Character association and path coefficient analysis for grain yield and its components in maize genotypes(*Zea mays* L.)

Abstract

Aim: An investigation was carried out to asses magnitude of the association between grain yield and its contributing characters.

Study design: randomized block design with three replications

Place and Duration of Study: Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendranagar, Hyderabad during *kharif*, 2019.

Methodology:A total of 39 maize genotypes including eight parents, 31 hybrids were evaluated in randomized block design with three replications.The data on twelve quantitative characters namely, days to 50 per cent tasseling, days to 50 per cent silking, days to maturity, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of kernel rows per ear, number of kernels per row, 100 kernel weight, shelling percentage and grain yield per plant were recorded.

Results: The results of this study indicated the greater genotypic correlation coefficient than the corresponding phenotypic correlation coefficient for all the traits studied which indicates that though there is strong inherent association between characters studied, its expression is masked due to influence of environment. Correlation coefficient analysis ofgrain yield per plant showedstrong and significant positive association with ear diameter at phenotypic (0.9016) and (0.9540) genotypic level followed by ear length (0.8976, 0.9360), number of kernels per row (0.8905, 0.9247), plant height (0.8399, 0.8697), 100 seed weight (0.8070, 0.8544), ear height (0.7170, 0.7550) and number of kernel rows per ear (0.3240, 0.3901).However, days to 50% tasseling and days to 50 % silking exhibit significant negative correlation with grain yield, while days to maturity showed non significantnegative. Path coefficient analysis revealed, theear diameter (0.3505) exerted maximum positive direct effect on grain yield per plant followed by 100 seed weight (0.2362), ear length (0.2273), number of kernels per row (0.1827), days to 50 per cent silking (0.1269), shelling percentage (0.1223).

Conclusion: The high direct effects of ear diameter, 100 seed weight, ear length and number of kernels per row (0.2971) appeared to be the main factor for their strong association with grain yield per plant. Hence direct selection for these traits would be effective for yield improvement.

Key words: Correlation coefficient, path coefficient, hybrids, Grain yield, maize.

1. Introduction

Maize (*Zeamays* L.) is one of the important cereal crops and occupies a prominent position in global agriculture. Globally, it is grown in an area of 206.16 million hectares with the production of 1215.90 million tones and a productivity of 5.90 tons per hectare (USDA reports, 2021-22). In India, it is grown in an area of 9.95 million hectares with the production and productivity of 33.72 million tonnes and 3.38

tonnes per hectare respectively (INDIASTAT, 2021-2022). Among the maize growing countries, India ranks 4th in area and 7th in production, representing around 4% of the world maize area and 2% of total production. In Telangana state, it is grown in an area of 0.41 million hectares with 2.22 million tonnes and 5.40 tonnes per hectare of production and productivity, respectively (INDIASTAT, 2021-2022). Since the centuries maize plant was known for it's multifariously use. Maize is used as human food, livestock feed, for producing alcohols and non alcohol drinks, built material, like a fuel, and like medical and ornamental plant (Bekric and Radosavljevic, 2008). Keeping the view of wide utilization of maize, the main goal of all maize breeding programs is to obtain new inbred and hybrids that will outperform the existing hybrids with respect to grain yield and yield attributes. In working towards this goal, particular attention is paid to grain yield as the most important agronomic characteristic. Grain yield is a complex quantitative trait that depends on a number of factors.Thus, knowledge of interrelationships between grain yield and its contributing components will improve the efficiency of breeding programs through the use of appropriate selection indices (Mohammadi et al., 2003).

Path coefficient analysis has been widely used in crop breeding to determine the nature of relationshipbetween grain yield and its contributing components, The components with significant direct effect on grain yield are potential for selection criteria. Path analysis showed direct and indirect effects of cause variables on effect variables. In path coefficient analysis, the correlation coefficient between two traits is separated into the components which measure the direct and indirect effects. Generally, this method provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components. Which could be used as target traits for selection and breeding criteria to bring out improvement to maize yields.Hence, the present investigation is carried out to assess the magnitude of the relationships among yield and its components for enhancing the usefulness of selection.

2. Materials and Methods

In the present investigation, a total of 39 maize genotypes including eight parents, 31 hybrids were evaluated in randomized block design with three replications at Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendranagar, Hyderabad. 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 data on twelve quantitative characters namely, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of kernel rows per ear, number of kernels per row, 100 kernel weight, shelling percentage and grain yield per plant were recorded on five randomly selected competitive plants in each replication, whereas days to 50 per cent tasseling, days to 50 per cent silking, days to maturity were recorded on plot basis. Ear diameter without husk was measured in centimeters at the middle of the ear at the time of harvest with vernier calipers. Correlation coefficients and path analysis were conducted following the methods of Al-Jibouri*et al*. (1958) and Dewey and Lu (1959) respectively.

3. Results and Discussion

Genotypic correlations reveal the existence of real associations, whereas the phenotypic correlations may occur by chance. Significant phenotypic correlations without significant genotypic associations are of no value, while a significant genotypic correlation and non-significant phenotypic correlation indicates that the association is masked by environmental effect. The phenotypic and genotypic correlations worked out on yield and yield contributing characters in 39 maize genotypes arepresented in Table 1. The results indicated that the genotypic correlation coefficient is greater than the corresponding phenotypic correlation coefficient for all the traits studied indicating strong inherent association between various traits. The similar results were obtained by Ram Reddy and Jabeen (2016) and Chourasia et al. (2020).

Character association studies indicated that grain yield per plant had highly significant and positive correlation with plant height, ear height, ear length, ear diameter, number of kernel rows per ear, number of kernels per row, 100-kernel weight and shelling percentage at genotypic and phenotypic level, suggesting that the importance of these traits for direct selection in any breeding programme designed to increase grain yield in maize. The significant positive association of grain yield with its component traits *viz.,* ear length, ear diameter, number of kernels per row, plant height, ear height and100 kernel weight were also reported by Ram reddy and Jabeen (2016), Kandel*et al*. (2017), Prakash *et al*. (2019) and Chaurasia *et al*. (2020).

Among the characters studied ear diameter recorded maximum significant positive correlation with grain yield at phenotypic (0.9016) and (0.9540) genotypic level followed by ear length (0.8976, 0.9360), number of kernels per row (0.8905, 0.9247), plant height (0.8399, 0.8697), 100 seed weight (0.8070, 0.8544), ear height (0.7170, 0.7550) and number of kernel rows per ear(0.3240, 0.3901).Hence, in the process of selection attention should be given for such traits for improvement of grain yield in maize.Days to 50 per cent tasseling and silking were shown significant negative correlation with plant height, number of kernel rows per ear, number of kernels per row, shelling percentage and grain yield at genotypic level and phenotypic level.Negative association of grain yield per plant with days to 50 per cent tasseling and silking was also obtained byMogesse*et al*. (2021). Ear diameter had maximum significant positive association with grain yield per plant and its other components *viz.,*number of kernels per row, plant height, ear hieghtand 100-kernel weight. In the earlier studies of Sumalini *et al* (2015), Ravindra Kumar and Karan Chaudhary (2018) and Singh *et al* (2019) a similar significant positive association of grain yield with ear diameter is observed.Plant height recorded a significant and positive correlation with grain yield and its other components except days to 50 per cent silking and tasseling and it shown non significant positive association with days to maturity at both genotypic and phenotypic level. Prakash *et al* (2019) also reported a significant positive association of plant height with grain yield in maize.

Path analysis partitions correlation coefficients into direct and indirect effect which probes the cause and effect relationship. (Wright, 1921). Hence, the path coefficient analysis was undertaken to know the direct and indirect effects in maize. The phenotypic and genotypic direct and indirect individual effects of different characters on grain yield in maize are presented in Table 2. The direct effects in path coefficient analysis revealed that, the ear diameter (0.3505) exhibited the largest direct effect on grain yield per plant followed by 100-kernel weight (0.2362), ear length (0.2273), number of kernels per row (0.2971), days to 50 per cent silking (0.1269), shelling percentage (0.1223), ear height (0.0621), number of kernel rows per ear (0.0036), plant height (-0.0429), days to 50 per cent tasseling (-0.0578) and days to maturity (-0.0701) at phenotypic level. Similarly, At genotypic level it found that character days to 50 percent silking (0.9258) exhibited the largest direct effect on grain yield per plant followed by 100-kernel weight (0.7919), days to maturity (0.7860), number of kernel rows per ear (0.5757), ear length (0.4718), shelling percentage (0.1282), ear height (0.2136), number of kernels per row (-0.0850), ear diameter (-0.2045), plant height (-0.5760) and days to 50 per cent tasseling (-1.5721). The direct selection in desirable direction for such traits can be effective for yield improvement.The high direct effect of ear diameter, 100-kernel weight, ear length and number of kernels per row appeared to be the main factor for their strong association with grain yield per plant. Hence, during selection attention should be given for such traits for improvement of grain yield. Days to 50 percent tasseling (-0.0578) and days to maturity (-0.0701) and plant height (-0.0429) had negative direct effect on grain yield at phenotypic level. While Plant height (-0.5760), Days to 50 percent tasseling (-1.5721), ear diameter (-0.2045) and number of kernels per row (-0.0850) had negative direct effect on grain yield at genotypic level. Similar results of direct negative effect of days to 50 per cent tasseling on grain yield was reported by earlier workers Devasree *et al*. (2020), for plant height by Shikha *et al*. (2020), for days to maturity by Netaji (1998). Days to 50 per cent tasseling showed a negative direct effect on grain yield per plant and it had indirect negative contribution on grain yield through days to 50 per cent silking and days to maturity, while indirect positive contribution through plant height, ear height, ear length, ear diameter, number of kernel rows per ear, number of kernels per row 100-kernel weight and shelling percentage at phenotypic and genotypic level. Similar results of direct negative effect of days to 50 per cent tasseling on grain yield was reported by earlier workers Venugopal *et al.* (2003) and Raghu *et al.* (2011) and Devasree *et al*. (2020).

Table 1. Phenotypic (P) and Genotypic (G) correlations for yield and yield component characters in maize

Source		Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Number of kernel rows per ear	Number of kernels per row	100-kernel weight (g)	Shelling percent (%)	Grain yield per plant (g)
Days to 50% tasseling	P	1.0000	0.9695**	0.8519**	-0.2304*	-0.0807	-0.1825*	-0.3058**	-0.4601**	-0.3681**	-0.1735	-0.3669**	-0.2930**
	G	1.0000	0.9846**	0.9164**	-0.2588**	-0.0672	-0.2163*	-0.4076**	-0.5903**	-0.4143**	-0.1991*	-0.4100**	-0.3390**
Days to 50% silking	P		1.0000	0.8722**	-0.2369*	-0.0820	-0.1664	-0.2813**	-0.4641**	-0.3456**	-0.1622	-0.3947**	-0.2730**
	G		1.0000	0.9111**	-0.2673**	-0.0726	-0.1987*	-0.3843**	-0.6118**	-0.4008**	-0.1968*	-0.4616**	-0.3157**
Days to maturity	P			1.0000	0.0147	0.1513	0.0588	-0.0425	-0.3854**	-0.1281	0.0766	-0.2698**	-0.0411
	G			1.0000	0.0284	0.2173*	0.0718	-0.0986	-0.5596**	-0.1545	0.0650	-0.3182**	-0.0253
Plant height (cm)	P				1.0000	0.8903**	0.8474**	0.8063**	0.2693**	0.7827**	0.7844**	0.3341**	0.8399**
	G				1.0000	0.9254	0.8866**	0.858**	0.3220**	0.8159**	0.8262**	0.4159**	0.8697**
Ear height (cm)	P					1.0000	0.7459**	0.7230**	0.2092*	0.6536**	0.6522**	0.1005	0.7170**
	G					1.0000	0.7945**	0.7843**	0.2540*	0.6932**	0.6880**	0.1470	0.7550**
Ear length (cm)	P						1.0000	0.8585**	0.2885**	0.8646**	0.7248**	0.3596**	0.8976**
	G						1.0000	0.9141**	0.3188**	0.9025**	0.7729**	0.4756**	0.9360**
Ear diameter (cm)	P							1.0000	0.4604**	0.8589**	0.6727**	0.3536**	0.9016**
	G							1.0000	0.5037**	0.9271**	0.7229**	0.4909**	0.9540**
Number of kernel rows per ear	P								1.0000	0.4332**	-0.0319	0.2108*	0.3240**
	G								1.0000	0.5048**	-0.0305	0.3404**	0.3901**
Number of kernels per row	P									1.0000	0.6777**	0.4517**	0.8905**
	G									1.0000	0.7303**	0.5293**	0.9247**
100-kernel weight (g)	P										1.0000	0.4555**	0.8070**
	G										1.0000	0.5654**	0.8544**
Shelling percent (%)	P											1.0000	0.5008**
	G											1.0000	0.6097**
Grain yield per plant (g)	P												1.0000
	G												1.0000

P represents Phenotypic correlation coefficient; **G** represents Genotypic correlation coefficient.

* Significant at 5 percent level; ** significant at 1 percent level

Table 2. Phenotypic (P) and Genotypic (G) path coefficients for various yield and its contributing characters in maize

Source		Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Number of kernel rows per ear	Number of kernels per row	100-kernel weight (g)	Shelling percent (%)	Grain yield per plant (g)
Days to 50% tasseling	P	**-0.0578**	-0.0561	-0.0493	0.0133	0.0047	0.0106	0.177	0.0266	0.0213	0.0100	0.0212	-0.2930**
	G	**-1.5721**	-1.5479	-1.4406	0.4068	0.1056	0.3400	0.6408	0.9280	0.6513	0.3129	0.6445	-0.3390**
Days to 50% silking	P	0.1231	**0.1269**	0.1107	-0.0301	-0.0104	-0.0211	-0.0357	-0.0589	-0.0439	-0.0206	-0.0501	-0.2730**
	G	0.9116	**0.9258**	0.8436	-0.2475	-0.0672	-0.1840	-0.3558	-0.5664	-0.3711	-0.1822	-0.4274	-0.3157**
Days to maturity	P	-0.0597	-0.0611	**-0.0701**	-0.010	-0.0106	-0.0041	0.0030	0.0270	0.0090	-0.0054	0.0189	-0.0411
	G	0.7203	0.7162	**0.7860**	0.0223	0.1708	0.0564	-0.0775	-0.4399	-0.1215	0.0511	-0.2501	-0.0253
Plant height (cm)	P	0.0099	0.0102	-0.0006	**-0.0429**	-0.0382	-0.0363	-0.0346	-0.0116	-0.0336	-0.0336	-0.0143	0.8399**
	G	0.1491	0.1540	-0.0164	**-0.5760**	-0.5331	-0.5107	-0.4942	-0.1855	-0.4700	-0.4759	-0.2396	0.8697**
Ear height (cm)	P	-0.0050	-0.0051	0.0094	0.0553	**0.0621**	0.0463	0.0449	0.0130	0.0406	0.0405	0.0062	0.7170**
	G	-0.0143	-0.0155	0.0464	0.1976	**0.2136**	0.1697	0.1675	0.0542	0.1481	0.1469	0.0314	0.7550**
Ear length (cm)	P	-0.0415	-0.0378	0.0134	0.1926	0.1695	**0.2273**	0.1951	0.0656	0.1965	0.1647	0.0817	0.8976**
	G	-0.1020	-0.0938	0.0339	0.4183	0.3748	**0.4718**	0.4312	0.1504	0.4258	0.3646	0.2244	0.9360**
Ear diameter (cm)	P	-0.1072	-0.0986	-0.0149	0.2826	0.2534	0.3009	**0.3505**	0.1614	0.3010	0.2357	0.1239	0.9016**
	G	0.0834	0.0786	0.0202	-0.1755	-0.1604	-0.1869	**-0.2045**	-0.1030	-0.1896	-0.1478	-0.1004	0.9540**
Number of kernel rows per ear	P	-0.0016	-0.0017	-0.0014	0.0010	0.0007	0.0010	0.0016	**0.0036**	0.0015	-0.0001	0.0007	0.3240**
	G	-0.3399	-0.3522	-0.3222	0.1854	0.1462	0.1836	0.2900	**0.5757**	0.2906	-0.0176	0.1960	0.3901**
Number of kernels per row	P	-0.0673	-0.0631	-0.0234	0.1430	0.1194	0.1579	0.1569	0.0791	**0.1827**	0.1238	0.0825	0.8905**
	G	0.0352	0.0341	0.0131	-0.0694	-0.059	-0.0767	-0.0788	-0.0429	**-0.0850**	-0.0621	-0.0450	0.9247**
100-kernel weight (g)	P	-0.0410	-0.0383	0.0181	0.1853	0.1541	0.1712	0.1589	-0.0075	0.1601	**0.2362**	0.1076	0.8070**
	G	-0.1576	-0.1558	0.0515	0.6542	0.5448	0.6120	0.5724	-0.0242	0.5783	**0.7919**	0.4478	0.8544**
Shelling percent (%)	P	-0.0449	-0.0483	-0.0330	0.0409	0.0123	0.0440	0.0432	0.0258	0.0552	0.0557	**0.1223**	0.5008**
	G	-0.0526	-0.0592	-0.0408	0.0533	0.0188	0.0610	0.0629	0.0436	0.0679	0.0725	**0.1282**	0.6097**

Phenotypic residual effect = 0.2658 Genotypic residual effect = 0.1679

* Significant at 5 percent level; ** significant at 1 percent level. **Bold** values are direct effects

Days to 50 per cent silking exhibited a positive direct genotypic effect on grain yield per plant. It had negative indirect contribution through all other characters under study except days to 50 per cent silking and days to maturity which were shown positive indirect contribution. Similar results of direct positive effect of days to 50 per cent silking on grain yield was reported by earlier workers Viola *et al*. (2003) and Devasree *et al* (2020).

Ear length had positive direct effect on grain yield per plant, while its correlation with grain yield per plant was positive and significant. The correlation was positive and significant mainly due to positive indirect contribution through days to maturity, plant height, ear height, ear diameter, ear length, number of kernels per ear, number of kernels per row, 100-kernel weight and shelling percentage at phenotypic and genotypic level. It also had indirect negative contribution through by days to 50 per cent tasseling and days to 50 % silking.Similar results were reported by Begum*et al.* (2016), Roy *et al* (2018) andShikha *et al*. (2020) who reported positive direct effect on ear height on grain yield in maize.Ear diameter had direct genotypic negative effect on grain yield per plant. It also showed indirect positive influence on grain yield through days to 50 per cent tasseling,days to 50 per cent silking and days to maturity.The indirect negative influence of ear diameter on grain yield was observed through plant height, ear height, ear diameter, ear length, number of kernels per ear, number of kernels per row, 100-kernel weight and shelling percentage. While it had direct positive influence on grain yield per plant at phenotypic level and indirect positive influence through all the characters studied except days to 50 per cent tasseling, silking and maturity which were shown negative indirect effects on grain yield per plant. Similar results of direct positive association of ear diameter with grain yield were reported by Kote *et al* (2014) and Ram Reddy and Jabeen (2016).

Number of kernel rows per ear had direct positive influence on grain yield. It had indirect positive contribution through plant height, ear height, ear diameter, ear length, number of kernels per ear, number of kernels per row and shelling percentage, while it had indirect negative contribution through days to 50 per cent tasseling, days to 50 per cent silking, days to maturity and 100-kernel weight at phenotypic and genotypic level. Similar results of direct positive effect of number of kernel rows per ear on grain yield was reported by earlier workers Nataraj *et al* (2015), Ravindra kumar and Karan Choudhary (2018) and Woldu Mogesse (2021).

The 100-kernel weight exhibited the direct genotypic positive effect on grain yield per plant. An indirect positive influence through plant height, ear height, ear diameter, ear length, number of kernels per row and shelling percentage and indirect negative influence through days to 50 per cent tasseling, days to 50 per cent silking and number of kernels rows per ear. Similar results of direct positive effect of 100-kernel weight on grain yield was found by earlier workers Roy *et al*. (2018) and Yahaya *et al*. (2021).The shelling percentage exhibited the direct genotypic positive effect on grain yield per plant. An indirect positive influence through plant height, ear height, ear diameter, ear length, number of kernels per ear, number of kernels per row and 100 kernel weight and indirect negative influence through days to 50 per cent tasseling, days to 50 per cent silking and days to maturity. Similar results of direct positive effect of shelling percentage on grain yield was found by earlier workers Soumya and Kamatar (2017), Prakash *et al* (2019), singh*et al*(2019) and Devasree *et al* (2020).

The residual effect was 0.2658 for phenotypic and 0.1679 for genotypic path coefficient analysis. As residual effect is low, it indicates that all the characters studied contributed for grain yield.

4. Conclusion

According to the study on correlation,selection of promising genotypes for ear diameter, ear length, number of kernels per row, plant height, 100-kernel weight and ear height may be associated with increasing grain yield of maize as they had highly significant positive association with grain yield. The path coefficient analysis clearly emphasized the need for selection, based on plant type with greater ear diameter, 100 kernel weight, ear length, days to 50 per cent silking, and number of kernel rows per ear as these traits were found to be the important contributors with direct effect on grain yield.

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