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TARGETING OF TRAITS THROUGH ASSESSMENT OF INTERRELATIONSHIP AND PATH ANALYSIS BETWEEN YIELD AND YIELD COMPONENTS FOR GRAIN YIELD IMPROVEMENT IN SINGLE CROSS HYBRIDS OF MAIZE (*Zea mays* L.)

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ABSTRACT: In an attempt to study the association of different quantitative traits in improving grain yield in maize hybrids, correlation and path studies were conducted between yield and yield contributing characters. Association studies revealed that, ten out of fifteen characters exhibited highly significant positive correlation with yield per plant. However, the highest correlation was evident for number of kernels per row (r_p= 0.8784**). While, the traits *viz.,* days to 50 per cent silking and days to 50 per cent tasseling displayed highly significant negative correlation with yield per plant. Path analysis revealed that, eight traits exerted positive direct effects on yield per plant. However, the trait cob length exerted maximum positive direct effect on grain yield per plant. On contrary, some of the characters *viz.,* days to 50 per cent silking, anthesis-silking interval, leaf area index, days to 50 per cent maturity, SPAD chlorophyll and number of branches per tassel exerted negative direct effects on yield per plant. The present study revealed that, direct selection for number of kernels per row, cob length, cob girth and 100-seed weight might be rewarding for the improvement of yield using the present elite inbreds and their F_1 hybrids.

Key words: Maize, Correlation, Path analysis, direct effects, Grain yield per plant.

INTRODUCTION

Maize is the third most important cereal grain in the world after rice and wheat. Globally maize is cultivated in an area of 159 million hectares with a production of 796.46 million tonnes (USDA, 2010) and in India maize ranks among the top four cereal crops occupying an area of 7.89 million ha with a production of 15.09 million tonnes and a productivity of 1904 kg ha^{-1}. Of late, the demand for maize is also growing as poultry feed besides human consumption. Therefore, keeping in mind the future demand of maize as a food for human and as a feed for livestock, there is a continuous need to evolve new hybrids, which should exceed the existing hybrids in yield. For this to happen, yield improvement through genetic approaches would become essential. Since yield is a complex character, which is the product of multiplicative interactions of a number of its component characters (Grafius, 1959), yield cannot be improved to a greater extent on its own. Hence, a clear picture of contribution of each component in final expression of complex character is essential. In order to achieve the goal of increased production by increasing the yield potential of the crop, knowledge on direction and magnitude of association between yield and yield related traits is essential for a plant breeder. Accordingly, the present investigation was carried out to understand the association of grain yield with yield components and also to determine the *inter se* association between the traits besides the direct and indirect effects of component traits in the single cross hybrids of maize generated using eight improved and diverse inbred lines.

MATERIALS AND METHODS

The initial experimental material consisted of eight elite inbred lines *viz.,* CM 209, CM 132, CM 133, CM 148, CM 149, BML 6, BML 7 and BML 15 which were maintained at Agriculture Research Station (ARS), Maize at Amberpet, Hyderabad. Using these eight parental lines, twenty eight single cross hybrids (F_1 hybrids) were generated in a diallel fashion during *kharif,* 2010. Tassel bag method was followed for hybridization. The evaluation trail was carried out in a Randomized Block Design (RBD) with three replications during *rabi,* 2010-2011 at wetland farm, S.V Agricultural College, Tirupati. The row to row and plant to plant spacing was 75 X 20 cm. Border rows were raised all along the field to avoid environmental influences. The crop was maintained healthy by following all other agronomic and plant protection practices applicable for commercial maize crop. The biometrical data were recorded from randomly selected five plants for fifteen traits *viz.,* leaf area index, plant height, cob length, cob girth, number of kernel rows per ear, number of kernels per row, SPAD (measured using SPAD meter) chlorophyll, tassel length, number of branches per tassel, 100-seed weight and grain yield per plant. However, the data for the traits *viz.,* days to 50 per cent tasseling, days to 50 per cent silking, anthesis-silking interval and days to 50 per cent maturity were recorded on plot basis. The replication wise mean values of genotypes were subjected to statistical analysis using INDOSTAT software. Mean values of both parents and crosses were subjected to correlation analysis as per the method suggested by Falconer (1967). Path coefficient analysis as proposed by Dewey and Lu (1959), was utilized for partitioning the total correlation in to direct and indirect effects.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed significant differences among the parents and crosses for all the traits under consideration, indicating the existence of sufficient variation in the material studied. Hence, the data was further subjected to correlation and path coefficient analysis to estimates the association existing between yield and yield contributing components and direct and indirect effects of yield related traits, respectively. The perusal of phenotypic and genotypic correlation (Table 2) analysis revealed that, yield per plant had highly significant positive phenotypic and very strong positive genotypic correlation with ten traits *viz.,* number of kernels per row, cob length, cob girth and 100-seed weight, plant height, leaf area index, tassel length, number of branches per tassel, number of kernel rows per ear and SPAD chlorophyll. However, the most yield determinative traits were number of kernels per row followed by cob length, cob girth and 100-seed weight and hence, simultaneous selection for these traits might bring an improvement in yield per plant. Similar results were also reported for number of kernels per row (Prakash et al., 2006); for cob length (Sreckov et al., 2010); for cob girth (Manivannan*,* 1998 and Chinnadurai and Nagarajan, 2011) and for 100-seed weight (Satyanarayana et al., 1990 and Chinnadurai and Nagarajan, 2011). Contrarily, yield per plant had significant negative phenotypic and genotypic correlations with two characters *i.e.,* days to 50 per cent tasseling and days to 50 per cent silking, indicating that selection for early tasseling and silking is desirable to increase grain yield per plant.

Besides the correlation studies, *inter se* association studies also provide an opportunity to select only those characters which are favourably associated among themselves as well as with yield. In the present investigation, studies on *inter se* associations among yield components revealed that the trait number of kernels per row exhibited highly significant positive association with most of the traits *viz.,* cob length, cob girth, 100-seed weight, tassel length, number of branches per tassel, days to 50 per cent tasseling and days to 50 per cent silking besides highly significant positive correlation with yield per plant. It was interesting to notice that, the trait number of kernels per row did not exhibit significant negative correlation with any of the other yield components except days to 50 per cent tasseling and days to 50 per cent silking and hence, the trait number of kernels per row could be exploited for the improvement of yield coupled with earliness using the present material. Highly significant favourable correlation among yield attributes indicates that, the unit increase in one trait will cause a unit increase in the associated trait, which inturn will cause an increase in the yield.

Grain yield, which is the major economic character in maize depends on several component traits, which are mutually related. Mere change in any one of the component would ultimately disturb the complex. Hence, these related traits have to be analyzed for its action namely direct effect of component character on grain yield and the indirect effects through other component traits on grain yield. Therefore, the total correlations were partitioned in to direct and indirect effects (Table 3 and Fig. 1).

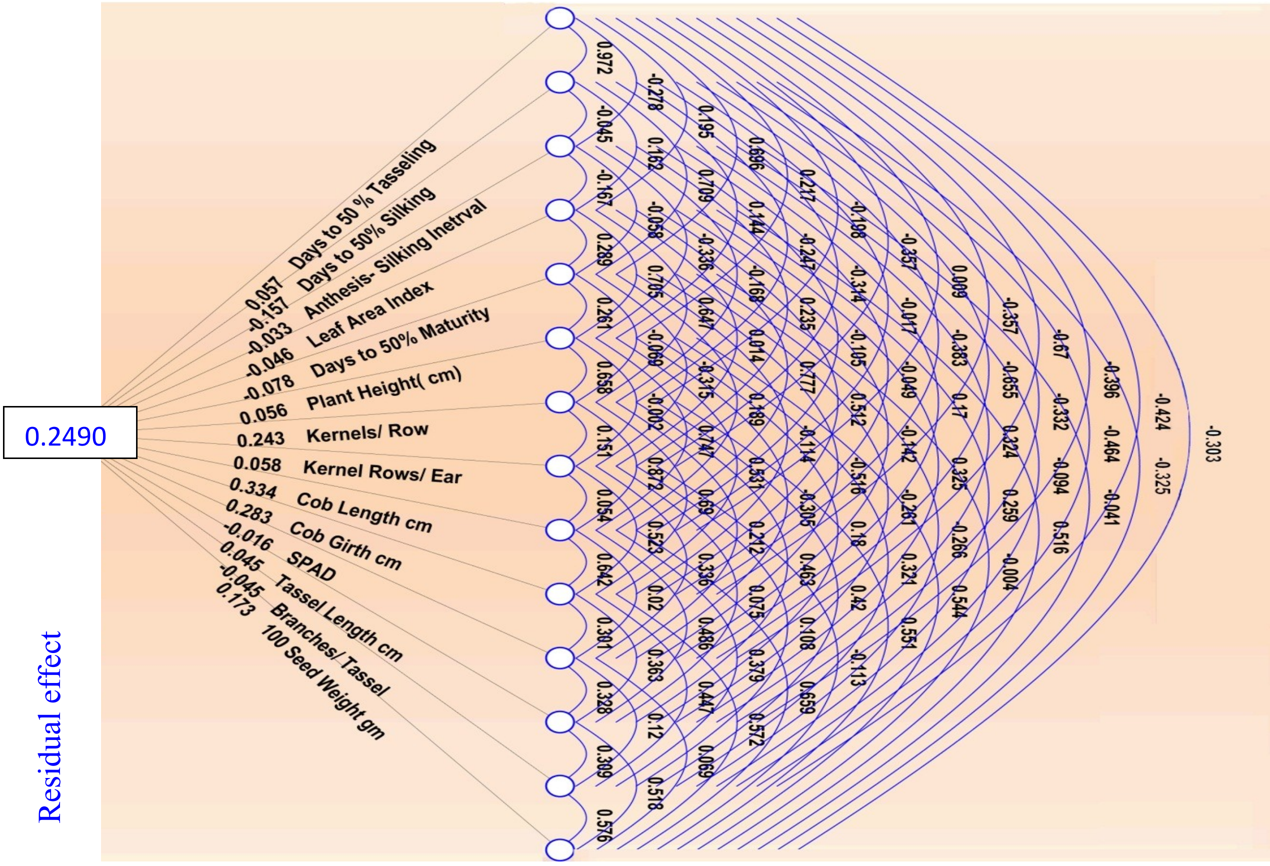

FIG. 1. PHENOTYPIC PATH DIAGRAM OF GRAIN YIELD AND ITS COMPONENTS IN MAIZE

The path analysis using grain yield per plant as dependent variable revealed that, cob length exerted maximum positive direct effect on grain yield per plant followed by cob girth, number of kernels per row, 100-seed weight, number of kernel rows per ear, days to 50 per tasseling, plant height and tassel length. Hence, these traits could be relied upon for selection of genotypes to improve genetic yield potential of maize. On contrary, some of the characters *viz.,* days to 50 per cent silking, anthesis-silking interval, leaf area index, days to 50 per cent maturity, SPAD chlorophyll and number of branches per tassel exerted negative direct effects on yield per plant. However, the negative indirect effects of SPAD chlorophyll and number of branches per tassel were nullified by their indirect positive effects through other component traits, which ultimately resulted in to highly significant positive correlation with grain yield per plant. Hence, indirect selection through other component characters with which these two traits exhibited positive indirect effects can be recommended so as to bring improvement in grain yield.

By and large, in the present study, the trait cob length influenced grain yield per plant directly and predominantly followed by cob girth, number of kernels per row and 100-seed weight. Similar results were also reported for cob length (Wannows et al., 2010); for cob girth (Sofi et al., 2007); for number of kernels per row (Mohan et al., 2002) and for 100-seed weight (Venugopal et al., 2003). Further, the association of these traits with grain yield per plant was also positive and highly significant, indicating the importance of these traits for grain yield improvement in the present material. Besides this, the traits cob length, cob girth and number of kernels per row also influenced grain yield per plant indirectly in a substantial magnitude through most of the other yield components as evident in the results (Table 3). Thus, selection for the genotypes with maximum cob length and cob girth accommodating more number of kernels per row and giving more seed-weight is a pre-requisite for attaining improvement in grain yield per plant using the present material.

Further in the present investigation, it was evident that 75 per cent of the yield contributing characters was utilized in this analysis as the residual effect was 0.249 (24.9 %) as revealed in the results (Fig. 1).

TABLE 1. ANALYSIS OF VARIANCE FOR YIELD AND YIELD COMPONENTS IN MAIZE

S.No.	Characters	Source of Variation		
		Replications (df=2)	Genotypes (df=35)	Error (df=70)
1.	Days to 50 % tasseling	3.01	68.42**	1.65
2.	Days to 50% silking	4.39	62.87**	1.73
3.	Anthesis-silking interval	1.01	2.88**	0.53
4.	Leaf area index	0.34	2.41**	0.25
5.	Days to 50% maturity	5.11	75.04**	2.63
6.	Plant height (cm)	395.00	1278.67**	67.61
7.	No. of kernel rows per ear	1.06	6.99**	0.47
8.	No. of kernels per row	21.93	98.04**	8.96
9.	Cob length (cm)	2.76	22.77**	1.53
10.	Cob girth (cm)	0.55	5.84**	0.39
11.	SPAD chlorophyll	24.74	83.41**	9.91
12.	Tassel length (cm)	10.45	73.04**	6.62
13.	No. of branches per tassel	9.08	40.67**	4.24
14.	100 seed weight (g)	5.53	42.53**	2.69
15.	Yield per plant (g)	500.31	3884.18**	206.91

*** Significant at 5% level, ** Significant at 1% level**

Table 2. PHENOTYPIC (r_P) AND GENOTYPIC (r_g) CORRELATION COEFFICIENTS AMONG YIELD AND YIELD COMPONENTS IN MAIZE

S. No.	Character		DT	DS	ASI	LAI	DM	PH	KRE	KR	CL	CG	SPAD	TL	BT	100SW	Correlation with G YP
1.	**DT**	r_p	**1.0000**	0.9721**	-0.2775**	0.1953*	0.6957**	0.2173*	-0.3574**	-0.1978*	0.0085	-0.357**	-0.6701**	-0.3957**	-0.424**	-0.3026**	-0.3448**
		r_g	**1.0000**	0.9826	-0.3186	0.2232	0.7280	0.2885	-0.3888	-0.2396	-0.0011	-0.4085	-0.8225	-0.4606	-0.5237	-0.3341	-0.3721
2.	**DS**	r_p		**1.0000**	-0.0446	0.1622	0.7091**	0.1440	-0.3142**	-0.2467*	-0.0167	-0.3833**	-0.6553**	-0.3324**	-0.4638**	-0.3247**	-0.3869**
		r_g		**1.0000**	-0.1369	0.2065	0.7366	0.2198	-0.3605	-0.2877	-0.0248	-0.4205	-0.8049	-0.3822	-0.5613	-0.3475	-0.4111
3.	**ASI**	r_p			**1.0000**	-0.1674	-0.0584	-0.3361**	0.2354*	-0.1683	-0.1048	-0.0494	0.1702	0.3243**	-0.0940	-0.0410	-0.1161
		r_g			**1.0000**	-0.1367	-0.1236	-0.4170	0.2336	-0.1904	-0.1207	0.0326	0.2788	0.5054	-0.0713	0.0085	-0.1136
4.	**LAI**	r_p				**1.0000**	0.2886**	0.7048**	0.0141**	0.6466**	0.7771	0.5118**	-0.1423	0.3250**	0.2586**	0.5162**	0.6196**
		r_g				**1.0000**	0.3296	0.8576	0.0634	0.7692	0.9100	0.5460	-0.2461	0.3840	0.3290	0.6089	0.6931
5.	**DM**	r_p					**1.0000**	0.2607	-0.315**	-0.0686	0.1886	-0.1138	-0.5161**	-0.2610**	-0.2655**	-0.0039	-0.1426
		r_g					**1.0000**	0.3279	-0.3531	-0.1181	0.1729	-0.1468	-0.6593	-0.2966	-0.3388	-0.0104	-0.1833
6.	**PH**	r_p						**1.0000**	-0.0015	0.6576**	0.7474**	0.5307**	-0.3047**	0.1797	0.3214**	0.5442**	0.6570**
		r_g						**1.0000**	0.0049	0.7961	0.8983	0.5964	-0.3626	0.2339	0.3998	0.6084	0.7390
7.	**KRE**	r_p							**1.0000**	0.1509	0.0541	0.5227**	0.3362**	0.0749	0.1081	-0.1127	0.2791**
		r_g							**1.0000**	0.2467	0.0804	0.6435	0.4416	0.0733	0.1172	-0.1001	0.3205
8.	**KR**	r_p								**1.0000**	0.8723**	0.6901**	0.2119*	0.4628**	0.4201**	0.5508**	0.8784**
		r_g								**1.0000**	0.9073	0.7878	0.1902	0.5435	0.5201	0.6641	0.9579
9.	**CL**	r_p									**1.0000**	0.6417**	0.0197	0.4864**	0.3794**	0.6589**	0.8479**
		r_g									**1.0000**	0.6872	-0.0884	0.5933	0.4494	0.7755	0.8864
10.	**CG**	r_p										**1.0000**	0.3013**	0.3627**	0.4466**	0.5715**	0.8426**
		r_g										**1.0000**	0.3919	0.4351	0.5465	0.5999	0.8922
11.	**SPAD**	r_p											**1.0000**	0.3281	0.1199	0.0689	0.2570**
		r_g											**1.0000**	0.3502	0.1277	0.0759	0.2680
12.	**TL**	r_p												**1.0000**	0.3089**	0.5178**	0.5319**
		r_g												**1.0000**	0.3237	0.6528	0.6152
13.	**BT**	r_p													**1.0000**	0.5765**	0.5068**
		r_g													**1.0000**	0.7327	0.6153
14.	**100SW**	r_p														**1.0000**	0.7209**
		r_g														**1.0000**	0.7955

*** Significant at 5% level, ** Significant at 1% level**

DT= Days to 50% Tasseling, DS = Days to 50% Silking, ASI = Anthesis –Silking Interval, LAI = Leaf Area Index, DM = Days to 50% Maturity, PH = Plant Height (cm), KRE = No. of Kernel Rows per Ear, KR= No. of Kernels per Row, CL = Cob Length (cm), CG = Cob Girth (cm), SPAD chlorophyll, TL = Tassel Length (cm), BT = No. of Branches per Tassel, 100SW = 100-Seed Weight (g), GYP = GrainYield per Plant (g).

TABLE 3. PHENOTYPIC PATH CO-EFFICIENTS AMONG GRAIN YIELD AND YIELD COMPONENTS IN MAIZE

S. No.	Character	DT	DS	ASI	LAI	DM	PH	KRE	KR	CL	CG	SPAD	TL	BT	100SW	GYP
1	**DT**	**0.0567**	-0.1527	0.0093	-0.0090	-0.0542	0.0122	-0.0206	-0.0481	0.0028	-0.1011	0.0107	-0.0178	0.0193	-0.0523	-0.3448**
2	**DS**	0.0551	**-0.1571**	0.0015	-0.0075	-0.0552	0.0081	-0.0181	-0.0601	-0.0056	-0.1086	0.0105	-0.0150	0.0211	-0.0561	-0.3869**
3	**ASI**	-0.0157	0.0070	**-0.0334**	0.0077	0.0045	-0.0189	0.0136	-0.0410	-0.0350	-0.0140	-0.0027	0.0146	0.0043	-0.0071	-0.1161
4	**LAI**	0.0111	-0.0255	0.0056	**-0.0460**	-0.0225	0.0397	0.0008	0.1574	0.2597	0.1450	0.0023	0.0146	-0.0117	0.0891	0.6196**
5	**DM**	0.0394	-0.1114	0.0019	-0.0133	**-0.0779**	0.0147	-0.0181	-0.0167	0.0630	-0.0322	0.0083	-0.0118	0.0121	-0.0007	-0.1426
6	**PH**	0.0123	-0.0226	0.0112	-0.0324	-0.0203	**0.0563**	-0.0001	0.1601	0.2498	0.1504	0.0049	0.0081	-0.0146	0.0940	0.6570**
7	**KRE**	-0.0203	0.0494	-0.0079	-0.0007	0.0245	-0.0001	**0.0576**	0.0367	0.0181	0.1481	-0.0054	0.0034	-0.0049	-0.0195	0.2791**
8	**KR**	-0.0112	0.0388	0.0056	-0.0297	0.0053	0.0370	0.0087	**0.2434**	0.2916	0.1955	-0.0034	0.0208	-0.0191	0.0951	0.8784**
9	**CL**	0.0005	0.0026	0.0035	-0.0357	-0.0147	0.0421	0.0031	0.2123	**0.3342**	0.1818	-0.0003	0.0219	-0.0172	0.1138	0.8479**
10	**CG**	-0.0202	0.0602	0.0016	-0.0235	0.0089	0.0299	0.0301	0.1679	0.2145	**0.2833**	-0.0048	0.0163	-0.0203	0.0987	0.8426**
11	**SPAD**	-0.0380	0.1030	-0.0057	0.0065	0.0402	-0.0172	0.0194	0.0516	0.0066	0.0854	**-0.0160**	0.0148	-0.0054	0.0119	0.2570**
12	**TL**	-0.0224	0.0522	-0.0108	-0.0150	0.0203	0.0101	0.0043	0.1126	0.1626	0.1028	-0.0053	**0.0450**	-0.0140	0.0894	0.5319**
13	**BT**	-0.0240	0.0729	0.0031	-0.0119	0.0207	0.0181	0.0062	0.1022	0.1268	0.1265	-0.0019	0.0139	**-0.0454**	0.0995	0.5068**
14	**100SW**	-0.0172	0.0510	0.0014	-0.0237	0.0003	0.0306	-0.0065	0.1341	0.2202	0.1619	-0.0011	0.0233	-0.0262	**0.1727**	0.7209**

*** Significant at 5% level, ** Significant at 1% level**; Residual Effect = 0.2490; Diagonals = Direct effect (bold); off diagonals = Indirect effects

DT= Days to 50% Tasseling, DS = Days to 50% Silking, ASI = Anthesis –Silking Interval, LAI = Leaf Area Index, DM = Days to 50% Maturity, PH = Plant Height (cm), KRE = No. of Kernel Rows per Ear, KR= No. of Kernels per Row, CL = Cob Length (cm), CG = Cob Girth (cm), SPAD chlorophyll, TL = Tassel Length (cm), BT = No. of Branches per Tassel, 100 SW = 100–Seed Weight (g), GYP = Grain Yield per Plant (g).

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