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Assessment of different genetic parameters of variability, association of correlation coefficient and direct and indirect effects on yield in Maize (*Zea mays* L.)

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Abstract

Grain yield in maize is a complex trait influenced by numerous interrelated quantitative characters. Understanding the direct and indirect effects of these traits is essential for effective selection in breeding programmes. The present study was conducted on 42 genotypes (39 inbreds and 3 checks) during *Rabi* 2024 at AICRP on Maize, Kolhapur to investigate the different genetic parameters of variability, association of yield with its component traits using correlation and path coefficient analyses. Among all, traits cob weight showed the high (> 20%) phenotypic and genotypic coefficient of variation, whereas moderate (10% - 20%) phenotypic and genotypic coefficient of variation were seen in grain yield per plant, cob length, number of kernels per row, thousand kernel weight, cob width, protein percent, number of kernel rows per cob, plant height and cob height. while days to 50% tasseling and days to 50% silking exhibited relatively low (<10%) phenotypic and genotypic coefficient of variation. Broad-sense heritability ranged from 86% and 99%. Highest heritability was observed in cob weight and protein percent. Genetic advance and genetic advance as per cent of mean were highest in cob weight. Correlation analysis revealed that grain yield per plant had highly significant positive associations with cob length, cob girth, thousand kernel weight, cob weight, number of kernels per row, plant height, days to 50% tasseling, days to 50% silking and cob height. Path coefficient analysis showed that cob weight (0.5808) exerted the maximum positive direct effect on grain yield followed by cob height (0.4062), thousand kernel weight (0.1710), plant height (0.1597), kernel rows per cob (0.1580), days to 50% silking (0.1377) and cob width (0.1014). Negative direct effects were observed for cob length (-0.1867), protein per cent (-0.0976) and days to 50% tasseling (-0.0362). These findings indicate that cob weight and kernel traits play major roles in yield determination and can be targeted for selection in breeding programmes.

Keywords: Maize, Correlation, Path coefficient, Direct effect, Indirect effect, Yield, Genetic advance

Introduction

Maize (*Zea mays* L.) is one of the world's most important cereal crops serving as a staple food, livestock feed and industrial raw material. Improving grain yield is a prime objective of maize breeding programmes but yield is a complex quantitative trait influenced by multiple genetic and environmental factors. The success of any breeding program relies on the magnitude of genetic variability present within the population. A wide range of variability increases the likelihood of identifying superior genotypes for selection. Along with variability, estimates of heritability and genetic advance are crucial for designing effective breeding strategies and predicting genetic improvement. As emphasized by Burton (1953)^[12], integrating genetic variability with heritability estimates provides a better prediction of expected genetic gain. However, as noted by Johnson *et al.* (1955)^[28], high heritability alone does not necessarily ensure high genetic advance, highlighting the need to consider both parameters together for effective selection. Correlation analysis provides insight into the degree of association among quantitative traits but it does not clarify whether such associations arise from direct effects or indirect influences through other traits. Path

coefficient analysis (1921) [69] and adapted by Dewey and Lu (1959) [19] partitions correlation coefficients into proposed by Wright direct and indirect effects thereby identifying the most important characters for selection. The present investigation was carried out to evaluate the different genetic parameters of variability, correlation coefficients and partition the direct and indirect effects of various yield-related traits in maize inbred lines.

Materials and Methods

The experiment was conducted at AICRP on Maize, Kasba Bawada, Kolhapur during *Rabi* 2024. The experimental material consisted of 42 genotypes. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Rows were spaced 0.60 m apart with 0.20 m plant to plant distance. The standard package of agronomical practices were followed to raise a healthy experimental maize crop. The five random plants were selected and all subsequent observations were recorded on them using in each replication of all entry. Observations were recorded on the following characters: days to 50% tasseling, days to 50% silking, plant height (cm), cob height (cm), cob length (cm), cob width (cm), number of kernel rows per cob, number of kernels per row, cob weight (g), 1000-kernel weight (g), grain yield per plant (g) and protein content (%). The different genetic parameters of variability were calculated based on the mean sum of squares obtained from the analysis of variance (ANOVA). Correlation coefficients were calculated at genotypic level. Path coefficient analysis was carried out using grain yield per plant as the dependent variable following the method of Dewey and Lu (1959) [19].

Results and Discussion

The highest GCV and PCV (>20%) were observed for cob weight (39.52,39.69), moderate GCV and PCV (10% to 20%) were recorded for Grain yield per plant, Cob length, no.of kernels per row, 1000 kernel weight, cob width, protein content % and plant height, whereas lowest GCV and PCV (<10%) were estimated by no. of kernel rows per cob, cob height, days to 50% tasseling and days to 50% silking. The heritability (b.s.) were ranged from 86% to 99% for all twelve characters. The highest genetic advance (>20%) was observed for cob weight, thousand kernel weight, grain yield per plant and plant height, moderate genetic advance (10-20%) was estimated by cob height and remaining traits showed low genetic advance (<10%). All characters showed moderate to high genetic advance per cent of mean. Moderate (10-20%) genetic advance percent of mean was recorded in days to 50% silking, days to 50% tasseling, cob height and plant height. Remaining characters exhibited high genetic advance per cent of mean (>20%). Table 1 estimates of different genetic parameters of variability for 12 characters of 42 genotypes of maize. Grain yield per plant exhibited a highly significant and positive genotypic correlation with several traits most notably cob weight ($r = 0.8809$) followed by cob height (0.7128), cob length ($r = 0.6648$), cob width ($r = 0.5820$), thousand kernel weight (0.4881), number of kernels per row ($r = 0.4257$), days to 50 per cent tasseling (0.3178), days to 50 per cent silking (0.3040), number of kernels rows per cob ($r = 0.2335$) and plant height (0.2326). In contrast protein

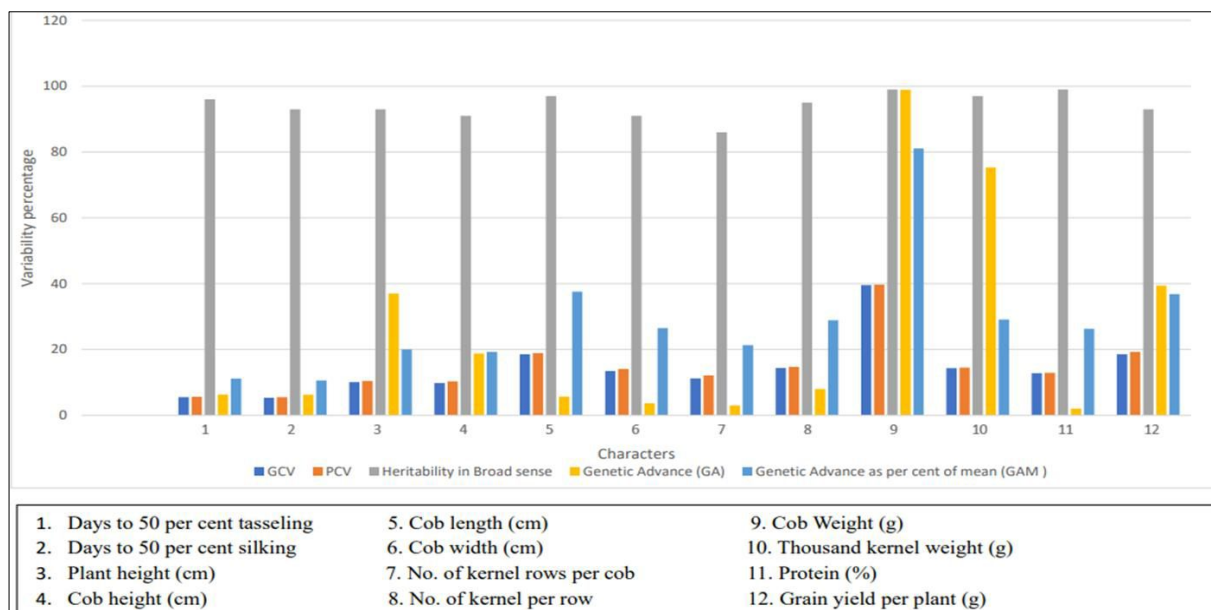
content showed a positive but non-significant correlation with grain yield ($r = 0.0877$). The traits with highly positive estimates of correlation would be used more confidently as the selection criteria for the improvement of grain yield in maize. Table 2 shows the Estimation of correlation coefficient at genotypic level in maize. For path coefficient analysis Table 3 estimates the direct and indirect effects at genotypic level in maize (*Zea mays* L.) the characters which had highest positive direct effect on yield were cob weight (0.5808) followed by cob height (0.4062), thousand kernel weight (0.1710), plant height (0.1597), number of kernel rows per cob (0.1580), days to 50 per cent silking (0.1377) and cob width (0.1014). Thus direct selection for these traits will be beneficial in yield improvement programme. While the characters like cob length (-0.1867), protein per cent (-0.0976), days to 50 per cent tasseling (-0.0362) and number of kernel rows per cob (-0.0024) exhibited negative direct effect on grain yield per plant, suggesting that their improvement in selection may not necessarily translate into higher productivity. The residual effect (0.293) indicated that other unmeasured factors also contributed to grain yield of maize.

Conclusion

The PCV values were higher than the GCV value for all characters. This showed that, all the characters were influenced by environmental factors. High heritability estimates were obtained for all twelve characters, indicated that variation observed was under genetic control and the characters were less influenced by environment. High heritability along with a high genetic advance as percent of mean indicates that additive gene action plays a major role in the expression of the trait, suggesting that selection would be highly effective for its improvement. Correlation analysis revealed that grain yield per plant exhibited highly significant positive associations with cob weight, cob height, cob length, cob width, thousand kernel weight, number of kernels per row, plant height, days to 50% tasseling and days to 50% silking. This suggests that these characters are important yield-contributing traits and simultaneous selection for them would be beneficial. For path analysis the character cob weight exhibited the highest positive direct effect on grain yield followed by cob width, days to 50% silking, cob length, thousand kernel weight, cob height, plant height and number of kernel rows per cob. The strong direct effects of these traits highlight their significant contribution to grain yield indicating that direct selection for these characters would be effective in development of high-yielding maize genotypes. Conversely, cob length and protein percentage were found to exert negative direct effects on yield. Although such traits may influence yield indirectly through their association with other components their direct contribution remains unfavourable. Hence careful consideration is required when incorporating these characters into breeding strategies. Breeding efforts targeting kernel and cob traits along with plant growth habit can effectively enhance maize yield. Integrating these traits into selection programmes will aid in developing superior varieties with higher productivity.

Table 1: Estimates of different genetic parameters of variability for 12 characters of 42 genotypes of maize.

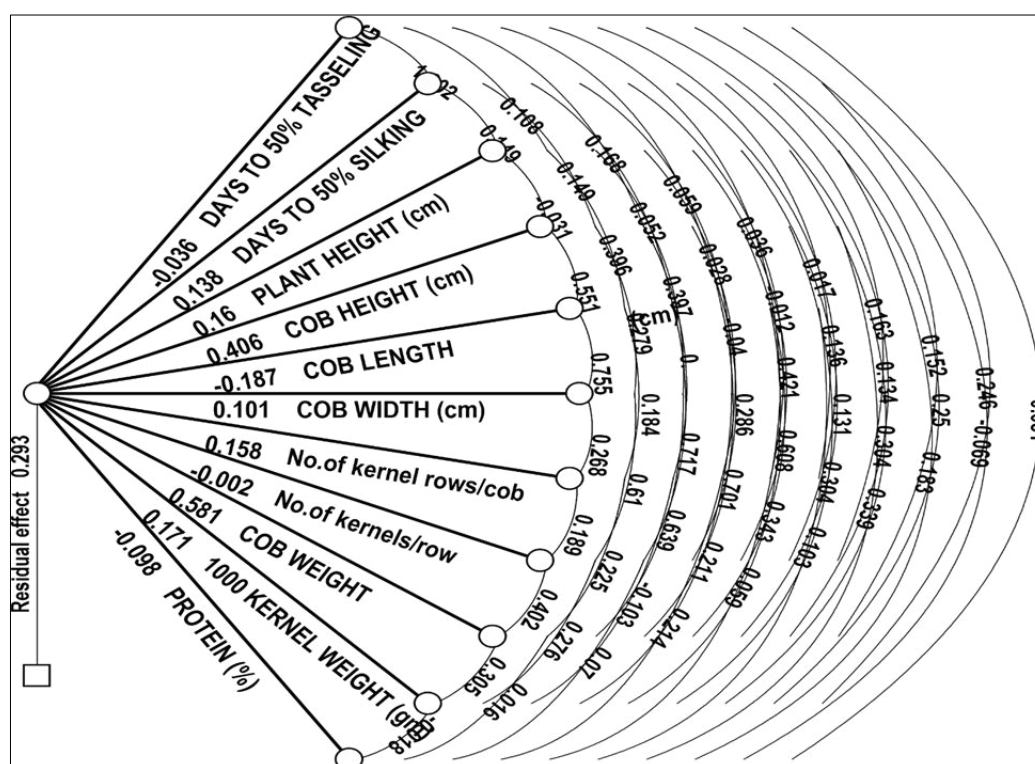
Sr. No.	Characters	Range		Mean	Coefficient of Variation (%)		Heritability in Broad sense (h^2 b. s.) %	Genetic Advance (GA)	Genetic Advance as per cent of mean (GAM)
		Min.	Max		GCV	PCV			
1	Days to 50 per cent tasseling	51.00	63.33	56.73	5.52	5.62	96	6.30	11.15
2	Days to 50 per cent silking	53.00	65.66	59.07	5.33	5.53	93	6.24	10.60
3	Plant height (cm)	133.00	214.17	186.00	10.07	10.45	93	37.00	20.00
4	Cob height (cm)	67.00	115.00	96.86	9.81	10.29	91	18.77	19.28
5	Cob length (cm)	8.40	20.30	15.00	18.56	18.89	97	5.66	37.56
6	Cob width (cm)	9.67	18.33	13.94	13.46	14.07	91	3.63	26.51
7	No. of kernel rows per cob	11.00	17.00	13.74	11.19	12.09	86	2.96	21.33
8	No. of kernels per row	18.00	36.00	27.58	14.35	14.70	95	7.98	28.85
9	Cob Weight (g)	55.17	250.00	125.36	39.52	39.69	99	98.91	81.06
10	Thousand kernel weight (g)	161.83	331.67	262.48	14.32	14.51	97	75.30	29.11
11	Protein (%)	5.60	9.80	31.72	12.81	12.88	99	2.03	26.27
12	Grain yield per plant (g)	62.33	154.33	109.31	18.56	19.30	93	39.40	36.84

**Fig 1:** Estimates of different genetic parameters of variability for 12 characters of 42 genotypes (39 inbreds and 3 hybrids) of maize"**Table 2:** Estimation of correlation coefficient at genotypic level in maize. *Significant at 5% level and ** Significant at 1% level.

Characters	Days to 50 % tasseling	Days to 50 % silking	Plant height (cm)	Cob height (cm)	Cob length (cm)	Cob width (cm)	No. of kernel rows per cob	No. of kernels per row	Cob weight (g)	Thousand kernel weight (g)	Protein (%)	Grain yield per plant(g)
Days to 50% tasseling	1.0000	1.0020**	0.1081	0.1679	0.0593	0.0363	0.0173	0.1631	0.1523	0.2464**	-0.0510	0.3178**
Days to 50% silking		1.0000	0.1485	0.1491	0.0515	0.0276	-0.0118	0.1362	0.1339	0.2496**	-0.0695	0.3040**
Plant height(cm)			1.0000	-0.0315	0.3960**	0.3973**	-0.0397	0.4213**	0.1306	0.3041**	0.1825*	0.2326**
Cob height (cm)				1.0000	0.5508**	0.2790**	-0.0005	0.2857**	0.6084**	0.3043**	0.3385**	0.7128**
Cob length (cm)					1.0000	0.7551**	0.1843*	0.7169**	0.7007**	0.3428**	0.1029	0.6648**
Cob width (cm)						1.0000	0.2683**	0.6096**	0.6388**	0.2110*	0.0588	0.5820**
No.of kernel rows per cob							1.0000	0.1892*	0.2246*	-0.1027	0.2142*	0.2335**
No.of kernels per row								1.0000	0.4023**	0.2756**	0.0695	0.4257**
Cob weight (g)									1.0000	0.3051**	0.0155	0.8809**
Thousand kernel weight(g)										1.0000	-0.0180	0.4881**
Protein (%)											1.0000	0.0877

Table 3: Estimation of direct and indirect effects at genotypic level in maize (*Zea mays* L.). *Significant at 5% level and ** Significant at 1% level, Residual effect =0.293.

Characters	Days to 50 percent tasseling	Days to 50 percent silking	Plant height (cm)	Cob height (cm)	Cob length (cm)	Cob width (cm)	Number of kernel rows per cob	Number of kernels per row	Cob weight (g)	Thousand kernel weight	Protein (%)	Grain yield per plant (g)
Days to 50 percent tasseling	-0.0362	-0.0363	-0.0039	-0.0061	-0.0021	-0.0013	-0.0006	-0.0059	-0.0055	-0.0089	0.0018	0.2178
Days to 50 percent silking	0.1380	0.1377	0.0205	0.0205	0.0071	0.0038	-0.0016	0.0188	0.0184	0.0344	-0.0096	0.3040
Plant height (cm)	0.0173	0.0237	0.1597	-0.0050	0.0632	0.0634	-0.0063	0.0673	0.0209	0.0486	0.0291	0.2326
Cob height (cm)	0.0682	0.0606	-0.0128	0.4062	0.2238	0.1133	-0.0002	0.1161	0.2472	0.1236	0.1375	0.7128
Cob length (cm)	-0.0111	-0.0096	-0.0739	-0.1028	-0.1867	-0.1410	-0.0344	-0.1339	-0.1308	-0.0640	-0.0192	0.6648
Cob width (cm)	0.0037	0.0028	0.0403	0.0283	0.0766	0.1014	0.0272	0.0618	0.0648	0.0214	0.0060	0.5820
Number of kernel rows per cob	0.0027	-0.0019	-0.0063	-0.0001	0.0291	0.0424	0.1580	0.0299	0.0355	-0.0162	0.0338	0.2335
Number of kernels per row	-0.0004	-0.0003	-0.0010	-0.0007	-0.0017	-0.0015	-0.0005	-0.0024	-0.0010	-0.0007	-0.0002	0.4257
Cob weight (g)	0.0885	0.0778	0.0758	0.3534	0.4070	0.3710	0.1304	0.2337	0.5808	0.1772	0.0090	0.8809
Thousand kernel weight (g)	0.0421	0.0427	0.0520	0.0520	0.0586	0.0361	-0.0176	0.0471	0.0522	0.1710	-0.0031	0.4881
Protein (%)	0.0050	0.0068	-0.0178	-0.0330	-0.0100	-0.0057	-0.0209	-0.0068	-0.0015	0.0018	-0.0976	0.0877

**Fig 2:** Genotypical path diagram for grain yield per plant in maize

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