# Genetic Variability and Inter-relationship among Grain Yield and It's Components in Maize (*Zea mays* L.)

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*Authors' contributions*

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

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## ABSTRACT

The present investigation was carried out to estimate genetic variability, correlation and path coefficient analysis for fifteen yield attributing traits of twenty maize genotypes in the *kharif* -2021 season at Field Experimentation Center, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Uttar Pradesh in Randomized block design replicated thrice. Among 20 genotypes, VL-19403(66.8g) and VL-19465(65.5g) genotypes were found to be superior for grain yield per plant over the check (Shaktiman-5). High GCV and PCV were observed for grain yield per plant, number of grains per row, number of grain rows per cob, harvest index, cob weight, ear height and biological yield per plant. Maximum heritability conjoined with higher genetic advance for the traits grain yield per plant, plant height, ear height, harvest index, biological yield and cob weight. Grain yield per plant was significantly strong association with harvest index, number of grains per row, cob weight, cob girth, cob length, ear height at both levels. The trait days to 50% tasselling had high direct positive effect on grain yield per plant at genotypic level and biological yield per plant had high direct positive effect on grain yield per plant at phenotypic level.

*Keywords: Maize; genetic variability; heritability; correlation; path coefficient analysis.*

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## 1. INTRODUCTION

Maize is a vital crop for billions of people, providing food, fodder, and industrial raw materials. It has a nutritional profile of 72 percent carbohydrates, 8-11 percent protein, and 4 percent fat, as well as iron 4.8mg/100g, Zn 4.6mg/100g, vitamin C, vitamin E, and vitamin K. USDA National Nutrient Database Currently, over 170 nations produce roughly 1162.3 million MT of maize from an area of 201.9 million ha with an average productivity of 5.75 t/ha; in India, it is grown in an area of 9.89 million ha and produces around 31.65 million tones with an average productivity of 31.99 q/ha, [1].

The demand for maize grain is always increasing. The global population is anticipated to reach 9 billion by 2050. Achievements in hybrid development should be sufficiently supported by germplasm enhancement, gene pool synthesis, and heterotic populations that represent variability for varied requirements. The understanding of the type and magnitude of genotypic and phenotypic variation found in crop species is critical in developing a successful breeding programme to evolve improved cultivars [2]. The presence of differences among individuals in a plant community is referred to as variability. The degree of gain acquired in a character under a specific selection pressure is referred to as genetic progress. High genetic advancement combined with high heritability estimates provides the best conditions for selection [3]. Correlation coefficient analysis exposes the amount and direction of yield components, whereas path analysis finds components that influence yield directly or indirectly. The cultivar with the course of time reduced the grain yield due to the deterioration by weeds, mixture and pollination. So, there is need to evaluate the new genotypes in breeding trials to identify the improved cultivars. As a result, the current study was conducted to determine the yield contributing features on seed yield per plant in *kharif* that would be useful for increasing productivity under the respective environmental conditions.

## 2. MATERIALS AND METHODS

During *kharif*-2021, the current experiment was carried out at the Field Experimentation Centre of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, U.P. The experiment was set up in a randomized block design with three replications, with the indicated packages and practices for a healthy crop included and row to row spacing is (45 cm) and plant to plant spacing is (20 cm) with plot size is of $2m^2$. Data for 15 quantitative characters were collected from five randomly selected plants for each genotype in all replications: days to 50% tasseling, days to 50% silking, anthesis to silking interval (ASI), days to 75 percent maturity, plant height, ear height, cob length, cob girth, cob weight, number of grain rows per cob, number of grains for each row, 100 seed weight, biological yield per plant, harvest index and yield per plant.

The statistical analysis was carried out in accordance with Panse and Sukhatme's instructions [4]. Burton's formula was used to calculate the genotypic (GCV) and phenotypic (PCV) coefficients of variation [5]. Heritability in broad sense, genetic advance and genetic advance as a percent of mean were calculated using the approach described by Lush [6] and Johnson et al. [7]. Correlation analysis was performed using the formula published by Al Jibouri et al. (1958) and path coefficient analysis was performed using the approach proposed by Dewey and Lu [8].

## 3. RESULTS AND DISCUSSION

The variations among the genotypes were identified by results of Analysis of Variance (Table 1), indicating ample scope for selection of promising lines for yield and it's components.

Higher GCV and PCV were found for grain yield per plant, number of grains per row, number of grain rows per cob, harvest index, cob weight, ear height and biological yield per plant (Table 2 & Fig. 1). Similar outputs were given by Rai et al. [9] for grain yield per plant, harvest index and Beulah et al. [10] for number of grains per row, number of grain rows per cob and Magar et al. [11] for cob weight, ear height, biological yield per plant.

Maximum heritability conjoined with high genetic advance for the traits grain yield per plant, plant height, ear height, cob weight, biological yield and harvest index. These findings were same as Bekele et al. [12] for these traits. These results suggested that additive gene action predominated and selection may be helpful for improving these features. The traits grain yield per plant, number of grains per row, number of grains per cob had higher heritability coupled

with high genetic advance as percent of mean. These observations were same as to Bartaula et al. [13] findings. This suggests that the genotypic variation in the genetic material analysed is most likely attributable to additive genetic variance, which can be efficiently utilized in crop improvement programmes through correct selection methods.

**Table 1. Analysis of variance for quantitative traits of maize**

| Traits | Mean Sum of Squares | | |
| --- | --- | --- | --- |
| | Genotypes (d=19) | Replication (df=2) | Error (df=38) |
| Days to 50% tasselling | 93.77* | 1.85 | 2.48 |
| Days to 50%silking | 92.23* | 1.87 | 2.15 |
| Anthesis to silking interval | 0.43* | 0.32 | 0.46 |
| Days to 75% maturity | 85.29* | 22.87 | 4.59 |
| Plant height | 1105.21* | 147.66 | 54.46 |
| Ear height | 730.95* | 432.67 | 45.19 |
| Cob length | 12.99* | 4.63 | 2.07 |
| Cob girth | 818.12* | 96.43 | 131.85 |
| Cob weight | 53.44* | 3.65 | 1.04 |
| Number of grain rows per cob | 53.44* | 3.65 | 1.04 |
| Number of grains per row | 53.71* | 5.91 | 3.99 |
| 100 grain weight | 46.62* | 0.93 | 0.27 |
| Biological yield per plant | 1706.93* | 383.69 | 218.44 |
| Harvest index | 465.24* | 27.27 | 48.41 |
| Grain yield per plant | 1089.94* | 18.95 | 92.83 |

*Indicates Level of significance at 5%.*

**Table 2. Genetic parameters for quantitative traits of maize**

| Traits | Genotypic Coefficient of Variance | phenotypic Coefficient of Variance | h² (Broad Sense %) | Genetic Advancement | Genetic Advance as % of Mean |
| --- | --- | --- | --- | --- | --- |
| Days to 50% tasseling | 9.966 | 10.101 | 97.4 | 11.212 | 20.257 |
| Days to 50%silking | 9.602 | 9.716 | 97.7 | 11.156 | 19.549 |
| Anthesis to silking interval | 5.456 | 22.072 | 6.1 | 0.048 | 2.778 |
| Days to 75% maturity | 5.768 | 5.93 | 94.6 | 10.394 | 11.559 |
| Plant height | 12.922 | 13.253 | 95.1 | 37.591 | 25.956 |
| Ear height | 29.278 | 30.227 | 93.8 | 30.167 | 58.418 |
| Cob length | 16.214 | 17.684 | 84.1 | 3.604 | 30.624 |
| Cob girth | 9.339 | 12.23 | 58.3 | 1.609 | 14.691 |
| Cob weight | 32.943 | 35.969 | 83.9 | 28.536 | 62.154 |
| Number of grain rows per cob | 37.862 | 38.237 | 98.1 | 8.525 | 77.233 |
| Number of grains per row | 41.997 | 43.65 | 92.6 | 8.069 | 83.239 |
| 100 grain weight | 16.022 | 16.069 | 99.4 | 8.074 | 32.911 |
| Biological yield per plant | 28.852 | 30.897 | 87.2 | 42.849 | 55.502 |
| Harvest index | 36.172 | 38.215 | 89.6 | 22.984 | 70.532 |
| Grain yield per plant | 65.907 | 68.907 | 91.5 | 35.921 | 98.858 |

## Table 3. Correlation coefficient for yield and yield contributing traits of maize

| Traits | | DT | DS | ASI | DM | PH | EH | CL | CG | CW | NGRPC | NGPR | SI | BYPP | HI | GYPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DT | $r_g$ | 1 | 1.000** | -0.214NS | 0.940** | -0.267* | -0.244NS | -0.153NS | -0.368** | -0.223NS | -0.174NS | -0.125NS | -0.261* | -0.179NS | -0.214NS | -0.229NS |
| | $r_p$ | 1 | 0.993** | -0.197NS | 0.881** | -0.260* | -0.231NS | -0.139NS | -0.211NS | -0.192NS | -0.165NS | -0.121NS | -0.242NS | -0.168NS | -0.197NS | -0.203NS |
| DS | $r_g$ | | 1 | -0.248NS | 0.942** | -0.283* | -0.268* | -0.176NS | -0.398** | -0.258* | -0.202NS | -0.138NS | -0.262* | -0.213NS | -0.248NS | -0.262* |
| | $r_p$ | | 1 | -0.213NS | 0.886** | -0.273* | -0.244NS | -0.141NS | -0.222NS | -0.208NS | -0.181NS | -0.118NS | -0.244NS | -0.191NS | -0.213NS | -0.226NS |
| ASI | $r_g$ | | | 1 | -0.280* | 0.558** | 0.585** | 0.875** | 0.768** | 0.903** | 0.983** | 0.381** | 0.103NS | 0.866** | 1.000** | 0.954** |
| | $r_p$ | | | 1 | -0.255* | 0.500** | 0.523* | 0.692* | 0.571** | 0.797** | 0.866** | 0.387** | 0.089NS | 0.737** | 1.000* | 0.921** |
| DM | $r_g$ | | | | 1 | -0.239NS | -0.255* | -0.257* | -0.501** | -0.306* | -0.250NS | -0.316* | -0.229NS | -0.268* | -0.280* | -0.319* |
| | $r_p$ | | | | 1 | -0.212NS | -0.204NS | -0.173NS | -0.257* | -0.218NS | -0.223NS | -0.249NS | -0.201NS | -0.208NS | -0.255* | -0.271* |
| PH | $r_g$ | | | | | 1 | 0.983** | 0.678** | 1.000** | 0.748** | 0.693** | 0.515** | 0.175NS | 0.789** | 0.558** | 0.721** |
| | $r_p$ | | | | | 1 | 0.965** | 0.583** | 0.578** | 0.658** | 0.646** | 0.513** | 0.162NS | 0.695** | 0.500** | 0.661** |
| EH | $r_g$ | | | | | | 1 | 0.649** | 1.000** | 0.725** | 0.677** | 0.545** | 0.129NS | 0.778** | 0.585** | 0.736** |
| | $r_p$ | | | | | | 1 | 0.605** | 0.593** | 0.660** | 0.677** | 0.554** | 0.119NS | 0.693** | 0.523** | 0.677** |
| CL | $r_g$ | | | | | | | 1 | 0.960** | 0.856** | 0.894** | 0.552** | 0.047NS | 0.808** | 0.692** | 0.867** |
| | $r_p$ | | | | | | | 1 | 0.586** | 0.821** | 0.750** | 0.518** | 0.072NS | 0.794** | 0.692** | 0.790** |
| CG | $r_g$ | | | | | | | | 1 | 0.906** | 0.929** | 0.774** | 0.439** | 1.000** | 0.768** | 0.945** |
| | $r_p$ | | | | | | | | 1 | 0.663** | 0.570** | 0.492** | 0.242NS | 0.676** | 0.571** | 0.666** |
| CW | $r_g$ | | | | | | | | | 1 | 0.885** | 0.520** | 0.203NS | 0.989** | 0.903** | 0.987** |
| | $r_p$ | | | | | | | | | 1 | 0.745** | 0.573** | 0.148NS | 0.965** | 0.797** | 0.925** |
| NGRPC | $r_g$ | | | | | | | | | | 1 | 0.453** | -0.058NS | 0.833** | 0.983** | 0.938** |
| | $r_p$ | | | | | | | | | | 1 | 0.446** | -0.061NS | 0.723** | 0.866** | 0.854** |
| NGPR | $r_g$ | | | | | | | | | | | 1 | 0.159NS | 0.518** | 0.381** | 0.489** |
| | $r_p$ | | | | | | | | | | | 1 | 0.135NS | 0.560** | 0.387** | 0.519** |
| HSW | $r_g$ | | | | | | | | | | | | 1 | 0.259* | 0.103NS | 0.173NS |
| | $r_p$ | | | | | | | | | | | | 1 | 0.196NS | 0.089NS | 0.144NS |
| BYPP | $r_g$ | | | | | | | | | | | | | 1 | 0.866** | 0.975** |
| | $r_p$ | | | | | | | | | | | | | 1 | 0.196NS | 0.089NS |
| HI | $r_g$ | | | | | | | | | | | | | | 1 | 0.954** |
| | $r_p$ | | | | | | | | | | | | | | 1 | 0.921** |
| GYPP | $r_g$ | | | | | | | | | | | | | | | 1 |
| | $r_p$ | | | | | | | | | | | | | | | 1 |

*DT= days to 50% taselling, DM= days to 50% silking, ASI= anthesis to silking interval, PH= plant height, EH= ear height, CL=Cob length, CG=Cob girth, CW= Cob weight, NGRPC= number of grain rows per cob, NGPR= number of grains per row, HSW=100seed weight, BYPP= biological yield per plant, HI= harvest index, GYPP= grain yield per plant. **\*, \*\* indicates significant level at 5% and 1%, NS= Non significant***

**Table 4. Path coefficient for yield and yield contributing traits of maize**

| Traits | | DT | DS | ASI | DM | PH | EH | CL | CG | CW | NGRPC | NGPR | HSW | BYPP | HI | GYPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DT | $r_g$ | **0.787** | 0.787 | 0.299 | 0.740 | -0.210 | -0.192 | -0.121 | -0.290 | -0.176 | -0.137 | -0.098 | -0.206 | -0.141 | -0.169 | -0.229[NS] |
| | $r_p$ | **0.222** | 0.221 | -0.034 | 0.204 | -0.059 | -0.053 | -0.033 | -0.063 | -0.047 | -0.038 | -0.027 | -0.057 | -0.039 | -0.046 | -0.203[NS] |
| DS | $r_g$ | -0.540 | **-0.540** | -0.216 | -0.508 | 0.153 | 0.145 | 0.095 | 0.215 | 0.139 | 0.109 | 0.075 | 0.141 | 0.115 | 0.134 | -0.262[*] |
| | $r_p$ | -0.157 | **-0.157** | 0.014 | -0.145 | 0.044 | 0.041 | 0.025 | 0.048 | 0.037 | 0.031 | 0.021 | 0.040 | 0.032 | 0.037 | -0.226[NS] |
| ASI | $r_g$ | -0.003 | 0.000 | **0.052** | 0.001 | -0.005 | -0.009 | -0.005 | -0.009 | -0.014 | -0.012 | 0.000 | 0.005 | -0.016 | 0.004 | 0.954[**] |
| | $r_p$ | -0.007 | -0.004 | **0.048** | -0.003 | -0.009 | -0.013 | -0.009 | -0.013 | -0.018 | -0.016 | -0.004 | 0.001 | -0.020 | -0.018 | 0.921[**] |
| DM | $r_g$ | -0.255 | -0.255 | -0.072 | **-0.271** | 0.065 | 0.069 | 0.070 | 0.136 | 0.083 | 0.068 | 0.086 | 0.062 | 0.073 | 0.076 | -0.319[*] |
| | $r_p$ | -0.104 | -0.104 | 0.007 | **-0.113** | 0.026 | 0.027 | 0.025 | 0.042 | 0.030 | 0.027 | 0.033 | 0.025 | 0.028 | 0.030 | -0.271[*] |
| PH | $r_g$ | -0.009 | -0.010 | 0.029 | -0.008 | **0.034** | 0.033 | 0.023 | 0.035 | 0.025 | 0.024 | 0.018 | 0.006 | 0.027 | 0.019 | 0.721[**] |
| | $r_p$ | 0.053 | 0.056 | 0.038 | 0.046 | **-0.200** | -0.195 | -0.127 | -0.157 | -0.142 | -0.135 | -0.103 | -0.034 | -0.150 | -0.107 | 0.661[**] |
| EH | $r_g$ | -0.009 | -0.009 | 0.048 | -0.009 | 0.035 | **0.035** | 0.023 | 0.038 | 0.025 | 0.026 | 0.019 | 0.005 | 0.027 | 0.021 | 0.736[**] |
| | $r_p$ | -0.063 | -0.068 | -0.072 | -0.062 | 0.255 | **0.262** | 0.165 | 0.214 | 0.182 | 0.185 | 0.143 | 0.033 | 0.195 | 0.147 | 0.677[**] |
| CL | $r_g$ | 0.012 | 0.014 | -0.101 | 0.021 | -0.055 | -0.052 | **-0.081** | -0.077 | -0.069 | -0.072 | -0.042 | -0.006 | -0.064 | -0.071 | 0.867[**] |
| | $r_p$ | -0.005 | -0.005 | -0.006 | -0.007 | 0.020 | 0.020 | **0.032** | 0.024 | 0.026 | 0.026 | 0.017 | 0.002 | 0.025 | 0.025 | 0.790[**] |
| CG | $r_g$ | -0.004 | -0.005 | 0.018 | -0.006 | 0.012 | 0.012 | 0.011 | **0.011** | 0.010 | 0.011 | 0.009 | 0.005 | 0.012 | 0.009 | 0.945[**] |
| | $r_p$ | 0.039 | 0.041 | 0.036 | 0.051 | -0.108 | -0.112 | -0.103 | **-0.137** | -0.105 | -0.100 | -0.084 | -0.046 | -0.112 | -0.089 | 0.666[**] |
| CW | $r_g$ | -0.107 | -0.123 | 0.915 | -0.146 | 0.357 | 0.346 | 0.408 | 0.432 | **0.477** | 0.422 | 0.248 | 0.097 | 0.472 | 0.431 | 0.987[**] |
| | $r_p$ | 0.050 | 0.056 | 0.087 | 0.064 | -0.167 | -0.164 | -0.198 | -0.181 | **-0.236** | -0.195 | -0.127 | -0.043 | -0.230 | -0.202 | 0.925[**] |
| NGRPC | $r_g$ | -0.037 | -0.043 | 0.331 | -0.053 | 0.146 | 0.153 | 0.188 | 0.196 | 0.186 | **0.211** | 0.095 | -0.012 | 0.175 | 0.207 | 0.938[**] |
| | $r_p$ | -0.014 | -0.016 | -0.027 | -0.020 | 0.055 | 0.058 | 0.068 | 0.059 | 0.067 | **0.081** | 0.037 | -0.005 | 0.064 | 0.076 | 0.854[**] |
| NGPR | $r_g$ | 0.009 | 0.010 | -0.052 | 0.022 | -0.036 | -0.038 | -0.036 | -0.054 | -0.036 | -0.032 | **-0.070** | -0.011 | -0.036 | -0.027 | 0.489[**] |
| | $r_p$ | 0.001 | 0.001 | 0.000 | 0.001 | -0.002 | -0.003 | -0.002 | -0.003 | -0.003 | -0.002 | **-0.005** | -0.001 | -0.002 | -0.002 | 0.519[**] |
| HSW | $r_g$ | -0.010 | -0.010 | -0.003 | -0.009 | 0.007 | 0.005 | 0.003 | 0.017 | 0.008 | -0.002 | 0.006 | **0.039** | 0.010 | 0.004 | 0.173[NS] |
| | $r_p$ | -0.003 | -0.003 | 0.000 | -0.003 | 0.002 | 0.002 | 0.001 | 0.004 | 0.002 | -0.001 | 0.002 | **0.013** | 0.003 | 0.001 | 0.144[NS] |
| BYPP | $r_g$ | -0.021 | -0.025 | 0.225 | -0.032 | 0.094 | 0.092 | 0.094 | 0.119 | 0.117 | 0.099 | 0.062 | 0.031 | **0.119** | 0.103 | 0.975[**] |
| | $r_p$ | -0.142 | -0.167 | -0.337 | -0.199 | 0.613 | 0.607 | 0.653 | 0.669 | 0.798 | 0.644 | 0.436 | 0.191 | **0.816** | 0.663 | 0.924[**] |
| HI | $r_g$ | -0.047 | -0.054 | 0.415 | -0.061 | 0.121 | 0.127 | 0.190 | 0.167 | 0.196 | 0.214 | 0.083 | 0.022 | 0.188 | **0.217** | 0.954[**] |
| | $r_p$ | -0.088 | -0.100 | -0.157 | -0.115 | 0.228 | 0.238 | 0.339 | 0.277 | 0.364 | 0.398 | 0.163 | 0.041 | 0.345 | **0.425** | 0.921[**] |

*DT= days to 50% taselling, DM= days to 50% silking, ASI= anthesis to silking interval, PH= plant height, EH= ear height, CL=Cob length, CG=Cob girth, CW= Cob weight, NGRPC= number of grain rows per cob, NGPR= number of grains per row, HSW= 100seed weight, BYPP= biological yield per plant, HI= harvest index, GYPP= grain yield per plant. **\*, \*\* indicates significant level at 5% and 1%, NS= Non significant.***
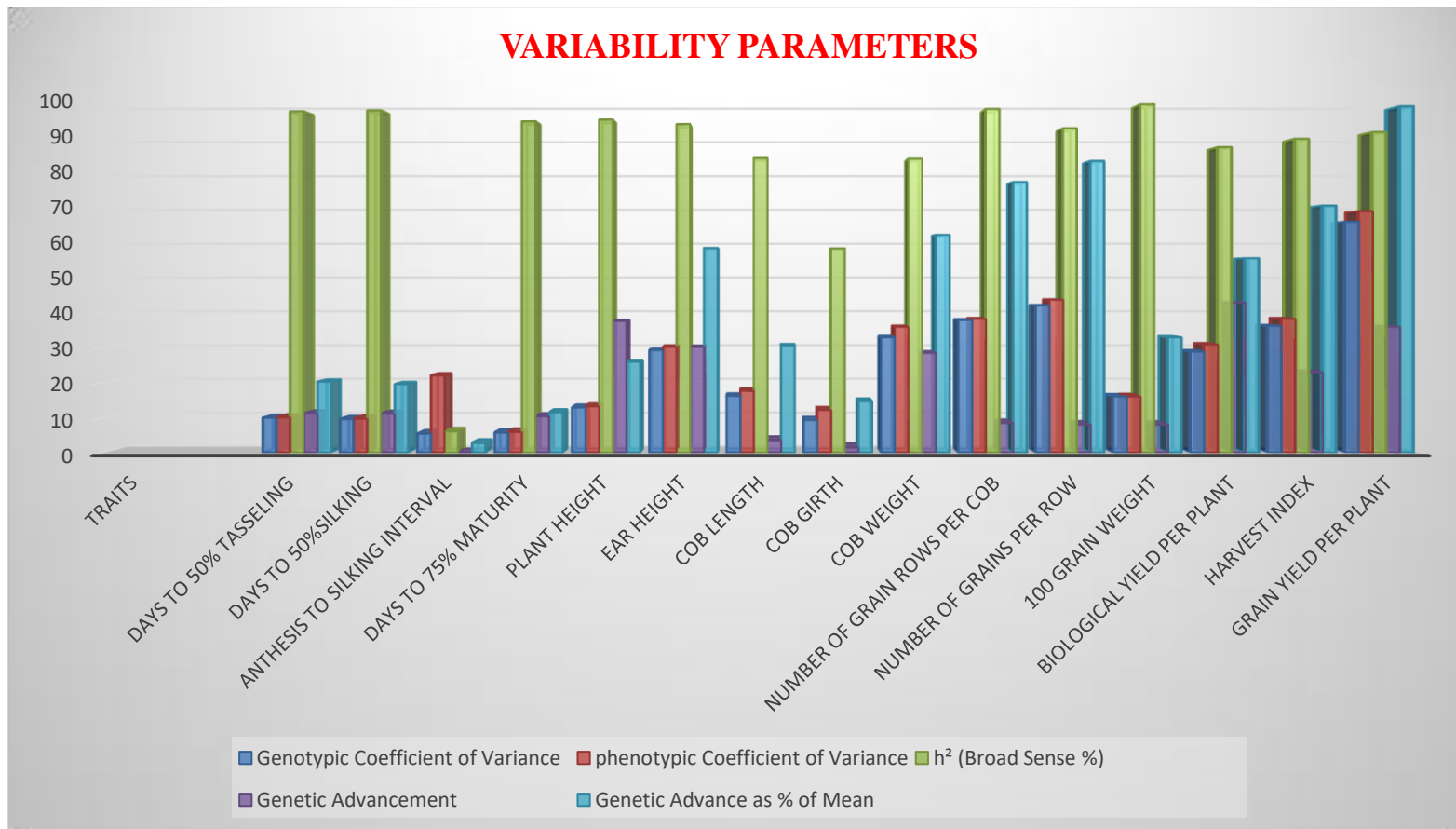
**Fig. 1. Genetic parameters for quantitative traits of maize**

The results of correlation analysis showed significant and non-significant association between yield and other component traits (Table 3). Grain yield per plant was significantly strong association with anthesis to silking interval, plant height, number of grain rows per cob, harvest index, number of grains per row, cob weight, cob girth, cob length and ear height at both levels. These findings were consistent with results of Kapoor et al. [14] for number of grains per row, cob weight, cob girth and Jawaharlal et al. [15] for harvest index, cob length and ear height. Days to maturity significantly positive closely associated with days to 50% silking. This was similar to results of Kumar et al. [16]. Number of grains per row significantly positive strongly associated with harvest index. This was similar to results of Suhaisini et al. [17]. Cob length significantly positive strongly associated with cob weight. This was similar to results of Hemavathy et al. [18]. These results were indicated the grain yield per plant was increased when their component traits performing well.

Path analysis furnished to contribution of component traits for grain yield per plant (Table 4) The days to 50% tasseling had high direct positive effect on grain yield per plant at genotypic level. The cob weight, harvest index moderately positive direct effect on grain yield per plant at genotypic level. These finding were similar with Ferdoush et al. [19] for highly positive direct effect and Sadaiah et al. [20] for moderately positive direct effect. The trait biological yield per plant highly positive directly affect with grain yield per plant at phenotypic level. The traits days to 50% tasseling, ear height, harvest index moderately positive direct effect with grain yield per plant at phenotypic level. These finding were similar with Wali et al. [21] for highly positive direct effect and Chinthiya et al. [22] for moderately positive direct effect. As a result, the features should be regarded as essential selection criteria in all maize improvement programmes and direct selection for the traits is advised for yield improvement [23].

## 4. CONCLUSION

The results revealed that there was considerable variability among the genotypes for all the characters. High GCV and PCV were recorded for grain yield per plant and maximum heritability coupled with high genetic advance was revealed for 100 grain weight. The characters anthesis to sillking interval, plant height, ear height, cob length, cob girth, cob weight, number of grain rows per cob, number of grains per row, biological yield and harvest index exhibited significant and positive correlation with grain yield per plant both at genotypic and phenotypic levels. Anthesis to silking, days to 50% tasselling, ear height, number of grain rows per cob, 100 seed weight, biological yield, harvest index had high direct positive effect on seed yield at both levels. Thus, these characters can be used as selection criteria for improvement in maize genotypes.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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