International Journal of Plant & Soil Science

34(22): 1512-1520, 2022; Article no.IJPSS.91799
ISSN: 2320-7035

Correlation and Path Coefficient Analysis of Grain Yield and Yield Related Traits in Maize (*Zea mays* L.)

Konidina Jagadeesh [a*φ], Kaila Satish Babu [aφ] and D. Praveen Kumar [aφ]

[a] *Department of Genetics and Plant Breeding, SHUATS, Prayagraj, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2022/v34i2231526

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/91799

Original Research Article

Received 05 July 2022
Accepted 08 September 2022
Published 09 September 2022

ABSTRACT

During Rabi-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.

[φ] *M.Sc. Scholar;*
**Corresponding author: E-mail: sivakarthikeyans925@gmail.com;*

Keywords: Maize (Zea mays L.); genetic variability; heritability; genetic advance; genotypic correlation; phenotypic correlation; genotypic path analysis; phenotypic path analysis.

1. INTRODUCTION

Maize (*Zea mays* L.) is a C. 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 58o N to 40o 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^{o}C and 27^{o}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.

With a total area under cultivation of 183.24 million hectares, maize produces 1036.07 million tonnes with a productivity of 5.65 t ha-1 worldwide. The USA is the largest maize-producing country, followed by Brazil, China, and Mexico. With an area, production, and productivity of 9.6 million hectares, 27.15 million tonnes, and 2.83 t ha-1, respectively, India is the sixth-largest producer of maize in the world. 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 a high nutritional value since it comprises 72% starch, 10% protein, 4.80% oil, 9.50% fibre, 3.0% sugar, 1.70% ash, 82% endosperm, 12% embryo, 5% bran testa, and 1% 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 [3].

The efficiency of a breeding programme is determined mainly by the direction and magnitude of association between yield and its components. Additionally, it depends on the proportionate weight assigned to each element that influences grain yield [4-6]. Grain yield is a complicated quantitative feature that is influenced by plant genetics and how those factors interact with the environment [7-9]. A statistical method for measuring the strength and association between two or more variables is correlation coefficient analysis. Estimates of correlation coefficients are helpful in locating the maize component qualities that can increase yield. By dividing the correlation coefficient into components of direct and indirect impacts, path coefficient analysis gives a full knowledge of the contributions of different features [10-12]. This aids the breeder in figuring out the elements of the yield. Knowing the associations between different characters and path coefficients is crucial for calculating the optimal contribution of characters that contribute to yield. This study also intends to evaluate correlation and path analysis in order to pinpoint characteristics that can be used to create 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

2. 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 Inbreeds in different environmental conditions. To screen out most promising lines of maize.

3. 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 [13], heritability Burton and Devane and genetic advance Johnson et al. [14], Ai Jibouri et al. [15], 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 [16].

3.1 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

3.2 Experimental Material

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

Software: Software version used for analysis R studios.

4. RESULTS 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. [17], Shankar et al. [18], Tadesse et al. [19] and Khulbe et al. [20]. The genotypic coefficient of variation estimations reflects the overall amount of genotypic variability present in the material.

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

Sl. No.	Source	Replication	Genotypes	Error
	Degrees of freedom (df)	2	30	60
1	Days to 50% tasselling	7.11	16.321**	8.12
2	Days to 50% silking	3.18	49.645**	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%*

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

Traits	GCV	PCV	Heritability (Broad sense) %	GA 5%	GAM 5%
Days to 50% tasselling	8.59	9.65	12.90	1.63	1.44
Days to 50% silking	3.59	6.23	40.90	2.26	1.94
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

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

Heritability, on the other hand, reflects the fraction of this genotypic polymorphism that is passed down from parents to offspring. Lush [21] 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. [22] and Mohammedali et al. [23].

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. [24] and Khulbe et al. [20].

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. [18], Supraja et al. [22] and Khulbe et al. [20].

Table 3. Genotypic and phenotypic correlation among the different traits evaluated in maize during Rabi-2021

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

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	1.653	0.869	1.2501	-0.468	-1.1164	1.0866	-1.061	-0.2878	-1.485	-0.6557	-1.2166	0.7338**
	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**
Number of Grains per row	G	1.2848	1.3048	4.2858	-1.329	-2.1292	-0.1825	-1.3002	-1.0949	-0.8802	-1.9935	-0.7513	0.4672**
	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**
100 grain weight (gm)	G	0.1407	0.1778	1.605	-0.2189	0.2502	0.4841	-0.2686	-0.3279	-0.2542	-0.1169	-0.3102	0.8496**
	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*

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) [25]. Cob weight (0.8958**,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. [26], Barrtaula et al. [27] and Dash et al. [28].

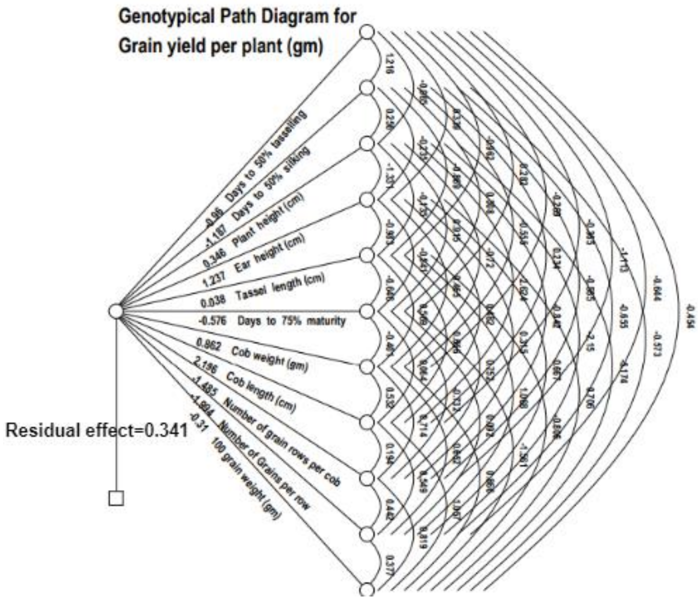

Fig. 1. Genotypic path diagram for grain yield per plant

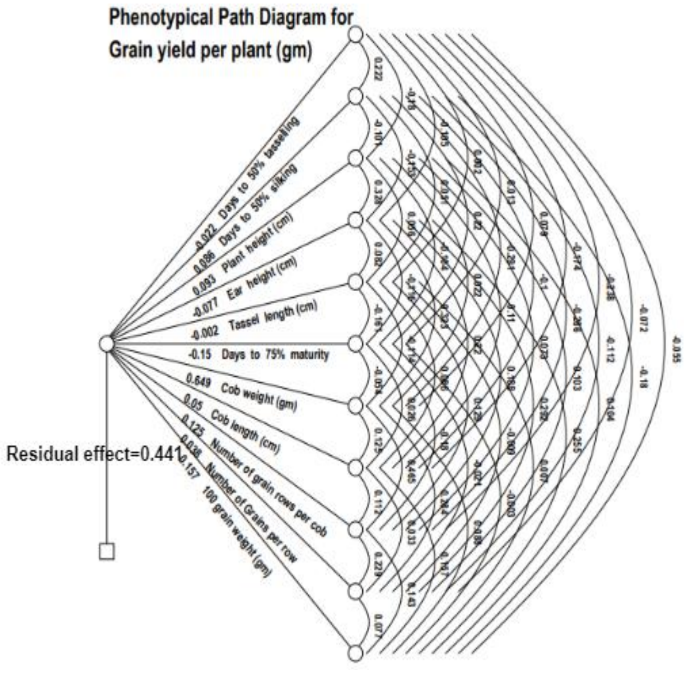

Fig. 2. Phenotypic path diagram for grain yield per plant

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. [29]. 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*.* [30], Kumar S et al*.* [31], Hemavathy AT et al*.* [32], Gazal A et al*.* [33].

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*.* [30], Kumar S et al*.* [31], Hemavathy AT et al*.* [32], Gazal A et al*.* [33], Sood BC et al*.* [34], Ulaganathan V, et al. [35].

5. 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Abdelmula AA, Sabiel SAI. Genotypic and differential responses of growth and yield of some maize (*Zea mays* L.) genotypes to drought stress. International Conference on Impact of Agricultural Research 1. 2007;1-6.
2. Abhirami S, Vanniarajan C, Amrugachamy S. Genetic variability studies in Maize (*Zea mays* L.) germplasm. Plant Archieves. 2005;5(1):105-8.
3. Agriculture at a glance – DAC&FW. Department of Agriculture, Cooperation and Farmer’s Welfare, Ministry of Agriculture, GOI, India; 2020.
4. Matsuoka H, Kosai Y, Saito M, Takeyama N, Suto H. Single-cell viability assessment with a novel Spectro-Imaging system. J Biotechnol. 2002;94(3):299-308.
5. Shikha B, Manpreet J, Ramanjit K 2019. Nutritive value of Maize. Maize – production and use. Intech Open. 1-14.
6. Wright S. Correlation and causation. Journal of Agriculture Research. 1921;20:557-587.
7. Ahmad SQ, Khan S, Ghaffar M, Ahmad F. Genetic diversity analysis for yield and other parameters in Maize (*Zea mays* L.) genotypes. Asian J Sci. 2011;3(5):385-8.
8. Al-Jibouri HA, Miller PA, Robinson HF. Genotypic and environmental variation and correlation in upland cotton cross of interspecies origin. Agron J. 1958;50(10):633-6.
9. Allard RW. Principles of plant breeding. New York: John Wiley & Sons Inc; 1960. 185 p.
10. Arun KS, Mishra SP, Roshan P. Studies on genetic variability parameters on grain yield and its yield attributing traits in Maize (*Zea mays* L.). Int J Curr Microbiol Appl Sci. ISSN: 2319-7706. 2015;7(9).
11. Awasthi RN, Singh HC. Tripathi, Mishra, D.K. and Shukla, N.S. Range Manag Agrofor. 2009 Genetic variability and selection parameters in Fodder Maize (*Zea mays* L.);30(1):59-61.
12. Fisher RA. XV.—The correlation between relatives on the supposition of Mendelian inheritance. Trans R Soc Edinb. 1919; 52(2):399-433.
13. Burton GW. Quantitative inheritance in grasses. Proceedings of the 6th intern grasslands congress. 1952;1:277-83.
14. Johnson HW, Robinson HF, Comstock RE. Genotypic and phenotypic correlations in soybeans and their implication in selection. Agron J. 1955;47(10):477-83.
15. Al-Jibouri HA, Miller PA, Robinson HF. Genotypic and environmental variances and covariances in upland cotton crosses

of interspecific origin. Agron J. 1958;50(10):633-6.
16. Dewey DR, Lu KH. A correlation and path coefficient analysis of component of crested wheat grass seed production. Agron J. 1959;51(2):515-8.
17. Khan AS, Ullah H, Shahwar D, Fahad S, Khan N, Yasir M et al. Heritability and correlation analysis of morphological and yield traits in maize. J Plant Biol Crop Res. 2018;2:1008.
18. Shankar M, Singh R, Shahi JP. Studies on genetic variability, heritability and genetic advance in maize (*Zea mays* L.) for yield and its components. Maize journal. 2018;7(1):23-6.
19. Tadesse J, Leta T. Association and path coefficient analysis among grain yield and related traits in Ethiopian maize (*Zea mays* L.) inbred lines. Afr J Plant Sci. 2019;13(9):264-72.
20. Khulbe RK, Sharma D, Pattanayak A, Kant L. Genetic variability, association and contribution of different characters towards grain yield in sweet corn (*Zea mays* var. saccharata) in North Western Hills. Indian J Hill. 2020;33(2):254-60.
21. Lush JL. Heritability off quantitative characters in farm animals. Proceedings of the Am soc animal prod 35; 1947; 293-301.
22. Supraja V, Sowmya HC, Kuchanur PH, Arunkumar B, Kisan B. Genetic variability and character association studies in maize (*Zea mays* L.) inbred lines. Int J Curr Microbiol Appl Sci. 2019;8(10):646-56.
23. Mohammedali AMd, Omer AMd, Abdalla GMd, Kamaleldin AMAT, Ahmed EMM. Genetic variability, heritability and genetic advance estimates in some Maize (*Zea mays* L.) Varieties in Sudan. Int J Food Sci Agric. 2020;5(1):85-90.
24. Al-Amin Md, Azad MAK, Shovon SR, Haque MF. Genetic variability and character association in Maize (*Zea mays* L.) inbred lines. Turkish JAF Sci.Tech. 2019;7(8):1125-31.
25. Sharma JR. Statistical and biometrical techniques in plant breeding. New age international (Pvt). New Delhi: Ltd [reprint. p. 2008. p. 35]; 1988.
26. Varalakshmi S, C. Wali MC, Deshpande SK, Harlapur SI. Correlation and Path coefficient analysis in single cross hybrids in maize. Int J Curr Microbiol Appl Sci. 2018;7(4):1840-3.
27. Bartaula S, Panthi U, Timilsena K, Acharya SS, Shrestha J. Variability, heritability and genetic advance of Maize (*Zea mays* L.) genotypes. Res Agric Livest Fish. 2019;6(2):163-9.
28. Dash AP, Lenka D, Tripathy SK, Swain D, Lenka D. Character association and path analysis of grain yield and its components in Maize (*Zea mays* L.) under heat stress. Int J Curr Microbiol Appl Sci. 2020;9(3):2750-8.
29. Mushtaq MA, Bajwa MM, Saleem M. Estimation of genetic variability and path analysis of grain yield and its components in chickpea (Cicer arietinum L.). Int J Sci Eng Research. 2013;4(1):1-4.
30. Sharma RK, Kumar S. Association analysis for grain yield and some quantitative traits in popcorn. Crop Improv. 1987;14(2):201-4.
31. Kumar S, Shahi JP, Singh J, Singh SP. Correlation and path analysis in early generation inbreeds of maize (*Zea mays* L.). Crop Improv. 2006;33(2):156-60.
32. Hemavathy AT, Balaji K, Ibrahim SJ, Anand G, Deepa S. Genetic variability and correlation studies in maize (*Zea mays* L.). Agric Sci Dig. 2008;28(2):112-4.
33. Gazal A, Ahmed Dar Z, Ahmad Lone A, Yousuf N, Gulzar S. Studies on maize yield under drought using correlation and path coefficient analysis. Int J Curr Microbiol Appl Sci. 2018;7(1):516-21.
34. Sood BC, Khajuria V. Genetic and anatomical characterization of land races of maize (*Zea mays* L.) for lodging and yield related traits. Indian J Genet. 2006;66(4):337-8.
35. Ulaganathan V, Ibrahim SM, Gurusamy A. Path analysis studies in maize genotypes. Ecol Environ Conserv. 2015;2(21): 909-13.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/91799