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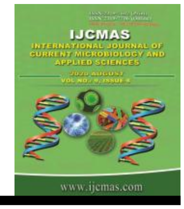

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Correlation and Path Coefficient Studies for Kernel Yield and Component Traits in Maize

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Correlation and path coefficient analysis for kernel yield and yield components was under taken in 49 maize inbred lines using simple lattice design with two replications during *kharif*, 2018 at Agricultural Research Station, Peddapuram, East Godavari district, Andhra Pradesh in order to understand the relationship between kernel yield and its component traits. The studies revealed significant and positive association of kernel yield plant^{-1} with cob length, cob girth and cob yield plant^{-1} at both phenotypic and genotypic levels. The path analysis revealed high positive and direct effect of cob yield plant^{-1} for kernel yield plant^{-1} in addition to strong positive association with kernel yield per plant indicating its true relationship with kernel yield plant^{-1}.Considering the nature and quantum of trait associations and their direct and indirect effects, cob yield plant^{-1} is identified as important selection criteria for effecting kernel yield improvement in maize.

Introduction

Maize is one of the most important crop belonging to the family Poaceae. In India, maize is grown throughout the year in most of the states. It is grown for both human as well as animal consumption. For producing high yielding genotypes in maize, selection based on yield alone is not useful because yield is a complex and polygenic character resulting from multiplicative interaction of its component traits. The cumulative effect of component traits determines yield and plays an important role in modification of yield as a whole in magnitude as well as in direction. Therefore, correlation studies are of considerable importance in any selection programme as they provide information on the degree and direction of relationship between two or more component traits. Besides this, path coefficient analysis is also important because it provides an effective means of estimating the direct and indirect effects of the independent variables on the dependent variable and permits a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each factor. Keeping these points in view the present investigation was carried out to estimate the character association and path coefficients for yield and its component traits.

Materials and Methods

The present investigation was carried out at Agricultural Research Station, Peddapuram, East Godavari district, Andhra Pradesh during *kharif*'2018. The experimental material comprised of 49 elite maize inbred lines. The genotypes were evaluated using simple lattice design with two replications and data was recorded for 14 traits, namely days to 50 percent tasseling, days to 50 percent silking, anthesis silking interval, days to maturity, plant height (cm), ear placement height (cm), cob length (cm), cob girth (cm), number of kernel rows per cob, number of kernels per row, cob yield per plant (g), kernel yield per plant (g), 100 kernel weight (g) and protein content (%) on five randomly selected plants, for each genotype, from each entry, in each replication.

Correlation coefficients were calculated at genotypic and phenotypic level using the formulae suggested by Falconer (1964) and path analysis was carried out as per the suggestions of Dewey and Lu (1959). The path coefficients were categorized as high, moderate and low based on the recommendations of Lenka and Mishra (1973). The statistical software used for analysis of the data is Statistical Analysis Software (SAS) 9.2 version and Windostat 9.1.

Results and Discussion

Correlation coefficient

The estimates of genotypic and phenotypic correlation coefficients for yield and yield components are presented in Table 1. The results revealed phenotypic and genotypic correlation coefficients to be of similar direction and significance in general. However, the phenotypic coefficients were observed to be of lower magnitude in general, compared to genotypic coefficients, indicating the masking effect of environment. The findings are in agreement with the reports of Lokeshwar Reddy *et al.*, (2018). The trait, cob yield plant^{-1} had recorded positive and significant association with kernel yield plant^{-1} followed by cob length and cob girth at both genotypic and phenotypic levels.

These results are in agreement with the findings of Bisen *et al.*, (2018). Whereas, the traits like kernel rows cob^{-1} and kernels row^{-1} exhibited significant and positive association at phenotypic level. These results are in agreement with the reports of Bikal and Timsina (2015). Further, the traits, namely, plant height and ear placement height recorded significant and positive correlation coefficients values with kernel yield per plant at genotypic level. The results are in conformity with the findings of Lad *et al.*, (2018) and Grace *et al.*, (2018). The trait, anthesis silking interval alone had however, recorded significant and negative correlation at genotypic level.

Association analysis among yield contributing traits, revealed positive and significant association of days to 50 per cent tasseling with days to 50 per cent silking, days to maturity, plant height and ear placement height; days to 50 per cent silking with days to maturity, plant height and ear placement height; days to maturity with plant height and ear placement height; plant height with ear placement height, cob length, 100 kernel weight and cob yield plant^{-1}; cob length with cob girth and cob yield plant^{-1}; cob girth with cob yield plant^{-1}and 100 kernel weight; and kernels row^{-1} with cob yield plant^{-1} at both genotypic level and phenotypic levels. Similar results were observed earlier by Lad *et al.*, (2018).

Table.1 Phenotypic (above the diagonal) and genotypic (below the diagonal) correlations among kernel yield and its attributing characters in maize (*Zea mays* L.)

Character	DT	DS	ASI	DM	PH	EPH	CL	CG	KR	KPR	CYP	100 KW	PC	KYP
DT	**1.0000**	0.9969**	0.0077	0.9135**	0.4206**	0.2415*	0.0830	0.0482	0.0599	0.1349	0.0310	0.0981	-0.2075*	0.0229
DS	0.9997**	**1.0000**	0.0331	0.9126**	0.4080**	0.2232*	0.0708	0.0342	0.0334	0.1335	0.0198	0.0988	-0.2044*	0.0201
ASI	0.0957	0.0942	**1.0000**	0.0029	-0.2373*	-0.2696**	-0.0956	-0.0790	-0.1795	0.0405	-0.0109	-0.0200	0.0120	0.0511
DM	0.9685**	0.9609**	-0.0159	**1.0000**	0.4803**	0.2984*	0.0755	0.0541	0.0774	0.0487	0.0258	0.1801	-0.2828**	0.0149
PH	0.4824**	0.4675**	-0.4465**	0.5590**	**1.0000**	0.7143**	0.2743**	0.1066	-0.0127	0.1841	0.2555*	0.3305**	-0.1847	0.1944
EPH	0.2832**	0.2639**	-0.5649**	0.3596**	0.8182**	**1.0000**	0.1772	0.0007	0.0502	0.1062	0.2257*	0.1681	-0.1074	0.1120
CL	0.1424	0.1169	-0.2837**	0.0760	0.4322**	0.3977**	**1.0000**	0.4687**	-0.0395	0.3595**	0.5218**	-0.0059	0.0399	0.5212**
CG	0.0206	0.0062	-0.0814	0.0031	0.2038*	0.0199	0.3191**	**1.0000**	0.1557	0.1757	0.6016**	0.2140*	0.0284	0.6082**
KR	0.0513	0.0230	-0.6644**	0.0692	0.1051	0.0138	-0.1295	0.1329	**1.0000**	-0.0079	0.2525*	-0.1093	-0.1380	0.2167*
KPR	0.2149*	0.2136*	0.1295	0.0662	0.2931**	0.1811	0.2940**	-0.0801	-0.3225**	**1.0000**	0.4841**	-0.0440	-0.0375	0.4068**
CYP	0.1158	0.0924	-0.3388**	0.1289	0.5946**	0.4086**	0.4734**	0.8437**	0.0863	0.2320*	**1.0000**	0.1691	-0.0411	0.9308**
100 KW	0.1596	0.1555	0.0949	0.3409**	0.4676**	0.2703**	-0.1265	0.3697**	-0.3151**	-0.1857	0.3734**	**1.0000**	-0.0345	0.1098
PC	-0.2920**	-0.2961**	0.1605	-0.4514**	-0.3219**	-0.1156	0.0977	0.2112*	-0.4513**	-0.2342*	0.0036	-0.0124	**1.0000**	0.0291
KYP	0.1069	0.0880	-0.2715**	0.0795	0.4176**	0.2033*	0.4147**	0.8235**	0.0315	0.0550	0.8826**	0.1575	0.1481	**1.0000**

* Significant at 5 per cent level ** Significant at 1 per cent level

DT: Days to 50 per cent Tasseling; DS: Days to 50 per cent Silking; ASI: Anthesis Silking Interval; DM: Days to Maturity; PH: Plant Height; EPH: Ear Placement Height; CL: Cob Length; CG: Cob Girth; KR: Kernel rows cob^{-1}; KPR: Kernels row^{-1}; CYP: Cob Yield Plant^{-1}; 100 KW: 100 kernel Weight; PC: Protein Content; KYP: Kernel Yield Plant^{-1}

Table.2 Direct (diagonal) and indirect effects (above and below the diagonal) of different traits on kernel yield per plant in maize (*Zea mays* L.)

Character		DT	DS	ASI	DM	PH	EPH	CL	CG	KR	KPR	CYP	100 GW	PC	GYP
DT	**G**	**-4.2147**	5.2070	0.0312	-0.9718	0.1258	-0.0586	-0.0029	-0.0156	-0.0095	-0.1903	0.2434	-0.0747	0.0375	0.1069
	P	**-1.1591**	1.1658	0.0003	0.0023	0.0362	-0.0280	0.0036	0.0027	0.0009	-0.0108	0.0292	-0.0070	-0.0132	0.0229
DS	**G**	-4.2135	**5.2086**	0.0307	-0.9641	0.1219	-0.0546	-0.0024	-0.0047	-0.0043	-0.1892	0.1941	-0.0728	0.0380	0.0880
	P	-1.1555	**1.1695**	0.0011	0.0023	0.0351	-0.0259	0.0031	0.0019	0.0005	-0.0106	0.0186	-0.0070	-0.0130	0.0201
ASI	**G**	-0.4032	0.4907	**0.3260**	0.0159	-0.1165	0.1168	0.0058	0.0613	0.1232	-0.1147	-0.7119	-0.0444	-0.0206	-0.2715**
	P	-0.0090	0.0387	**0.0332**	0.0001	-0.0204	0.0313	-0.0042	-0.0044	-0.0028	-0.0032	-0.0103	0.0014	0.0008	0.0511
DM	**G**	-4.0822	5.0047	-0.0052	**-1.0034**	0.1458	-0.0744	-0.0016	-0.0024	-0.0128	-0.0586	0.2710	-0.1595	0.0580	0.0795
	P	-1.0588	1.0673	0.0001	**0.0025**	0.0413	-0.0346	0.0033	0.0030	0.0012	-0.0039	0.0243	-0.0128	-0.0179	0.0149
PH	**G**	-2.0330	2.4349	-0.1456	-0.5609	**0.2608**	-0.1692	-0.0088	-0.1537	-0.0195	-0.2595	1.2495	-0.2188	0.0414	0.4176**
	P	-0.4875	0.4771	-0.0079	0.0012	**0.0860**	-0.0829	0.0120	0.0060	-0.0002	-0.0147	0.2405	-0.0235	-0.0117	0.1944
EPH	**G**	-1.1936	1.3743	-0.1842	-0.3608	0.2134	**-0.2068**	-0.0081	-0.0150	-0.0026	-0.1604	0.8586	-0.1265	0.0149	0.2033*
	P	-0.2799	0.2610	-0.0089	0.0007	0.0614	**-0.1161**	0.0077	0.0000	0.0008	-0.0085	0.2124	-0.0120	-0.0068	0.1120
CL	**G**	-0.6000	0.6089	-0.0925	-0.0763	0.1127	-0.0822	**-0.0205**	-0.2406	0.0240	-0.2604	0.9948	0.0592	-0.0126	0.4147**
	P	-0.0962	0.0828	-0.0032	0.0002	0.0236	-0.0206	**0.0436**	0.0262	-0.0006	-0.0287	0.4911	0.0004	0.0025	0.5212**
CG	**G**	-0.0870	0.0324	-0.0265	-0.0031	0.0532	-0.0041	-0.0065	**-0.7540**	-0.0246	0.0709	1.7731	-0.1730	-0.0271	0.8235**
	P	-0.0559	0.0400	-0.0026	0.0001	0.0092	-0.0001	0.0204	**0.0558**	0.0024	-0.0140	0.5662	-0.0152	0.0018	0.6082**
KR	**G**	-0.2160	0.1196	-0.2166	-0.0694	0.0274	-0.0028	0.0026	-0.1002	**-0.1854**	0.2856	0.1814	0.1475	0.0580	0.0315
	P	-0.0694	0.0390	-0.0060	0.0002	-0.0011	-0.0058	-0.0017	0.0087	**0.0154**	0.0006	0.2376	0.0078	-0.0087	0.2167*
KPR	**G**	-0.9059	1.1127	0.0422	-0.0664	0.0764	-0.0375	-0.0060	0.0604	0.0598	**-0.8855**	0.4876	0.0869	0.0301	0.0550
	P	-0.1563	0.1562	0.0013	0.0001	0.0158	-0.0123	0.0157	0.0098	-0.0001	**-0.0798**	0.4556	0.0031	-0.0024	0.4068**
CYP	**G**	-0.4882	0.4810	-0.1104	-0.1294	0.1551	-0.0845	-0.0097	-0.6361	-0.0160	-0.2055	**2.1015**	-0.1747	-0.0005	0.8826**
	P	-0.0359	0.0231	-0.0004	0.0001	0.0220	-0.0262	0.0228	0.0336	0.0039	-0.0386	**0.9411**	-0.0120	-0.0026	0.9308**
100 GW	**G**	-0.6725	0.8100	0.0310	-0.3421	0.1220	-0.0559	0.0026	-0.2787	0.0584	0.1644	0.7847	**-0.4679**	0.0016	0.1575
	P	-0.1137	0.1156	-0.0007	0.0004	0.0284	-0.0195	-0.0003	0.0119	-0.0017	0.0035	0.1591	**-0.0713**	-0.0022	0.1098
PC	**G**	1.2307	-1.5424	0.0523	0.4529	-0.0840	0.0239	-0.0020	-0.1592	0.0837	0.2074	0.0075	0.0058	**-0.1285**	0.1481
	P	0.2405	-0.2390	0.0004	-0.0007	-0.0159	0.0125	0.0017	0.0016	-0.0021	0.0030	-0.0387	0.0025	**0.0634**	0.0291

P: Phenotypic level G: Genotypic level Residual effect at genotypic level = 0.1247 Residual effect at phenotypic level =0.3164

DT: Days to 50% tasseling; DS: Days to 50% silking; ASI: Anthesis silking interval; DM: Days to maturity; PH: Plant height; EPH: Ear placement height; CL: Cob Length; CG: Cob girth; KR: Kernel rows cob^{-1}; KPR: Number of kernels row^{-1}; CYP: Cob yield plant^{-1}; 100 GW: 100 kernel weight; PC: Protein content; KYP: Grain yield plant^{-1}

Fig.1 Genotypic path diagram showing direct and indirect effects of yield components on kernel yield plant^{-1} in maize (*Zea mays* L.)

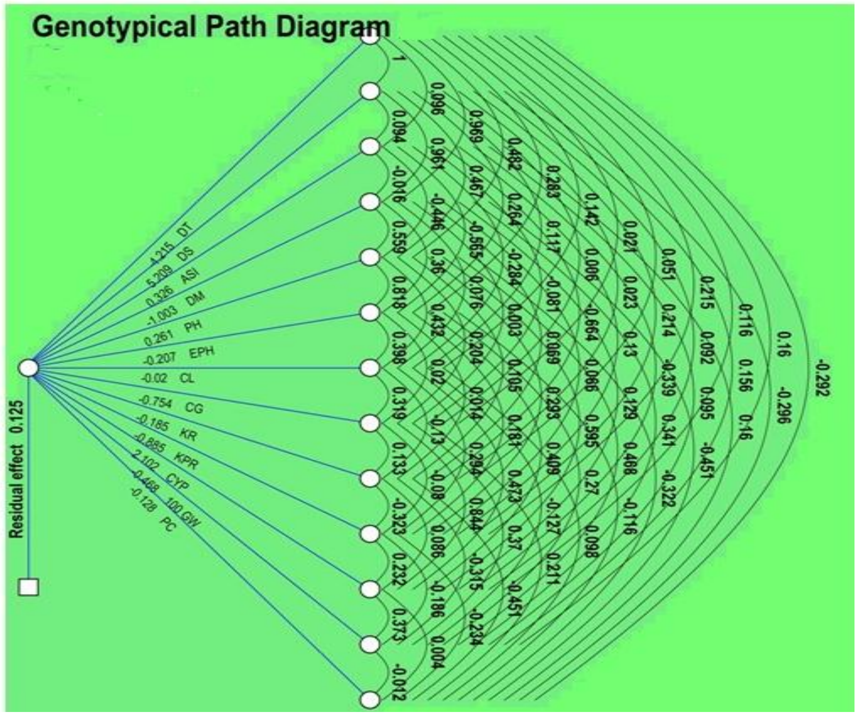
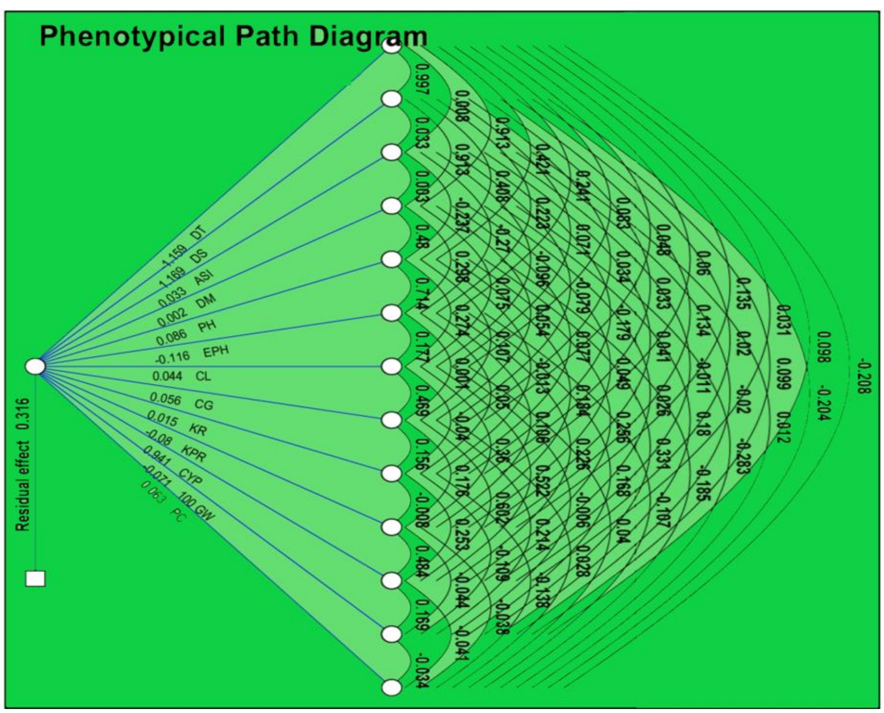


Fig.2 Phenotypic path diagram showing direct and indirect effects of yield components on kernel yield plant^{-1} in maize (*Zea mays* L.)



The analysis also revealed negatively significant inter-character association of protein content with days to 50 percent tasseling, days to 50 percent silking and days to maturity. These results are in consonance with the findings of Sukumar *et al.,* (2018) and Lad *et al.,* (2018). Association of anthesis silking interval with plant height and ear placement height was also noticed to be significant and negative at both genotypic and phenotypic levels, indicating the need for balanced selection, while effecting improvement for these traits.

The characters, namely cob length, cob girth and cob yield plant^{-1} had exhibited significant and positive correlation at both genotypic and phenotypic level with kernel yield and hence may be considered as important selection criteria for kernel yield improvement in maize.

Path analysis

Estimates of direct and indirect effects of individual characters towards kernel yield are presented in Table 2 and Figures 1 & 2. A perusal of the results revealed residual effect of 0.1247 at genotypic level and 0.3164 percent at phenotypic level, indicating that 87.53 percent and 68.36 percent of the variability in the dependent variable, kernel yield plant $^{-1}$ was explained by the independent variable or traits studied in the present investigation at genotypic and phenotypic levels, respectively.

The path coefficient analysis revealed high positive direct effect of cob yield yield plant^{1} for kernel yield at both genotypic and phenotypic levels coupled with positive and significant association of the trait with kernel yield per plant indicating its importance as effective selection criteria for kernel yield improvement in maize. The results are in agreement with the findings of Gazal *et al.,* 2018. However, days to 50 percent silking recorded non-significant positive direct effect (Grace *et al.,* 2018). Further, the traits like cob yield per plant, cob girth and kernel rows cob^{-1} at phenotypic level and anthesis silking interval and plant height at genotypic level had exhibited significant positive direct effects on kernel yield per plant. The results of plant height are in agreement with the findings of Grace *et al.,* (2018) and those of anthesis silking interval with reports of Kumar *et al.,* (2017).

The traits cob length, (p_p =0.0436) and cob girth (p_p =0.0558) exhibited low direct effects but strong correlation with grain yield due to the high indirect effect *via* cob yield plant^{-1}. Similar results were reported by Lakshmi *et al.,* (2018) and Sukumar *et al.,* (2018). Futher, significant negative direct effect was exhibited by the trait number of kernels row^{-1} (p_p = -0.0798 and p_g = -0.8855) for kernel yield plant^{-1} *via* indirect effect through 100 kernel weight (p_p = 0.003 and p_g = 0.2074). Similar findings were reported earlier by Nirmal *et al.,* (2018).

The results of path coefficient analysis thus revealed the importance of cob yield per plant for genetic improvement of the kernel yield plant$^{-1.}$

In conclusion the studies on character association and path coefficient for kernel yield per plant and yield component characters revealed the importance of cob yield per plant^{-1} in improvement of kernel yield plant$^{-1.}$ Hence, cob yield per plant^{-1} is identified as an effective selection crioteria for kernel yield improvement in maize.

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