A-6024
[1-5]

RESEARCH ARTICLE Indian Journal of Agricultural Research

Character Association and Causation Analysis of Certain Quantitative Traits in Maize (*Zea may* L.)

Kanhaiya Lal[1], Sarvendra Kumar[1], Shiv Prakash Shrivastav[2],
Vishal Singh[2], Chandramani Kuswaha[1]

10.18805/IJARe.A-6024

ABSTRACT

Background: Grain yield in maize and most of the crops is a complex character so knowledge of character association and direct and indirect effect of different characters on yield is crucial for making efficient selection strategy to develop the inbred and/or hybrids having desirable combination of the characters.

Methods: The experiment was conducted using 77 genotypes in randomized block design at Student Instructional Farm CS Azad University of Agriculture and Technology, Kanpur (UP) India. Data on 17 different characters were collected and analyzed by standard procedure to identify the characters having significant desirable relationship and direct or indirect effects on grain yield.

Result: The genotypes that were studied showed highly significant variability for all the characters, indicating the great opportunity of selection. Greater genotypic correlation coefficients than phenotypic correlation coefficients for most of the characters showed true relationship. So the selection of elite genotypes on the basis of such characters would be fruitful. Cob weight, kernels per row, kernels per cob and shelling percentage showed highly significant positive relationship with grain yield per plant. Seed vigour index, cobs per plant, cob weight and kernels per row have had high direct positive impact on grain yield per plant at both genotypic and phenotypic level. Therefore, the above mentioned characters may be utilized for making efficient selection strategy to select the elite genotypes.

Key words: Correlation coefficient, Maize, Path Coefficient, Shelling percentage, Variability.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world. In India the average production of maize is 28.77 million tonnes from an area of 9.57 million hectare with the average productivity of 3.006 tonnes per hectare (DES, 2021). Grain yield in maize and most of the crops is a quantitative trait which controlled polygenically so effective yield improvement and simultaneous improvement in yield components are imperative (Bello and Olaoye, 2009). Selection on the basis of grain yield alone is usually not very effective and efficient. However, selection based on its component characters could be more efficient and reliable (Muhammad *et al.*, 2003). This is the reason that several workers emphasized the use of component approach for successful breeding programme for higher yield (Moll *et al.*, 1962). Therefore, the knowledge of interrelationship between different characters and the direct and indirect contribution of such characters on yield is crucial for making efficient selection strategy to develop the inbreds and/or hybrids having desirable combination of the characters.

MATERIALS AND METHODS

The experiment was conducted using 77 genotypes including twenty-one parental lines (eighteen females and three males), their Fifty-four F1 hybrids (produced by crossing eighteen lines (female) and three testers (male) in line × tester mating design during *Kharif*-2018) and two checks (Bharat Kaveri and Don 1588). The experiment was carried out in randomized block design (RBD) with three replications during *Rabi* 2018-19 at Student Instructional Farm CS Azad University of Agriculture and Technology, Kanpur (UP) India. The plot length was 4 m and inter and intra row spacing was 60 × 25 cm. Data on flowering and maturity traits were recorded on plot basis while, data on yield traits were recorded on plant basis (Five plants from each genotype from each replication were randomly selected and tagged for recording the observations). Analysis of variance was done as per Panse and Sukhatme, 1985. Data on 17 different characters were collected and analyzed to identify the characters having significant desirable relationship with grain yield and the direct and indirect contribution of such characters on grain yield. The simple

[1]Department of Genetics and Plant Breeding, CS Azad University of Agriculture and Technology, Kanpur-208 002, Uttar Pradesh, India.
[2]Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya-224 229, Uttar Pradesh, India.

Corresponding Author: Kanhaiya Lal, Department of Genetics and Plant Breeding, CS Azad University of Agriculture and Technology, Kanpur-208 002, Uttar Pradesh, India.
Email: kanhaiyaagri.gpb@gmail.com

How to cite this article: Lal, K., Kumar, S., Shrivastav, S.P., Singh,V. and Kuswaha, C. (2022). Character Association and Causation Analysis of Certain Quantitative Traits in Maize (*Zea may* L.). Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-6024.

Submitted: 23-06-2022 **Accepted:** 18-11-2022 **Online:** 08-12-2022

correlation coefficient between different characters was estimated according to Searle, (1961). Path coefficient analysis was carried out according to Dewey and Lu, (1959).

RESULTS AND DISCUSSION

Success of any breeding programme largely depends on the available variability for different characters among the genotypes studied. The analysis of variance for different quantitative traits was done and presented in Table 1 which revealed significant amount of variability in the genotypes for all the traits, indicating the great opportunity of selection for elite genotypes. Thakur *et al*., (2016), Patil *et al*., (2016) and Dar *et al*., (2018)a have also reported highly significant variation for all the characters under study.

The interrelationship between different characters was worked out and given in Table 2. The genotypic correlation coefficients were found greater than phenotypic correlation coefficients for most of the characters that showed true relationship. So the selection of elite genotypes on the basis of such characters would be rewarding. Raghu *et al*., (2011) and Singh *et al*., (2022) also reported the same results. Grain yield per plant showed highly significant positive correlation with cob weight (0.801, 0.796), kernels per row (0.752, 0.740), kernels per cob (0.736, 0.729), shelling percentage (0.725, 0.699), cob diameter (0.590, 0.536), plant height (0.523, 0.515), 100-kernel weight (0.460, 0.456), kernel rows per cob (0.425, 0.404), cob length (0.343, 0.318) and days to 75% dry husk (0.233, 0.207) at genotypic level and phenotypic level respectively. However, grain yield had significant positive correlation with germination percentage (0.149, 0.161) and cobs per plant (0.137, 0.148). Highly significant positive association of grain yield per plant with days to 75% dry husk showed that long duration (late maturity) improves the grain yield per plant in maize. Positive association of grain yield per plant with days to maturity, plant height, ear height, ear length, ear girth, number of kernel rows per plant, number of kernels per row, 100- kernel weight and shelling percentage in also reported by Kumar *et al*., (2014). Positive and highly significant correlation of grain yield with ear height, days to 50% male flower initiation, days to 50% female flower initiation, days to maturity, 1000 grain weight, ear weight at genotypic and phenotypic level also reported by Shukla, (2017). Positive relationship of ear girth, kernels per row and ear length with grain yield per plant has also reported by Sumalini and Manjulatha, (2012). Prakash *et al*., (2019) and Raghu *et al*., (2011) also reported significant and positive relationship of grain yield per plant with plant height, ear length, ear girth, kernel rows per ear, kernels per row and 100-grain weight. Significant positive association of kernel rows per cob and kernels per row with grain yield per plant have also reported by Pahadi and Sapkota, (2016). Similar results have also been reported by Kinfe and Tsehaye, (2015); Kumar *et al*., (2015); Patil *et al*., (2016); Bartaula *et al*., (2019); Prakash *et al*., (2019). Seedling length and seed vigour index were found to be negatively associated with grain yield per plant but the relation was non-significant. This indicates the need of causation analysis to conclude the result since correlation gives only an idea about the yield contributing characters but does not provide the exact picture of direct and indirect contributions to yield.

Path analysis partitions the correlation coefficient into direct and indirect effects of component characters (independent variables) on yield (dependent variable). It gives the understanding of cause-and-effect relationship

Table 1: Analysis of variance for design of experiment (RBD) for yield and its component traits.

Source of variation	Replication	Treatment	Error
d.f.	2	76	152
Days to 50% tasseling	6.043	39.143**	2.065
Days to 50% silking	4.013	37.951**	2.096
Days to 75% dry husk	5.848	35.474**	2.274
Plant height (cm)	12.233	1319.980**	10.639
Number of cobs/plant	0.001	0.133**	0.002
Cob length (cm)	0.206	13.314**	0.57
Cob diameter (cm)	0.298	4.286**	0.302
Cob weight (g)	2.497	2230.974**	4.545
Number of kernel rows/cob	0.435	5.792**	0.16
Number of kernels/row	0.82	95.123**	0.536
Number of kernels/cob	14.465	24675.988**	7.144
100-Kernel weight (g)	0.682	32.532**	0.839
Shelling percentage (%)	4.261	144.440**	4.455
Germination percentage (%)	1.874	29.988**	2.313
Seedling length (cm)	1.688	59.592**	0.65
Seed vigour index	11133.02	564701.361**	9671.771
Grain yield/plant (g)	3.421	2427.317**	9.816

*, **significant at 5% and 1% level, respectively.

Table 2: Estimates of genotypic and phenotypic correlation coefficients among 17 characters in Maize (*Zea mays* L.).

Traits		Days to 50%	Days to 50% silking	Days to 75% dry husk	Plant height (cm)	Number of cobs /plant	Cob length (cm)	Cob diameter (cm)	Cob weight (g)	Number of kernel rows/cob	Number of kernels /row	Number of kernels /cob	100-Kernel weight (g)	Shelling percentage (%)	Germination percentage (%)	Seedling length (cm)	Seed vigour index	Grain yield/ plant (g)
Days to 50%	G	1.000	0.974**	0.529**	0.146*	-0.303**	0.254**	0.189**	0.173**	0.003	0.051	0.029	0.225**	-0.089	-0.002	-0.137*	-0.130*	-0.009
tasseling	P	1.000	0.966**	0.575**	0.132*	-0.280**	0.228**	0.147*	0.164*	-0.005	0.050	0.027	0.198**	-0.091	-0.016	-0.129*	-0.125	-0.012
Days to 50%	G		1.000	0.544**	0.205**	-0.310**	0.310**	0.233**	0.237**	0.046	0.113	0.093	0.248**	-0.044	0.001	-0.170**	-0.159*	0.052
silking	P		1.000	0.589**	0.184**	-0.289**	0.269**	0.185**	0.220**	0.038	0.105	0.087	0.216**	-0.051	-0.019	-0.160*	-0.153*	0.042
Days to 75%	G			1.000	0.104	-0.006	0.139*	0.231**	0.231**	0.095	0.105	0.099	0.363**	0.159*	-0.030	-0.083	-0.080	0.233**
dry husk	P			1.000	0.093	-0.012	0.128	0.174**	0.212**	0.075	0.098	0.091	0.317**	0.131*	-0.022	-0.081	-0.077	0.207**
Plant height (cm)	G				1.000	-0.046	0.343**	0.347**	0.489**	0.145*	0.450**	0.401**	0.310**	0.249**	-0.005	0.033	0.030	0.523**
	P				1.000	-0.044	0.315**	0.316**	0.482**	0.142*	0.439**	0.396**	0.294**	0.234**	-0.003	0.033	0.030	0.515**
Number of cobs/plant	G					1.000	-0.361**	-0.397**	-0.435**	-0.350**	-0.364**	-0.414**	-0.031	-0.059	0.021	0.206**	0.201**	0.137*
	P					1.000	-0.330**	-0.345**	-0.425**	-0.324**	-0.352**	-0.404**	-0.042	-0.066	0.057	0.208**	0.208**	0.148*
Cob length (cm)	G						1.000	0.547**	0.570**	0.351**	0.340**	0.392**	0.342**	0.023	0.016	-0.152*	-0.141*	0.343**
	P						1.000	0.341**	0.533**	0.236**	0.354**	0.370**	0.292**	0.013	0.013	-0.133*	-0.122	0.318**
Cob diameter (cm)	G							1.000	0.782**	0.400**	0.629**	0.623**	0.515**	0.443**	0.142*	-0.208**	-0.164*	0.590**
	P							1.000	0.706**	0.442**	0.517**	0.559**	0.476**	0.393**	0.127	-0.188**	-0.146*	0.536**
Cob weight (g)	G								1.000	0.534**	0.857**	0.866**	0.500**	0.574**	0.127	-0.253**	-0.212**	0.801**
	P								1.000	0.510**	0.847**	0.863**	0.488**	0.537**	0.117	-0.246**	-0.203**	0.796**
Number of kernel	G									1.000	0.448**	0.691**	-0.109	0.473**	0.139*	-0.163*	-0.120	0.425**
rows/cob	P									1.000	0.392**	0.662**	-0.102	0.432**	0.116	-0.160*	-0.120	0.404**
Number of kernels/row	G										1.000	0.952**	0.120	0.753**	0.110	-0.216**	-0.179**	0.752**
	P										1.000	0.945**	0.107	0.708**	0.095	-0.209**	-0.172**	0.740**
Number of kernels/cob	G											1.000	0.044	0.744**	0.126	-0.242**	-0.200**	0.736**
	P											1.000	0.035	0.706**	0.109	-0.240**	-0.197**	0.729**
100-Kernel weight (g)	G												1.000	0.107	0.031	-0.018	-0.015	0.460**
	P												1.000	0.148*	0.061	-0.005	0.005	0.456**
Shelling percentage (%)	G													1.000	0.108	-0.041	-0.014	0.725**
	P													1.000	0.116	-0.030	-0.002	0.699**
Germination percentage (%)	G														1.000	0.269**	0.442**	0.149*
	P														1.000	0.266**	0.456**	0.161*
Seedling length (cm)	G															1.000	0.983**	-0.089
	P															1.000	0.979**	-0.078
Seed vigour index	G																1.000	-0.052
	P																1.000	-0.036

Table 3: Estimates of direct and indirect effects of 16 characters on grain yield per plant at genotypic and phenotypic level.

Traits		Days to 50% tasseling	Days to 50% silking	Days to 75% dry husk	Plant height (cm)	Number of cobs /plant	Cob length (cm)	Cob diameter (cm)	Cob weight (g)	Number of kernel rows/cob	Number of kernels /row	Number of kernels /cob	100-Kernel weight (g)	Shelling percentage (%)	Germination percentage (%)	Seedling length (cm)	Seed vigour index	Grain yield/ plant (g)
Days to 50% tasseling	G	**0.173**	-0.132	-0.024	0.006	-0.164	0.009	-0.010	0.094	0.001	0.021	-0.004	0.042	-0.014	0.000	0.132	-0.139	-0.009
	P	**0.084**	-0.045	-0.023	0.006	-0.151	0.005	-0.005	0.088	-0.001	0.015	-0.001	0.036	-0.016	0.002	0.058	-0.065	-0.012
Days to 50% silking	G	0.169	**-0.136**	-0.025	0.009	-0.168	0.011	-0.012	0.128	0.009	0.046	-0.013	0.046	-0.007	0.000	0.164	-0.170	0.052
	P	0.081	**-0.046**	-0.024	0.009	-0.156	0.006	-0.006	0.118	0.006	0.032	-0.003	0.040	-0.009	0.002	0.072	-0.079	0.042
Days to 75% dry husk	G	0.092	-0.074	**-0.045**	0.005	-0.003	0.005	-0.012	0.125	0.019	0.042	-0.014	0.067	0.025	0.006	0.080	-0.085	0.233**
	P	0.048	-0.027	**-0.041**	0.005	-0.006	0.003	-0.006	0.114	0.013	0.030	-0.003	0.058	0.023	0.003	0.036	-0.040	0.207**
Plant height (cm)	G	0.025	-0.028	-0.005	**0.044**	-0.025	0.012	-0.018	0.264	0.029	0.181	-0.055	0.057	0.040	0.001	-0.032	0.032	0.523**
	P	0.011	-0.009	-0.004	**0.048**	-0.024	0.007	-0.011	0.259	0.024	0.132	-0.014	0.054	0.041	0.000	-0.015	0.015	0.515**
Number of cobs/plant	G	-0.053	0.042	0.000	-0.002	**0.542**	-0.013	0.020	-0.235	-0.069	-0.147	0.056	-0.006	-0.009	-0.005	-0.199	0.213	0.137*
	P	-0.023	0.013	0.001	-0.002	**0.540**	-0.007	0.012	-0.228	-0.054	-0.105	0.014	-0.008	-0.011	-0.007	-0.094	0.108	0.148*
Cob length (cm)	G	0.044	-0.042	-0.006	0.015	-0.196	**0.036**	-0.028	0.308	0.069	0.137	-0.053	0.063	0.004	-0.003	0.147	-0.150	0.343**
	P	0.019	-0.012	-0.005	0.015	-0.178	**0.021**	-0.012	0.287	0.039	0.106	-0.013	0.053	0.002	-0.002	0.060	-0.063	0.318**
Cob diameter (cm)	G	0.033	-0.032	-0.010	0.015	-0.215	0.020	**-0.051**	0.422	0.079	0.254	-0.085	0.095	0.070	-0.030	0.201	-0.175	0.590**
	P	0.012	-0.009	-0.007	0.015	-0.186	0.007	**-0.034**	0.379	0.074	0.155	-0.019	0.087	0.068	-0.015	0.085	-0.076	0.536**
Cob weight (g)	G	0.030	-0.032	-0.010	0.022	-0.236	0.021	-0.040	**0.540**	0.105	0.346	-0.118	0.092	0.091	-0.027	0.244	-0.225	0.801**
	P	0.014	-0.010	-0.009	0.023	-0.229	0.011	-0.024	**0.537**	0.085	0.254	-0.030	0.089	0.093	-0.014	0.111	-0.105	0.796**
Number of kernel rows/cob	G	0.001	-0.006	-0.004	0.006	-0.189	0.013	-0.021	0.289	**0.197**	0.181	-0.094	-0.020	0.075	-0.029	0.157	-0.128	0.425**
	P	0.000	-0.002	-0.003	0.007	-0.175	0.005	-0.015	0.274	**0.167**	0.117	-0.023	-0.019	0.075	-0.014	0.072	-0.062	0.404**
Number of kernels/row	G	0.009	-0.015	-0.005	0.020	-0.197	0.012	-0.032	0.463	0.088	**0.403**	-0.130	0.022	0.119	-0.023	0.208	-0.190	0.752**
	P	0.004	-0.005	-0.004	0.021	-0.190	0.008	-0.018	0.455	0.065	**0.300**	-0.033	0.020	0.122	-0.011	0.094	-0.089	0.740**
Number of kernels/cob	G	0.005	-0.013	-0.005	0.018	-0.224	0.014	-0.032	0.468	0.136	0.384	**-0.136**	0.008	0.118	-0.027	0.234	-0.213	0.736**
	P	0.002	-0.004	-0.004	0.019	-0.218	0.008	-0.019	0.464	0.111	0.283	**-0.035**	0.007	0.122	-0.013	0.108	-0.102	0.729**
100-Kernel weight (g)	G	0.039	-0.034	-0.016	0.014	-0.017	0.012	-0.027	0.270	-0.022	0.049	-0.006	**0.185**	0.017	-0.007	0.018	-0.016	0.460**
	P	0.017	-0.010	-0.013	0.014	-0.023	0.006	-0.016	0.262	-0.017	0.032	-0.001	**0.183**	0.026	-0.007	0.002	0.002	0.456**
Shelling percentage (%)	G	-0.015	0.006	-0.007	0.011	-0.032	0.001	-0.023	0.310	0.093	0.304	-0.101	0.020	**0.158**	-0.023	0.039	-0.015	0.725**
	P	-0.008	0.002	-0.005	0.011	-0.036	0.000	-0.014	0.289	0.072	0.212	-0.024	0.027	**0.173**	-0.014	0.014	-0.001	0.699**
Germination percentage (%)	G	0.000	0.000	0.001	0.000	0.012	0.001	-0.007	0.068	0.027	0.045	-0.017	0.006	0.017	**-0.212**	-0.260	0.470	0.149*
	P	-0.001	0.001	0.001	0.000	0.031	0.000	-0.004	0.063	0.019	0.029	-0.004	0.011	0.020	**-0.120**	-0.120	0.236	0.161*
Seedling length (cm)	G	-0.024	0.023	0.004	0.002	0.112	-0.006	0.011	-0.136	-0.032	-0.087	0.033	-0.003	-0.006	-0.057	**-0.966**	1.044	-0.089
	P	-0.011	0.007	0.003	0.002	0.112	-0.003	0.007	-0.132	-0.027	-0.063	0.008	-0.001	-0.005	-0.032	**-0.451**	0.507	-0.078
Seed vigour index	G	-0.023	0.022	0.004	0.001	0.109	-0.005	0.009	-0.115	-0.024	-0.072	0.027	-0.003	-0.002	-0.094	-0.949	**1.063**	-0.052
	P	-0.010	0.007	0.003	0.001	0.112	-0.003	0.005	-0.109	-0.020	-0.052	0.007	0.001	0.000	-0.055	-0.442	**0.518**	-0.036

Genotypic R SQUARE was 0.9787 and RESIDUAL EFFECT was 0.1461, Phenotypic R SQUARE was 0.9748 and RESIDUAL EFFECT was 0.1586, Bold values shows direct and normal values shows indirect effects.

between different character combinations. The direct and indirect effects of different characters on grain yield per plant are presented in Table 3. High direct positive impact on grain yield per plant was exhibited by seed vigour index (1.063, 0.518), cobs per plant (0.542, 0.540), cob weight (0.540, 0.537) and kernels per row (0.403, 0.300) at genotypic and phenotypic level respectively. Bello *et al*., (2010) also reported highest direct effects on grain yield per plant by ear weight. The grain yield of a population of maize was improved markedly through indirect selection for the number of ears per plant (Lonnquist, 1967).Thus, seed vigour index, cobs per plant, cob weight and kernels per row emerged as most important direct yield contributors. Similar findings have also reported by Shukla, (2017), Raghu *et al*., (2011) and Singh *et al*., (2022).

CONCLUSION

Thus the combined study of correlation and path coefficient analysis indicating that the cob weight, shelling percentage, cob diameter, germination percentage and seed vigour index should be utilized in formulation of selection strategy for evaluation of parental lines and/or hybrids in maize.

Conflict of interest: None.

REFERENCES

Bartaula, S., Panthi, U., Timilsena, K., Acharya, S.S. and Shrestha, J. (2019). Variability, heritability and genetic advance of maize (*Zea mays* L.) genotypes. Res. Agric. Livest. Fish. 6(2): 163-169.

Bello, O.B. and Olaoye, G. (2009). Combining ability for maize grain yield and other agronomic characters in a typical southern guinea savanna ecology of Nigeria. Afr. J. Biotech. 8(11): 2518-2522.

Bello, O.B., Abdulmaliq, S.Y., Afolabi, M.S. and Ige, S.A. (2010). Correlation and path coefficient analysis of yield and agronomic characters among open pollinated maize varieties and their F1 hybrids in a diallel cross. African Journal of Biotechnology. 9(18): 2633-2639.

Dar, A., Dar, Z.A., Lone, A.A., Kamaluddin, S.P.A., Hussan, S., Dar, M.S. and Alie, W. (2018a). Genetic variability studies involving drought tolerance related traits in maize genotypes. Journal of Agriculture and Ecology Research International. 14(2): 1-13.

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

DES (2021). Directorate of Economics and Statistics, Govt. of India. Agricultural Statistics at a Glance.

Kinfe, H. and Tsehaye, Y. (2015). Studies of heritability, genetic parameters, correlation and path coefficient in elite maize hybrids. Acad. Res. J. Agri. Sci. Res. 3(10): 296-303.

Kumar, G.P., Prashanth, Y., Reddy, V.N., Kumar, S.S. and Rao, P.V. (2014). Character association and path coefficient analysis in maize (*Zea mays* L.). International Journal of Applied Biology and Pharmaceutical Technology. 5(1): 257-260.

Kumar, V., Singh, S.K., Bhati, P.K., Sharma, A., Sharma, S.K. and Mahajan, V. (2015). Correlation, path and genetic diversity analysis in maize (*Zea mays* L.). Environment and Ecology. 33(2A): 971-975.

Lonnquist, J.H. (1967). Mass selection for prolification in maize. Zuchter. 37: 185-188.

Moll, R.N., Sathawana, W.S. and Robinson, H.F. (1962). Heterosis and genetic diversity in varietal crosses of maize. Crop Sci. 2: 197-198.

Muhammad, B.A., Muhammad, R., Muhammad, S.T., Amer, H., Tariq, M. and Muhammad, S.A. (2003). Character association and path coefficient analysis of grain yield and yield components in maize. Pak. J. Biological Sci. 6(2): 136-138.

Pahadi, P. and Sapkota, M. (2016). Variability, correlation and path coefficient analysis in maize (*Zea mays* L.) genotypes in Baitadi, Nepal. Int. J. Exp. Res. Rev. 6: 25-34.

Panse, V.G. and Sukhatme, P.V. (1985). Statistical Methods for Agricultural Workers. 4th Ed. ICAR, New Delhi pp. 361.

Patil, S.M., Kumar, K., Jakhar, D.S., Rai, A., Borle, U.M. and Singh, P. (2016). Studies on variability, heritability, genetic advance and correlation in maize (*Zea mays* L.). International Journal of Agriculture, Environment and Biotechnology. 9(6): 1103-1108.

Prakash, R., Ravikesavan, R., Vinodhana, N., Kumari, S.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., Kumar S.S. and Saidaiah, P. (2011). Character association and path analysis in maize (*Zea mays* L.). Madras Agric. J. 98 (1-3): 7-9.

Searle, S.R. (1961). Phenotypic, genetic and environmental correlation. Biometrics. 17(3): 474-480.

Shukla, N. (2017). Genetic variation and association study for grain yield in germplasm accessions of maize (*Zea mays* L.). Indian Journal of Agricultural Research. 51(2): 120-127.

Singh, P.K., Sushma, B. and Kumari, N. (2022). Character association and path analysis for yield components and biochemical traits in maize (*Zea mays* L.) genotypes. Indian Journal of Agricultural Research. 56(2): 135-140.

Sumalini, K. and Manjulatha, G. (2012). Heritability, correlation and path coefficient analysis in maize. Maize Journal. 1(2): 97-101.

Thakur, S., Sinha, S.K., Mehta, N. and Thakur, D. (2016). Genetic analysis of yield and its components in maize (*Zea mays* L.) inbred lines using line × tester analysis. International Journal of Agriculture Sciences. 8(53): 2768-2773.