

## Correlation and Path Analysis in Elite Maize (*Zea mays* L.) Lines

### Abstract

**Aim:** To study the association between characters through correlation and path analysis for 30 elite maize lines

**Study Design:** Randomized Block Design with three replications.

**Place and Duration of study:** The experiment was conducted at Seed Research and Technology Centre *Rabi* 2020-21

**Methodology:** Character association studies will help to assess the relationship among the yield and its contributing traits for enhancing the efficiency selection. In view of this, the present research work was carried out to assess the correlation coefficient and path analysis among thirty maize inbred lines for eighteen yield, yield contributing characters and seedling vigour traits in maize (*Zea mays* L.).

**Results:** Correlation studies revealed that plant height (0.3566\*\*), ear height (0.2135\*\*), ear length (0.3505\*\*), ear diameter (0.4973\*\*), number of kernel rows (0.3471\*\*), 100-seed weight (0.5359\*\*), cob yield per plant (0.9883\*\*) and seed vigour index-2 (0.3412\*\*) were significant and positively correlated with the grain yield per plant. Path analysis showed that cob yield per plant had the highest direct effect followed by shelling percentage (0.0094), seed vigour index -1 (0.0131), seed vigour index-2 (0.0125), 100 seed weight (0.0122), days to tasseling (0.0108), germination first count (0.0094), speed of germination (0.0060), number of kernels per row (0.0058), ear diameter (0.0057) suggesting that the selection of these characters will help to increase the grain yield per plant directly.

**Keywords:** Maize, inbreds, Correlation, Path analysis, Coefficient

### Introduction

Maize (*Zea mays* L.) is grown as a multipurpose crop of global importance and *queen of the cereal*. Traditionally, maize is a *kharif* crop, but can be grown round the year. In India, it is the third most important food crop after rice and wheat in terms of area (9.8 million hectares), production (31.6 million tonnes) and productivity (31.9 quintals per hectare) (*Indiastat*, 2020-21).

Grain yield is the most economically important character and the focus of many maize breeding programmes. However, It is a complex trait, a product of many components which subjects it to high environmental influence. As a result, direct selection would not be effective and efficient. Only a better understanding and knowledge of the interrelations

between grain yield and its contributing components through the use of correlation and path coefficient analysis can significantly improve the efficiency of breeding programmes through the use of appropriate selection indices (Singh *et al.*, 2020).

Genetic correlation analysis is a handy technique which elaborates the degree of association among important quantitative traits. The studies on correlation are quite old and extensive but, unfortunately, there is hardly any rule set on how much a character contributes towards the expression of other characters in a plant population (Ahmed *et al.*, 2020). Sometimes, estimates of correlation coefficients provide misleading results as the correlation between two variables may be due to the involvement of third factor. As number of variable increases, the measurement of the contribution of each variable towards the observed correlation is imperative. Therefore, portioning of the observed correlation coefficients into components of direct and indirect influences provide perceptions in the characterization of more complex traits like yield (Shikha *et al.*, 2020).

Under such condition, path coefficient analysis (Dewey and Lu 1957) which partitions the correlation coefficient, provides precise information on the direct and indirect effects in order to perceive the most influencing characters to be utilized as selection criteria in maize breeding programmes. Such studies could lead plant breeders in the selection of traits contributing towards the characters of concern, and ultimately their improvement through hybridization. Accordingly, the present study was carried out with the objective of generating information on relationship among yield and yield contributing traits to find important traits for selection process.

## **Materials and methods**

The field experiment was conducted at Seed Research and Technology Centre (SRTC), Rajendranagar, during *rabi* 2020-21 laid out in Randomized Block Design. Thirty maize genotypes were sown by adopting a spacing of 75 X 20 cm, the plot size was 24m<sup>2</sup> in 6 metres length with 4 rows and three replications. Recommended agronomic package of practices was followed to raise a healthy crop.

Data were recorded on 10 randomly selected plants for characters viz., plant height, ear height, ear length, ear diameter, number of rows per ear, number of kernels per row, 100-seed weight, shelling percentage, cob yield per plant, germination 1<sup>st</sup> count, germination 2<sup>nd</sup> count, seed vigour index-1, seed vigour index-2, speed of germination, and grain yield per plant. Days to 50% tasseling, days to 50% silking and days to maturity, observations were taken on the plot basis. Readings from ten plants were averaged replication wise and the mean value was used for statistical analysis. The data collected was subjected to statistical analysis using INDOSTAT software version 9.2 and the methods adopted by the software for the analysis of variance (ANOVA) was as described by Panse and Sukhatme (1985). Correlation coefficients were calculated by using the formulae given by Johnson *et al.*, (1955). The direct and indirect effects at both the genotypic and phenotypic levels were measured by considering the grain yield per plant as a dependent variable, using path coefficient analysis, as proposed by Wright (1921) and Dewey and Lu (1959).

## **Results and Discussion**

The direction and level of correlation between yield and its component features, as well as among themselves, determine the effectiveness of yield selection. Character

association gives information on the kind and level of relationship between pairs of metric features and aids in character selection. In 30 genotypes, phenotypic and genotypic correlations on yield, yield contributing traits and seed vigour traits were determined. In general, genotypic correlations were higher than phenotypic correlations, showing a strong inherent link between the characters investigated.

Phenotypic correlation studies revealed that plant height (0.3566\*\*), ear height (0.2135\*\*), ear length (0.3505\*\*), ear diameter (0.4973\*\*), number of kernels of row (0.3471\*\*), 100-seed weight (0.5359\*\*), cob yield per plant (0.9883\*\*), and seed vigour index-2 (0.3412\*\*) were positive and significantly correlated with grain yield per plant (Table 1). The significant correlation indicates that there is strong association between various traits and grain yield per plant. Therefore, selection for these characters will be rewarding in yield improvement. The results were in agreement with the findings of Muliadi *et al.* (2021), Chavan *et al.* (2020), Jilo *et al.* (2020) and Prakash *et al.* (2019). Hence simultaneous selection can be done in these positively correlated traits through further breeding programmes.

Number of rows per ear (0.1213), germination 1<sup>st</sup> count (0.1504), germination 2<sup>nd</sup> count (0.0884), seed vigour index-1 (0.1882) and speed of germination (0.1269) showed positive correlation with grain yield per plant. Similar results also reported by Ahmed *et al.* (2020) for number of rows per ear, Sheidaei *et al.* (2014) and Ramyashree *et al.* (2015) for germination 1<sup>st</sup> count, germination 2<sup>nd</sup> count, seed vigour index-1, and speed of germination in soyabean. Therefore, it suggests that during the selection, preference should be given to these characters for a better yield. The correlation between two variables may be attributable to a third component, high correlation coefficients may not always give the accurate picture or may mislead the judgement.

Days to tasseling (-0.1746), days to maturity (-0.1758), and shelling percentage (-0.0677) exhibited non significant negative correlation whereas days to silking (-0.2280\*) recorded negatively significant correlation. The negative correlation will hinder the improvement in such situations some economic compromises has to be made. There result are in agreement with the finding of Chavan *et al.*, (2020) and Prakash *et al.* (2019).

Path coefficient analysis provides an exact picture of the relative importance of direct and indirect effects of each of the component character towards yield. It measures the cause of the association between two variables based on all possible simple correlations among the various characters and also based on the assumptions of linearity and additively. It provides actual contribution of traits on the yield in the form of direct and indirect effects. As a result, it aids breeders in determining the best and most important component traits during selection to improve yield. The direct and indirect effects of yield contributing traits on grain yield are given in Table 2.

Path coefficient analysis revealed that days to tasseling (0.0108), ear diameter (0.0057), number of kernels per row (0.0058), 100-seed weight (0.0122), shelling percentage (0.1439), cob yield per plant (1.0014), germination 1<sup>st</sup> count (0.0094), seed vigour index-1

(0.0131), seed vigour index-2 (0.0125) and speed of germination (0.0060), had positive direct effect on grain yield per plant, implying that selecting for these characteristics would likely to result in an overall improvement in grain yield per plant. Similar findings were reported by Muliadi *et al.* (2021), Jilo *et al.* (2020) and Ahmed *et al.* (2020) for days to 50% tasseling, ear diameter, number of kernels per row, cob yield per plant, Grace *et al.*, (2018) for 100 seed weight, Prakash *et al.*, (2019) for Shelling percentage, Ramyashree *et al.* (2015) for seed vigour traits in soyabean. As a result, it is advised that these characteristics should be prioritized in the yield improvement programme. This means that if other characters remain constant, an increase in one of these characters will result in an increase in grain yield, confirming that these characters are the significant contributors to phenotypic crop improvement.

On the contrary, negative direct effect exhibited by some traits like days to silking (-0.0169), days to maturity (-0.0092), plant height (-0.0168), ear height (-0.0018), ear length (-0.0202), number of rows per ear (-0.0041), germination 2<sup>nd</sup> count (-0.0134) exhibited negative direct effect. These findings are in conformity with the findings of Muliadi *et al.* (2021), Jilo *et al.* (2020), Taiwo *et al.* (2020) for days to silking, ear height and ear length, Ahmed *et al.* (2020) and Chavan *et al.*, (2020) for days to maturity, plant height and number of rows per ear, Ramyashree *et al.* (2015) for germination 2<sup>nd</sup> count. As a result, the findings suggest that indirect selection of these traits could be more effective.

Residual effect for phenotypic and genotypic are 0.0499, 0.1768 respectively and are low in magnitude. Low values of residual effect indicate that the traits included in the study explained high percentage of variation in grain yield.

### **Conclusion:**

According to the findings of this study, the traits ear height, ear diameter, ear length, number of kernels per row, 100 seed weight, seed vigour index-2 and cob weight per plant were important for selecting maize genotypes because these traits had a positive significant correlation, and most of these traits also had direct effects on cob weight per plant.

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**Table 1. Phenotypic (P) and Genotypic (G) correlation coefficients of yield, yield components and seed vigour traits in maize (*Zea mays* L.)**

Character		DT	DS	DM	PHT	EHT	EL	ED	NR	NKR
DT	P	<b>1.000</b>	0.9722**	0.5781**	0.0142	-0.1081	0.1599	-0.0928	-0.1017	-0.0300
	G	<b>1.000</b>	0.9897	1.5602	0.0725	-0.1102	0.1380	-0.0780	-0.1867	-0.1022
DS	P		<b>1.000</b>	0.5671**	-0.0755	-0.1593	0.1600	-0.1112	-0.1114	-0.0475
	G		<b>1.000</b>	1.6275	-0.0425	-0.1694	0.1050	-0.0993	-0.2019	-0.0950
DM	P			<b>1.000</b>	-0.0587	-0.0203	0.0271	-0.1740	-0.1772	-0.1199
	G			<b>1.000</b>	-0.0343	-0.3300	0.2209	-0.1437	-0.2676	-0.0901
PHT	P				<b>1.000</b>	0.4116**	0.3662**	0.1140	-0.1339	0.0924
	G				<b>1.000</b>	0.5699	0.4693	0.0418	-0.4786	0.0762
EHT	P					<b>1.000</b>	0.3187**	0.1000	-0.0785	0.2324*
	G					<b>1.000</b>	0.4180	0.1477	-0.1115	0.3599
EL	P						<b>1.000</b>	-0.1941	-0.1836	0.3829**
	G						<b>1.000</b>	-0.2744	-0.5065	0.5995
ED	P							<b>1.000</b>	0.5163**	0.1124
	G							<b>1.000</b>	0.7612	-0.0192
NR	P								<b>1.000</b>	0.1861
	G								<b>1.000</b>	0.2617
NKR	P									<b>1.000</b>
	G									<b>1.000</b>
100 SWT	P									
	G									
SHP	P									
	G									
CYP	P									
	G									
GM 1 <sup>st</sup>	P									
	G									
GM 2 <sup>nd</sup>	P									
	G									
SVI-1	P									
	G									
SVI-2	P									
	G									
SPG	P									
	G									

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

DT: Days to Tasseling, DS: Days to Silking, DM: Days to maturity, PHT: Plant height (m), EHT: Ear height (cm), EL: Ear length (cm), ED: Ear diameter, NR: Number of rows per ear, NKR: Number of kernels per row, 100 SW: 100-seed weight, SHP: Shelling %, CYP: Cob yield per plant (g), GM 1<sup>st</sup>: Germination 1<sup>st</sup> count, GM 2<sup>nd</sup>: Germination 2<sup>nd</sup> count, SVI-1: Seed Vigour index-1, SVI-2: Seed Vigour index-2, SPG: Speed of Germination, GYP: Grain yield per plant (g).

**Table 1. (Contd.) Phenotypic (P) and Genotypic (G) correlation coefficients of yield, yield components and seed vigour traits in maize (*Zea mays* L.)**

Character		100 SWT	SHP	CYP	GM 1 <sup>st</sup>	GM 2 <sup>nd</sup>	SVI-1	SVI-2	SPG	GYP
DT	P	-0.0693	-0.1684	-0.1318	-0.3042**	-0.4021**	-0.1850	-0.2652*	0.1587	<b>-0.1746</b>
	G	-0.0899	-0.3015	-0.1350	-0.3536	-0.4697	-0.1778	-0.3041	0.1955	<b>-0.1915</b>
DS	P	-0.1029	-0.1824	-0.1823	-0.3092**	-0.4228**	-0.1871	-0.3186**	0.1047	<b>-0.2280*</b>
	G	-0.1381	-0.2879	-0.1758	-0.3679	-0.5052	-0.1832	-0.3796	0.1335	<b>-0.2311</b>
DM	P	-0.0461	-0.0803	-0.1459	-0.1236	-0.1475	-0.0523	-0.1836	0.1041	<b>-0.1758</b>
	G	-0.2459	-0.3632	-0.3554	-0.6629	-0.8890	-0.3933	-0.3082	0.0600	<b>-0.4287**</b>
PHT	P	0.4220**	0.1899	0.3377**	0.1695	0.1539	0.0816	0.2818**	0.1212	<b>0.3566**</b>
	G	0.5648	0.2609	0.3873	0.2816	0.2909	0.1565	0.3888	0.1825	<b>0.4185**</b>
EHT	P	0.1817	0.1655	0.1844	0.1497	0.1219	0.3317**	0.3124**	0.0108	<b>0.2135*</b>
	G	0.1761	0.1925	0.1957	0.1184	0.0754	0.0391	0.3007	-0.0021	<b>0.2244*</b>
EL	P	0.1718	0.1666	0.3297**	0.0836	0.0686	0.2907**	0.5047**	0.1305	<b>0.3505**</b>
	G	0.2323	0.2028	0.3910	0.1409	0.1556	0.3917	0.6170	0.1595	<b>0.4252**</b>
ED	P	0.1883	-0.3850**	0.5371**	-0.1105	-0.2294*	-0.0760	-0.1253	0.2861**	<b>0.4973**</b>
	G	0.2219	-0.7040	0.6311	-0.1212	-0.2772	-0.0834	-0.1414	-0.3796	<b>0.5633**</b>
NR	P	-0.3519**	-0.4008**	0.1677	-0.0839	-0.1254	0.0425	-0.1367	0.3902**	<b>0.1213</b>
	G	-0.4434	-0.9300	0.1846	-0.0603	-0.1471	0.0847	-0.1716	0.6084	<b>0.1069</b>
NKR	P	-0.2368*	-0.1269	0.3343**	0.1706	0.1585	0.4387**	0.3339**	0.1495	<b>0.3471**</b>
	G	-0.3623	-0.1322	0.4489	0.2695	0.2806	0.6682	0.4761	0.2227	<b>0.4582**</b>
100 SW	P	<b>1.000</b>	0.1727	0.5161**	-0.0209	-0.0148	-0.3014	0.1060	-0.1579	<b>0.5359**</b>
	G	<b>1.000</b>	0.2237	0.5446	-0.0377	-0.0344	-0.3269	0.1017	0.1687	<b>0.5634**</b>
SHP	P		<b>1.000</b>	-0.2052	0.1789	0.2125*	0.0944	0.2719**	-0.3837**	<b>-0.0677</b>
	G		<b>1.000</b>	-0.2894	0.2520	0.03084	0.1253	0.3573	-0.4917	<b>-0.1641</b>
CYP	P			<b>1.000</b>	0.1123	0.0481	0.1505	0.2826**	0.1729	<b>0.9883**</b>
	G			<b>1.000</b>	0.1115	0.0464	0.1572	0.3004	0.1843	<b>0.9915**</b>
GM 1 <sup>st</sup>	P				<b>1.000</b>	0.8417**	0.5606**	0.2663*	0.0649	<b>0.1504</b>
	G				<b>1.000</b>	0.8372	0.5386	0.2413	0.0372	<b>0.1558</b>
GM 2 <sup>nd</sup>	P					<b>1.000</b>	0.4474**	0.3945**	0.0672	<b>0.0884</b>
	G					<b>1.000</b>	0.4038	0.3808	0.0352	<b>0.0951</b>
SVI-1	P						<b>1.000</b>	0.5543**	0.1982	<b>0.1882</b>
	G						<b>1.000</b>	0.5464	0.1871	<b>0.1919</b>
SVI-2	P							<b>1.000</b>	0.2915**	<b>0.3412**</b>
	G							<b>1.000</b>	0.2813	<b>0.3642**</b>
SPG	P								<b>1.000</b>	<b>0.1269</b>
	G								<b>1.000</b>	<b>0.1363</b>

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

**DT:** Days to Tasseling, **DS:** Days to Silking, **DM:** Days to maturity, **PHT:** Plant height (m), **EHT:** Ear height (cm), **EL:** Ear length (cm), **ED:** Ear diameter, **NR:** Number of rows per ear, **NKR:** Number of kernels per row, **100 SW:** 100-seed weight, **SHP:** Shelling %, **CYP:** Cob yield per plant (g), **GM 1<sup>st</sup>:** Germination 1<sup>st</sup> count, **GM 2<sup>nd</sup>:** Germination 2<sup>nd</sup> count, **SVI-1:** Seed Vigour index-1, **SVI-2:** Seed Vigour index-2, **SPG:** Speed of Germination, **GYP:** Grain yield per plant (g).

**Table. 2. Phenotypic (P) and Genotypic (G) path coefficients of yield, yield components and seed vigour traits in maize (*Zea mays* L.)**

Character		DT	DS	DM	PHT	EHT	EL	ED	NR	NKR
DT	P	<b>0.0108</b>	-0.0164	-0.0053	-0.0002	0.0002	-0.0032	-0.0005	0.0004	-0.0009
	G	<b>0.5997</b>	9.2149	0.8509	0.1199	0.0673	-0.1836	-0.0309	-0.1292	-0.2523
DS	P	0.0105	<b>-0.0169</b>	-0.0052	0.0013	0.0003	-0.0032	-0.0006	0.0005	-0.0015
	G	-0.5011	<b>0.3106</b>	0.8876	-0.0704	0.1035	-0.1397	-0.0393	-0.1397	-0.2347
DM	P	0.0063	-0.0096	<b>-0.0092</b>	0.0010	0.0000	-0.0005	-0.0010	0.0007	-0.0038
	G	-1.9779	15.1533	<b>0.5453</b>	-0.0567	0.2016	-0.2939	-0.0569	-0.1852	-0.2226
PHT	P	0.0002	0.0013	0.0005	<b>-0.0168</b>	-0.0007	-0.0074	0.0006	0.0006	0.0029
	G	-0.6958	-0.3961	-0.0187	<b>1.6544</b>	-0.3482	-0.6245	0.0165	-0.3312	0.1881
EHT	P	-0.0012	0.0027	0.0002	-0.0069	<b>-0.0018</b>	-0.0064	0.0006	0.0003	0.0073
	G	1.0577	-1.5772	-0.1800	0.9428	<b>-0.6110</b>	-0.5562	0.0585	-0.0772	0.8888
EL	P	0.0017	-0.0027	-0.0002	-0.0062	-0.0006	<b>-0.0202</b>	-0.0011	0.0008	0.0120
	G	-1.3248	0.9773	0.1205	0.7764	-0.2554	<b>-1.3307</b>	-0.1086	-0.3505	1.4805
ED	P	-0.0010	0.0019	0.0016	-0.0019	-0.0002	0.0039	<b>0.0057</b>	-0.0021	0.0035
	G	0.7491	-0.9247	-0.0784	0.0691	-0.0903	0.3651	<b>0.3960</b>	0.5267	-0.0474
NR	P	-0.0011	0.0019	0.0016	0.0022	0.0001	0.0037	0.0029	<b>-0.0041</b>	0.0058
	G	1.7919	-1.8794	-0.1459	-0.7917	0.0681	0.6740	0.3014	<b>0.6920</b>	0.6464
NKR	P	-0.0011	0.0019	0.0016	0.0022	0.0001	0.0037	0.0029	-0.0041	<b>0.0058</b>
	G	0.9808	-0.8847	-0.0491	0.1260	-0.2199	-0.7977	-0.0076	0.1811	<b>2.4696</b>
100 SWT	P	-0.0008	0.0017	0.0004	-0.0071	-0.0003	-0.0035	0.0011	0.0015	-0.0074
	G	0.8629	-1.2854	-0.1341	0.9344	-0.1076	-0.3091	0.0879	-0.3069	-0.8948
SHP	P	-0.0018	0.0031	0.0007	-0.0032	0.0007	-0.0034	-0.0022	0.0017	-0.004
	G	2.8943	-2.6802	-0.198	0.4316	-0.1176	-0.2699	-0.2787	-0.6436	-0.3264
CYP	P	-0.0014	0.0031	0.0013	-0.0057	-0.0003	-0.0067	0.003	-0.0007	0.0105
	G	1.2958	-1.6366	-0.1938	0.6407	-0.1196	-0.5202	0.2499	0.1278	1.1085
GM 1 <sup>st</sup>	P	-0.0033	0.0052	0.0011	-0.0028	-0.0003	-0.0017	-0.0006	0.0003	0.0054
	G	3.3945	-3.4258	-0.3615	0.4658	-0.0724	-0.1875	-0.0480	-0.0418	0.6654
GM 2 <sup>nd</sup>	P	-0.0044	0.0072	0.0014	-0.0026	-0.0002	-0.0014	-0.0013	0.0005	0.0050
	G	4.5089	-4.7040	-0.4848	0.4812	-0.0461	-0.2070	-0.1098	-0.1018	0.6930
SVI-1	P	-0.0020	0.0032	0.0005	-0.0014	-0.0006	-0.0059	-0.0004	-0.0002	0.0138
	G	1.7068	-1.7053	-0.2145	0.2589	-0.1889	-0.5213	-0.0330	0.0586	1.6502
SVI-2	P	-0.0029	0.0054	0.0017	-0.0047	-0.0006	-0.0102	-0.0007	0.0006	0.0105
	G	2.9192	-3.5345	-0.3317	0.6432	-0.1837	-0.8211	-0.0560	-0.1187	1.1758
SPG	P	0.0017	-0.0018	-0.001	-0.002	0.0000	-0.0026	0.0016	-0.0016	0.0047
	G	-1.8766	1.2430	0.0327	0.3020	0.0013	-0.2123	0.1503	0.4211	0.5500
<b>Genotypic Residual effect = 0.1739      Phenotypic Residual effect = 0.0499      Bold values are direct effects</b>										

DT: Days to Tasseling, DS: Days to Silking, DM: Days to maturity, PHT: Plant height (m), EHT: Ear height (cm), EL: Ear length (cm), ED: Ear diameter, NR: Number of rows per ear, NKR: Number of kernels per row, 100 SW: 100-seed weight, SHP: Shelling %, CYP: Cob yield per plant (g), GM 1<sup>st</sup>: Germination 1<sup>st</sup> count, GM 2<sup>nd</sup>: Germination 2<sup>nd</sup> count, SVI-1: Seed Vigour Index-1, SVI-2: Seed Vigour Index-2, SPG: Speed of Germination, GYP: Grain yield per plant (g).

Contd. Table.2. Phenotypic (P) and Genotypic (G) path coefficients of yield, yield components and seed vigour traits in maize (*Zea mays* L.)

Character		100 SWT	SHP	CYP	GM 1 <sup>st</sup>	GM 2 <sup>nd</sup>	SVI-1	SVI-2	SPG	GYP	
DT	P	-0.0008	-0.0242	-0.1320	-0.0028	0.0054	-0.0024	-0.0033	0.0010	-0.1746	
	G	-0.2478	0.3828	0.3055	-0.1829	0.1423	0.0907	-0.6045	-0.1348	-0.1915	
DS	P	-0.0013	-0.0263	-0.1826	-0.0029	0.0057	-0.0025	-0.0040	0.0006	-0.2280	
	G	-0.3806	0.3654	0.3978	-0.1903	0.1531	0.0934	-0.7546	-0.0920	-0.2311	
DM	P	-0.0006	-0.0116	-0.1461	-0.0012	0.0020	-0.0007	-0.0023	0.0006	-0.1758	
	G	-0.6778	0.4610	0.8044	-0.3429	0.2693	0.2006	-1.2089	-0.0414	-0.4287	
PHT	P	0.0051	0.0273	0.3382	0.0016	-0.0021	0.0011	0.0035	0.0007	0.3566	
	G	1.5569	-0.3312	-0.8764	0.1456	-0.0881	-0.0798	0.7729	-0.1259	0.4185	
EHT	P	0.0022	0.0238	0.1847	0.0014	-0.0016	0.0044	0.0039	0.0001	0.2135	
	G	0.4854	-0.2443	-0.4429	0.0613	-0.0229	-0.1576	0.5977	0.0015	0.2244	
EL	P	0.0021	0.0240	0.3302	0.0008	-0.0009	0.0038	0.0063	0.0008	0.3505	
	G	0.6402	-0.2575	-0.8848	0.0729	-0.0471	-0.1998	1.2266	-0.1100	0.4252	
ED	P	0.0023	-0.0554	0.5379	-0.0010	0.0031	-0.0010	-0.0016	0.0017	0.4973	
	G	0.6117	0.8937	-1.4282	-0.0627	0.0840	0.0425	-0.2811	-0.2617	0.5633	
NR	P	-0.0043	-0.0577	0.1680	-0.0008	0.0017	0.0006	-0.0017	0.0024	0.1213	
	G	-1.2224	1.1807	-0.4178	-0.0312	0.0446	-0.0432	-0.3410	-0.4195	0.1069	
NKR	P	-0.0029	-0.0183	0.3347	0.0016	-0.0021	0.0058	0.0042	0.0009	0.3471	
	G	-0.9988	0.1678	-1.0158	0.1394	-0.0850	-0.3408	0.9464	-0.1535	0.4582	
100 SW	P	<b>0.0122</b>	0.0249	0.5169	-0.0002	0.0002	-0.0040	0.0013	-0.0010	0.5359	
	G	<b>2.7566</b>	-0.2840	-1.2326	-0.0195	0.0104	0.1667	0.2021	0.1163	0.5634	
SHP	P	0.0021	<b>0.1439</b>	-0.2055	0.0017	-0.0028	0.0012	0.0034	-0.0023	-0.0677	
	G	0.6166	<b>-1.2695</b>	0.655	0.1303	-0.0934	-0.0639	0.7102	0.339	-0.1641	
CYP	P	0.0063	-0.0295	<b>1.0014</b>	0.0011	-0.0006	0.002	0.0035	0.001	0.9883	
	G	1.5014	0.3674	<b>-2.2631</b>	0.0577	-0.0141	-0.0802	0.5971	-0.1271	0.9915	
GM 1 <sup>st</sup>	P	-0.0003	0.0257	0.1124	<b>0.0094</b>	-0.0113	0.0074	0.0033	0.0004	0.1504	
	G	-0.1038	-0.3199	-0.2523	<b>0.5172</b>	-0.2536	-0.2747	0.4797	-0.0256	0.1558	
GM 2 <sup>nd</sup>	P	-0.0002	0.0306	0.0482	0.0079	<b>-0.0134</b>	0.0059	0.0049	0.0004	0.0884	
	G	-0.0947	-0.3915	-0.1050	0.4331	<b>-0.3029</b>	-0.2059	0.7569	-0.0243	0.0951	
SVI-1	P	-0.0037	0.0136	0.1508	0.0052	-0.0060	<b>0.0131</b>	0.0069	0.0012	0.1882	
	G	-0.9011	-0.1591	-0.3557	0.2786	-0.1223	<b>-0.5100</b>	1.0861	-0.1290	0.1990	
SVI-2	P	0.0013	0.0391	0.2830	0.0025	-0.0053	0.0073	<b>0.0125</b>	0.0018	0.3412	
	G	0.2802	-0.4535	-0.6798	0.1248	-0.1154	-0.2786	<b>1.9878</b>	-0.1940	0.3642	
SPG	P	-0.0019	-0.0552	0.1731	0.0006	-0.0009	0.0026	0.0036	<b>0.006</b>	0.1269	
	G	-0.4651	0.6242	-0.4172	0.0192	-0.0107	-0.0954	0.5593	<b>-0.6895</b>	0.1363	
		<b>Genotypic Residual effect = 0.1768</b>			<b>Phenotypic Residual effect = 0.0499</b>			<b>Bold values are direct effects</b>			

DT: Days to Tasseling, DS: Days to Silking, DM: Days to maturity, PHT: Plant height (m), EHT: Ear height (cm), EL: Ear length (cm), ED: Ear diameter, NR: Number of rows per ear, NKR: Number of kernels per row, 100 SW: 100-seed weight, SHP: Shelling %, CYP: Cob yield per plant (g), GM 1<sup>st</sup>: Germination 1<sup>st</sup> count, GM 2<sup>nd</sup>: Germination 2<sup>nd</sup> count, SVI-1: Seed Vigour index-1, SVI-2: Seed Vigour index-2, SPG: Speed of Germination, GYP: Grain yield per plant (g).