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

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ABSTRACT

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Correlation studies indicated that ear height, ear length, ear girth, Number of kernel rows per ear, Number of kernels per row, 100 kernel weight, Shelling percentage, Crude protein content, tryptophan and lysine contents exhibited significantly positive correlations with grain yield. Path coefficient analysis indicated that ASI, KPR Crude Protein, 100 kernel weight exerted at the highest positive direct effects both at genotypic and phenotypic levels and hence these traits play an important role in generating the high yielding genotypes through breeding programmes.

Introduction

Maize (*Zea mays* L.) is a staple food in many parts of the world and part of this maize will be consumed directly by humans and it has been utilizing for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. It is the third most important cereal crop of India after rice and wheat.

It belongs to the grass family, Poaceae and is highly cross pollinated crop. Due to its high genetic variability, numbers of high yielding genotypes have been developed. Malnutrition

problems were observed where maize was consumed as staple food due to lack of essential amino acids especially among children, lactating mothers.

This is mainly attributed to the fact that majority of zein (seed storage protein of maize) fraction which is completely devoid of lysine and tryptophan is the primary cause of poor protein quality in maize because of which its biological value and net protein utilization was less. With the increased consumption as staple food, efforts were made to develop the nutrient rich corns by improving the lysine and tryptophan contents

in the normal maize background. Incorporation of modified opaque 2 into normal maize so that the digestibility and biological values were improved with the enhanced levels of lysine and tryptophan contents. QPM has balanced leucine: isoleucine ratio with the enriched niacin levels.

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 at three locations *i.e.* ARS, Adilabad, College farm, College of Agriculture, Rajendra nagar, Hyderabad and RARS, Polasa, Jagtial of Telangana state. 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 taken on various characters *i.e.* Days to 50 per cent anthesis, Days to 50 per cent silking, Anthesis silking interval (ASI), 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 content (%) and grain yield. Genotypic and phenotypic correlations were carried out while Path coefficient analysis was done based on the procedure given by Dewey and Lu (1959).

Results and Discussion

Grain yield which is a complex trait is influenced by number of yield attributing traits. Hence, there is a need to understand the inter relationships among them to formulate a sound breeding programme. Real associations are due to Genotypic correlations while phenotypic associations are 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.

Pooled (across three locations) phenotypic and genotypic correlations were worked out on yield and yield contributing characters in 36 crosses and 9 parents at the above mentioned three locations and 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 associated with days to 50% silking and days to maturity while, it had significantly negative associations with ear length, ear girth, number of kernels per row, 100- kernel weight, shelling percentage, crude protein, tryptophan, lysine content and grain yield.

Similar results were reported earlier in maize for association of grain yield per plant with days to 50 percent tasseling by Jayakumar *et al.*, (2007), Pavan *et al.*, (2011) and Mural *et al.*, (2012).

Days to 50 per cent silking

Days to 50 percent silking association was significant and positive with days to maturity. Negative and significant association was noticed with ear length, ear girth, number of kernels per row, 100- kernel weight, shelling percentage, crude protein, tryptophan and lysine contents and grain yield.

Earlier negative association of grain yield per plant with days to 50 per cent silking was reported Sofi and Rather (2007), Jaya Kumar *et al.*, (2007), Pavan *et al.*, (2011), Mural *et al.*, (2012) and Neha Rani and Niral (2015).

Anthesis silking interval

For ASI analysis, none of the traits exhibited significantly positive or negative associations with anthesis silking interval. Similar results were reported earlier in maize by Pavan *et al.*, (2011).

Days to maturity

Significant and negative association was recorded with 100- kernel weight, shelling percentage, crude protein, tryptophan and lysine content and grain yield at Adilabad, Jagtial and in pooled analysis.

The results are in concurrence with the earlier findings of were reported earlier in maize for the association of grain yield per plant with days to maturity by Jaya Kumar *et al.*, (2007).

Plant height

Days to anthesis, days to silking, ear height, ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100 kernel weight and shelling percentage exhibited significantly positive association with plant height while, tryptophan and lysine showed significantly negative association with the

plant height. The results are in accordance with the earlier findings Muhammad Rafiq *et al.*, (2010), Pavan *et al.*, (2011), Raghu *et al.*, (2011), Ram Reddy *et al.*, (2012), Mural *et al.*, (2012) and Neha Rani and Niral (2015).

Ear height

For ear height, significantly positive associations were observed with ear length, ear girth, number of kernel rows per ear, number of kernels per row, 100- kernel weight and grain yield at all the three locations while, days to maturity, crude protein, tryptophan and lysine had significantly negative association with the ear height.

Similar results were reported earlier in maize for the association of grain yield with ear height by Sofi and Rather (2007), Raghu *et al.*, (2011), Ram Reddy *et al.*, (2012), Mural *et al.*, (2012) and Neha Rani and Niral (2015).

Ear Length exhibited significantly positive associations with number of kernel rows per ear, number of kernels per row, 100- kernel weight, shelling percentage, crude protein, tryptophan content and grain yield whereas, it exhibited significantly negative association with days to maturity.

Similar results were reported earlier in maize for the association of grain yield with ear height by Sofi and Rather (2007), Raghu *et al.*, (2011), Ram Reddy *et al.*, (2012), Mural *et al.*, (2012) and Neha Rani and Niral (2015).

This trait 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 at all the three locations. It also exhibited a significantly positive association with lysine

content at Hyderabad while, a positive but non-significant association was observed at Adilabad and Jagtial locations for lysine contents. The trait also exhibited significantly negative association with days to maturity. In pooled analysis, the trait had significantly positive association with ear girth, number of kernel rows per ear, number of kernels per row, 100- kernel weight, shelling percentage, crude protein, tryptophan, lysine and grain yield. While, days to maturity exhibited significantly negative association.

Similar results were reported earlier in maize for the association of grain yield with ear height by Sofi and Rather (2007), Ram Reddy *et al.*, (2012), Mural *et al.*, (2012) and Ravi *et al.*, (2012), and Neha Rani and Niral (2015).

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, it exhibited significantly negative association with days to maturity and lysine. These results are in agreement with the earlier findings of Kumar *et al.*, (2006), Jaya Kumar *et al.*, (2007), Raghu *et al.*, (2011), Ram Reddy *et al.*, (2012) and Ravi *et al.*, (2012) in maize for the association of grain yield with number of kernel rows per ear.

Number of kernels per row

Number of kernels per row had significant and positive association with 100-kernel weight, shelling percentage, crude protein, tryptophan and grain yield while, days to maturity and lysine were significantly and negatively associated with number of kernels per row.

These results are in accordance with the earlier findings of Sofi and Rather (2007), Muhammad Rafiq *et al.*, (2010) and Ram

Reddy *et al.*, (2012) in maize for the association of grain yield with number of kernels per row.

100-kernel weight

Significant and positive associations were observed with shelling percentage, crude protein and grain yield while, it exhibited significantly negative association with lysine. Negative but non-significant association was observed with tryptophan content. These results are in concurrence with the earlier findings of Kumar *et al.*, (2006), Muhammad Rafiq *et al.*, (2010), Pavan *et al.*, (2011), Sofi and Rather (2007) and Neha Rani and Niral (2015) in maize for the association of grain yield with 100-kernel weight.

Shelling percentage

This character associated significantly and positively with crude protein, tryptophan, lysine and grain yield. These results are in agreement with the earlier findings of Pavan *et al.*, (2011), Mural *et al.*, (2012) and Preeti Sharma *et al.*, (2017) in maize for the association of shelling percentage with grain yield and other traits.

Crude protein

Tryptophan and grain yield were associated significantly and positively with crude protein content while, non-significant positive and non-significant negative associations were observed with lysine content. These results are in concurrence with the earlier findings in maize for the association of grain yield and crude protein by Om Prakash *et al.*, (2006) and Neharani and Niral (2015).

Tryptophan

This character exhibited significantly positive association with lysine and grain yield. These

results are in concurrence with the earlier findings in maize for the association of grain yield and tryptophan by Om Prakash *et al.*, (2006) and Neharani and Niral (2015).

Lysine

Lysine content was significantly and positively associated with grain yield. Similar results were reported in maize by Preeti sharma *et al.*, (2017).

The study of character association among the yield components in pooled analysis revealed the significantly positive association of grain yield with ear height, 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. These results are in concurrence with the earlier findings in maize for the association of grain yield and lysine by Om Prakash *et al.*, (2006) and Neharani and Niral (2015) and Preeti Sharma *et al.*, (2017).

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. Path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlations (Wright, 1921). Hence, the path coefficient analysis was undertaken to know the direct and indirect effects.

Based on the pooled data recorded on the genotypes in the present investigation, the phenotypic and genotypic correlations were estimated to determine direct and indirect effects of yield and yield contributing characters. The results are presented (Table 2 & Fig.1).

Days to 50 per cent anthesis showed a positive direct effect (0.0541) on grain yield with significantly negative correlation (-0.3735) which was mainly due to indirect negative contribution through number 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. It also showed indirect positive effects through number of kernel rows per ear and tryptophan contents. The results of direct negative effect of days to 50 per cent tasseling on grain yield are in agreement with the earlier findings of Kumar *et al.*, (2006).

Days to 50 per cent silking showed negative direct effect (-0.0210) on grain yield the correlation was significantly negative (-0.3708) which was mainly attributed to the indirect negative contribution 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 while, it had indirect positive effects through days to 50 per cent anthesis, anthesis silking interval, number of kernel rows per ear and tryptophan contents.

Similar results of direct negative and positive effects of days to 50 per cent silking on grain yield was reported by earlier workers Viola *et al.*, (2003) and Pavan *et al.*, (2011). Anthesis silking interval had direct effect was positive (0.0499) with positive correlation (0.0236) mainly due to the indirect positive contribution exhibited through plant height, ear length, ear girth, number of kernels per row, days to maturity, 100 kernel weight and tryptophan. Indirect negative effects on grain yield exhibited through days to 50 per cent anthesis, days to 50 per cent silking, ear height, number of kernel rows per ear, shelling percentage, crude protein and lysine contents. Similar results of direct positive effect of days to 50 per cent silking on grain yield were reported by Kumar *et al.*, (2006).

Days to maturity exhibited, negative direct effect was recorded (-0.1283) with significantly negative correlation with grain yield (-0.3675) was due to indirect negative effects 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 effects through days to 50 per cent anthesis, number of kernel rows per ear and tryptophan content. Direct negative effects of days to maturity in maize were also reported by Pavan *et al.*, (2011).

Plant height showed a negative direct effect while, correlation was positive with grain yield (0.0326) was due to the indirect positive contribution 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 while, indirect negative contribution was 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 which was similar to the

trend that was observed at Adilabad. Similar results of direct positive and negative effects of plant height on grain yield were reported by earlier workers like Pavan *et al.*, (2011).

Ear height had direct positive contribution (0.0522) and the correlation was significantly positive (0.1529) with grain yield was due to the indirect positive contribution 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.

While, indirect negative contribution exhibited through plant height, days to 50 per cent anthesis, anthesis silking interval, number of kernel rows per ear, crude protein and lysine contents. These results are comparable with the findings of Ram Reddy *et al.*, (2012) who reported positive direct effect on ear height on grain yield in maize.

Ear girth had direct positive influence (0.2395) on grain yield and the correlation was significantly positive (0.6018). 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 whereas, it had negative indirect effect on grain yield through plant height, days to 50 per cent anthesis, number of kernel rows per ear and tryptophan content. These results are in agreement with the findings of Sofi and Rather (2007) and Ram Reddy *et al.*, (2012).

Ear length exhibited positive direct effect (0.0625) on grain yield and the correlation was significantly positive (0.5773) was due to indirect positive influence exhibited through days to 50 per cent silking, anthesis silking interval, ear height, ear girth, number of kernels per row, days to maturity, 100-kernel weight, shelling percentage, crude protein and

lysine while, it had indirect negative contribution through plant height, days to 50 per cent anthesis, number of kernel rows per ear, and tryptophan. Similar results were reported earlier by Sofi and Rather (2007) and Ram Reddy *et al.*, (2012). Number of Kernel rows per ear exhibited direct negative effect (-0.2909) on grain yield and the correlation was significantly positive (0.3407) was due to 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, 100-kernel weight, shelling percentage and crude protein whereas, indirect negative influence on grain yield exhibited through plant height, days to 50 per cent anthesis, tryptophan and lysine contents. These results are in concurrence with the direct positive effect of number of kernel rows per ear on grain yield was reported earlier by Pavan *et al.*, (2011).

Number of kernels per row had direct positive influence (0.1872) on grain yield and the correlation was significantly positive (0.4110) was due to the indirect positive influence through days to 50 per cent silking, anthesis silking interval, ear height, ear length, ear girth, days to maturity, 100-kernel weight, shelling percentage and crude protein whereas, it exhibited indirect negative influence through plant height, days to 50 per cent anthesis, number of kernel rows per ear, tryptophan and lysine contents. The results are in agreement with the findings of Sofi and Rather (2007), Mohammad Rafiq *et al.*, (2010) and Tulu (2014) who reported direct positive effect of number of kernels per row on grain yield.

100-KerneK weight exhibited the direct positive effect (0.1198) on grain yield and the correlation was significantly positive (0.5171) was due to the indirect it had 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 influence through plant height, days to 50 per cent anthesis, number of kernel rows per ear and lysine contents. The results on direct positive effect of 100-seed weight on grain yield was found by earlier workers Srinivasu (2004), Kumar *et al.*, (2006), Sofi and Rather (2007), Muhammad Rafiq *et al.* (2010) and Neha Rani and Niral (2015).

Shelling percentage exhibited direct positive effect (0.5812) was recorded on grain yield and the correlation was significantly positive (0.7724) while, it had 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, crude protein and lysine. It had indirect negative contribution through plant height, days to 50 per cent anthesis, through anthesis silking interval, number of kernel rows per ear and tryptophan contents. Similar results of direct positive effect of shelling percentage on grain yield was found by earlier by Kumar *et al.*, (2006).

Crude3 protein content had direct positive effect (0.0326) was recorded on grain yield and the correlation was significantly positive (0.2475) was due 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, 100-kernel weight, shelling percentage and lysine whereas, indirect negative contribution observed through days to 50 per cent anthesis, anthesis silking interval, ear height, number of kernel rows per ear and tryptophan contents. These results are in agreement with the findings of Ramana Reddy *et al.*, (2013) who reported direct positive and negative effects of crude protein content on grain yield.

Table.1 Phenotypic (G) and Genotypic (G) pooled Correlations for sixteen characters

Character		PH	DA	DS	ASI	EH	EL	EG	KRE	KPR	DM	100KW	SP	CP	TRY	LYS	GY
PH	P	1.0000	0.2150**	0.2095**	-0.0450	0.7215**	0.1227*	0.2190**	0.2343*	0.1346**	0.0248	0.1452**	0.1053*	-0.0648	-0.3592**	-0.3481**	0.0326
	G	1.0000	0.2276	0.2235	-0.1516	0.7493	0.1298	0.2305	0.2574	0.1307	0.0179	0.1484	0.1117	-0.0723	-0.3895	-0.3803	0.0326
DA	P		1.0000	0.9928**	-0.0259	-0.0169	-0.2916**	-0.2384**	-0.0636	-0.1127*	0.5071**	-0.1639**	-0.449**1	-0.4740**	0.4082**	-0.3168**	-0.3735**
	G		1.0000	0.9998	-0.0804	-0.0164	-0.3075	-0.2623	-0.0879	-0.1094	0.5793	-0.1691	-0.4772	-0.5097	-0.4717	-0.3174	-0.3862
DS	P			1.0000	0.0606	-0.0190	-0.2899**	-0.2374**	-0.0584	-0.1124*	0.5033**	-0.1620**	-0.4547**	-0.4735**	0.4162**	-0.3196**	-0.3708**
	G			1.0000	-0.0429	-0.0205	-0.3080	-0.2634	-0.0878	-0.1089	0.5814	-0.1665	-0.4847	-0.5126	-0.4812	-0.3228	-0.3846
ASI	P				1.0000	-0.0326	0.0121	0.0061	0.0446	0.0076	-0.0375	0.0189	-0.0831	-0.0200	-0.0890	-0.0177	0.0236
	G				1.0000	-0.1278	0.0023	-0.0199	0.0115	0.0199	0.0381	0.0927	-0.2054	-0.0543	-0.2774	-0.1639	0.0757
EH	P					1.0000	0.2672**	0.3068**	0.2756*	0.2254**	-0.1233*	0.0430**	0.2033	-0.0735**	0.1330**	-0.1105*	0.1529**
	G					1.0000	0.2693	0.3139	0.2955	0.2297	-0.1504	0.0393	0.2106	-0.0759	-0.1350	-0.1182	0.1549
EL	P						1.0000	0.8209**	0.6230*	0.6053**	-0.3897**	0.4825**	0.6064**	0.3268**	0.3398**	0.1608**	0.5773**
	G						1.0000	0.8345	0.6542	0.6183	-0.4225	0.4991	0.6335	0.3422	0.3602	0.1706	0.5841
EG	P							1.0000	0.7861*	0.7263**	-0.3591**	0.6627**	0.6170**	0.2724**	0.1806**	-0.0856	0.6018**
	G							1.0000	0.8195	0.7562	-0.3796	0.6905	0.6429	0.2809	0.1827	-0.0759	0.6117
KRE	P								1.0000	0.8084**	-0.3051**	0.6288**	0.3605**	0.1911**	0.0672	-0.2364**	0.3407**
	G								1.0000	0.8691	-0.3140	0.6784	0.3975	0.1851	0.0606	-0.2406	0.3609
KPR	P									1.0000	-0.2699**	0.5473**	0.4041**	0.1535**	0.1506**	-0.2403**	0.4110**
	G									1.0000	-0.3156	0.5677	0.4315	0.1613	0.1712	-0.2670	0.4195

Character		PH	DA	DS	ASI	EH	EL	EG	KRE	KPR	DM	100KW	SP	CP	TRY	LYS	GY
DM	P										1.0000	-	-	-	-	-	-
	G										1.0000	0.3111**	0.2731*	0.2524*	0.2685*	0.2792*	0.3675*
100KW	P											1.0000	0.4690*	0.2138*	-0.0556	-	0.5171*
	G											1.0000	0.4929	0.2339	-0.0542	0.1431*	0.5308
SP	P												1.0000	0.4009*	0.2628*	0.1846*	0.7724*
	G												1.0000	0.4249	0.2879	0.1977	0.8029
CP	P													1.0000	0.4451*	0.0215	0.2475*
	G													1.0000	0.4815	0.0311	0.2556
Try	P														1.0000	0.3678*	0.0689*
	G														1.0000	0.4145	0.0718
Lys	P															1.0000	0.2287*
	G															1.0000	0.2407

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	SP: Shelling percentage
PH: Plant height (cm)	CP: Crude protein content (%)
EH: Ear height (cm)	TRY: Tryptophan content (%)
EG: Ear girth (cm)	LY: Lysine content (%)
EL: Ear length (cm)	GY: Grain yield (g/plant)

Table.2 Phenotypic (P) and Genotypic (G) pooled Path coefficients for various characters in QPM maize

Characters		PH	DA	DS	ASI	EH	EL	EG	KRE	KPR	DM	100KW	SP	CP	TRY	LYS	GY
PH	P	-0.1477	0.0116	-0.0044	-0.0022	0.0377	0.0077	0.0524	-0.0682	0.0252	-0.0032	0.0174	0.0612	-0.0021	0.1028	-0.0556	0.0326
	G	-0.1152	-0.2442	0.2617	-0.0203	0.0464	-0.0036	0.0622	-0.1027	0.0373	-0.0025	0.0156	0.0770	-0.0031	0.1064	-0.0824	0.0326
DA	P	-0.0318	0.0541	-0.0208	-0.0013	-0.0009	-0.0182	-0.0571	0.0185	-0.0211	-0.0651	-0.0196	-0.2610	-0.0155	0.1169	-0.0506	- 0.3735**
	G	-0.0262	-1.0728	1.1709	-0.0107	-0.0010	0.0085	-0.0707	0.0351	-0.0312	-0.0797	-0.0178	-0.3289	-0.0216	0.1288	-0.0688	-0.3862
DS	P	-0.0310	0.0537	-0.0210	0.0030	-0.0010	-0.0181	-0.0569	0.0170	-0.0210	-0.0646	-0.0194	-0.2643	-0.0155	0.1192	-0.0510	- 0.3708**
	G	-0.0257	-1.0726	1.1712	-0.0057	-0.0013	0.0085	-0.0710	0.0350	-0.0310	-0.0800	-0.0175	-0.3340	-0.0218	0.1314	-0.0699	-0.3846
ASI	P	0.0067	-0.0014	-0.0013	0.0499	-0.0017	0.0008	0.0015	-0.0130	0.0014	0.0048	0.0023	-0.0483	-0.0007	0.0255	-0.0028	0.0236
	G	0.0175	0.0862	-0.0503	0.1337	-0.0079	-0.0001	-0.0054	-0.0046	0.0057	-0.0052	0.0098	-0.1416	-0.0023	0.0758	-0.0355	0.0757
EH	P	-0.1066	-0.0009	0.0004	-0.0016	0.0522	0.0167	0.0735	-0.0802	0.0422	0.0158	0.0052	0.1181	-0.0024	0.0381	-0.0177	0.1529**
	G	-0.0863	0.0176	-0.0240	-0.0171	0.0619	-0.0075	0.0847	-0.1180	0.0655	0.0207	0.0041	0.1452	-0.0032	0.0369	-0.0256	0.1549
EL	P	-0.0181	-0.0158	0.0061	0.0006	0.0140	0.0625	0.1966	-0.1813	0.1133	0.0500	0.0578	0.3524	0.0107	-0.0973	0.0257	0.5773**
	G	-0.0150	0.3299	-0.3607	0.0003	0.0167	-0.0277	0.2251	-0.2612	0.1763	0.0582	0.0526	0.4366	0.0145	-0.0984	0.0370	0.5841
EG	P	-0.0323	-0.0129	0.0050	0.0003	0.0160	0.0513	0.2395	-0.2287	0.1360	0.0461	0.0794	0.3586	0.0089	-0.0517	-0.0137	0.6018**
	G	-0.0266	0.2814	-0.3085	-0.0027	0.0194	-0.0231	0.2697	-0.3272	0.2156	0.0523	0.0727	0.4430	0.0119	-0.0499	-0.0165	0.6117
KRE	P	-0.0346	-0.0034	0.0012	0.0022	0.0144	0.0390	0.1883	-0.2909	0.1513	0.0391	0.0754	0.2095	0.0062	-0.0192	-0.0378	0.3407**
	G	-0.0297	0.0943	-0.1028	0.0015	0.0183	-0.0181	0.2210	-0.3992	0.2478	0.0432	0.0715	0.2739	0.0079	-0.0166	-0.0521	0.3609

Characters		PH	DA	DS	ASI	EH	EL	EG	KRE	KPR	DM	100KW	SP	CP	TRY	LYS	GY
KPR	P	-0.0199	-0.0061	0.0024	0.0004	0.0118	0.0379	0.1740	-0.2352	0.1872	0.0346	0.0656	0.2349	0.0050	-0.0431	-0.0384	0.4110**
	G	-0.0151	0.1174	-0.1275	0.0027	0.0142	-0.0171	0.2040	-0.3469	0.2851	0.0434	0.0598	0.2974	0.0068	-0.0468	-0.0579	0.4195
DM	P	-0.0037	0.0274	-0.0106	-0.0019	-0.0064	-0.0244	-0.0860	0.0888	-0.0505	-0.1283	-0.0373	-0.1587	-0.0082	0.0769	-0.0446	-0.3675**
	G	-0.0021	-0.6215	0.6809	0.0051	-0.0093	0.0117	-0.1024	0.1254	-0.0900	-0.1376	-0.0366	-0.2121	-0.0121	0.0716	-0.0702	-0.3992
100KW	P	-0.0214	-0.0089	0.0034	0.0009	0.0022	0.0302	0.1587	-0.1829	0.1025	0.0399	0.1198	0.2726	0.0070	0.0159	-0.0229	0.5171**
	G	-0.0171	0.1814	-0.1951	0.0124	0.0024	-0.0138	0.1862	-0.2708	0.1619	0.0478	0.1053	0.3397	0.0099	0.0148	-0.0344	0.5308
SP	P	-0.0156	-0.0243	0.0095	-0.0041	0.0106	0.0379	0.1478	-0.1049	0.0756	0.0350	0.0562	0.5812	0.0131	-0.0752	0.0295	0.7724**
	G	-0.0129	0.5120	-0.5677	-0.0275	0.0130	-0.0176	0.1734	-0.1587	0.1230	0.0424	0.0519	0.6892	0.0180	-0.0786	0.0428	0.8029
CP	P	0.0096	-0.0256	0.0099	-0.0010	-0.0038	0.0204	0.0652	-0.0556	0.0287	0.0324	0.0256	0.2330	0.0326	-0.1274	0.0034	0.2475**
	G	0.0083	0.5469	-0.6003	-0.0073	-0.0047	-0.0095	0.0758	-0.0739	0.0460	0.0392	0.0246	0.2928	0.0425	-0.1315	0.0067	0.2556
Try	P	0.0531	-0.0221	0.0087	-0.0044	-0.0069	0.0213	0.0433	-0.0196	0.0282	0.0344	-0.0067	0.1527	0.0145	-0.2863	0.0587	0.0689**
	G	0.0449	0.5061	-0.5635	-0.0371	-0.0084	-0.0100	0.0493	-0.0242	0.0488	0.0361	-0.0057	0.1984	0.0204	-0.2731	0.0898	0.0718
Lys	P	0.0514	-0.0171	0.0067	-0.0009	-0.0058	0.0101	-0.0205	0.0688	-0.0450	0.0358	-0.0172	0.1073	0.0007	-0.1053	0.1597	0.2287**
	G	0.0438	0.3405	-0.3780	-0.0219	-0.0073	-0.0047	-0.0205	0.0960	-0.0761	0.0446	-0.0167	0.1363	0.0013	-0.1132	0.2167	0.2407

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	SP: Shelling percentage
PH: Plant height (cm)	CP: Crude protein content (%)
EH: Ear height (cm)	TRY: Tryptophan content (%)
EG: Ear girth (cm)	LY: Lysine content (%)
EL: Ear length (cm)	GY: Grain yield (g/plant)

Tryptophan content exhibited direct negative effect (-0.2863) on grain yield and the correlation was significantly positive (0.0689) was due to the indirect positive contribution 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, it had indirect negative influence through days to 50 per cent anthesis, anthesis silking interval, ear height, number of kernel rows per ear and 100-kernel weight.

Similar results of direct positive effect of tryptophan content on grain yield was found by earlier workers. These results are in agreement with the findings of Ramana Reddy *et al.*, (2013) who reported direct negative effects of tryptophan content on grain yield.

Lysine content had direct positive effect (0.1597) was noticed on grain yield and the correlation was significantly positive (0.2287) was due to the 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. While, 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 contents.

Path coefficient analysis revealed that shelling percentage, ear girth and lysine at Adilabad; number of kernels per row, shelling percentage and 100-kernel weight at Hyderabad; shelling percentage and ear girth in pooled analysis exhibited the highest positive direct effects at both the genotypic and phenotypic levels on grain yield and hence these traits play an important role in generating the high yielding genotypes in the future breeding programmes.

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