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Maize (*Zea mays* L.) genetic variability, character association, and path coefficient analysis, correlation and yield genotypes

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Abstract

In order to evaluate genetic variability, correlation, and path coefficient analysis among sixteen genotypes of maize for yield and yield-attributing variables, a field experiment was carried out. Three replications and a Randomized Block Design were used to set up the experiment. Significant differences between genotypes for every attribute were found by analysis of variance, suggesting that there is enough genetic variability. Grain yield per plot, grain yield per ear, and total yield showed high genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV), indicating more room for selection. The number of kernels per row, grain yield per ear, and seed index all showed high heritability and high genetic advancement, suggesting additive gene activity. Grain yield was found to be strongly positively correlated with plant height, number of kernels per row, grain yield per ear, and shelling percentage, according to correlation analysis. Grain yield per plot had the largest direct impact on overall yield, followed by plant height and grain yield per ear, according to path analysis. Therefore, these characteristics can be employed as selection criteria to increase maize production.

Keywords: Heritability, correlation, path analysis, genetic variability, maize

Introduction

After rice and wheat, maize (*Zea mays* L.) is the third most significant cereal crop in the world. It was first grown in Mexico and Central America, but because of its increased productivity and broad range of adaptation, it is currently grown all over the world under a variety of environments (Yousuf *et al.*, 2021) ^[20].

Because of its tremendous potential for output and ability to adapt to a variety of conditions among all the grains, maize is the most produced and is grown all over the world. Due to its high yield, greater economic return, and numerous applications, maize has become more and more popular among farmers in recent years. It is used for different applications including food, feed, industrial items, fodder and bio-fuel (Mishra *et al.*, 2024) ^[6].

Maize is a major food crop and the main source of calories and protein for the majority of individuals who experience food insecurity globally (Shiferaw *et al.*, 2011) ^[13].

Maize is commonly referred to as the "queen of cereals" due to its larger output potential than any other cereal crop. Although it may be produced year-round in southern India, maize is primarily planted in northern India during the *Kharif* (monsoon) season because it is a warm-weather crop. Animal and poultry feed accounts for over 60% of India's maize grain production, with the remainder 14% going to the starch industry, 13% to food, 7% to processed food, and 6% to export (iimr.icar.gov.in). At current pricing, maize contributes approximately 9% of the country's food basket and over 400 billion to the agricultural GDP. Additionally, it generates over one billion labor hours of employment in the downstream industrial and agricultural sectors. The amount and quality of nutrient-rich feed given to meat and milch animals affects their output and productivity (Roy *et al.*, 2019) ^[11].

For milch animals, maize is a high-quality feed that boosts body weight and produces higher-quality milk. Since green fodder is thought to be the cornerstone of the dairy business, its availability is essential to encouraging sustainable dairy production (Naik *et al.*, 2012) ^[8].

However, in mixed crop-livestock systems, developing countries like India face a shortage of green and stored fodder. Roughly 23.4% of cattle in India lack dry fodder, whereas 11.4% need green fodder (Roy *et al.*, 2019) ^[11].

Path coefficient analysis is a standardized partial regression coefficient that aids in evaluating the cause-and-effect relationship, effective selection, and the division of the correlation coefficient into direct and indirect effects of different traits toward the dependent variable. Path analysis is crucial for figuring out how closely yield and its constituent parts are related. The path coefficient (Wright, 1921; Dewey and Lu, 1959) ^[17, 3].

The selection of optimal genotypes for rapid improvement through appropriate breeding techniques is aided by knowledge of genetic diversity, heritability, and genetic advancement. The improvement in the mean genotypic value is referred to as genetic progress of the chosen plants compared to the base population. According to Johnson *et al.* (1955) ^[4], genetic gain should also be taken into account in order to reach a more trustworthy conclusion, even though the heritable estimates provide a helpful indication of relative values of selection based on phenotypic expression. Heritability estimates provide reliable information about the extent to which a particular genetic trait will be transmitted to the subsequent generations and thus could help significantly in making desirable selections. Breeders must therefore estimate heritability in order to assess the genetic potential of breeding materials, find attractive hybridization combinations, and use efficient selection strategies. The selection process will be easier and take less time if the heritability is larger, and the genetic improvement will be

greater (Allard, 1960) ^[2]. Genetic metrics that are effective biometric instruments for evaluating genetic variability include genotypic coefficient of variance, phenotypic coefficient of variance, heritability, and genetic advancement.

In addition to differentiation and diversity of genetic stocks, precise knowledge of genetic parameters like coefficient of variation, heritability, genetic advance, and the impact of environment on the expression of yield and yield components aids the breeder in choosing a variety of parents for the exploitation of heterosis (Singh *et al.*, 2020) ^[14].

Materials and Methods

The current experiment aims to assess fifteen maize germplasm lines along with one check variety using a Randomized Block Design at the Main Experiment Station Prof. Rajendra Singh (Rajju Bhaiya) University, Prayagraj. Sowing was done during the *kharif* season of 2025. The field was organized into 3 blocks, with each block containing sixteen plots (fifteen genotypes and one checks). Each plot will feature three rows, each plot two meters long, with 20 cm plant-to-plant spacing and 60 cm row spacing. Observations was taken from 5 randomly selected plants per plot, except for days to 50% tasseling and days to maturity, which was recorded on a plot basis. Grain yield was found to be strongly positively correlated with plant height, number of kernels per row, grain yield per ear, and shelling percentage, according to correlation analysis. Grain yield per plot had the largest direct impact on overall yield, followed by plant height and grain yield per ear, according to path analysis. Therefore, these characteristics can be employed as selection criteria to increase maize production.

Table 1: List of Genotypes

Notations	Experimental material	Sources.
V ₁	KL-155939 (Origin: HY23R-D73B-CWK-30)	Banaras Hindu University (BHU)
V ₂	VL-22312 (Origin: HY23R-Y73B-SIK-3)	Banaras Hindu University (BHU)
V ₃	VL-24245 (Origin: HY23R-Y27B-SIK-45)	Banaras Hindu University (BHU)
V ₄	VL-24194 (Origin: HY23R-Y31B-SIK-79)	Banaras Hindu University (BHU)
V ₅	VL-234466 (Origin: HY23R-Y41B-SIK-68)	Banaras Hindu University (BHU)
V ₆	VL-24189 (Origin: HY23R-Y31B-SIK-72)	Banaras Hindu University (BHU)
V ₇	VL-18448 (Origin: HY23R-Y76B-AC-2)	Banaras Hindu University (BHU)
V ₈	VL-24342 (Origin: HY23R-FA71B-AC-114)	Banaras Hindu University (BHU)
V ₉	VL-234040 (Origin: HY23R-D41B-CWK-61)	Banaras Hindu University (BHU)
V ₁₀	VL-19994 (Origin: HY23R-Y74B-SIK-64)	Banaras Hindu University (BHU)
V ₁₁	VL-236135 (Origin: HY23R-Y46-SIK-313)	Banaras Hindu University (BHU)
V ₁₂	VL-186245 (Origin: HY23R-D72B-CWK-116)	Banaras Hindu University (BHU)
V ₁₃	VL-24323 (Origin: HY23R-D41B-CWK-98)	Banaras Hindu University (BHU)
V ₁₄	VL-24286 (Origin: HY23R-W52B-NEK-119)	Banaras Hindu University (BHU)
V ₁₅	VL-223314 (Origin: HY23R-Y52B-SIK-15)	Banaras Hindu University (BHU)
Check (variety)	EARLY WONDER	Prayagraj



Fig 1: Photo taken during discussion with advisor and plant tagging in PRSU agriculture research field.

Results and Discussion

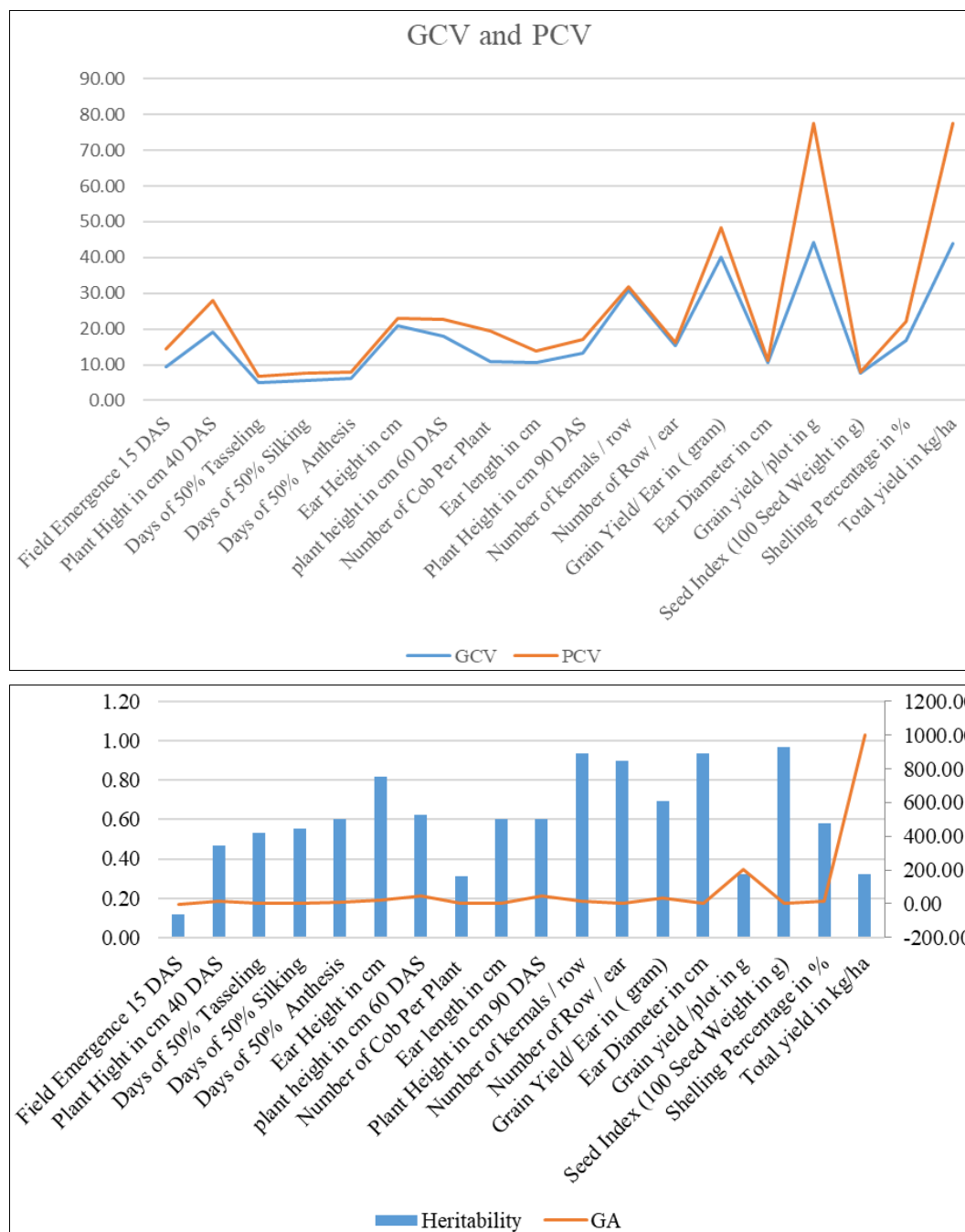
Table 02 showed the mean values of different traits of sixteen maize genotypes. The genetic parameters presented in Table 03 indicated that the higher genotypic variance was found for the total yield kg/ha (740554.76) and lowest for number of cob/plant (0.02). The highest values of phenotypic variance were obtained for trait total yield kg/ha (2310403.57) and lowest for number of cob/plant (0.05). The highest genotypic coefficients of variability were obtained for grain yield/plot gm. (44.16%) followed by total yield kg/ha (43.96%) while the lowest for day of 50% tasseling (5.00%) followed by day of 50% silking (5.70%). The highest value of the PCV was found for total yield kg/ha (77.67) followed by grain yield/plot gm.(77.61%) while lowest value was obtained for the day of 50%tasseling (6.85%)

Table 2: Mean value of different traits of maize genotypes

Genotype	Field Emergence 15 DAS	Plant Height in cm 40 DAS	Days of 50% Tasseling	Days of 50% Silking	Days of 50% Anthesis	Ear Height in cm	plant height in cm 60 DAS	Number of Cob Per Plant	Ear length in cm	Plant Height in cm 90 DAS	Number of kernels / row	Number of Row / ear	Grain Yield/ Ear in (gram)	Ear Diameter in cm	Grain yield /plot in g	Seed Index (100 Seed Weight in g)	Shelling Percentage in%	Total yield in kg/ha
V ₁	22.33	53.07	63.00	67.33	69.67	54.80	126.87	1.13	15.13	182.53	18.80	11.33	43.67	3.26	263.67	26.20	65.73	1318.33
V ₂	24.67	68.93	58.67	63.00	64.67	62.27	162.93	1.13	14.47	217.20	22.47	16.27	71.87	3.70	443.00	27.53	73.00	2215.00
V ₃	24.00	61.73	59.67	62.67	64.00	65.20	157.07	1.20	9.80	224.87	12.33	9.87	28.73	3.51	451.67	27.09	75.12	2258.33
V ₄	26.67	62.93	64.67	68.33	70.67	66.80	164.80	1.00	14.60	226.13	23.33	11.07	31.00	3.60	143.67	24.38	60.60	718.33
V ₅	22.67	60.53	63.33	66.33	67.33	73.47	178.27	1.00	14.47	247.60	22.87	10.20	38.60	3.44	234.33	27.35	55.87	1171.67
V ₆	22.00	38.80	64.33	67.33	70.00	49.33	114.20	1.27	14.80	176.40	14.47	8.40	16.00	2.67	58.33	25.37	39.39	291.67
V ₇	21.33	55.47	60.00	63.67	65.67	77.33	171.27	1.20	15.27	235.47	25.80	12.33	66.47	3.65	596.00	30.12	71.51	2980.00
V ₈	22.67	55.60	59.33	62.33	63.67	47.67	171.13	1.60	15.33	236.20	23.60	12.20	71.67	3.44	556.33	30.07	73.05	2781.67
V ₉	21.00	71.33	55.33	56.33	58.00	53.80	161.53	1.33	15.00	223.53	17.67	11.67	57.40	2.94	690.67	27.39	84.08	3453.33
V ₁₀	26.33	74.27	55.33	57.00	58.00	67.20	184.67	1.00	15.33	229.40	26.80	11.67	69.53	3.52	730.33	24.95	77.78	3651.67
V ₁₁	23.00	41.20	60.00	66.33	68.67	40.13	114.20	1.00	11.73	171.40	10.73	10.53	25.20	3.77	59.00	24.24	53.22	295.00
V ₁₂	26.00	60.80	62.00	65.67	68.67	63.60	160.87	1.27	12.80	197.40	17.40	11.67	40.80	3.65	342.33	25.32	67.11	1711.67
V ₁₃	23.00	66.27	53.67	57.33	59.00	57.33	185.67	1.40	12.87	222.67	19.20	11.27	51.53	3.39	544.33	23.34	73.08	2721.67
V ₁₄	24.33	91.33	57.33	61.33	62.00	85.40	228.47	1.27	15.73	282.80	31.80	10.93	80.73	3.53	681.33	28.12	74.67	3376.67
V ₁₅	23.00	45.73	62.67	67.00	69.67	47.93	116.33	1.07	12.73	166.20	11.00	9.00	30.87	3.02	226.00	24.33	48.92	1130.00
Check (variety)	22.67	47.60	57.00	58.67	60.67	85.47	202.07	1.07	15.60	251.20	29.53	12.73	86.07	4.31	247.33	28.01	52.46	1236.67

Table 3: Estimates of genetic components for maize genotypes

Genotypes	Vg	Vp	Ve	GCV	PCV	ECV	Heritability	GA	GA AS%
Field Emergence 15 DAS	10.54	11.48	12.82	9.53	14.43	15.25	0.12	-0.81	3.47
Plant Height in cm 40 DAS	129.77	278.93	149.16	19.07	27.96	20.45	0.47	16.01	26.80
Days of 50% Tasseling	8.91	16.78	7.87	5.00	6.85	4.69	0.53	4.48	7.50
Days of 50% Silking	12.95	23.30	10.35	5.70	7.64	5.09	0.56	5.53	8.75
Days of 50% Anthesis	16.30	27.03	10.73	6.21	8.00	5.04	0.60	6.46	9.93
Ear Height in cm	168.09	205.52	37.42	20.79	22.99	9.81	0.82	24.15	38.73
plant height in cm 60 DAS	858.29	1373.55	515.27	18.03	22.80	13.97	0.62	47.71	29.35
Number of Cob Per Plant	0.02	0.05	0.04	10.86	19.50	16.19	0.31	0.15	12.45
Ear length in cm	2.26	3.76	1.50	10.66	13.74	8.67	0.60	2.40	17.03
Plant Height in cm 90 DAS	838.46	1398.50	560.05	13.27	17.14	10.85	0.60	46.19	21.17
Number of kernels / row	40.12	42.79	2.68	30.92	31.93	7.99	0.94	12.63	61.66
Number of Row / ear	3.01	3.34	0.33	15.31	16.14	5.09	0.90	3.39	29.94
Grain Yield/ Ear in (gram)	412.11	596.06	183.95	40.09	48.22	26.79	0.69	34.77	68.68
Ear Diameter in cm	0.14	0.15	0.01	10.69	11.06	2.84	0.93	0.74	21.29
Grain yield /plot in g	29936.01	92436.68	62500.67	44.16	77.61	63.81	0.32	202.83	51.77
Seed Index (100 Seed Weight in g)	4.17	4.30	0.13	7.71	7.83	1.36	0.97	4.14	15.63
Shelling Percentage in%	122.41	210.33	87.92	16.93	22.19	14.35	0.58	17.39	26.61
Total yield in kg/ha	740554.76	2310403.57	1570348.50	43.96	77.67	64.03	0.32	1002.97	51.25



followed by day of 50% silking (7.64%). In the current studies except for day of 50% tasseling all the traits showed greater values of PCV%. Similar results were obtained by Ojo *et al.* (2006) ^[10]; Moulin, *et al.*, (2009) ^[7] and Ali *et al.* (2012) ^[11]. The highest heritability values were found for grain yield/cob (68.68%), number of kernels /row (61.66%), grain yield /plot gm. (51.77%) and total yield kg/ha (51.25%) while the field emergence 15 DAS showed the lowest heritability value (3.47%). The higher values of heritability of aforementioned traits are indicative that selection can be made on the basis of these traits (Ojo *et al.* 2006; Moulin *et al.*, 2009 ^[7] and Ali *et al.*, 2012) ^[10, 1].

Correlations

It is evident from the correlation analysis that several yield contributing traits exhibited positive and significant association

with grain yield at both genotypic and phenotypic levels. Grain yield per plot showed a strong and positive significant correlation with total yield (1.00 & 1.00) at both levels. Similarly, grain yield per ear exhibited a positive and significant association with total yield (0.7591 & 0.6296), indicating its direct contribution towards productivity. Similar findings were also reported by Ojo *et al.* (2006) ^[10] and Malik *et al.* (2005) ^[5]. Plant height at 60 DAS and 90 DAS showed positive and significant correlation with total yield (0.6451 & 0.6311; 0.7148 & 0.4922) at genotypic and phenotypic levels, respectively. Number of kernels per row also exhibited strong positive and significant association with total yield (0.6137 & 0.3656), while number of rows per ear showed moderate positive association (0.5157 & 0.2591) at both levels. These results are in agreement with the findings of Yousuf and Saleem (2001) ^[19] and Ojo *et al.* (2006) ^[10], who also reported similar associations in maize.

Table 4: Genotypic and correlation for different traits of maize genotypes

Genotypes	Field Emergence 15 DAS	Plant Height in cm 40 DAS	Days of 50% Tasseling	Days of 50% Silking	Days of 50% Anthesis	Ear Height in cm	Plant height in cm 60 DAS	Number of Cob Per Plant	Ear length in cm	Plant Height in cm 90 DAS	Number of kernal / row	Number of Row / ear	Grain Yield/ Ear in (gram)	Ear Diameter in cm	Grain yield /plot in g	Seed Index (100 Seed Weight in g)	Shelling Percentage in%	Total yield in kg/ha
Field Emergence 15 DAS	1	0.4699	0.1674	0.2443	0.193	0.1913	0.4016	-0.1981	-0.1215	0.3101	0.2582	0.249	-0.3673	0.4485	-0.5553 *	-0.6164 *	0.0323	-0.5604 *
Plant Height in cm 40 DAS		1	-0.4571	-0.5019 *	-0.577 *	0.559 *	0.7483 **	0.2248	0.2495	0.7454 **	0.6521 **	0.416	0.5677 *	0.0865	0.8125 **	0.207	0.959 **	0.8092 **
Days of 50% Tasseling			1	0.9802 **	0.9695 **	-0.2587	-0.5072 *	-0.2749	-0.0709	-0.4417	-0.3757	-0.465	-0.7309 **	-0.274	-0.8192 **	-0.1168	-0.7949 **	-0.8206 **
Days of 50% Silking				1	0.999 **	-0.3429	-0.5894 *	-0.32	-0.216	-0.5438 *	-0.4409	-0.4038	-0.7176 **	-0.1901	-0.8587 **	-0.1988	-0.7723 **	-0.8604 **
Days of 50% Anthesis					1	-0.3844	-0.6388 **	-0.3139	-0.2195	-0.6063 *	-0.4872	-0.3972	-0.7359 **	-0.1939	-0.8875 **	-0.2432	-0.78 **	-0.8889 **
Ear Height in cm						1	0.9127 **	-0.189	0.404	0.8947 **	0.825 **	0.284	0.6191 *	0.5714 *	0.4332	0.4374	0.1985	0.4316
plant height in cm 60 DAS							1	0.0872	0.4119	1.0209 **	0.9436 **	0.4294	0.8649 **	0.5461 *	0.6479 **	0.4496	0.5722 *	0.6451 **
Number of Cob Per Plant								1	0.1047	0.2017	0.0337	0.0761	0.4007	-0.3676	0.7277 **	0.5037 *	0.5869 *	0.7282 **
Ear length in cm									1	0.461	0.8469 **	0.3726	0.663 **	0.0169	0.2108	0.4881	0.0114	0.21
Plant Height in cm 90 DAS										1	0.9479 **	0.3869	0.8226 **	0.4785	0.7171 **	0.6353 **	0.5739 *	0.7148 **
Number of kernal / row											1	0.4996 *	0.8864 **	0.503 *	0.6146 *	0.5228 *	0.3389	0.6137 *
Number of Row / ear												1	0.7749 **	0.5685 *	0.5121 *	0.4096	0.5464 *	0.5157 *
Grain Yield/ Ear in (gram)													1	0.5316 *	0.7585 **	0.6474 **	0.5449 *	0.7591 **
Ear Diameter in cm														1	0.0165	0.2306	0.1324	0.0163
Grain yield /plot in g															1	0.5378 *	1.1775 **	1.0 **
Seed Index (100 Seed Weight in g)																1	0.361	0.5389 *
Shelling Percentage in%																	1	1.1819 **
Total yield in kg/ha																		1

** = Highly significant at 1% probability, * = Significant at 5% probability.

Table 05: Phenotypic correlation for different traits of maize genotypes

Genotypes	Field Emergence 15 DAS	Plant Height in cm 40 DAS	Days of 50% Tasseling	Days of 50% Silking	Days of 50% Anthesis	Ear Height in cm	Plant height in cm 60 DAS	Number of Cob Per Plant	Ear length in cm	Plant Height in cm 90 DAS	Number of kernal / row	Number of Row / ear	Grain Yield/ Ear in (gram)	Ear Diameter in cm	Grain yield /plot in g	Seed Index (100 Seed Weight in g)	Shelling Percentage in%	Total yield in kg/ha
Field Emergence 15 DAS	1	0.24	0.0068	-0.0099	-0.0041	0.1653	0.0895	-0.2558	-0.0974	-0.0132	0.1024	0.0778	0.1872	0.1728	0.2168	-0.1485	0.1576	0.2166
Plant Height in cm 40 DAS		1	-0.5679 **	-0.5245 **	-0.568 **	0.4372 **	0.7425 **	0.1041	0.2326	0.6491 **	0.4628 **	0.2529	0.491 **	0.0908	0.7351 **	0.1338	0.5757 **	0.7338 **
Days of 50% Tasseling			1	0.9313 **	0.9287 **	-0.1016	-0.6328 **	-0.3492 *	-0.1067	-0.4454 **	-0.2822	-0.3142 *	-0.5582 **	-0.2058	-0.6903 **	-0.0846	-0.4779 **	-0.6907 **
Days of 50% Silking				1	0.9842 **	-0.174	-0.6315 **	-0.3331 *	-0.1709	-0.476 **	-0.3429 *	-0.2827	-0.6015 **	-0.1536	-0.7011 **	-0.1495	-0.4826 **	-0.7023 **
Days of 50% Anthesis					1	-0.2112	-0.6831 **	-0.321 *	-0.2008	-0.5574 **	-0.3885 **	-0.2826	-0.6225 **	-0.1637	-0.7332 **	-0.2015	-0.5263 **	-0.7342 **
Ear Height in cm						1	0.6689 **	-0.2667	0.3253 *	0.6834 **	0.7334 **	0.2467	0.5125 **	0.5053 **	0.226	0.3895 **	0.2087	0.2237
plant height in cm 60 DAS							1	0.2477	0.4005 **	0.8644 **	0.7373 **	0.3303 *	0.6562 **	0.4247 **	0.6324 **	0.3502 *	0.4385 **	0.6311 **
Number of Cob Per Plant								1	0.0783	0.1405	0.0219	0.083	0.0955	-0.2376	0.27	0.2489	0.2361	0.2708
Ear length in cm									1	0.3815 **	0.6385 **	0.2785	0.5451 **	-0.0108	0.3189 *	0.358 *	0.1378	0.3174 *
Plant Height in cm 90 DAS										1	0.6954 **	0.2592	0.5748 **	0.3698 **	0.4933 **	0.4947 **	0.3889 **	0.4922 **
Number of kernal / row											1	0.4582 **	0.7417 **	0.4414 **	0.3676 *	0.4924 **	0.311 *	0.3656 *
Number of Row / ear												1	0.5737 **	0.5073 **	0.259	0.3851 **	0.4251 **	0.2591
Grain Yield/ Ear in (gram)													1	0.4533 **	0.631 **	0.5286 **	0.5062 **	0.6296 **
Ear Diameter in cm														1	0.0131	0.2242	0.0626	0.0128
Grain yield /plot in g															1	0.3183 *	0.6557 **	1.0 **
Seed Index (100 Seed Weight in g)																1	0.2844	0.3173 *
Shelling Percentage in%																	1	0.6552 **
Total yield in kg/ha																		1

** = Highly significant at 1% probability, * = Significant at 5% probability.

Ear height had a positive relationship with total yield (0.4316 & 0.2237), though the magnitude was comparatively lower. Grain yield per ear also showed significant positive association with number of kernels per row (0.8864 & 0.7417) and number of rows per ear (0.7749 & 0.5737), suggesting that these traits are key determinants of yield. Similar relationships were also observed by Malik *et al.* (2005) ^[5].

On the other hand, days to 50% tasseling, silking and anthesis exhibited negative and significant correlation with total yield (-0.8206 & -0.6907; -0.8604 & -0.7023; -0.8889 & -0.7342) at genotypic and phenotypic levels, respectively. This indicates that early flowering genotypes are more productive compared to late maturing ones. These findings are in conformity with the reports of Ojo *et al.* (2006) ^[10] and Yousuf and Saleem (2001) ^[19].

Shelling percentage showed a positive and significant association with total yield (1.1819 & 0.6552), whereas seed index exhibited a moderate positive correlation (0.5389 & 0.3173). However, traits like ear diameter (0.0163 & 0.0128) and number of cobs per plant (0.7282 & 0.2708) showed inconsistent or low magnitude associations, indicating limited direct contribution towards yield. Similar observations were also noted by Malik *et al.* (2005) ^[5].

Field emergence showed a negative association with total yield at genotypic level (-0.5604) but weak positive association at phenotypic level (0.2166), indicating environmental influence on trait expression. In general, genotypic correlation coefficients were higher than phenotypic correlations for most of the traits, indicating that the observed associations are largely governed by genetic factors with minimal environmental interference. These findings are in close agreement with earlier reports of Yousuf and Saleem (2001) ^[19] and Ojo *et al.* (2006) ^[10].

Path coefficient analysis

Path coefficient analysis at both genotypic and phenotypic levels revealed that grain yield per plot had the highest positive direct effect on total yield (1.0032 and 0.9952), indicating that it is the most important yield contributing trait. Similarly, grain yield per ear also exhibited a positive direct effect on total yield (0.0043 and 0.0109), though its magnitude was comparatively lower. Similar results were also obtained by Ojo *et al.* (2006) ^[10]; Rehman *et al.* (2007) and Ali *et al.*, (2011). Among growth traits, plant height at 60 DAS showed a positive direct effect

(0.0042 and 0.0397), followed by plant height at 90 DAS (0.0019 and 0.0090) at phenotypic and genotypic levels, respectively. Ear height also exhibited a positive direct contribution (0.0014 and 0.0268), suggesting that plant stature plays an important role in determining yield. Yield attributing traits such as number of kernels per row showed a small but positive direct effect (-0.0003 and -0.0147 showing slight variation across levels), whereas number of rows per ear exhibited positive direct effects (0.0019 and -0.0063), indicating mixed influence depending on genetic and environmental interaction. Similar results were also reported by Taiwo *et al.* (2020) ^[16] and Saritha *et al.* (2022) ^[12] in maize. Days to 50% tasseling, silking and anthesis exhibited negative direct effects on total yield at both levels (e.g., -0.0058, -0.0057, -0.0058 at phenotypic level and -0.0217, -0.0212, -0.0050 at genotypic level), indicating that delayed flowering reduces yield potential. This supports the earlier correlation findings. A similar kind of positive direct effect of plant height was found by Yaregal *et al.* (2021) ^[18] and Sirigireddy *et al.* (2022) ^[15]. Ear diameter showed a low but positive direct effect (0.0033 and 0.0183), while seed index also contributed positively (0.0013 and 0.0120). However, shelling percentage exhibited a negative direct effect (-0.0014 and -0.0046), suggesting that its contribution to yield is mainly through indirect effects. Similar results were obtained by O' Regan *et al.* (1992) ^[9]; Malik *et al.* (2005) ^[5] and Ali *et al.* (2011).

Indirect Effects

Most traits influenced yield indirectly through key components like grain yield per plot and grain yield per ear. For example. Plant height (60 & 90 DAS) contributed indirectly via grain yield per plot and kernels per row. Number of kernels per row showed strong indirect effects via grain yield per ear. Number of rows per ear contributed indirectly through grain yield per plot. Ear height influenced yield indirectly through plant height and grain yield traits. Flowering traits (tasseling, silking, anthesis) showed negative indirect effects through grain yield per plot and kernel traits, reinforcing their overall negative association with yield.

Field emergence and number of cobs per plant had negligible direct effects but contributed indirectly through yield components, indicating their limited importance in direct selection.

Table 5: Genotypic Path coefficient analysis direct indirect effect of various traits

Genotypes	Field Emergence 15 DAS	Plant Height in cm 40 DAS	Days of 50% Tasseling	Days of 50% Silking	Days of 50% Anthesis	Ear Height in cm	Plant height in cm 60 DAS	Number of Cob Per Plant	Ear length in cm	Plant Height in cm 90 DAS	Number of kernels / row	Number of Row / ear	Grain Yield/ Ear in (gram)	Ear Diameter in cm	Grain yield /plot in g	Seed Index (100 Seed Weight in g)	Shelling Percentage In%	Total Yield in kg/ha
Field Emergence 15 DAS	0.0059	0.0092	-0.0036	0.0007	-0.0010	0.0051	-0.0160	-0.0022	-0.0022	-0.0028	-0.0038	-0.0016	0.0040	0.0082	-0.5526	-0.0074	-0.0001	-0.5604
Plant Height in cm 40 DAS	0.0028	0.0195	0.0099	-0.0014	0.0029	0.0150	-0.0297	0.0025	0.0046	-0.0067	-0.0096	-0.0026	-0.0062	0.0016	0.8085	0.0025	-0.0044	0.8092
Days of 50% Tasseling	0.0010	-0.0089	-0.0217	0.0027	-0.0049	-0.0069	0.0202	-0.0031	-0.0013	0.0040	0.0055	0.0029	0.0079	-0.0050	-0.8152	-0.0014	0.0036	-0.8206
Days of 50% Silking	0.0014	-0.0098	-0.0212	0.0027	-0.0050	-0.0092	0.0234	-0.0036	-0.0040	0.0049	0.0065	0.0025	0.0078	-0.0035	-0.8546	-0.0024	0.0035	-0.8604
Days of 50% Anthesis	0.0011	-0.0112	-0.0210	0.0027	-0.0050	-0.0103	0.0254	-0.0036	-0.0040	0.0054	0.0072	0.0025	0.0080	-0.0035	-0.8832	-0.0029	0.0036	-0.8889
Ear Height in cm	0.0011	0.0109	0.0056	-0.0009	0.0019	0.0268	-0.0363	-0.0021	0.0074	-0.0080	-0.0121	-0.0018	-0.0067	0.0104	0.4311	0.0052	-0.0009	0.4316
plant height in cm 60 DAS	0.0024	0.0146	0.0110	-0.0016	0.0032	0.0244	-0.0397	0.0010	0.0076	-0.0092	-0.0139	-0.0027	-0.0094	0.0100	0.6448	0.0054	-0.0026	0.6451
Number of Cob Per Plant	-0.0012	0.0044	0.0060	-0.0009	0.0016	-0.0051	-0.0035	0.0113	0.0019	-0.0018	-0.0005	-0.0005	-0.0044	-0.0067	0.7242	0.0060	-0.0027	0.7282
Ear length in cm	-0.0007	0.0049	0.0015	-0.0006	0.0011	0.0108	-0.0164	0.0012	0.0184	-0.0041	-0.0124	-0.0023	-0.0072	0.0003	0.2098	0.0059	-0.0001	0.2100
Plant Height in cm 90 DAS	0.0018	0.0145	0.0096	-0.0015	0.0031	0.0239	-0.0406	0.0023	0.0085	-0.0090	-0.0139	-0.0024	-0.0089	0.0087	0.7137	0.0076	-0.0026	0.7148
Number of kernels / row	0.0015	0.0127	0.0081	-0.0012	0.0025	0.0221	-0.0375	0.0004	0.0156	-0.0085	-0.0147	-0.0031	-0.0096	0.0092	0.6117	0.0063	-0.0016	0.6137
Number of Row / ear	0.0015	0.0081	0.0101	-0.0011	0.0020	0.0076	-0.0171	0.0009	0.0068	-0.0035	-0.0073	-0.0063	-0.0084	0.0104	0.5096	0.0049	-0.0025	0.5157
Grain Yield/ Ear in (gram)	-0.0022	0.0111	0.0158	-0.0020	0.0037	0.0166	-0.0344	0.0045	0.0122	-0.0074	-0.0130	-0.0049	-0.0109	0.0097	0.7548	0.0078	-0.0025	0.7591
Ear Diameter in cm	0.0026	0.0017	0.0059	-0.0005	0.0010	0.0153	-0.0217	-0.0042	0.0003	-0.0043	-0.0074	-0.0036	-0.0058	0.0183	0.0164	0.0028	-0.0006	0.0163
Grain yield /plot in g	-0.0033	0.0158	0.0177	-0.0023	0.0045	0.0116	-0.0257	0.0082	0.0039	-0.0064	-0.0090	-0.0032	-0.0082	0.0003	0.9952	0.0065	-0.0054	1.0000
Seed Index (100 Seed Weight in g)	-0.0036	0.0040	0.0025	-0.0005	0.0012	0.0117	-0.0179	0.0057	0.0090	-0.0057	-0.0077	-0.0026	-0.0070	0.0042	0.5352	0.0120	-0.0017	0.5389
Shelling Percentage in%	0.0002	0.0187	0.0172	-0.0021	0.0039	0.0053	-0.0227	0.0066	0.0002	-0.0051	-0.0050	-0.0034	-0.0059	0.0024	1.1719	0.0043	-0.0046	1.1819

Table 6: Phenotypic Path coefficient analysis direct indirect effect of various traits

Genotypes	Field Emergence 15 DAS	Plant Height in cm 40 DAS	Days of 50% Tasseling	Days of 50% Silking	Days of 50% Anthesis	Ear Height in cm	Plant height in cm 60 DAS	Number of Cob Per Plant	Ear length in cm	Plant Height in cm 90 DAS	Number of kernels / row	Number of Row / ear	Grain Yield/Ear in (gram)	Ear Diameter in cm	Grain yield /plot in g	Seed Index (100 Seed Weight in g)	Shelling Percentage In%	Total yield in kg/ha
Field Emergence 15 DAS	0.0002	-0.0003	0.0001	0.0001	0.0000	-0.0002	-0.0004	-0.0004	0.0000	-0.0003	-0.0003	0.0002	-0.0008	0.0006	0.2175	0.0002	-0.0002	0.2166
Plant Hight in cm 40 DAS	0.0005	-0.0001	-0.0051	0.0030	0.0033	-0.0006	-0.0031	0.0002	0.0001	0.0012	-0.0001	0.0005	-0.0021	0.0003	0.7375	-0.0002	-0.0008	0.7338
Days of 50% Tasseling	0.0040	0.0001	0.0090	-0.0053	-0.0054	0.0001	0.0027	-0.0005	0.0000	-0.0009	0.0001	-0.0006	0.0024	-0.0007	-0.6925	0.0001	0.0007	-0.6907
Days of 50% Silking	0.0000	0.0001	0.0084	-0.0057	-0.0057	0.0003	0.0027	-0.0005	-0.0001	-0.0009	0.0001	-0.0005	0.0026	-0.0005	-0.7033	0.0002	0.0007	-0.7023
Days of 50% Anthesis	0.0001	0.0001	0.0083	-0.0056	-0.0058	0.0003	0.0029	-0.0005	-0.0001	-0.0011	0.0001	-0.0005	0.0027	-0.0005	-0.7355	0.0003	0.0007	-0.7342
Ear Height in cm	0.0003	0.0000	-0.0009	0.0010	0.0012	-0.0014	-0.0028	-0.0004	0.0001	0.0013	-0.0002	0.0005	-0.0022	0.0017	0.2267	-0.0005	-0.0003	0.2237
plant height in cm 60 DAS	0.0000	-0.0001	-0.0057	0.0036	0.0039	-0.0010	-0.0042	0.0004	0.0001	0.0017	-0.0002	0.0006	-0.0028	0.0014	0.6344	-0.0004	-0.0006	0.6311
Number of Cob Per Plant	-0.0005	-0.0001	-0.0031	0.0019	0.0019	0.0004	-0.0010	0.0015	0.0000	0.0003	0.0000	0.0002	-0.0004	-0.0008	0.2709	-0.0003	-0.0003	0.2708
Ear length in cm	0.0000	-0.0003	-0.0010	0.0010	0.0012	-0.0005	-0.0017	0.0001	0.0004	0.0007	-0.0002	0.0005	-0.0023	0.0000	0.3199	-0.0005	-0.0002	0.3174
Plant Height in cm 90 DAS	0.0004	-0.0001	-0.0040	0.0027	0.0032	-0.0010	-0.0036	0.0002	0.0001	0.0019	-0.0002	0.0005	-0.0025	0.0012	0.4949	-0.0006	-0.0006	0.4922
Number of kernels / row	0.0019	-0.0001	-0.0025	0.0019	0.0022	-0.0011	-0.0031	0.0000	0.0002	0.0013	-0.0003	0.0009	-0.0032	0.0015	0.3688	-0.0006	-0.0004	0.3656
Number of Row / ear	0.0030	-0.0003	-0.0028	0.0016	0.0016	-0.0004	-0.0014	0.0001	0.0001	0.0005	-0.0001	0.0019	-0.0025	0.0017	0.2598	-0.0005	-0.0006	0.2591
Grain Yield/ Ear in (gram)	0.0004	-0.0001	-0.0050	0.0034	0.0036	-0.0007	-0.0028	0.0001	0.0002	0.0011	-0.0002	0.0011	-0.0043	0.0015	0.6330	-0.0007	-0.0007	0.6296
Ear Diameter in cm	0.0003	0.0000	-0.0018	0.0009	0.0009	-0.0007	-0.0018	-0.0003	0.0000	0.0007	-0.0001	0.0010	-0.0020	0.0033	0.0131	-0.0003	-0.0001	0.0128
Grain yield /plot in g	0.0004	-0.0001	-0.0062	0.0040	0.0042	-0.0003	-0.0027	0.0004	0.0001	0.0009	-0.0001	0.0005	-0.0027	0.0000	1.0032	-0.0004	-0.0009	1.0000
Seed Index (100 Seed Weight in g)	-0.0003	0.0000	-0.0008	0.0008	0.0012	-0.0006	-0.0015	0.0004	0.0001	0.0010	-0.0001	0.0007	-0.0023	0.0007	0.3193	-0.0013	-0.0004	0.3173
Shelling Percentage in%	0.0003	-0.0001	-0.0043	0.0027	0.0030	-0.0003	-0.0018	0.0003	0.0000	0.0007	-0.0001	0.0008	-0.0022	0.0002	0.6578	-0.0004	-0.0014	0.6552

Conclusion

These parameters showed genotypes VL-18448 (29.80 q/ha), VL-24342 (27.89 q/ha), VL-234040 (34.53q/ha), VL- 19994 (36.31 q/ha), VL-24323 (27.21 q/ha), VL-24286 (33.76 q/ha), are varieties of high yield. Analysis of variance had significant for all characters under study. In the study highest GCV, PCV was shown for Grain yield /plot in g (44.16%), (77.67%) and heritability broad sense in Seed Index (100 Seed Weight in g) (97.91%). Whereas highest genetic advance was observed for Total yield in kg/ha (1000.97%). Grain yield /plot in (g) exhibited highly significant positive association with Grain Yield/ Ear in (gram), Plant Height in cm 90 DAS, Number of Cob Per Plant, plant height in cm 60 DAS, Plant Height in cm 40 DAS, Shelling Percentage in%, Total yield in kg/ha. Maximum positive direct effect at genotypic level viz. Grain yield /plot in (g) (0.9952) followed by Ear Height in cm (0.0268), Plant Height in cm 40 DAS (0.0195), Ear length in cm (0.0184), Ear Diameter in cm (0.0183), Seed Index (100 Seed Weight in g) (0.0120).

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Author contribution

Contributed to the conception and design of the analysis paper. Contributed to the data collection. Data and analysis tools were used to write the analyzed paper. Also evaluated the paper and then suggested publishing it in this journal.

References

1. Ali Q, Elahi M, Ahsan M, Tahir MHN, Basra SMA. Genetic evaluation of maize (*Zea mays* L.) accessions for growth-related seedling traits. *International Journal of Agriculture and Veterinary Medical Sciences*. 2012;6(3):164–172. doi:10.5455/ijavms.20110608051727.
2. Allard RW. Principles of plant breeding. New York: John Wiley and Sons; 1960.
3. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of maize seed production. *Agronomy Journal*. 1959;57(2):515–518.
4. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*. 1955;47:314–318.
5. Malik HN, Malik SI, Hussain M, Chughtai SUR, Javed HI. Genetic correlation among various quantitative characters in maize (*Zea mays* L.) hybrids. *Journal of Agriculture and Social Sciences*. 2005;3:262–265.
6. Mishra DK, Singh B, Chakraborty M, Verma N, Surin SS, Mishra SK. Combining ability and heterosis in maize (*Zea mays* L.) inbred lines. *Journal of Scientific Research and Reports*. 2024;30(6):943–954.
7. Moulin S, Baret F, Bruguier N, Bataille C. Assessing the vertical distribution of leaf chlorophyll content in a maize crop. *INRA–Unité Climat, Sol et Environnement*; 2009. p. 7803–7929.
8. Naik PK, Swain BK, Chakurkar EB, Singh NP. Performance of dairy cows on green fodder maize-based ration in coastal hot and humid climate. *Animal Nutrition and Feed Technology*. 2012;12(2):265–270.
9. O'Ragan BP, Cress WA, Van Staden J. Response of two maize cultivars to water stress. Pretoria (South Africa): Department of Agriculture; 1992. p. 23–25.
10. Ojo DK, Omikunle OA, Oduwaye OA, Ajala MO. Heritability, character correlation and path coefficient analysis among six inbred lines of maize (*Zea mays* L.). *World Journal of Agricultural Sciences*. 2006;2:352–358.
11. Roy AK, Agrawal RK, Bhardwaj NR, Mishra AK, Mahanta SK. Revisiting national forage demand and availability scenario. In: *Indian fodder scenario: redefining state-wise status*. Jhansi, India: ICAR-AICRP on Forage Crops and Utilization; 2019. p. 1–21.
12. Saritha A, Ramanjaneyulu AV, Umarani E. Studies on character association and path coefficient analysis for grain yield and its contributing characters in maize (*Zea mays* L.). *International Journal of Environment and Climate Change*. 2022;12(12):102–109.
13. Shiferaw B, Prasanna BM, Hellin J, Bänziger M. Crops that feed the world 6: past successes and future challenges to the role played by maize in global food security. *Food Security*. 2011;3:307–327.
14. Singh SB, Gupta BB, Singh SP. Genetic divergence in exotic inbreds of maize (*Zea mays* L.). *Progressive Agriculture*. 2020;7(1–2):1–4.
15. Sirigireddy GMR, Gaibriyal M, Thupakula VK, Yeruva VSR, Nalla S. Correlation and path coefficient analysis for grain yield components in maize (*Zea mays* L.). *International Journal of Plant and Soil Science*. 2022;34(23):24–36.
16. Taiwo OP, Nwonuala AI, Isaiah BF, Olawamide DO, Agbugba IK. Correlation and path coefficient analysis studies on grain yield and its contributing characters in maize (*Zea mays* L.). *International Journal of Plant and Soil Science*. 2020;32(7):7–13.
17. Wright S. Correlation and causation. *Journal of Agricultural Research*. 1921;20:257–287.
18. Yaregal D, Assefa G, Mulualet T. Genetic variability, heritability, trait associations and path coefficient analysis of maize (*Zea mays* L.) inbred lines at Pawe, Northwestern Ethiopia. *Asian Journal of Plant Science and Research*. 2021;11(2):57–64.
19. Yousuf M, Saleem M. Correlation analysis of S1 families of maize for grain yield and its components. *International Journal of Agriculture and Biology*. 2001;4:387–388.
20. Yousuf N, Dar SA, Shikari AB, Dar ZA, Lone AA, Sofi PA, et al. Assessment of genetic diversity at molecular and morphological levels of temperate maize landraces collected from diverse ecological niches in Kashmir. *Indian Journal of Genetics and Plant Breeding*. 2021;81(4):557–565.