of selection. Genotypic correlations reveal the existence of real associations, whereas, the phenotypic correlations due to genotype x environment interactions. Significant phenotypic correlations without significant genotypic associations are of no value. If the genotypic correlation is significant and phenotypic is not, it means that the existing real association is masked by environmental effect. This indicates the importance of genotypic correlation compared to phenotypic correlation. Correlation coefficient is a statistical measure used to find out the degree and direction of relationship between two or more variables. The information on the interrelationship among the characters facilitates the choice of a suitable breeding method to be applied and selecting the parents for crop improvement. The genetic correlation coefficients between the characters at genotypic as well as phenotypic levels, as an important from breeding point of view have been presented in Table 1. In general, phenotypic correlations provide the information on phenotypic expression of the traits and hence the phenotypic correlations have been discussed hereunder.

Days to 50 per cent anthesis was significantly and positively correlated with days to 50% silking and days to maturity while, it had negatively significant association with ear length, ear girth, shelling percentage, crude protein, tryptophan and lysine contents whereas, negative and non-significant association was observed with grain yield at all the three locations. Days to 50 per cent silking exhibited significantly positive association with days to maturity while, it exhibited significantly negative significant association with ear length, ear girth, shelling percentage, crude protein, tryptophan and lysine content and grain yield whereas, 100-kernel weight exhibited positive association. Anthesis silking interval exhibited negative and non-significant associations with ear height, ear length, number of kernels per row, days to maturity, tryptophan and lysine contents. Days to maturity exhibited significant and negative association was recorded with 100- kernel weight, shelling percentage, crude protein, tryptophan and lysine content and grain yield. The association of plant height was significant and positive with days to anthesis, days to silking, ear height, ear girth and number of kernel rows per ear at all the three locations while, it exhibited significantly negative association with tryptophan and lysine contents and positive but non-significant association registered with grain yield.

Ear height exhibited significantly positive association with ear length, ear girth, number of kernel rows per ear, number of kernels per row. None of the traits exhibited significantly negative association with ear height. It also exhibited significantly positive association with shelling percentage where, the association of ear height was found positive but non-significant with grain yield. Ear girth exhibited significant and positive associations were recorded with number of kernel rows per ear, number of kernels per row, 100 kernel weight, shelling percentage, crude protein and grain yield. While the association was significant and positive with tryptophan content. Ear length exhibited positive and significant associations with ear girth, number of kernel rows per ear, number of kernels per row, 100- kernel weight, shelling percentage, crude protein, tryptophan and grain yield. It also exhibited a positive but non-significant association with lysine content at Adilabad. The trait also exhibited significantly negative association with days to maturity.

Number of kernel rows per ear exhibited significantly positive association of number of kernel rows per ear was with number of kernels per row, 100- kernel weight, shelling percentage and grain yield while, it exhibited significantly negative association with days to maturity and lysine content. Number of kernels per row exhibited positive and significant association with 100-kernel weight, shelling percentage and grain yield whereas, its association with tryptophan content was significantly positive. Days to maturity and lysine contents were significantly and negatively associated with the character.100-

kernel weight exhibited Significant and positive associations were observed with shelling percentage, crude protein and grain yield while, it association was negative but non-significant for lysine and tryptophan contents. Shelling percentage associated significantly and positively with crude protein, tryptophan and grain yield. Tryptophan, lysine and grain yield were associated significantly and positively with crude protein content. Tryptophan content exhibited significantly positive association with lysine, its association was positive but non-significant with grain yield. Lysine content was significantly and positively associated with grain yield.

The study of character association among the yield components revealed the significantly positive association of grain yield with Anthesis silking interval, ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100-kernel weight, shelling percentage, crude protein, tryptophan and lysine while, significantly negative associations were recorded with days to 50 per cent anthesis, days to 50 per cent silking, and days to maturity whereas, positive non-significant associations were registered for plant height, ear height and tryptophan contents (Table 1).

Path coefficient analysis

The genetic architecture of seed yield is based on the balance or overall net effect produced by various yield components interacting with one another. The association of different component characters among themselves and with yield is quite important for devising an efficient selection criterion for yield. The total correlation between yield and its component characters may be some times misleading, as it might be an over-estimate or under-estimate because of its association with other characters. If relationship is due to multiple effects of gene(s) it is difficult to separate these effects by selecting a particular character. Hence, indirect selection by correlated response may not be some times fruitful. The study of character association among the yield components revealed the significantly positive association of grain yield with Anthesis silking interval, ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100-kernel weight, shelling percentage, crude protein, tryptophan and lysine while, significantly negative associations were recorded with days to 50 per cent anthesis, days to 50 per cent silking, and days to maturity whereas, positive non-significant associations were registered for plant height, ear height and tryptophan contents.

Days to 50 per cent anthesis exhibited a positive direct effect (0.1133) on grain yield. Significantly negative correlation (-0.3751) of the trait with grain yield was recorded which is mainly due to the indirect negative influence through plant height, days to 50 per cent silking, anthesis silking interval, ear height, ear length, ear girth, number of kernels per row, days to maturity, 100 kernel weight, shelling percentage, crude protein and lysine. This trait exhibited indirect positive contribution exhibited through number of kernel rows per ear and tryptophan content.

Days to 50 per cent silking exhibited negative direct effect (-0.1093) on grain yield was exhibited by days to 50 per cent silking with grain yield at Adilabad with significantly negative correlation (-0.3739) which was mainly due to indirect negative contribution exhibited through plant height, ear height, ear length, ear girth, number of kernels per row, days to maturity, 100- kernel weight, shelling percentage, crude protein and lysine at Adilabad and over locations whereas, days to 50 per cent anthesis, anthesis silking interval, number of kernel rows per ear and tryptophan exhibited indirect positive influence.

Table.1 Phenotypic (G) and Genotypic (G) Correlations for 16 characters at Adilabad

Character		PH	DA	DS	ASI	EH	EL	EG	KRE	KPR	DM	100KW	SP	CP	TRY	LYS	GY
PH	P	**1.0000**	0.2263**	0.2201**	-0.0587	0.7190***	0.1250	0.2186**	0.2193**	0.1249	0.0371	0.1325	0.1375	-0.0736	-0.3464***	-0.3312***	**0.0181**
	G	**1.0000**	0.2394	0.2298	0.5355	0.7587	0.1341	0.2327	0.2342	0.1205	0.0338	0.1388	0.1419	-0.0899	-0.3704	-0.3713	**0.0191**
DA	P		**1.0000**	0.9943***	-0.0370	-0.0192	-0.2960***	-0.2483**	-0.1433	-0.1081	0.5918***	-0.1658*	-0.4069***	-0.5024***	-0.4410***	-0.2898***	**-0.3751*** **
	G		**1.0000**	1.0003	0.0299	-0.0216	-0.2990	-0.2522	-0.1478	-0.1111	0.5992	-0.1744	-0.4219	-0.5287	-0.4635	-0.3008	**-0.3812**
DS	P			**1.0000**	0.0538	-0.0257	-0.2961***	-0.2453**	-0.1395	-0.1101	0.5902***	-0.1615	-0.4132***	-0.4961***	-0.4569***	-0.3006***	**-0.3739*** **
	G			**1.0000**	0.0098	-0.0300	-0.3004	-0.2525	-0.1490	-0.1106	0.6010	-0.1681	-0.4283	-0.5249	-0.4761	-0.3136	**-0.3816**
ASI	P				**1.0000**	-0.0718	-0.0052	0.0319	0.0345	-0.0127	-0.0058	0.0299	-0.0848	0.0503	-0.1509	-0.0988	**0.0014*** **
	G				**1.0000**	0.4390	0.0655	0.0236	0.0634	-0.0069	-0.0732	-0.3825	0.2833	-0.2409	0.7113	0.7272	**-0.0071**
EH(cm)	P					**1.0000**	0.2811***	0.3257***	0.2890***	0.2283**	-0.1525	0.0459	0.2340**	-0.0779	-0.1115	-0.0947	**0.1445**
	G					**1.0000**	0.2830	0.3295	0.3013	0.2366	-0.1565	0.0419*	0.2394	-0.0791	-0.1137	-0.1000	**0.1450**
EL(cm)	P						**1.0000**	0.8257***	0.6771***	0.6082***	-0.4567***	0.4855***	0.6016***	0.3344***	0.3524***	0.1439	**0.5645*** **
	G						**1.0000**	0.8332	0.6969	0.6172	-0.4655	0.5007	0.6144	0.3462	0.3669	0.1511	**0.5684**
EG(cm)	P							**1.0000**	0.8405***	0.7507***	-0.4220***	0.6703***	0.6193***	0.2704**	0.1811*	-0.0874	**0.5889*** **
	G							**1.0000**	0.8641	0.7677	-0.4315	0.6998	0.6418	0.2809	0.1893	-0.0895	**0.5974**
KRE	P								**1.0000**	0.8402***	-0.3685***	0.6574***	0.4593***	0.2234**	0.0964	-0.1831*	**0.4105*** **
	G								**1.0000**	0.8771	-0.3910	0.7078	0.4986	0.2272	0.1181	-0.1890	**0.4239**
KPR	P									**1.0000**	-0.3304***	0.5492***	0.4422***	0.1473	0.1698*	-0.2554**	**0.4031*** **
	G									**1.0000**	-0.3427	0.5764	0.4569	0.1531	0.1811	-0.2791	**0.4084**
DM	P										**1.0000**	-0.3567***	-0.3488***	-0.3049***	-0.2817***	-0.3227***	**-0.4489*** **
	G										**1.0000**	-0.3728	-0.3644	-0.3354	-0.2961	-0.3321	**-0.4575**
100KW	P											**1.0000**	0.5044***	0.2231**	-0.0265	-0.1410	**0.5168*** **
	G											**1.0000**	0.5276	0.2485	-0.0331	-0.1574	**0.5333**
SP	P												**1.0000**	0.3845***	0.2399**	0.1307	**0.7785*** **
	G												**1.0000**	0.4086	0.2494	0.1318	**0.7980**
CP (%)	P													**1.0000**	0.4731***	0.0355	**0.2832*** **
	G													**1.0000**	0.5055	0.0383	**0.2873**
Try (%)	P														**1.0000**	0.3645***	**0.0896**
	G														**1.0000**	0.3819	**0.0914**
Lys (%)	P															**1.0000**	**0.2217*** **
	G															**1.0000**	**0.2293**

Contd…

Table.2 Phenotypic (P) and Genotypic (G) path coefficients for various characters in QPM maize at Adilabad

Character		PH	DA	DS	ASI	EH	EL	EG	KRE	KPR	DM	100KW	SP	CP	TRY	LYS	GY
PH	P	**-0.1488**	0.0256	-0.0241	-0.0015	0.0219	0.0079	0.0531	-0.0640	0.0212	-0.0045	0.0133	0.0812	-0.0057	0.1034	-0.0610	**0.0181**
	G	**-0.0990**	0.0383	-0.0346	-0.0140	0.0152	0.0051	0.0675	-0.1110	0.0377	-0.0037	0.0165	0.0869	-0.0064	0.1124	-0.0918	**0.0191**
DA	P	-0.0337	**0.1133**	-0.1087	-0.0009	-0.0006	-0.0187	-0.0603	0.0418	-0.0183	-0.0712	-0.0167	-0.2401	-0.0392	0.1317	-0.0534	**-0.3751*** **
	G	-0.0237	**0.1601**	-0.1505	-0.0008	-0.0004	-0.0114	-0.0732	0.0700	-0.0348	-0.0658	-0.0207	-0.2585	-0.0379	0.1406	-0.0743	**-0.3812**
DS	P	-0.0328	0.1126	**-0.1093**	0.0014	-0.0008	-0.0188	-0.0596	0.0407	-0.0187	-0.0710	-0.0162	-0.2438	-0.0387	0.1364	-0.0553	**-0.3739*** **
	G	-0.0228	0.1601	**-0.1505**	-0.0003	-0.0006	-0.0114	-0.0732	0.0706	-0.0346	-0.0660	-0.0199	-0.2624	-0.0376	0.1445	-0.0775	**-0.3816**
ASI	P	0.0087	-0.0042	-0.0059	**0.0253**	-0.0022	-0.0003	0.0077	-0.0100	-0.0022	0.0007	0.0030	-0.0501	0.0039	0.0451	-0.0182	**0.0014*** **
	G	-0.0530	0.0048	-0.0015	**-0.0261**	0.0088	0.0025	0.0068	-0.0301	-0.0022	0.0080	-0.0454	0.1736	-0.0173	-0.2158	0.1797	**-0.0071**
EH	P	-0.1070	-0.0022	0.0028	-0.0018	**0.0304**	0.0178	0.0791	-0.0843	0.0387	0.0183	0.0046	0.1381	-0.0061	0.0333	-0.0174	**0.1445**
	G	-0.0751	-0.0035	0.0045	-0.0115	**0.0200**	0.0108	0.0956	-0.1428	0.0741	0.0172	0.0050	0.1467	-0.0057	0.0345	-0.0247	**0.1450**
EL	P	-0.0186	-0.0335	0.0324	-0.0001	0.0086	**0.0633**	0.2007	-0.1975	0.1032	0.0549	0.0488	0.3550	0.0261	-0.1052	0.0265	**0.5645*** **
	G	-0.0133	-0.0479	0.0452	-0.0017	0.0057	**0.0380**	0.2417	-0.3303	0.1933	0.0512	0.0594	0.3764	0.0248	-0.1113	0.0373	**0.5684**
EG	P	-0.0325	-0.0281	0.0268	0.0008	0.0099	0.0523	**0.2430**	-0.2451	0.1274	0.0507	0.0674	0.3654	0.0211	-0.0541	-0.0161	**0.5889*** **
	G	-0.0230	-0.0404	0.0380	-0.0006	0.0066	0.0317	**0.2901**	-0.4096	0.2404	0.0474	0.0830	0.3932	0.0201	-0.0574	-0.0221	**0.5974**
KRE	P	-0.0326	-0.0162	0.0152	0.0009	0.0088	0.0429	0.2042	**-0.2916**	0.1426	0.0443	0.0661	0.2710	0.0174	-0.0288	-0.0337	**0.4105*** **
	G	-0.0232	-0.0237	0.0224	-0.0017	0.0060	0.0265	0.2506	**-0.4740**	0.2747	0.0430	0.0840	0.3054	0.0163	-0.0358	-0.0467	**0.4239**
KPR	P	-0.0186	-0.0122	0.0120	-0.0003	0.0069	0.0385	0.1824	-0.2450	**0.1697**	0.0397	0.0552	0.2609	0.0115	-0.0507	-0.0470	**0.4031*** **
	G	-0.0119	-0.0178	0.0166	0.0002	0.0047	0.0235	0.2227	-0.4157	**0.3131**	0.0377	0.0684	0.2799	0.0110	-0.0550	-0.0690	**0.4084**
DM	P	-0.0055	0.0670	-0.0645	-0.0001	-0.0046	-0.0289	-0.1025	0.1075	-0.0561	**-0.1202**	-0.0359	-0.2058	-0.0238	0.0841	-0.0594	**-0.4489*** **
	G	-0.0033	0.0959	-0.0904	0.0019	-0.0031	-0.0177	-0.1252	0.1853	-0.1073	**-0.1099**	-0.0442	-0.2232	-0.0240	0.0898	-0.0821	**-0.4575**
100KW	P	-0.0197	-0.0188	0.0177	0.0008	0.0014	0.0307	0.1629	-0.1917	0.0932	0.0429	**0.1006**	0.2977	0.0174	0.0079	-0.0260	**0.5168*** **
	G	-0.0137	-0.0279	0.0253	0.0100	0.0008	0.0190	0.2030	-0.3355	0.1805	0.0410	**0.1187**	0.3232	0.0178	0.0101	-0.0389	**0.5333**
SP	P	-0.0205	-0.0461	0.0452	-0.0021	0.0071	0.0381	0.1505	-0.1339	0.0750	0.0419	0.0507	**0.5901**	0.0300	-0.0716	0.0241	**0.7785*** **
	G	-0.0141	-0.0675	0.0644	-0.0074	0.0048	0.0234	0.1862	-0.2363	0.1431	0.0400	0.0626	**0.6126**	0.0293	-0.0757	0.0326	**0.7980**
CP	P	0.0110	-0.0569	0.0542	0.0013	-0.0024	0.0212	0.0657	-0.0651	0.0250	0.0367	0.0224	0.2269	**0.0780**	-0.1413	0.0065	**0.2832*** **
	G	0.0089	-0.0846	0.0790	0.0063	-0.0016	0.0132	0.0815	-0.1077	0.0480	0.0369	0.0295	0.2503	**0.0716**	-0.1534	0.0095	**0.2873**
TRY	P	0.0516	-0.0500	0.0499	-0.0038	-0.0034	0.0223	0.0440	-0.0281	0.0288	0.0339	-0.0027	0.1415	0.0369	**-0.2986**	0.0671	**0.0896**
	G	0.0367	-0.0742	0.0716	-0.0186	-0.0023	0.0139	0.0549	-0.0560	0.0567	0.0325	-0.0039	0.1528	0.0362	**-0.3034**	0.0944	**0.0914**
Lysine (%)	P	0.0493	-0.0328	0.0329	-0.0025	-0.0029	0.0091	-0.0212	0.0534	-0.0433	0.0388	-0.0142	0.0771	0.0028	-0.1088	**0.1841**	**0.2217*** **
	G	0.0368	-0.0481	0.0472	-0.0190	-0.0020	0.0057	-0.0260	0.0896	-0.0874	0.0365	-0.0187	0.0807	0.0027	-0.1159	**0.2471**	**0.2293**

DA: Days to 50 per cent anthesis	KRE: Number of kernel rows per ear
DS: Days to 50 per cent silking	KPR: Number of kernels per row
ASI: Anthesis silking interval	100-KW: 100-Kernel weight (g)
DM: Days to maturity (cm)	SP: Shelling percentage
PH: Plant height (cm)	CP: Crude protein (%)
EH: Ear height (cm)	TRY: Tryptophan (%)
EG: Ear girth (cm)	LY: Lysine (%)
EL: Ear length (cm)	GY: Grain yield (g/plant)

Anthesis silking interval had Direct effect was positive (0.0253) on grain yield with significantly negative correlation (-0.0014) mainly due to the indirect negative influence through days to 50 per cent anthesis, days to 50 per cent silking, ear height, ear length, number of kernel rows per ear, number of kernels per row, shelling percentage and lysine. The indirect positive contribution exhibited through plant height, ear girth, days to maturity, 100 kernel weight, crude protein and tryptophan contents.

Days to maturity had direct negative effect (-0.1202) on grain yield at yield with significantly negative correlation (-0.4489) was mainly due to indirect negative contribution through plant height, days to 50 per cent silking, anthesis silking interval, ear height, ear length, ear girth, number of kernels per row, 100 kernel weight, shelling percentage, crude protein and lysine whereas, it had indirect positive influence through days to 50 per cent anthesis, number of kernel rows per ear and tryptophan content.

Plant height exhibited negative direct effect (-0.1488) on grain yield with positive correlation (0.0181) which was mainly attributed to the indirect positive influence through days to 50 per cent anthesis, ear height, ear length, ear girth, number of kernels per row, 100- kernel weight, shelling percentage and tryptophan. Indirect negative contribution observed through days to 50 per cent silking, anthesis silking interval, number of kernel rows per ear, days to maturity, crude protein and lysine contents.

Ear height (cm) had direct effect was positive (0.0304) and the correlation was positive with grain yield (0.1445)due to the indirect positive influence of ear height on grain yield was observed through days to 50 per cent silking, ear length, ear girth, number of kernels per row, days to maturity, 100-kernel weight, shelling percentage and tryptophan whereas, it had indirect negative influence through plant height, days to 50 per cent anthesis, anthesis silking interval, number of kernel rows per ear, crude protein content and lysine contents.

Ear girth exhibited direct positive effect (0.2430) and the correlation was significantly positive (0.5889) with grain yield was due to the indirect positive influence on grain yield through days to 50 per cent silking, anthesis silking interval, ear height, ear length, number of kernels per row, days to maturity, 100-kernel weight, shelling percentage and crude protein content whereas, indirect negative influence of ear girth on grain yield was observed through plant height, days to 50 per cent anthesis, number of kernel rows per ear, tryptophan and lysine contents.

Ear length exhibited positive direct effect (0.0633) on grain yield and the correlation was significantly positive (0.5645) was due to the indirect positive influence on grain yield through days to 50 per silking, ear height, ear girth, number of kernels per row, days to maturity, 100-kernel weight, shelling percentage, crude protein and lysine. Indirect negative influence exhibited through plant height, days to 50 per cent anthesis, number of kernel rows per ear, tryptophan and lysine contents.

Number of kernel rows per ear had direct negative influence (-0.2916) on grain yield and the correlation was significantly positive (0.4105) was mainly attributed to the indirect positive contribution through days to 50 per cent silking, anthesis silking interval, ear height, ear length, ear girth, number of kernels per row, days to maturity,100-kernel weight, shelling percentage and crude protein while, indirect negative effects through plant height, days to 50 per cent anthesis, tryptophan and lysine contents.

Number of kernels per row direct positive influence (0.1697) was observed on grain yield and the correlation was significantly positive (0.4031) was mainly attributed to the indirect positive influence through days to 50 per cent silking, ear height, ear length, ear girth, days to maturity, 100-kernel weight, shelling percentage and crude protein. Indirect negative contribution was observed through plant height, days to 50 per cent anthesis, anthesis silking interval, number of kernel rows per ear, tryptophan and lysine contents.

100-kernel weight exhibited the direct positive effect (0.1006) on grain yield and the correlation was significantly positive (0.5168) was due to the indirect positive influence through days to 50 per cent silking, anthesis silking interval, ear height, ear length, ear girth, number of kernels per row, days to maturity, shelling percentage, crude protein and tryptophan whereas, it had indirect negative contribution through plant height, days to 50 per cent anthesis, number of kernel rows per ear and lysine contents.

Shelling percentage exhibited the direct positive effect (0.5900) on grain yield and the correlation was significantly positive at Adilabad (0.7785) was due to indirect positive influence through days to 50 per cent silking, ear height, ear length, ear girth, number of kernels per row, days to maturity, 100-kernel weight, shelling percentage, crude protein and lysine whereas, it had indirect negative influence through plant height, days to 50 per cent anthesis, anthesis silking interval, number of kernel rows per ear and tryptophan contents.

Crude protein content had direct positive effect (0.0780) on grain yield and the correlation was significantly positive (0.2832) was due to the indirect positive influence through plant height, days to 50 per cent silking, anthesis silking interval, ear length, ear girth, number of kernels per row, days to maturity, 100-kernel weight, shelling percentage and lysine whereas, it had indirect negative influence through days to 50 per cent anthesis, ear height, number of kernel rows per ear and tryptophan contents.

Tryptophan content exhibited the direct negative effect (-0.2986) on grain yield and the correlation was positive (0.0896) was mainly attributed to the indirect positive influence through plant height, days to 50 per cent silking, ear length, ear girth, number of kernels per row, days to maturity, shelling percentage, crude protein and lysine contents while, indirect negative influence noticed through days to 50 per cent anthesis, anthesis silking interval, ear height, number of kernel rows per ear and 100-kernel weight.

Lysine exhibited the direct positive effect (0.1841) on grain yield and the correlation was significantly positive (0.2217) was due to indirect positive influence through plant height, days to 50 per cent silking, ear length, number of kernel rows per ear, days to maturity, shelling percentage and crude protein whereas, it had indirect negative influence through days to 50 per cent anthesis, anthesis silking interval, ear height, ear girth, number of kernels per row,100-kernel weight and tryptophan content (Table 2).

Path coefficient analysis revealed that shelling percentage, ear girth and lysine at Adilabad exhibited the highest positive direct effects and hence these traits play an important role in generating the high yielding genotypes in the future breeding programmes. Similar kinds of studies were reported earlier by Srinivasu (2004), Kumar *et al.,* (2006), Sofi and Rather (2007), Muhammad Rafiq *et al.,* (2010), Ramana Reddy *et al.,* (2013) and Neha Rani and Niral (2015).

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