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# Genetic variability studies in Maize (*Zea mays* L.)

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## Abstract

The present experiment was conducted by using fifty maize genotypes and three checks at Wheat and Maize Research Unit, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. This investigation was carried out during *Rabi* 2024-2025 in randomized block design with two replications. A set of fifty-three maize genotypes were used to estimate genetic variability, for yield and yield attributing characters. Significant variability was observed among the genotypes for all traits studied. Traits such as grain yield per plant (34.71%), anther-silking interval (32.07%) and number of grains per ear (29.42%) exhibited high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), suggesting the presence of substantial genetic variability. High heritability estimates were recorded for most traits, with values ranging from 57% (number of cobs per plant) to 99% (plant height, ear height and number of grains per ear), indicating the effectiveness of selection based on phenotypic performance.

Furthermore, high genetic advance as a percentage of mean was observed for grain yield per plant (70.97%), number of grains per ear (60.56%) and anther-silking interval (55.31%), signifying that these traits are primarily governed by additive gene action and can be improved through direct selection. In contrast, traits such as ear length, ear girth and number of cobs per plant showed moderate to low heritability and genetic advance, suggesting the influence of non-additive gene effects or environmental factors. Overall, the study highlights the scope for genetic improvement in maize, particularly for traits contributing directly to yield and offers valuable insights for maize breeders targeting yield enhancement through effective selection strategies.

**Keywords:** Maize, variability, heritability, genetic advance per mean

## Introduction

Maize (*Zea mays* L.) is a member of the sub-family *Panicoideae* of the family *Poaceae* and tribe *Maydeae*. It is believed to be the native of Central America and Mexico and is evolved from teosinte (*Zea mexicana*). Maize, known as queen of cereals, globally occupies 1st rank in productivity among cereals with 5.82 t/ha followed by 4.66 t/ha of rice and 3.55 t/ha of wheat. Maize, being a C4 plant, is physiologically more efficient with higher per day productivity. It has wider adaptation over different environmental conditions and cultivated from latitude 58° N to 40° S, from mean sea level to higher than 3000 m altitude and in areas receiving 250 mm to 5000 mm yearly rainfall.

Maize (*Zea mays* L.) is the third most significant cereal crop in India after rice and wheat, playing a vital role in providing food, animal feed, fodder, fuel and serving as a key raw material for a variety of industrial products such as starch, oil, proteins, alcoholic beverages, sweeteners, cosmetics and biofuels. This crop is highly adaptable to diverse agro-climatic conditions, thriving from sea level up to elevations exceeding 3000 meters and is a major contributor to crop diversification efforts. At present, maize is cultivated across more than eight million hectares in India, yielding a total production of 16.8 million tons, with an average productivity exceeding 2000 kg per hectare. It accounts for about seven percent of the country's food supply. Maize holds significant value in India's agricultural sector, being used for human consumption (26%), poultry feed (43%), livestock feed (11%), industrial applications (12%) and seed or other purposes (3%).

Maize is a globally important staple crop valued for its high nutritional and industrial utility. It contains approximately 70% carbohydrates, 10% protein, 5-7% fat and 2% minerals, along with essential vitamins such as B-complex, vitamin C, folic acid and provitamin A (beta-carotene), which supports vision and immune function. While maize is rich in micronutrients like iron, zinc, magnesium and phosphorus, it is deficient in lysine and tryptophan essential amino acids. Its variable carotenoid content, especially beta-carotene, enhances its nutritional significance, particularly in regions with limited access to diverse diets. Beyond nutrition, maize has extensive industrial applications, being a source for starch, alcohol, glucose, lactic acid, synthetic materials and animal feed. Green maize is also highly demanded in urban markets.

Grain yield, a complex quantitative trait in maize, is the primary target in most breeding programs. Effective improvement depends on understanding key genetic parameters such as variability, heritability, genetic advance and trait correlations. The presence of sufficient genetic variability in base material is critical for developing high-yielding cultivars. Parameters like phenotypic and genotypic coefficients of variation (PCV and GCV) are essential to quantify trait variability.

## 2. Material and Methods

The experimental material constituted fifty-three maize genotypes acquired from CIMMYT, Mexico (Table 2.1). The sowing was done with 60 × 20 cm inter and intra row spacing and with a plot size of 0.6 m × 4.0m. The seed were sown on 10th December, 2024. These genotypes were sown in Randomized Block Design with two replications. Five competitive plants per genotype in each replication were selected randomly and observations are recorded as per the DUS guidelines.

**Table 2.1:** Details of genotypes pedigree name and their source

| Sr. No | Genotype | Sr. No | Genotype | Sr. No | Genotype |
|---|---|---|---|---|---|
| 1 | V2197-23 | 19 | V2199-11 | 37 | V2201-55 |
| 2 | V2198-1 | 20 | V2199-12 | 38 | V2202-5 |
| 3 | V2198-3 | 21 | V2199-13 | 39 | V2202-7 |
| 4 | V2198-4 | 22 | V2200-5 | 40 | V2202-13 |
| 5 | V2198-5 | 23 | V2200-6 | 41 | V2202-21 |
| 6 | V2198-9 | 24 | V2200-8 | 42 | V2202-26 |
| 7 | V2198-10 | 25 | V2201-1 | 43 | V2202-29 |
| 8 | V2198-13 | 26 | V2201-3 | 44 | V2202-42 |
| 9 | V2198-15 | 27 | V2201-11 | 45 | V2202-44 |
| 10 | V2198-22 | 28 | V2201-17 | 46 | V2202-52 |
| 11 | V2198-23 | 29 | V2201-18 | 47 | V2202-54 |
| 12 | V2198-24 | 30 | V2201-19 | 48 | V2202-55 |
| 13 | V2198-25 | 31 | V2201-22 | 49 | V2203-23 |
| 14 | V2198-27 | 32 | V2201-25 | 50 | V2203-37 |
| 15 | V2199-1 | 33 | V2201-35 | | CHECKS |
| 16 | V2199-5 | 34 | V2201-48 | 51 | PDKV Arambh |
| 17 | V2199-8 | 35 | V2201-51 | 52 | Phule Champion |
| 18 | V2199-9 | 36 | V2201-52 | 53 | Phule Maharshi |

### 2.1 Statistical Analysis

The mean values of each genotype were employed for statistical analysis. The phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV) was estimated as per the formula suggested by Burton (1952) [1]. Heritability percent in broad sense, genetic advance and genetic advance as per cent Mean was estimated by the formula given by Johnson *et al.* (1955). [2]

## 3. Results and Discussion

**Analysis of variance:** The analysis of variance (ANOVA) for twelve quantitative traits among fifty-three maize genotypes revealed highly significant differences ($p<0.01$) for all characters studied, indicating the presence of substantial genetic variability within the experimental material. Traits associated with flowering, namely days to 50% tasseling, days to 50% silking and anthesis-silking interval, exhibited significant mean sum of squares, confirming the existence of genetic variation for earliness. Similarly, growth-related traits such as plant height and ear height showed highly significant differences, with plant height recording the highest treatment mean sum of squares (1160.47), highlighting large genetic diversity. Yield-contributing traits, including ear length, ear girth, number of grains per ear, hundred seed weight, grain yield per plant, number of cobs per plant and shelling percentage, also displayed significant variability, with the number of grains per ear (12754.32) and grain yield per plant (1279.05) registering the largest mean squares. The significant differences observed across all studied traits demonstrate the presence of adequate genetic variability, which is essential for effective selection and improvement in maize breeding programs.

Similar results have been reported by Khan *et al.* (2017) [3], who observed highly significant differences among maize genotypes for tasseling, silking, plant height, ear traits and grain yield under local conditions, confirming the presence of substantial genetic variability. Likewise, Kumar *et al.* (2024) [4] reported significant genotypic mean squares for twelve traits, including flowering, height, kernel traits and yield, emphasizing the potential for effective selection, particularly for traits with high heritability and genetic advance. In another study, Genetic variability and association studies (2023) demonstrated significant variation among 52 maize genotypes for yield and related characters, with anthesis-silking interval, kernel rows, kernels per row, 100-kernel weight and grain yield showing high heritability coupled with high genetic advance, indicating their suitability for direct selection. More recently, Mazloom *et al.* (2025) [7] also confirmed highly significant differences among maize genotypes for physiological and yield-related traits and further grouped genotypes using multivariate analysis to identify superior performers.

**Table 3.1:** Aanlysis of variance for yield and yield contributing characters in fifty-three genotypes of maize

| Source of Variation | Replication | Treatment | Error |
|---|---|---|---|
| **Degrees of freedom** | 1 | 52 | 52 |
| **Mean Sum of Squares** | | | |
| Days for 50% Tasseling | 0.46 | 121.40** | 2.40 |
| Days for 50% Silking | 0.24 | 140.93** | 2.88 |
| Anther silking interval | 0.06 | 1.98** | 0.32 |
| Plant height | 31.40 | 1160.47** | 3.76 |
| Ear height | 97.28 | 465.22** | 3.64 |
| Ear length | 8.43 | 8.00** | 2.72 |
| Ear girth | 46.75 | 6.19** | 2.18 |
| Number of grains per ear | 49.86 | 12754.32** | 7.97 |
| Hundred seed weight | 5.66 | 86.75** | 2.78 |
| Grain yield per plant | 0.10 | 1279.05** | 9.73 |
| Number of cobs per plant | 0.15 | 0.05** | 0.02 |
| Shelling% | 29.14 | 104.60** | 3.58 |

## Mean performance

The mean performance of fifty-three maize genotypes for twelve morphological and yield-related traits revealed considerable variation, indicating the presence of genetic diversity among the tested material. For flowering traits, the average number of days required to attain 50% tasseling and 50% silking were 75.61 and 78.72 days, respectively, with genotypes V2199-5 and V2199-9 being the earliest and V2202-13 and V2202-42 being the latest to flower. The anthesis-silking interval (ASI) ranged from 1.00 to 5.25 days, averaging 3.09 days, where genotypes V2198-9 and V2199-11 exhibited the shortest ASI, while V2202-44 recorded the longest. Plant height varied widely, from 89.80 cm in genotype V2201-51 to 215.50 cm in the check Phule Maharshi, with an overall mean of 133.42 cm. Similarly, ear height ranged from 29.20 cm (V2198-23) to 112.40 cm (Phule Maharshi), averaging 66.11 cm. Ear length and ear girth also exhibited variability, with mean values of 19.16 cm and 14.98 cm, respectively, the longest ear being recorded in V2201-19 (24.50 cm) and the highest girth in V2202-42 (19.80 cm).

Significant variation was also recorded for yield contributing traits. The number of grains per ear ranged from 129.95 (V2201-18) to 459.20 (V2201-25), with a mean of 271.44. Hundred seed weight showed a range between 20.10 g (V2202-29) and 52.35 g (Phule Maharshi), with an average of 34.37 g. Grain yield per plant varied markedly from 35.33 g (V2202-44) to 124.49 g (V2201-51), with a mean of 72.84 g, while the check varieties PDKV Arambh, Phule Champion and Phule Maharshi performed competitively, yielding 110.95 g, 112.60 g and 107.53 g per plant, respectively. The number of cobs per plant ranged between 1.4 (V2198-1, Phule Champion) and 2.2 (V2202-44), with a general mean of 1.87. Shelling percentage showed a wide variation from 55.67% (V2203-37) to 84.65% (V2201-25), averaging 70.26%. Overall, the substantial variability in the mean performance of these genotypes for flowering, growth and yield-related traits highlights the potential of certain lines such as V2201-51, V2201-25, V2202-52 and V2201-48 as promising candidates for future breeding programs aimed at improving yield potential and adaptability.

**Table 3.2:** Mean values of fifty-three genotypes for different yield attributing characters in maize under field conditions

| Sr. No | Genotypes | DT | DS | ASI | PH | EH | EL | EG | NGPE | HSW | NCPP | SP | GYPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | V2197-23 | 77.00 | 79.50 | 2.50 | 132.70 | 68.20 | 22.50 | 14.70 | 171.80 | 26.00 | 1.60 | 63.64 | 65.80 |
| 2 | V2198-1 | 71.00 | 73.00 | 2.00 | 157.20 | 85.50 | 22.50 | 18.40 | 174.10 | 28.60 | 1.40 | 82.96 | 62.70 |
| 3 | V2198-3 | 66.00 | 69.50 | 3.00 | 133.10 | 60.20 | 17.65 | 14.65 | 147.20 | 26.10 | 1.80 | 67.46 | 52.70 |
| 4 | V2198-4 | 74.50 | 77.50 | 2.50 | 130.90 | 59.20 | 18.15 | 14.80 | 149.55 | 37.55 | 1.70 | 71.08 | 60.95 |
| 5 | V2198-5 | 75.50 | 79.00 | 3.50 | 99.40 | 41.60 | 20.90 | 16.80 | 320.90 | 31.00 | 2.00 | 78.63 | 106.15 |
| 6 | V2198-9 | 71.00 | 73.00 | 1.00 | 142.00 | 74.35 | 19.05 | 17.20 | 307.50 | 35.75 | 1.70 | 76.84 | 99.43 |
| 7 | V2198-10 | 69.50 | 72.00 | 2.50 | 124.40 | 53.90 | 20.60 | 13.95 | 266.65 | 40.15 | 1.90 | 81.95 | 104.80 |
| 8 | V2198-13 | 68.50 | 70.50 | 2.00 | 125.40 | 56.80 | 21.05 | 14.10 | 304.65 | 41.30 | 1.80 | 75.94 | 83.03 |
| 9 | V2198-15 | 71.50 | 75.00 | 3.50 | 137.60 | 63.70 | 21.25 | 16.90 | 257.50 | 40.35 | 1.70 | 62.00 | 79.13 |
| 10 | V2198-22 | 69.00 | 71.50 | 2.50 | 138.00 | 51.40 | 17.70 | 17.10 | 372.85 | 45.80 | 1.70 | 67.21 | 66.78 |
| 11 | V2198-23 | 72.00 | 73.50 | 1.50 | 97.60 | 29.20 | 17.75 | 14.15 | 254.20 | 26.85 | 1.90 | 66.32 | 55.72 |
| 12 | V2198-24 | 73.50 | 75.00 | 3.50 | 122.90 | 68.10 | 20.70 | 17.70 | 326.35 | 35.30 | 1.90 | 77.41 | 93.79 |
| 13 | V2198-25 | 73.50 | 76.50 | 2.50 | 131.80 | 72.40 | 18.75 | 16.90 | 223.65 | 38.10 | 1.90 | 64.27 | 84.03 |
| 14 | V2198-27 | 67.50 | 70.00 | 2.00 | 140.20 | 82.05 | 22.50 | 13.15 | 214.15 | 37.20 | 1.80 | 73.08 | 63.63 |
| 15 | V2199-1 | 72.50 | 75.50 | 2.00 | 103.70 | 41.60 | 21.50 | 12.05 | 314.25 | 27.80 | 1.90 | 65.29 | 48.71 |
| 16 | V2199-5 | 61.50 | 63.00 | 1.50 | 133.80 | 68.40 | 17.40 | 13.40 | 377.00 | 46.00 | 1.90 | 65.54 | 43.83 |
| 17 | V2199-8 | 70.00 | 73.00 | 3.00 | 124.00 | 54.95 | 18.40 | 12.85 | 298.70 | 31.75 | 1.70 | 67.20 | 40.58 |
| 18 | V2199-9 | 61.50 | 64.00 | 2.50 | 107.30 | 64.60 | 18.05 | 12.90 | 322.70 | 37.45 | 1.90 | 71.44 | 79.58 |
| 19 | V2199-11 | 65.00 | 66.00 | 1.00 | 109.50 | 51.20 | 19.50 | 13.30 | 324.40 | 23.15 | 1.80 | 65.44 | 71.46 |
| 20 | V2199-12 | 66.00 | 68.00 | 2.00 | 126.30 | 59.55 | 16.85 | 15.70 | 260.60 | 25.70 | 1.90 | 64.44 | 85.38 |
| 21 | V2199-13 | 69 | 72.5 | 2.5 | 116.8 | 63.05 | 17.1 | 11.9 | 282.5 | 33.15 | 1.7 | 77.4 | 60.29 |
| 22 | V2200-5 | 70.5 | 72.5 | 2 | 123.1 | 62.15 | 19 | 15.45 | 182.9 | 28.5 | 2.1 | 79.4 | 53.38 |
| 23 | V2200-6 | 72.5 | 75 | 2.5 | 103.8 | 41.5 | 21.3 | 17.25 | 313.8 | 23.6 | 2 | 70.84 | 49.88 |

| Sr. No | Genotypes | DT | DS | ASI | PH | EH | EL | EG | NGPE | HSW | NCPP | SP | GYPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | V2200-8 | 73.5 | 75 | 1.5 | 110.8 | 57.4 | 20.75 | 14.7 | 177.8 | 38.2 | 2 | 72.73 | 54.23 |
| 25 | V2201-1 | 62 | 64.5 | 2.5 | 129.3 | 59.1 | 20.2 | 16.25 | 193.2 | 42.25 | 1.9 | 67.77 | 53.37 |
| 26 | V2201-3 | 81.5 | 86 | 5.15 | 138.3 | 61 | 18.4 | 13.3 | 149.5 | 42 | 2.1 | 61.36 | 49.08 |
| 27 | V2201-11 | 86.5 | 91 | 4.75 | 137.1 | 57.1 | 19.8 | 16.6 | 360.8 | 32 | 1.9 | 80.18 | 53.47 |
| 28 | V2201-17 | 79 | 83 | 3.75 | 120.2 | 59.3 | 18.7 | 15.7 | 135.5 | 35.65 | 1.9 | 61.48 | 64.95 |
| 29 | V2201-18 | 79.5 | 83 | 3.3 | 134.4 | 61.6 | 18.8 | 13.15 | 129.95 | 33.75 | 1.8 | 68.93 | 77.74 |
| 30 | V2201-19 | 76 | 79 | 3.5 | 123.9 | 63.88 | 24.5 | 16.9 | 326.75 | 31.3 | 1.9 | 61.56 | 70.95 |
| 31 | V2201-22 | 70.5 | 73.5 | 3.05 | 130 | 67.05 | 21.9 | 15.2 | 243.5 | 36.8 | 2.1 | 79.49 | 65.1 |
| 32 | V2201-25 | 80.5 | 84 | 3.75 | 136.1 | 73.5 | 17.75 | 14.75 | 459.2 | 40.75 | 2 | 84.65 | 115.21 |
| 33 | V2201-35 | 83.5 | 87 | 3.9 | 136.4 | 68.75 | 17.3 | 17.7 | 265.4 | 30.8 | 1.9 | 66.63 | 54.12 |
| 34 | V2201-48 | 74 | 77.5 | 3.85 | 132.25 | 68.8 | 18.9 | 16 | 347.45 | 39.5 | 1.9 | 82.51 | 121.35 |
| 35 | V2201-51 | 84.5 | 88 | 3.75 | 89.8 | 50.5 | 21.15 | 14.8 | 257.15 | 44 | 1.8 | 73.83 | 124.49 |
| 36 | V2201-52 | 86.5 | 90.5 | 3.9 | 147.1 | 69.7 | 19.9 | 14.95 | 381.1 | 41.5 | 2 | 79.59 | 72.16 |
| 37 | V2201-55 | 86 | 89.5 | 3.5 | 148.3 | 77.45 | 18.1 | 12.7 | 303.7 | 41.4 | 1.8 | 76.8 | 119.33 |
| 38 | V2202-5 | 87.5 | 91 | 3.75 | 136.9 | 61 | 20.95 | 13.75 | 353.5 | 31.5 | 1.9 | 64.6 | 102.86 |
| 39 | V2202-7 | 82.5 | 86.5 | 3.9 | 103.2 | 52.8 | 15.9 | 12.2 | 277.7 | 25.55 | 1.8 | 57.02 | 40.48 |
| 40 | V2202-13 | 90 | 93 | 2.9 | 123.7 | 63.5 | 16.7 | 15 | 315 | 29.45 | 2 | 63.01 | 41.14 |
| 41 | V2202-21 | 81.5 | 84.5 | 3.05 | 134.3 | 71.7 | 18.2 | 14.6 | 223.05 | 33 | 2 | 70.385 | 75.31 |
| 42 | V2202-26 | 80.5 | 84 | 3.5 | 158.8 | 70.35 | 21.5 | 13.9 | 270 | 33.4 | 2 | 70.625 | 68.245 |
| 43 | V2202-29 | 83.5 | 87 | 3.5 | 141.5 | 75.3 | 17.8 | 15.25 | 232.8 | 20.1 | 1.9 | 69.155 | 52.01 |
| 44 | V2202-42 | 89 | 93 | 3.9 | 137.7 | 76.3 | 19.9 | 19.8 | 138.2 | 34.7 | 2.1 | 61.36 | 51.355 |
| 45 | V2202-44 | 79.5 | 84 | 5.25 | 148.05 | 91.5 | 16.4 | 17 | 312.4 | 27.05 | 2.2 | 77.43 | 35.33 |
| 46 | V2202-52 | 84 | 88 | 3.75 | 145 | 80.2 | 18.4 | 14.8 | 378.45 | 28.7 | 2 | 66.96 | 121.5 |
| 47 | V2202-54 | 85 | 89 | 3.9 | 152 | 73.7 | 18.9 | 15.8 | 317.15 | 31.6 | 1.9 | 75.07 | 81.98 |
| 48 | V2202-55 | 86.5 | 91 | 4.25 | 108.6 | 53.4 | 18.2 | 14.5 | 140.85 | 36.95 | 2 | 67.91 | 39.15 |
| 49 | V2203-23 | 77.5 | 82.5 | 4.75 | 146.8 | 73.2 | 19.8 | 12.3 | 292 | 37.55 | 1.9 | 56.67 | 62.62 |
| 50 | V2203-37 | 85 | 89 | 3.9 | 135.3 | 74.7 | 18.5 | 14.9 | 173.2 | 35.75 | 1.9 | 55.67 | 50.25 |
| 51 | PDKV Arambh | 66.5 | 70.5 | 3.8 | 204.25 | 103.25 | 14.9 | 14.7 | 373 | 33.8 | 1.5 | 73.94 | 110.95 |
| 52 | Phule Champion | 67 | 70.5 | 3.75 | 204.4 | 102.2 | 15.1 | 13.9 | 360.7 | 32.85 | 1.4 | 69.89 | 112.6 |
| 53 | Phule Maharshi | 70 | 72.5 | 2.75 | 215.5 | 112.4 | 17.9 | 13.7 | 329.35 | 52.35 | 2 | 71.32 | 107.53 |
| Range Lowest | | 61.5 | 63 | 1 | 89.8 | 29.2 | 14.9 | 11.9 | 129.95 | 20.1 | 1.4 | 55.67 | 35.33 |
| Range Highest | | 90 | 93 | 5.25 | 215.5 | 112.4 | 24.5 | 19.8 | 459.2 | 52.35 | 2.2 | 84.65 | 124.49 |
| Mean | | 75.61 | 78.73 | 3.1 | 133.42 | 66.12 | 19.16 | 14.98 | 271.44 | 34.37 | 1.87 | 70.27 | 72.84 |
| C.V. (%) | | 2.05 | 2.16 | 18.33 | 1.57 | 3.55 | 8.87 | 11.72 | 1.1 | 4.95 | 8.51 | 2.9 | 4.28 |
| C.D. at 5% | | 3.12 | 3.41 | 1.14 | 4.2 | 4.71 | 3.41 | 3.52 | 5.99 | 3.41 | 0.32 | 4.08 | 6.26 |

DT- Days to 50% tasseling, DS- Days to 50% silking, ASI - Anthesis silking interval, PH - Plant height, EH - Ear height, EL - Earlength, EG - Ear girth, NGPE - Number of grains per ear, HSW - Hundred seed weight, NCPP - Number of cobs per plant, SP-Shelling percentage, GYPP- Grain yield per plant.

## Variability studies

The variability studies of fifty-three maize genotypes for twelve quantitative traits revealed substantial differences in genotypic and phenotypic variances, heritability and genetic advance, indicating varying levels of genetic control. Flowering traits such as days to 50% tasseling and days to 50% silking exhibited low GCV and PCV values, but both traits recorded very high heritability (>97%) along with moderate genetic advance, suggesting that they are largely governed by additive gene action and may respond to selection, though with limited efficiency. In contrast, the anthesis silking interval (ASI) showed high GCV (29.34%) and PCV (32.07%), coupled with high heritability (83%) and genetic advance (55.31%), confirming its effectiveness for direct selection and its importance under stress breeding programs. Plant height and ear height displayed high heritability (>99%) with substantial genetic advance (>37%), suggesting additive gene action and suitability for selection-based improvement.

Yield contributing traits exhibited notable genetic variability. Ear length and ear girth recorded moderate heritability (66% and 64%) with low to moderate genetic advance, implying a complex mode of inheritance involving non-additive gene action. In contrast, the number of grains per ear, 100-seed weight and grain yield per plant showed very high heritability (>96%) and high genetic advance, reflecting the predominance of additive genetic effects and their reliability for improvement through direct selection. The number of cobs per plant exhibited moderate heritability (57.90%) with low genetic advance, suggesting environmental influence and limited scope for direct selection. Shelling percentage showed high heritability (96.60%) with moderate genetic advance (20.47%), indicating additive genetic control and potential utility in selection. Overall, traits such as ASI, number of grains per ear, 100-seed weight and grain yield per plant were identified as the most promising traits for effective genetic improvement, whereas traits with low to moderate heritability and genetic advance such as ear length, ear girth and number of cobs per plant may require alternative breeding strategies, including heterosis or recurrent selection.

These results are in close agreement with the findings of Mishra *et al.* (2023) [8] and Ogunniyan and Olakojo (2015) [9], who also reported high heritability and genetic advance for ASI and grain yield, highlighting their potential in selection and stress-breeding programs. Similarly, Kumar *et al.* (2024) [4] observed high heritability and genetic advance for plant height, ear height and kernel yield per plant, supporting their effectiveness in selection-based improvement. In contrast, traits such as days to 50% tasseling and silking in the present study displayed low GCV and PCV but very high heritability with moderate genetic advance, a pattern also noted by Magar *et al.* (2021) [6], indicating that these traits may respond to selection, but with limited efficiency. Further, traits such as ear length, ear girth and number of cobs per plant, which showed moderate heritability and low to moderate genetic advance, appear to be under non-additive gene control, consistent with the observations of Kumar *et al.* (2024) [4]. Overall, the consistency of these findings across multiple studies underscores the importance of traits such as ASI, number of grains per ear, 100-seed weight and grain yield per plant as promising selection criteria for effective genetic improvement in maize.

**Table 3.3:** Estimates of variability parameters for twelve characters for yield and yield contributing characters in fifty-three genotypes of maize

| Sr. No | Characters | Mean | Range | | Phenotypic Variance | Genotypic Variance | PCV (%) | GCV (%) | Heritability in broad sense ($H^2$) (%) | Genetic Advance as 5% of mean |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | | | | | | |
| 1 | Days for 50% Tasseling | 75.61 | 61.50 | 90 | 60.70 | 59.50 | 10.30 | 10.20 | 98 | 20.80 |
| 2 | Days for 50% Silking | 78.72 | 63.00 | 93 | 70.46 | 69.02 | 10.66 | 10.55 | 97 | 21.51 |
| 3 | Anther silking interval | 3.09 | 1.00 | 5.25 | 0.98 | 0.82 | 32.07 | 29.34 | 83 | 55.31 |
| 4 | Plant height | 133.42 | 89.80 | 215.5 | 580.24 | 578.35 | 18.05 | 18.02 | 99 | 37.07 |
| 5 | Ear height | 66.11 | 29.20 | 112.4 | 232.61 | 230.78 | 23.06 | 22.97 | 99 | 47.14 |
| 6 | Ear length | 19.15 | 14.90 | 24.5 | 4.00 | 2.64 | 10.44 | 8.48 | 66 | 14.20 |
| 7 | Ear girth | 14.98 | 11.90 | 19.8 | 3.09 | 2.00 | 11.73 | 9.44 | 64 | 15.64 |
| 8 | Number of grains per ear | 271.43 | 129.95 | 459.2 | 6377.16 | 6373.18 | 29.42 | 29.41 | 99 | 60.56 |
| 9 | Hundred seed weight | 34.36 | 20.10 | 52.35 | 43.37 | 41.98 | 19.16 | 18.85 | 96 | 38.21 |
| 10 | Grain yield per plant | 1.87 | 1.40 | 2.2 | 639.53 | 634.66 | 34.71 | 34.58 | 90 | 70.97 |
| 11 | Number of cobs per plant | 70.26 | 55.66 | 84.645 | 0.02 | 0.01 | 8.72 | 6.63 | 57 | 10.40 |
| 12 | Shelling percentage | 70.26 | 35.33 | 124.49 | 52.29 | 50.50 | 10.29 | 10.11 | 96 | 20.47 |

**GCV** = Genotypic coefficient of variation, **PCV** = Phenotypic coefficient of variation.

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