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Interrelationships among grain yield and its component traits in maize genotypes

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Abstract
The character association and direct, indirect effects for yield and its contributing characters among 80 maize (*Zea mays* L.) genotypes was assessed at experimental field of Agricultural Research Station (ARS), Karimnagar, Telangana, during *kharif*, 2024. The characters like ear girth, ear height, number of kernels per row, number of kernel rows per ear are positively correlated with grain yield. The characters ear girth, test weight, number of kernels per row, ear length shows highest positive direct effect on grain yield at genotypic level and test weight ear length, number of kernels per row, number of kernel rows per ear sow highest positive direct effect on grain yield at phenotypic level.

Keywords: Maize, correlation, path analysis and grain yield

Introduction
Maize (*Zea mays* L.), the third most important crop in India. As a C_4 plant, it is fertilizer-responsive, has high yield potential, and extensive cross-pollination, making it ideal for genetic improvement by plant breeders. Grain yield is a complex, multigenic quantitative trait governed by multiple interrelated morphological and physiological components. Deciphering the interplay among these yield-contributing traits is vital for breeding high-performing maize lines. Correlation analysis reveals the degree and direction of association between grain yield and various traits, but it does not distinguish direct influence from indirect effects mediated through other variables. Path coefficient analysis bridges this gap by partitioning total correlations into direct and indirect effects, thereby elucidating the causal pathways that influence yield. This study aims to assess to characterize the associations, and dissect the direct and indirect contributions of component traits to grain yield in diverse maize genotypes. Unraveling these relationships is crucial for breeders to identify the most effective target traits and optimize selection indices for yield improvement.

Materials and Methods
The present study was conducted during the kharif season of 2024 at the Agricultural Research Station (ARS), Karimnagar, Telangana. A total of 80 inbred lines, including four checks (BML-6, BML-7, LM-13 and LM-14), were evaluated. These genotypes were arranged in an Augmented Block Design, with checks replicated across blocks. Each genotype was planted in two rows, each measuring 3 m in length, with a spacing of 60 cm between rows and 20 cm within rows. Standard recommended agronomic practices were followed throughout the crop period.
From each entry in each block, five plants were randomly selected and observations on various pre-harvest and post-harvest traits were recorded on five plants selected at random from each entry in each block for days to 50 percent anthesis, days to 50 percent silking, anthesis silking interval, days to maturity, plant height (cm), ear length (cm), ear length (cm), ear girth (cm), number of kernel rows per ear, number of kernels per row, grain yield per plant (g), test weight (g) and shelling (%). The phenotypic and genotypic correlation coefficients were estimated following the method described by Johnson 1955. Path coefficient analysis was performed as described by Dewey and Lu 1959 partitioning the genotypic correlation coefficients into their direct and indirect effects.

Results and Discussions

Correlation studies, presented in table 1, 2 describe degree and direction of characters towards grain yield per plant. Genotypically, grain yield was positively significant with days to 50 percent anthesis, days to 50 percent silking, ear height, ear length, ear girth, number of kernel rows per ear, kernels per row, test weight and negatively associated with anthesis silking interval and days to maturity positive and significant with ear height, ear length, ear girth, number of kernel rows per ear, kernels per row, test weight and negatively associated with shelling and anthesis silking interval phenotypically. The findings were similar with ear height, ear length, ear girth, number of kernel rows per ear, kernels per row, test weight Dar *et al.* (2015) [5], Reddy *et al.* (2022) [11], Kovačević *et al.* (2024) [8], Aziz and Zubaidy (2024) [3], Nataraj (2014) [9], Prasad and Shivani (2017) [10].

Among the various evaluated characters, ear girth recorded highest positive significant association with grain yield followed by test weight, ear length, number of kernel rows per ear, ear height, number of kernels per row, days to 50 percent silking followed by days to 50 percent anthesis at genotypic level and ear girth, test weight, ear length, number of kernel rows per ear, number of kernels per row at phenotypic level.

Table 1: Genotypical correlation studies for 14 characters of maize genotypes

Character	DFA	DFS	ASI	DM	PH (cm)	EH (cm)	EL (cm)	EG (cm)	NKRE	NKR	TW (g)	Shelling (%)	Yield (g)
DFA	1.0000	0.7819***	-0.3309***	-0.5319***	0.0637	0.3787***	-0.0979	0.3173***	-0.0065	0.0742	0.1587*	0.1907***	0.2351***
DFS		1.0000	0.3664***	-0.7085***	-0.0098	0.4403***	0.0524	0.3189***	0.0347	0.1342*	0.1928***	-0.0400	0.2634***
ASI			1.0000	-0.2044***	-0.0301	-0.0291	0.2005***	-0.0461	0.0714	0.1078	-0.0139	-0.3410***	-0.0963
DM				1.0000	-0.0211	-0.2014***	-0.0231	-0.1581*	-0.0184	-0.0413	-0.1039	0.0678	-0.1054
PH (cm)					1.0000	0.5496***	0.2381***	0.1399*	0.1589*	0.1955***	0.2346***	0.0778	0.0924
EH (cm)						1.0000	0.3787***	0.4208***	0.2868***	0.3217***	0.5078***	0.0192	0.4175***
EL (cm)							1.0000	0.4368***	0.4073***	0.6574***	0.5492***	-0.1233	0.5709***
EG (cm)								1.0000	0.6996***	0.2783***	0.6717***	0.0446	0.7391***
NKRE									1.0000	0.3938***	0.4342***	-0.0061	0.5302***
NKR										1.0000	0.4392***	0.0015	0.4188***
TW											1.0000	-0.1253*	0.7210***
Shelling (%)												1.0000	-0.0537

Table 2: Phenotypical correlation studies for 14 characters of maize genotypes

Character	Days to 50% anthesis	Days to 50% 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	Test weight (g)	Shelling (%)	Yield (g)
DFA	1.0000	0.3846***	-0.1469*	0.2400***	0.0165	0.1487*	-0.0272	0.0983	0.0209	0.0340	0.0744	0.0523	0.0992
DFS		1.0000	0.1105	0.3511***	-0.0056	0.1389*	0.0179	0.1023	0.0101	0.0409	0.0507	-0.0280	0.0734
ASI			1.0000	0.0662	-0.0270	-0.0276	0.1954**	-0.0509	0.0675	0.1008	-0.0060	-0.2783***	-0.0961
DM				1.0000	-0.0268	0.1229	0.0163	0.0791	0.0069	0.0539	0.0329	0.0151	0.0800
PH (cm)					1.0000	0.5289***	0.2185***	0.1258*	0.1520*	0.1808**	0.2201***	0.0494	0.0902
EH (cm)						1.0000	0.3604***	0.3982***	0.2688***	0.3142***	0.4826***	0.0179	0.4068***
EL (cm)							1.0000	0.4029***	0.3744***	0.6248***	0.5186***	-0.1138	0.5416***
EG (cm)								1.0000	0.6422***	0.2585***	0.6197***	0.0228	0.6956***
NKRE									1.0000	0.3663***	0.4043***	0.0000	0.5069***
NKR										1.0000	0.4095***	0.0065	0.4062***
TW											1.0000	-0.0966	0.6788***
Shelling (%)												1.0000	-0.0436

* Significant at 5 percent level; ** Significant at 1 percent level, DFA = Days to 50% anthesis, DFS = Days to 50% silking, ASI = Anthesis silking interval, DM = days to maturity, PH = Plant height, EH = Ear height, EL = Ear length, EG = Ear girth, NKRE = No. of kernel rows per ear, NKR = No. of kernels per row, TW = test weight.

Table 3: Path analysis of various characters in maize inbred lines

Characters		DFA	DFS	ASI	DM	PH (cm)	EH (cm)	EL (cm)	EG (cm)	NKRE	NKR	Test weight (g)	Shelling (%)	GYP (g)
DFA	G	-0.0232	-0.0645	0.0077	0.0355	-0.0015	-0.0088	0.0023	-0.0074	0.0001	-0.0017	-0.0037	-0.0044	0.2351
	P	0.0410	0.0158	-0.0060	0.0098	0.0007	0.0061	-0.0011	0.0040	0.0009	0.0014	0.0030	0.0021	0.0992
DFS	G	-0.1005	-0.0361	-0.0132	0.0617	0.0004	-0.0159	-0.0019	-0.0115	-0.0013	-0.0048	-0.0070	0.0014	0.2634
	P	0.0096	0.0251	0.0028	0.0088	-0.0001	0.0035	0.0004	0.0026	0.0003	0.0010	0.0013	-0.0007	0.0734
ASI	G	0.0252	-0.0279	-0.0762	0.0156	0.0023	0.0022	-0.0153	0.0035	-0.0054	-0.0082	0.0011	0.0260	-0.0963
	P	0.0086	-0.0064	-0.0582	-0.0039	0.0016	0.0016	-0.0114	0.0030	-0.0039	-0.0059	0.0004	0.0162	-0.0961
DM	G	0.2338	0.2608	0.0312	-0.1526	0.0032	0.0307	0.0035	0.0241	0.0028	0.0063	0.0159	-0.0104	-0.1054
	P	0.0112	0.0164	0.0031	0.0466	-0.0013	0.0057	0.0008	0.0037	0.0003	0.0025	0.0015	0.0007	0.0800
PH (cm)	G	0.0004	-0.0001	-0.0002	-0.0001	0.0060	0.0033	0.0014	0.0008	0.0010	0.0012	0.0014	0.0005	0.0924
	P	0.0001	0.0000	-0.0001	-0.0001	0.0041	0.0022	0.0009	0.0005	0.0006	0.0007	0.0009	0.0002	0.0902
EH (cm)	G	-0.0042	-0.0049	0.0003	0.0022	-0.0061	-0.0111	-0.0042	-0.0047	-0.0032	-0.0036	-0.0057	-0.0002	0.4175
	P	-0.0006	-0.0005	0.0001	-0.0005	-0.0021	-0.0039	-0.0014	-0.0016	-0.0011	-0.0012	-0.0019	-0.0001	0.4068
EL (cm)	G	-0.0139	0.0075	0.0286	-0.0033	0.0339	0.0540	0.1425	0.0622	0.0580	0.0937	0.0783	-0.0176	0.5709
	P	-0.0044	0.0029	0.0320	0.0027	0.0357	0.0590	0.1636	0.0659	0.0613	0.1022	0.0848	-0.0186	0.5416
EG (cm)	G	0.1259	0.1265	-0.0183	-0.0627	0.0555	0.1670	0.1733	0.3968	0.2776	0.1104	0.2666	0.0177	0.7391
	P	0.0331	0.0344	-0.0171	0.0266	0.0423	0.1340	0.1356	0.0065	0.2161	0.0870	0.2085	0.0077	0.6956
NKRE	G	-0.0006	0.0032	0.0066	-0.0017	0.0147	0.0264	0.0375	0.0645	0.0922	0.0363	0.0400	-0.0006	0.5302
	P	0.0027	0.0013	0.0087	0.0009	0.0196	0.0346	0.0483	0.0828	0.1289	0.0472	0.0521	0.0000	0.5069
NKR	G	0.0140	0.0253	0.0204	-0.0078	0.0369	0.0607	0.1241	0.0525	0.0744	0.1888	0.0829	0.0003	0.4188
	P	0.0055	0.0067	0.0164	0.0088	0.0295	0.0512	0.1018	0.0421	0.0597	0.1629	0.0667	0.0011	0.4062
TW(g)	G	0.0428	0.0520	-0.0037	-0.0280	0.0633	0.1369	0.1481	0.1811	0.1171	0.1184	0.2696	-0.0338	0.7210
	P	0.0208	0.0142	-0.0017	0.0092	0.0615	0.1348	0.1448	0.1731	0.1129	0.1144	0.2793	-0.0270	0.6788
Shelling (%)	G	-0.0077	0.0016	0.0138	-0.0027	-0.0031	-0.0008	0.0050	-0.0018	0.0002	-0.0001	0.0051	-0.0404	-0.0537
	P	-0.0014	0.0007	0.0073	-0.0004	-0.0013	-0.0005	0.0030	-0.0006	0.0000	-0.0002	0.0025	-0.0262	-0.0436

Diagonal values are direct effects. DFA = Days to 50% anthesis, DFS = Days to 50% silking, ASI = Anthesis silking interval, DM = days to maturity, PH = Plant height, EH = Ear height, EL = Ear length, EG = Ear girth, NKRE = No. of kernel rows per ear, NKR = No. of kernels per row, TW = test weight.

Path coefficient analysis of study presented in table 3, further indicated that ear girth (0.3968) has the highest positive direct effect on grain yield per plant, followed by test weight, number of kernels per row, ear length, plant height is positive genotypically and phenotypically same as findings of Damtie *et al.* 2021 [4]. However, phenotypically test weight (0.2793) has strongest positive direct effect on grain yield per plant followed by number of kernels per row, ear length, number of kernel rows per ear this in line with Al-Rawi *et al.* (2024) [2], days to maturity, days to 50 percent anthesis, days to 50 percent silking. Ear girth, days to 50 percent anthesis, ear length are in line with Akshaya *et al.* (2022) [1], Nataraj (2014) [9], Prasad and Shivani (2017) [10].

Conclusion

The yield-contributing traits such as ear girth, ear length, number of kernel rows per ear, number of kernels per row, and test weight showed a positive and significant association with grain yield, and a negative association with the anthesis-silking interval. Grain yield was significantly correlated and had direct effects with ear girth, ear length, number of kernel rows per ear, number of kernels per row, and test weight, while it exhibited indirect effects through ear height and shelling percentage.

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