

TITLE

CORRELATION AND PATH COEFFICIENT ANALYSIS OF GRAIN YIELD AND YIELD RELATED TRAITS IN MAIZE (*Zea mays* L.)

Article type: *Original Research Article*

ABSTRACT

During Kharif-2021, the present trial was carried out at the field experimentation centre of the Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad to assess genetic association and path coefficient analysis in thirty-one maize genotypes, including one check variety MAKKA SHUATA-3 for eighteen quantitative traits. Based on the mean performance of 31 maize varieties. Grain yield per plant was highest in the case of MAKKA-3 (111.60 gm), MGC-240 (85.33 gm), and GP (84.17 gm) genotypes. An Analysis of Variance revealed significant differences in grain yield and its components for all the genotypes. This indicated a high amount of genetic variability 100 grain weight and cob weight records high GCV and PCV, as well as high heritability. In genotypic and phenotypic correlation, cob weight and 100-grain weight are highly and significantly correlated with grain yield. And genotypic path analysis revealed that cob weight, 100 grain weight, number of rows per cob, cob length, days to 75% maturity, number of grains per row, and ear height. Phenotypic path results showed that cob weight, 100 grain weight, number of grain rows per cob, number of grains per row, days to 75% maturity, ear height, and highest direct effect on grain yield. This indicates a true relationship between these traits, and selecting these traits will improve yields.

Key Words: Maize (*Zea mays* L.), Genetic variability, Heritability, Genetic advance, Genotypic correlation, Phenotypic correlation, Genotypic path analysis, and Phenotypic path analysis.

INTRODUCTION

Maize (*Zea mays* L.) is a C₄ plant that belongs to the Poaceae grass family (Graminaceae) with chromosome number (2n-2x=20). It is an extremely valuable cereal crop with excellent adaptability under varied agro-climatic conditions. It is known as the queen of cereals due to its high genetic potential. The latitude of maize cultivation ranges from 58° N to 40° S, while the height of cultivation ranges from sea level to 3000 meters altitudes. It can withstand rainfall of between 250 mm and 5000 mm per year. However, most of the area under this crop is in the warmer parts of temperate regions and in a humid-subtropical climate. The highest production occurs in areas with the warmest monthly temperatures between 21°C and 27°C and a frost-free season of 120 to 180 days. It can be grown in soils ranging from 5.5 to 8.0 pH, but it is sensitive to salinity.

Globally, maize is cultivated in an area of 183.24 million hectares with a production of 1036.07 million tonnes and a productivity of 5.65 t ha⁻¹. Among the maize-growing countries, the USA is the most significant, followed by Brazil, China, and Mexico. India stands sixth among the maize-producing countries in the world with an area, production, and productivity of 9.6 million hectares, 27.15 million tonnes, and 2.83 t ha⁻¹, respectively. In addition, the 2.83 t ha⁻¹ productivity is lower than the world average, which is caused by about 70-75 percent of the area being under rainfed conditions, where the crop suffers from heat and drought stress. Karnataka is one of the major maize producing states in the country with an area of 1.18-million-hectares, production 3.27 million tonnes and productivity 2773 kg ha⁻¹. The maximum crude protein content of this plant is 9.9% when it is at the early and full bloom stages, decreasing to % at the milking stage, and then to 6%t at maturity. It has high nutritive value as it contains 72 percent starch, 10 percent protein, 4.80 percent oil, 9.50 percent fiber, 3.0 percent sugar, 1.70 percent ash, 82 percent endosperm, 12 percent embryo, 5 percent bran testa and 1 percent tip cap.

Globally, maize is an essential food crop. It is the primary food source as well as the primary source of protein and calories for millions of people in the world. Maize accounts for about 15 to 56% of the total daily calories in the diets of people in several developing countries in Africa and Latin America. Animal protein is scarce and

expensive [1]. Food is produced for low-income families in Ethiopia and served in a variety of dishes. Though several hundred million people depend on maize, its common (normal) variety lacks two essential amino acids, namely, lysine and tryptophan, which are required in the biosynthesis of proteins [2]. Therefore, the discovery of the recessive allele of the opaque-2 maize gene was a significant breakthrough in the alleviation of global protein deficiency.

In India, during the 2019-2020 cropping seasons, 9.7 million ha of land was covered with maize with a national average productivity of 2.9 tonnes/ha and production of 28.6 million tonnes is still far below the world average 5.1 tons/ha (**Department of Agriculture Cooperation, 2020**).

The efficiency of a breeding programme is determined mainly by the direction and magnitude of association between yield and its components. In addition, it depends on the relative importance of each factor involved in contributing to grain yield. Grain yield is a complex quantitative trait that depends on plant genetics and its interaction with environmental conditions. Correlation coefficient analysis is a statistical technique which measures the degree and association between two or more variables. Estimates of correlation coefficients are useful in identifying the component traits which can be used for yield improvement in maize. Path coefficient analysis provides a thorough understanding of the contribution of various characters by partitioning the correlation coefficient into components of direct and indirect effects. This helps the breeder in determining the yield components. To calculate the optimum contribution of yield contributing characters, it is essential to know the association of various characters along with path coefficients. In addition, this study aims to assess correlation and path analysis to identify component traits for developing high-yielding correlation and path analysis.

1.1 Objectives

1. To evaluate of thirty-one germplasms for yield and yield contributing characters
2. To study the character association between maize germplasm for yield and yield attributing traits.
3. To study direct and indirect effects of different characters and to provide information on actual contribution of traits on seed yield

JUSTIFICATION

Most of the tropical germplasm may not be considered as manageable resources, as they could be too diverse to be used directly and have to undergo a cumbersome pre-breeding process. Thus, Genetic variation can be unlocked from tropical maize germplasm through genetic approaches. So, it is important to understand the genetic variation present among the maize inbred lines and the performance of these Inbreds in different environmental conditions. To screen out most promising lines of maize.

MATERIALS AND METHODS

The current study includes thirty-one genotypes of maize in Rabi 2021 at SHUATS, Prayagraj's experimentation center for Genetics and Plant Breeding. During Rabi-2021, the experiment was conducted in a randomized complete block design with three replications, with the indicated packages and practices for a healthy crop included. Days to 50% tasselling, Days to 50% silking, Anthesis-silking interval, Plant height (cm) Ear height (cm), Leaf width (cm), Leaf length (cm), Days to 75% maturity, Tassel length (cm), Cob weight (gm), Cob girth (cm), Cob length (cm), Number of grain rows per cob, Number of grains per row, 100 kernel weight (g), Biological yield per plant, Harvest index (%), Grain yield per plant (g). As per established methods, data were statistically analyzed to determine the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), heritability, genetic advance and genetic advance as a percent mean. For the analysis of variance, genotypic coefficient of variation, and phenotypic coefficient of variation, standard statistical methods were utilized **Burton**, heritability **Burton and Devane** and genetic advance **Johnson et al., Ai Jibouri et al.**, used genotypic and phenotypic variances and co-variances to calculate genotypic and phenotypic correlation coefficients. The path coefficient study was carried out using the technique proposed by **Dewey and Lu**.

2.1 Layout Description

- Crop: Maize (*Zea mays* L.)
- Season: Rabi, 2021
- Experimental design: Randomized Block Design
- Number of genotypes: 31
- Number of replications: 03
- Size of each bund: 0.5 m

- Gross area: 198 sq.m
- Net area: 162 sq.m
- Individual plot size: 3 m
- Spacing: 60X 20 cm
- Recommended Fertilizer dose: N: P: K @ 120:60:60 kg/ha

2.2 Experimental Material

Source: Professor Jayashankar Telangana State Agriculture University, Hyderabad, Telangana.

SOFTWARE: Software version used for analysis R studios.

RESULT AND DISCUSSION

For all of the traits studied, the analysis of variance indicated substantial differences between the genotypes (Table 1). As a result, it revealed a significant level of genetic heterogeneity among thirty-one maize genotypes. Evaluation of genetic characteristics, correlation, and path coefficient analysis aid in the examination of significant traits during the selection process for optimizing maize productivity. (Table 2) displays the genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance (GA), and genetic advance as a percent of mean GA (percent) for all yield contributing characteristics.

For all of the characters, PCV was higher than the matching GCV, indicating that the environment had an impact. The highest PCV and GCV were found for grain yield per plant (45.70 and 39.03), ear height (22.91 and 21.02), Number of grains per row (19.09 and 11.82), 100 grain weight (15.34 and 3.30), Plant height (14.52 and 12.03), Number of grain rows per cob (12.02 and 8.02), Cob length (10.51 and 4.48), Days to 50% tasselling (9.65 and 8.59), Tassel length (7.90 and 3.98), Days to 50% silking (6.23 and 3.59), Days to 75% maturity (2.36 and 1.96). Similar findings were reported by **Khan *et al.* (2018)**, **Shankar *et al.* (2018)**, **Tadesse *et al.* (2019)**, and **Khulbe *et al.* (2020)**. The genotypic coefficient of variation estimations reflects the overall amount of genotypic variability present in the material.

Heritability, on the other hand, reflects the fraction of this genotypic polymorphism that is passed down from parents to offspring. **Lush (1947)** proposed the broad sense heredity idea. It influences how effective genotypic variability may be used in a breeding programme. (Table 2) shows the heritability estimates obtained during the current investigation. The heritability of these traits is moderate to high, ranging from 61.6 percent to 90.2 percent. 100 grain weight (72.90), Ear height (61.00). The high heritability values of the qualities examined in this study revealed that they were less influenced by the environment. This allowed for successful selection of traits based on phenotypic appearance using a simple selection strategy and indicating the possibility of genetic progress. Similar findings were reported by **Supraja et al. (2019)** and **Mohammedali et al. (2020)**.

High genetic advance was recorded for Grain yield per plant (31.89), Cob weight (22.86), Ear height (17.11). Similar findings were reported by **Al-Amin et al. (2019)** and **Khulbe et al. (2020)**.

High genetic progress was recorded for grain yield per plant (68.67), Cob weight (37.38), and Ear height (28.81). Similar findings were reported by **Shankar et al. (2018)**, **Supraja et al. (2019)**, and **Khulbe et al. (2020)**.

The correlation study examined the association between yield and yield contributing features. (Table 3) shows the phenotypic and genotypic correlation coefficients between the investigated features of 31 maize genotypes on different quantitative traits. In most cases, the genotypic correlation was higher than that of phenotypic correlation; revealing that the association may be largely due to genetic reason (strong coupling linkage) (**Sharma, 1988**). Cob weight (0.8496**,0.6974**), 100 grain weight (0.8496**,0.7183**), no. Of grain rows per cob (0.7338**,0.6083**), cob length (0.6941**,0.5735**), days to 75% maturity (0.4896**,0.4129**), no. Of grains per row (0.4672**,0.4638**), ear height (0.4470**,0.3813**). Are positively and significantly correlated with grain yield per plant in both genotypic and phenotypic correlation. Similar findings were reported by **Varalakshmi et al. (2018)**, **Barrtaula et al. (2019)**, and **Dash et al. (2020)**.

Path analysis is one of the most accurate statistical techniques for determining the interdependence of features and the degree of control of independent characters on seed production. It can occur directly or indirectly **Mushtaq et al. (2013)**. When it comes to choosing high yielding germplasm, the idea of direct and indirect influence of yield contributing traits on the final end product yield in any crop is crucial. (Table 4) depicted the direct and indirect effects of 12 different quantitative characters. In genotypic Cob

weight (0.8958**), 100 grain weight (0.8496**), Number of grain rows per cob (0.7338**), Cob length (0.6941**), Days to 75% maturity (0.4896**), Number of grains per row (0.4672**), Ear height (0.4470**). Similar findings were reported by **Sharma RK *et al.*, (1987), Kumar S *et al.*, (2006) Hemavathy AT *et al.*, (2008) Gazal A *et al.*, (2018)**

In Phenotypic 100 grain weight (0.7183**), Cob weight (0.6974**), Number of grain rows per cob (0.6083**), Cob length (0.5735**), Number of Grains per row (0.4638**), Days to 75% maturity (0.4129**), Ear height (0.3813**). Similar findings were reported by **Sharma RK *et al.*, (1987), Kumar S *et al.*, (2006) Hemavathy AT *et al.*, (2008) Gazal A *et al.*, (2018), Sood BC *et al.*, (2006), Ulaganathan V *et al.*, (2015).**

CONCLUSION:

Among thirty-one genotypes, MAKKA-3 (111.60 gm), MGC-240 (85.33 gm), and GP (84.17 gm) are the most popular. There was a high GCV and PCV for grain yield per plant, cob weight, and ear height, as well as a high heritability for grain yield per plant. In phenotypic and genotypic correlation, cob weight and 100-grain weight are highly correlated with grain yield. Genotypic path analysis suggests that cob length, ear height, and 100-grain weight affect grain yield directly the most. Therefore, these characters should be given previously during selection for yield improvement in maize.

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Table 1: Analysis of variance for 12 quantitative characters of 31 Maize genotypes.

S.No.	source		Replication		Genotypes		Error	
	Degrees of freedom (df)	GCV	PCV	Heritability (Broad sense) %	GA 5%	GAM 5%		
1	Days to 50% tasselling	8.59	7.11	16.321**	1.63	8.12		
2	Days to 50% silking	3.59	6.23	48.645**	2.26	10.91		
3	Plant height (cm)		29.345	119.954**		21.46		
4	Ear height (cm)		7.295	4.676**		5.98		
5	Tassel length (cm)		15.09	4.952**		0.48		
6	Days to 75% maturity		100.18	71.34**		14.56		
7	Cob weight (g)		7.29	22.109**		1.19		
8	Cob length (cm)		9.325	3.339**		6.28		
9	Number of grain rows per cob		28.145	23.485**		0.09		
10	Number of Grains per row		24.3825	4.841**		0.24		
11	100 grain weight (g)		32617.14	33.508**		0.34		
12	Grain yield per plant (g)		7.0435	170.771**		24.78		

Level of significance at 5 %, ** Level of significance at 1%

Plant height (cm)	12.03	14.52	35.12	1.14	0.75
Ear height (cm)	21.02	22.91	61.00	17.11	28.81
Tassel length (cm)	3.98	7.90	20.69	0.38	1.17
Days to 75% maturity	1.96	2.36	16.50	1.23	0.80
Cob weight (gm)	23.72	31.00	58.50	22.86	37.38
Cob length (cm)	4.48	10.51	18.20	0.48	3.94
Number of grain rows per cob	8.02	12.02	44.50	1.31	11.02
Number of Grains per row	11.82	19.09	38.30	2.76	15.06
100 grain weight (gm)	3.30	15.34	14.58	0.46	1.46
Grain yield per plant (gm)	39.03	45.70	72.90	31.89	68.67

Table 2: Genetic parameters for 12 quantitative characters in Maize genotypes

PCV: Phenotypic Coefficient of Variation, GCV: Genotypic Coefficient of Variation, h^2_{bs} : heritability (broad sense), GA: Genetic Advance, GAM: Genetic Advance as Percent Mea

TRAITS		Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Tassel length (cm)	Days to 75% maturity	Cob weight (gm)	Cob length (cm)	Number of grain rows per cob	Number of Grains per row	100 grain weight (gm)	Grain yield per plant (gm)
Days to 50% tasselling	G	1.0000**	0.9856**	-0.0648	0.3388	-0.9617**	0.2822	-0.2691	-0.3652*	-0.7423**	-0.6445**	-0.4536**	-0.1616
	P	1.0000**	0.7382**	-0.1796	-0.1053	-0.4563**	0.0126	0.0787	-0.6453**	-0.238	-0.072	-0.3591*	-0.0126
Days to 50% silking	G		1.0000**	0.2559	-0.2348	-0.8691**	0.3085	-0.5547**	0.2336	-0.5852**	-0.6545**	-0.5731**	-0.3807**
	P		1.0000**	-0.1013	-0.1533	-0.4521**	0.2196	-0.3562*	-0.1001	-0.3863**	-0.1122	-0.18	-0.3126
Plant height (cm)	G			1.0000**	-0.8456**	-0.1349	0.9154**	-0.7196**	-0.4532**	-0.8419**	-0.6482**	-0.8921**	-0.6491**
	P			1.0000**	-0.5629**	0.0561	-0.1041	0.0219	0.1095	0.0726	0.1027	0.104	-0.5489**
Ear height (cm)	G				1.0000**	-0.9828**	-0.5407**	0.4649**	0.4816**	0.3151	0.6667**	0.7057**	0.4470**
	P				1.0000**	-0.4862**	-0.116	0.3232	0.3963**	0.188	0.2916	0.2551	0.3813**
Tassel length (cm)	G					1.0000**	-0.6457**	0.5694**	0.6562**	0.7518**	1.068	-0.8064**	0.0382
	P					1.0000**	-0.1609	-0.1141	0.3812**	0.1288	-0.0095	0.0068	-0.028
Days to 75% maturity	G						1.0000**	-0.4008**	0.064	-0.7317**	0.0916	-0.5062**	0.4896**
	P						1.0000**	-0.3128	0.0259	-0.1805	-0.0206	-0.0034	0.4129**
Cob weight (gm)	G							1.0000**	0.5321**	0.7145**	0.6522**	0.8660**	0.8958**
	P							1.0000**	0.3963**	0.4645**	0.2837	0.0881	0.6974**
Cob length (cm)	G								1.0000**	0.1938	0.5492**	0.7968**	0.6941**
	P								1.0000**	0.1118	0.0335	0.1568	0.5735**
Number of grain rows per cob	G									1.0000**	0.4415**	0.8193**	0.7338**
	P									1.0000**	0.2288	0.1434	0.6083**
Number of Grains per row	G										1.0000**	0.3769*	0.4672**
	P										1.0000**	0.0769	0.4638**
100 grain weight (gm)	G											1.0000**	0.3769*
	P											1.0000**	0.7183**
Grain yield per plant (gm)	G												1.000
	P												1.000

Table 3: Genotypic and Phenotypic correlation among the different traits evaluated in Maize during Rabi-2021.

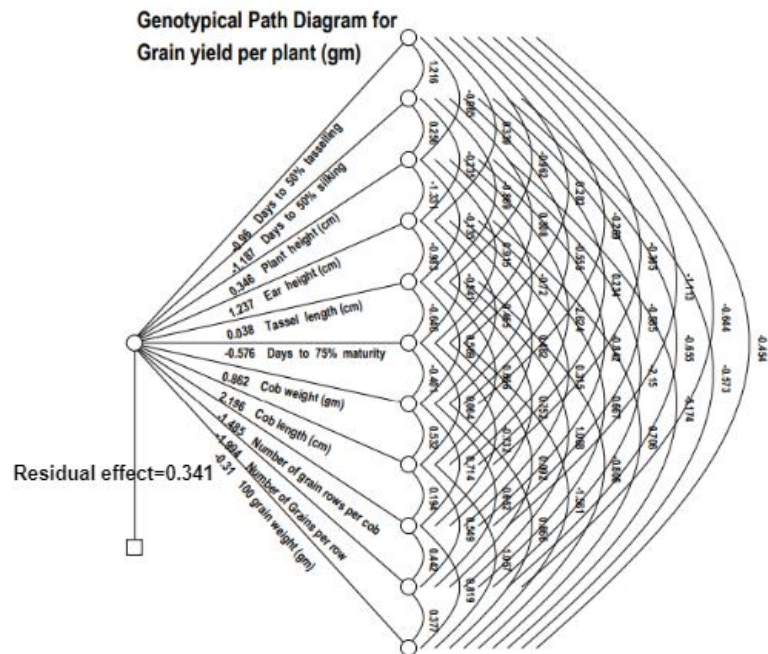
G*: genotypic correlation, P*: phenotypic correlation

Table 4: Direct (Bold) and indirect effect at genotypic and phenotypic level for different quantitative traits on seed yield.

TRAITS		Days to 50% tasselling	Days to 50% silking	Plant height (cm)	Ear height (cm)	Tassel length (cm)	Days to 75% maturity	Cob weight (gm)	Cob length (cm)	Number of grain rows per cob	Number of Grains per row	100 grain weight (gm)	Grain yield per plant (gm)
Days to 50% tasselling	G	-0.96	-1.1677	0.0622	-0.3253	0.9232	-0.2709	0.2583	0.3506	1.0686	0.6187	0.4354	-0.1616
	P	-0.0224	-0.005	0.004	0.0024	0.0061	-0.0003	-0.0018	0.0039	0.0053	0.0016	0.0012	-0.0126
Days to 50% silking	G	-1.4444	-1.1874	-0.3039	0.2788	1.032	-0.3663	0.6586	-0.2774	0.6949	0.7772	0.6805	-0.3807**
	P	0.0191	0.0857	-0.0087	-0.0131	0.0044	0.0188	-0.0249	-0.0086	-0.0245	-0.0096	-0.0154	-0.3126
Plant height (cm)	G	-0.0224	0.0884	0.3456	-0.4601	-0.0466	0.3164	-0.2487	-0.9067	-0.2909	-0.7429	-1.7881	-0.6491**
	P	-0.0167	-0.0094	0.0932	0.0305	0.0052	-0.0097	0.002	0.0102	0.0068	0.0096	0.0097	-0.5489**
Ear height (cm)	G	0.4192	-0.2905	-1.6471	1.2371	-1.2159	-0.6689	0.5751	0.5958	0.3899	0.8247	0.873	0.4470**
	P	0.0081	0.0118	-0.0252	-0.0769	-0.0063	0.0089	-0.0249	-0.0169	-0.0145	-0.0224	-0.0196	0.3813**
Tassel length (cm)	G	-0.0363	-0.0328	-0.0051	-0.0371	0.0377	-0.0244	0.0215	0.0247	0.0284	0.0403	-0.0304	0.0382
	P	0.0018	-0.0001	-0.0001	-0.0002	-0.0024	0.0004	0.0003	-0.0002	-0.0003	0.0048	0.0045	-0.028
Days to 75% maturity	G	-0.1625	-0.1776	-0.527	0.3113	0.3717	-0.5757	0.2307	-0.0368	0.4212	-0.0527	0.8984	0.4896**
	P	-0.0019	-0.033	0.0156	0.0174	0.0242	-0.1503	0.0081	-0.0039	0.0271	0.0031	0.0005	0.4129**
Cob weight (gm)	G	-0.2318	-0.4779	-0.62	0.4005	0.4905	-0.3453	0.8615	0.4584	0.6155	0.5619	0.746	0.8958**
	P	0.0511	-0.1891	0.0142	0.2099	-0.0741	-0.035	0.6494	0.0811	0.3017	0.1842	0.0572	0.6974**
Cob length (cm)	G	-0.802	0.5131	-5.7618	1.0577	1.441	0.1406	1.1685	2.1961	0.4256	1.2062	2.3212	0.6941**
	P	-0.0087	-0.005	0.0055	0.0109	0.0043	0.0013	0.0062	0.0499	0.0056	0.0017	0.0078	0.5735**
Number of grain rows per cob	G												
	P	1.653	0.869	1.2501	-0.468	-1.1164	1.0866	-1.061	-0.2878	-1.485	-0.6557	-1.2166	0.7338**
Number of Grains per row	G												
	P	-0.0298	-0.0359	0.0091	0.0236	0.0161	-0.0226	0.0582	0.014	0.1253	0.0287	0.018	0.6083**
100 grain weight (gm)	G												
	P	1.2848	1.3048	4.2858	-1.329	-2.1292	-0.1825	-1.3002	-1.0949	-0.8802	-1.9935	-0.7513	0.4672**
	G												
	P	-0.0028	-0.0043	0.0039	0.0111	-0.0004	-0.0008	0.0108	0.0013	0.0087	0.0382	0.0029	0.4638**
	G												
	P	0.1407	0.1778	1.605	-0.2189	0.2502	0.4841	-0.2686	-0.3279	-0.2542	-0.1169	-0.3102	0.8496**
	G												
	P	-0.0028	-0.0043	0.0039	0.0111	-0.0004	-0.0008	0.0108	0.0013	0.0087	0.0382	0.0029	0.4638**

G*: genotypic path analysis, P*: phenotypic path analysis.

4.5.1 Genotypic path diagram for grain yield per plant



4.5.2 Phenotypic path diagram for grain yield per plant

