Character association and path coefficient analysis to determine interrelationships among grain yield and its components in maize genotypes(Zea mays L.)

Abstract

Aim:A study was carried out to evaluate the magnitude of correlation between grain yield and its various contributing characters.

Methodology:39 genotypes of maize, comprising 31 hybrids and 8 parents, were assessed using randomized block design with three replications.The data recorded on twelve quantitative characters including days to 50 percent tasseling, days to 50 percent 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.

Results:

The results of this study showed higher genotypic correlation coefficient for all the characters studied compared to the corresponding phenotypic correlation coefficient. This suggests that, despite the strong inherent association between the traits under study, environments' influence masked its expression.Ear diameter was found to have a strong and significant positive correlation with grain yield per plant 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).Days to 50% silking and days to 50% tasselling, however, exhibited significant negative association with grain yield, while days to maturity showed non-significant negative. In path coefficient analysis the maximum positive direct effect on grain yield per plant was found by the ear diameter (0.3505), followed by the 100 seed weight (0.2362), ear length (0.2273), number of kernels per row (0.1827), days to 50% silking (0.1269), and shelling percentage (0.1223).

Conclusion: The strong correlation of ear diameter, 100 seed weight, ear length and number of kernels per row (0.2971) with grain yield per plant appears to be mostly due to their high direct effects. Therefore, improving yield could be achieved through direct selection for these attributes.

Keywords: 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, grown in an area of 206.16 million hectares globally and produces 1215.90 million tonnes with a productivity of 5.90 tons per hectare (USDA data, 2021-22). In India it is cultivated in 9.95 million hectares area with 33.72 million tonnes production and 3.38 tonnes of productivity" (INDIASTAT, 2021–2022)."India is the fourth-largest in area and seventh in production among countries which grow maize; it accounts for around 4% of the world's total maize area and 2% of its total production. In Telangana state,the area under maize cultivation is 0.41 million hectares with productionand productivity of 2.22

million tonnes and 5.40 tonnes per hectare, respectively" (INDIASTAT, 2021–2022).The maize plant has been valued for its various uses for ages. Maize is used as fuel, food for humans, feed for cattle, building material. It is also used to produce alcohol and non-alcoholic drinks (Bekric& Radosavljevic, 2008). "All maize improvement programs aim to produce new inbred and hybrids that will surpass the current inbred and hybrids in terms of grain yield and yield traits, keeping with the widespread use of maize.In order to accomplish this goal, particular focus has to paid for grain yield as the most crucial agronomic trait.Grain yield is a complex quantitative character which depends on multiple factors.Therefore, the information on interrelationships among grain yield and its contributing attributes would enhance the effectiveness of breeding programs through the execution of suitable selection indices"(Mohammadi et al., 2003).In crop breeding, path coefficient analysis is employed to ascertain the nature of the relationship among grain yield and its contributing traits. The traits that have a large direct effect on grain yield have the potential to serve as selection criteria. Both direct and indirect effects of cause variables on effect variables were measured using path analysis. The correlation coefficient between two characters is divided into the components which measures the direct and indirect effects in path coefficient analysis. In general, path coefficient analysis, gives more information among variables than do correlation coefficients. Since this analysis shows the direct effect of particular yield components on yield as well as the indirect effects through other yield components. This could be use to determine the target characters for selection criteria in order to enhance maize yields.

Therefore, the current study was conducted to determine the magnitude of the relations between yield and its contributing characters in order to improve the effectiveness of selection.

2. Materials and Methods

This study was conducted with a total of 39 maize genotypes which includes eight parents and31 hybrids. These genotypes were evaluated in RBD(randomized block design) with three replications at Winter Nursery Centre, ICAR-Indian Institute of Maize Research, Rajendranagar, Hyderabadduring *kharif*, 2019. Each entry was planted in two four-meter-long rows, with a 20cm spacing between each plant and a 75 cm spacing between each row.The data on 12 characters namely, days to 50 percent tasseling, days to 50 percent 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.Five randomly selected competitive plants in each replication were used to record the data on characters, 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. Data was recorded on plot basisfor days to 50% tasseling, days to 50% silking, and days to maturity. With vernier calipers, the ear's diameter without husk was measured in cm at middle of the ear at harvest time.Analysis of variance was doneby statistical analysis for partitioning the total variation into due to treatments and replications as per Panse and Sukhatme (1985). The correlation coefficients between all thecharacters were calculated according to Singh and Chaudhary's (1979). Path coefficients were calculated using method given by Dewey and Lu's (1959) recommended methodology.Indostat software (Indostat Inc. Hyderabad, India) was used to analyze the data.

3. Results and Discussion

Genotypic correlations show the existence of true interactions, while phenotypic correlations could happen by chance.A significant genotypic correlation and a non-significant phenotypic correlation suggest that the relationship is being obscured by an environmental impact, whereas significant phenotypic correlations with non significant genotypic associations are of no value. The phenotypic and genotypic correlations estimated on yield and otherits contributing characters in 39 maize genotypes arepresented in Table 1.The findings showed that for each trait under study, the genotypic correlation coefficient is higher than the corresponding phenotypic correlation coefficient, demonstrating a strong inheritant relation between the different characters. Ram Reddy and Jabeen (2016) and Chourasia et al. (2020) also found similar results."Grain yield per plant exhibited a highly significant and positive correlation, both at the genotypic and phenotypic levels, 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. These findings suggest that these traits are important for direct selection in any breeding program aimed at improving maize grain yield.Character association studies indicated that grain yield per plant hada 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 thegenotypic and phenotypic level, suggesting that the importance of these traits for direct selection in any breeding programdesigned to increase grain yield in maize" (Ram Reddy and Jabeen, 2016). Similarly, Ram Reddy and Jabeen (2016), Kandel et al. (2017), Prakash et al. (2019), Chaurasia et al. (2020) and Akshaya *et al.* (2022)reported "a significant positive association between grain yield and its component traits, namely, ear length, ear diameter, number of kernels per row, plant height, ear height, and 100 kernel weight".Yahaya *et al.* (2021) forplant height, ear length, ear diameter and100 kernel weight and Priyanto*et al.* (2023) for shelling percentage and other yield attributes.The highest significant positive correlation with grain yield was found by ear diameter at both the phenotypic (0.9016) and genotypic (0.9540) levels among the studied charactersfollowed 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 order to increase maize grain yields these traits should be emphasized during the selection process.Akshaya *et al.* (2022) and Priyanto*et al.* (2023)reported "high positive correlation with grain yield by ear diameter, ear length, number of kernels per row, plant height and 100 seed weight"andYahaya *et al.* (2021) byplant height, ear length, ear diameter and 100 seed weight. Days to 50 percenttasseling and silking were recorded significant negative correlation with plant height, number of kernel rows per ear, number of kernels per row, shelling percentage and grain yield at both genotypic and phenotypic level.Mogesseet al. (2021) and Akshaya et al. (2022) were found "a negative correlation between grain yield and the number of days to 50% tasseling and silking.The high significant positive correlation exhibited by ear diameter with grain yield per plant as well as its other components*viz.,*number of kernels per row, plant height, ear heightand 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 correlationbetween grain yield and ear diameter is reported.Plant height recorded a significant and positive correlation with grain yield and its other components except days to 50 percent silking and tasseling and it shown non significant positive correlation with days to maturity at genotypic level and phenotypic level. Prakash *et al* (2019) observed a significant positive correlation of plant height with grain yield in maize. Similarly negative correlation of plant height with days to 50 percent silking and tasseling was also reported earlier by kshaya*et al.* (2022)."Path analysis separates correlation coefficients as direct and indirect effects, which asses the cause and effect relationship"(Wright, 1921). Hence, in order to determine the direct and indirect effects the path coefficient analysis was conducted on maize. The direct and indirect individual effects of studied characterson grain yield, both phenotypic and genotypic levels are given in Table 2.The direct effects in path coefficient analysis indicated 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 percent 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 percent tasseling (-0.0578) and days to maturity (-0.0701) at thephenotypic level. Atgenotypic level the character days to 50 percent silking (0.9258) recorded the maximum 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 percent tasseling (-1.5721). For such traits, direct selection in the desired direction can be useful in increasing yield. Themain cause for strong correlation of characters ear diameter, 100-kernel weight, ear length and number of kernels per row with grain yield per plant appears to be high direct effect on grain yield per plant. Thus, in order to increase grain yield, consideration should be given to these characters during selection.Akshaya et al. (2022) also reported similar findings of a high positive direct effect of characters ear diameter, 100-kernel weight, ear length, and the number of kernels per row on grain yield. Priyanto*et al.* (2023) reported high positive direct effects of shelling percentage, ear diameter,ear height and test weight on grain yield. At phenotypic level Days to 50 percent tasseling (-0.0578), days to maturity (-0.0701) and plant height (-0.0429) recorded negative direct effect on grain yield. While Plant height (-0.5760), Days to 50 percent tasseling (-1.5721), ear diameter (-0.2045) and number of kernels per row (-0.0850)exhibited negative genotypic direct effect on grain yield. The negative direct effect on grain yield was reported by Devasree et al. (2020) for days to 50 percent tasseling, Shikha et al. (2020) for plant height , Netaji (1998) for days to maturity, Akshaya et al. (2022) for days to maturity, plant height and number of kernels per row.Days to 50 percent tasseling showed a direct negative effect on grain yield per plant and negative indirect effect via days to 50 percent silking and days to maturity, while positive indirect effect via ear height, 100-kernel weight, plant height, ear length, number of kernel rows per ear, ear diameter, number of kernels per row and shelling percentage at phenotypic and genotypic levels. Previous researchers Venugopal et al. (2003), Raghu et al. (2011), and Devasree et al. (2020) indicated similar results of negative direct effect of days to 50% tasseling on grainyield.Days to 50 percent silking shown a genotypic direct positive effect on grain yield per plant. It had indirect negative contribution through all the traits studied except two traits days to 50 percent silking and days to maturity both were shown positive indirect contribution. Earlier, Viola et al. (2003) and Devasree et al. (2020) showed a positive direct influence by days to 50% silking on grain yield.Ear length had direct influence in desirable direction on grain yield, while its correlation with grain yield per plant was positive and significant. The positive and significant association with grain yield was mainly due to it's indirect positive effects via 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 indirectly contributed negatively by tasseling and silking at 50% and 50%.Begumet al. (2016), Roy et al. (2018), and Shikha et al. (2020) recorded "direct effect in positive direction of ear length on maize grain yield. Ear diameter had genotypic negative direct influence on grain yield per plant and indirect positive influence through days to 50 percent tasseling,days to 50 percent silking and days to maturity. It had negative indirect effect on grain yield through plant height, number of kernels per ear,ear height, number of kernels per row, ear diameter, 100-kernel weight,ear length and shelling percentage. At phenotypic level ear diameterrecorded direct effect in positive direction on grain yield per plant and anindirect positive influence through all the traitsunder study except days to 50 percent tasseling, silking and maturity which were shown negative indirect effects on grain yield per plant". Direct effect in positive direction of ear diameter with grain yield was observed earlier by Kote *et al* (2014) and Ram Reddy and Jabeen (2016).The trait, number of kernel rows per ear recordedapositive direct influence on grain yield. It hadan positive indirect contribution via ear diameter, plant height, ear length, ear height, number of kernels per ear, shelling percentage and number of kernels per row, while negative indirect effect through days to100-kernel weight, days to maturity, 50 percenttasselling and silking at thephenotypic and genotypic level. The directinfluence in positive direction on grain yield by number of thekernel rows per ear was also observed by Nataraj *et al* (2015), Ravindra kumar and Karan Choudhary (2018) and Woldu Mogesse (2021).

Table 1. Phenotypic (P) and Genotypic (G) correlations for yield and its other attributes 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= Phenotypic correlation coefficient; **G**= represents Genotypic correlation coefficient.

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

Table 2. Direct and indirect effects of various yield and its contributing traitsin maize.6

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

100-kernel weight recorded direct influencein desirable direction on grain yield per plantat genotypic level. It shown positive indirect effect through plant height, number of kernels per row,ear diameter, ear length, ear heightand shelling percentage andan indirect effect in negative direction through days to 50 percent tasseling, days to 50 percent silking and number of kernels rows per ear. Direct effect of 100-kernel weight on grain yield in positive was reported earlier researchers Roy *et al*. (2018) and Yahaya *et al*. (2021).The shelling percentage exhibited a direct positive influence on grain yield per plant at genotypic and indirect effect through plant height, ear height, ear diameter, ear length, number of kernels per ear, number of kernels per row and 100 kernel weight in positive direction while negatively through days to 50 percent tasseling, days to 50 percent silking and days to maturity. Previously Soumya and Kamatar (2017), Prakash et al (2019), singhetal(2019) and Devasree et al (2020) observedthedirect influencein positive direction on grain yield byshelling percentage.The residual effect in phenotypic path coefficient analysiswas 0.2658 andfor genotypic path coefficient analysis it was 0.1679 (Table 2). The lower residual effect indicates, the traits consider under studywere contributed tomaize grain yield.

4. Conclusion

The correlation study indicated that the selection for ear diameter, ear length, number of kernels per row, plant height, 100-kernel weight, and ear height would increase maize grain yield because these traits showed a strong positive correlation with grain yield.The results of the path coefficient analysis emphasized the need for selection of plant type with greater ear diameter, 100 kernel weight, ear length, days to 50 percent silking, and number of kernel rows per ear. These characters were found to be the key factors that directly affect grain yield.

REFERENCES

Begum, S., Ahmed, A., Omy, S.H., Rohman, M.M and Amiruzzaman, M.2016. Genetic Variability, Character Association and Path Analysis in Maize (*Zea mays* L.). Bangladesh Journal of AgriculturalResearch. 41(1): 173-182.

Akshaya M, Shantakumar G, O Sridevi, Sangamesh Nevani. Correlation and path coefficient analysis for determining interrelationships among grain yield and yield related characters in maize hybrids(*Zeamays* L.). 2022. Pharma Innovation.11(3):1343-1346.DOI: 10.22271/tpi.2022.v11.i3r.11477

Bekric, V., and Radosavljevic, M. 2008. Savremenipristupiupotrebekukuruza. PTEP, 12:93–96. http://scindeks-clanci.ceon.rs/data/pdf/ 1450-5029/2008/1450-50290803093B.pdf

Chaurasia, N.K., Nirala, R.B.P., Singh, B and Mandal, S.S. 2020. Trait Association and Path Coefficient Analysis in Maize (*Zea mays* L.) for grain yield and its attributes. Journal of Pharmacognosy and Phytochemistry. 9(6): 527-531.

Devasree, S., Ganesan. K.N., Ravikesavan, R., Senthil, N and Paranidharan, V. 2020. Relationship between yield and its component traits for enhancing grain yield in single cross hybrids of maize (*Zea mays* L.). Electronic Journal of Plant Breeding. 11 (3):796-802.

Dewey, D.R and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal. 51: 515-518.

India stat, 2021-22. Ministry of Agriculture and farmers welfare, Govt. of India.https://www.indiastat.com/table/telangana-state/agriculture/selected-state-season-wise-area-production-product/1440451.

India stat, 2021-22. Ministry of Agriculture and farmers welfare, Govt. of India.https://www.indiastat.com/table/agriculture/selected-state-season-wise-area-production-product/1440451.

Kandel, B.P., Poude, A., Sharma, S and Subedi, M. 2017. Correlation and path coefficient analysis of early maize genotype in Western Hill of Nepal. Nepalese Journal of Agricultural Sciences. 15.

Kote, U.B., Kumar, P.V.B., Ahamed, M.L., Rani, Y.A., Rao, V.S and Adilakshmi. D. 2014. Correlation and Path Analyses in Maize (*Zea mays* L.). *Electronic Journal of Plant Breeding*. 5(3): 538-544.

Kumar, R and Choudhary, K. 2018. Variability, heritability, character association and path analysis in maize (*Zea mays* L.). *Agriways*. 6(1): 1-8.

Mogesse, W. 2021. Correlation and Path Coefficient Analysis for Grain Yield and Yield Related Trait of Maize (*Zea mays* L.) Inbreed Lines. International Journal of Current Research and Academic Review. 9(02): 138-150.

Mohammadi, S.A., Prasanna, B.M and Singh, N.N. 2003. Sequential path model for determining interrelationships among grain yield and related characters in Maize. Crop Science. 43: 1690-1697.

Nataraj, V., Shahi, J.P and Vandana, D. 2015. Character Association and Path Analyses in Maize (*Zea mays* L.). *Environment and Ecology*. 33(1): 78-81.

Netaji, S.V.R. 1998. Heterosis and Combining ability studies on grain yield and its component characters in medium duration selected inbred lines of maize. *M.Sc.(Ag.) Thesis.* Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad.

Panse, V.G., Sukhatme, P.V. 1985. Statistical methods for agricultural workers, Indian Council of Agricultural Research, 4th edition, New Delhi.

Priyanto SB, Prayitno OD, Efendi R. 2023. Correlation and path analysis maize hybrid yield. Jurnal Lahan Suboptimal: Journal of Suboptimal Lands. 12 (1): 80-87. DOI: 10.36706/JLSO.12.1.2023.629.

Prakash, R., Ravikesavan, R.,Vinodhana, N.K and Senthil, A. 2019. Genetic Variability, Character Association and Path Analysis for Yield and Yield Component Traits in Maize (*Zea mays* L.). Electronic Journal of Plant Breeding. 10(2): 518-524.

Raghu, B., Suresh, J., Sudheer Kumar, S and Saidaiah, P. 2011. Character association and path analysis in maize (Zea mays L.). Madras Agricultural Journal. 98(1-3): 7-9.

Reddy, V.R and Jabeen, F. 2016. Narrow Sense Heritability, Correlation and Path Analysis in Maize (*Zea mays* L.). SABRAO Journal of Breeding and Genetics. 48(2): 120-126.

Roy, P.R., Haque, Md. A., Ferdausi, A., Abdullah, Md and Al Bari. 2018. Genetic Variability, Correlation and Path Co-efficient Analyses of Selected Maize (*Zea mays* L.) genotypes. Fundamental and Applied Agriculture. 3(1): 382–389.

Shikha, K., Shahi, J.P and Singh, S. 2020. Path Coefficient Analysis in Maize (*Zea mays* L.) hybrids. Journal of Pharmacognosy and Phytochemistry. 9(2): 278-282.

Singh, R.K., Chaudhary, B.D. 1979. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, Ludhiana.

Singh, R., Sinha, S.K., Ekka, R.E and Dinesh, T. 2019. Genetic variability and association path analysis in maize (*Zea mays* l.) genotypes. *International Journal of Current Advanced Research*. 8(2): 17511–17514.

Soumya, H.H and Kamatar, M.Y. 2017. Correlation and path analysis for yield and yield components in single cross maize hybrids (*Zea mays* L.). Journal of Farm Sciences. 30(2): 153-156.

Venugopal, M., Ansari, N.A and Rajani Kanth, T. 2003. Correlation and path analysis in maize. *Crop Research.* 25 (3): 525-529.

Viola, G., Ganesh, M., Reddy, S.S and Kumar, C.V.S. 2003. Studies on correlation and path coefficient analysis of elite baby corn (*Zea mays* L.) lines. *Progressive Agriculture.* 3 (1/2): 22-24.

Wright, S. 1921. Correlation and Causation. Journal of Agricultural Research. 20: 557-585.

Yahaya, M.S., Bello, I and Unguwanrimi, A.Y. 2021. Correlation and Path-Coefficient Analysis for Grain Yield and Agronomic Traits of Maize (*Zea mays* L.). Science World Journal. 16 (1).