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# Genetic variability and Trait associated in Maize in Eastern U.P. conditions of Northern India

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**ABSTRACT: The population of the country is increasing at an immense rate, and agricultural land is being the limiting factor, thus increase in productivity of maize is a key important but nowadays the nutrient and the yield of the crop is low due to abiotic and abiotic stress. This is the main reason for low yield in the maize in eastern U.P. region. therefore, to refill the research gap the experiment was conducted on genetic variability parameters, correlation, and path analysis in fifteen maize genotypes for twenty quantitative traits and yield characters in *Rabi* 2021-2022. The Experiment was conducted in a Randomized Complete Block Design and replicated thrice. The Analysis of variance for all twenty quantitative characters revealed that treatment differences were highly significant under study at 1% level of significance with exception of days to 50% tasseling. Genotypes MZ1908, MZ1914 and NBPGR 36548 depicted highest grain yield. The values of PCV were higher than GCV, moreover, values for all the characters and large difference between the values of PCV and GCV are number of leaves per plant, leaf width, cob length, cob diameter, number of kernel rows per cob, dry weight, fresh weight, and biological yield therefore, these indicated that the environmental factors significantly influenced the expression of these traits. All the traits studied had more heritability, genetic advance at 5% selection intensity and genetic advance as percent of mean and high expected heritability was found in number of cobs per plant where as the higher genetic advance was found in weight of cob. Correlation studies have shown that selection based on weight of cob, biological yield and 100 seed weight has a positive correlation and direct effects with grain yield per plant at phenotypic level. Biological yield (g),weight of cob (g), Seed index (100 seed weight (g)), number of kernels per row and leaf width. Therefore, effective selection can be attempted for these traits which would help in improvement of grain yield in maize genotypes suitable for rabi season.**

**Keywords:** PCV, GCV, Heritability, Genetic advance, Correlation studies.

## INTRODUCTION

Maize (*Zea mays* L.) is a highly significant and emerging crop that can adapt well to various agro-climatic conditions. It is the world's third most important crop, following Wheat and Rice and is often referred as Queen of Cereals. Norman. E. Borlauga renowned scientist, believes that, maize has the highest potential for yield among all cereals. However in the 2019-2020 around 9.7 million hectares of land was covered with maize in India with a national average productivity of 2.9 tones per hectare and production of 28.6 million tones. This is still far below the world average of 5.1 tons per hectare (Department of Agriculture Cooperation, 2020). In Uttar Pradesh, maize occupies an area 0.73 million hectares with an average productivity of 1.67 tones per hectare and a production of 1.23 million tons. (The International Plant Nutrition Institute (IPNI), Regional Profiles-India, 2018). Plant breeding primarily focuses on assessing and utilizing of genetic variability, selecting of desirable types and testing superior genotypes. To effectively allocate resources for selecting desired traits, it is important to estimate heritability, which allows for maximum genetic gain with minimal time and resources (Smalley *et al.*, 2004). The study of genetic parameters such as coefficient of variation due to genotype, coefficient of variation due to phenotype and heritability provides a clear understanding of t the extent of variability present in a plant population and the efficiency of selection of genotypes based on phenotype in a highly variable population (Bocanski *et al.,* 2009). The knowledge on genetic variability parameters, includes coefficient of variation due to phenotype (PCV), coefficient of variation due to genotype (GCV), heritability is a main pre-requisite for any plant breeder to work with crop breeding programs **(**Shankar *et al.,* 2018). The study of coefficient of variation due to phenotypic character (PCV) and coefficient of variation due to genotypic character (GCV) is useful for comparing the amount of phenotypic and genotypic variations among different traits and estimating the potential for improvement through selection. The selection of breeding program parameters among other factors depend on the magnitude of their coefficient of variations particularly the genotypic coefficient of variation (Bello *et al.*, 2012). In plant breeding experiments, the correlation coefficient is a statistical measure used to determine the degree and direction of association between two characters. It helps whether the relationship is positive or negative and the strong or weak the relationship can be judged by using coefficient of correlation (Bello *et al.,* 2010). Path-coefficient analysis is a valuable tool for establishing the exact correlation in terms of cause and effect. It helps determine the relative importance of direct and indirect effects of measured traits on grain by partitioning both direct and indirect effect. Path coefficient analysis measures the influence of one trait on another by means of partitioning both direct and indirect effects. Therefore, both correlation and path coefficient analysis are useful in identifying the appropriate traits for selection and improvement of the complex characteristics such as yield (Ghosh *et al.,* 2014).

## MATERIALS AND METHOD

*A. Site selection for research material*

From November 2021 to March 2022, an experiment was conducted in the field experimentation station center in SHUATS college located in Naini, Prayagraj, Allahabad, Uttar Pradesh Geographically, it is located at 25.414878 °N and 81.845190 °E in the southern part of the Uttar Pradesh at an elevation of 98 meters (322 ft) and stands at the junction of two rivers, the Ganges and Yamuna. The soil in this area has been analyzed both physically and chemically revealing that soils are sandy loamy soils. The temperatures at the location site ranged from 8.03°C to 37.06°C (Krishi Vigyan Kendra, Allahabad) with an average of 24.69°C, at the experimental site. Rainfall totaled 2.63 mm on average. The maximum and minimum temperatures observed during the crop growing season were in March (37°C) and November (8°C), respectively. Similarly, the greatest precipitation (22mm) and relative humidity (95%) in January were recorded in respectively (Agro-meteorological Observatory Unit, College of Forestry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Allahabad) - 211007).

*B. Selection of experimental design*

The planting genotypes includes *MZ*1908, MZ1909 MZ1910, MZ1911, MZ1912, MZ1913, MZ1914, MZ1915, MZ1916, MZ1917, NBPGR 53000NBPGR 36548, NBPGR 32809, NBPGR36548-1, HKI 1-3, HQPM-5(CHECK). these genotypes were obtained from the Directorate of Research SHUATS, Prayagraj. The experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications. Each Individual plots consisted of 3 rows of 4cm length, with a spacing of 60 cm × 60 cm (row to row × plant to plant).

*C. Data collection and observations*

From ten randomly selected plants from each experimental plot data was collected. These selected plants were observed for phenological traits (Days to silking, days to tasseling, and anthesis to silking interval (ASI)), biometrical traits (plant height, leaf parameters, cob length, cob width, and cob diameter), and yield attributing traits (number of cobs per plant, number of kernel rows per cob, number of kernels per rows, 100 grain weight). grain yield (kg $ha^{-1}$), Biological yield and fodder parameters (Fresh weigh, Dry weight) were recorded.

*D. Data observation and analyzing*

Following the collection of data grain yield (kgs $^{-1}$) was computed using the formula proposed by Bartaula *et al.* (2019); Carangal *et al.* (1971); Shrestha *et al.* (2018) with standardization with 15% grain moisture. The data on all characters were subjected to standard analysis of variance methods (Panse and Sukhatme 1967). Genotypic and phenotypic coefficients of correlation (Singh and Chaudhary 1985), broad sense heritability (Johnson *et al.,* 1955), genetic advance (Burton, 1952), and genetic advance as a percentage of mean (Johnson *et al*., 1955) were also calculated. The experimental data was processed using Excel 2010 and R- studio 3.5.0, and analyzed using SPSS 20. The analysis was performed using a Randomized Complete Block Design (RCBD). The means of the treatment were compared using the least significant difference (LSD) at a 5% level of significance (Gomez and Gomez 1984).

## RESULT AND DISCUSSION

Field studies were conducted to find out the genetic variability and correlations in agro and morphological traits in maize genotypes. The findings were studied, assessed, and reviewed, with evidence from earlier studies to back them up.

*A. Analysis of variance (ANOVA)*

The mean data for eleven characters were subjected to Analysis of Variance (ANOVA) for the design of experiment. The ANOVA for different characters indicated that the mean sum of squares of treatments, showed significant differences among the genotypes at 1% and 5% levels of significance for all the characters except for days to 50% tasseling This suggests that the selected genotypes were quite variable and a considerable amount of variability existed. The existence of significant genetic variability among the treatments for all the quantitative characters studied was also noticed by Anshuman *et al*. (2013); Zaman and Alam (2013).

*B. Genotypic and Phenotypic variation*

The data presents estimate of variability parameter for different morphological, physiological and yield trails.

The phenotypic and genotypic variation ranged from 29.42% to 1.12% and 35.01 % to 1.87% for the studied characters, respectively. Comparatively high genotypic coefficient of variation was observed in the number of cobs (29.42%) and weight of cobs (26.2%). On other hand higher phenotypic coefficient of correlation was seen in grain yield per plant (35.01%), number of cobs (30.33%), weight of cobs (26.98%), anthesis and silking Interval (25.15%), shank weight (22.5%), and 100 seed weight (20.96%). genotypes based on these traits may be effective and their phenotypic expression would align with the genotypic potential (Singh *et al*., 1994). furthermore, there were nominal differences in traits such as days to 50% tasseling, days to 50% silking, plant height and cob length between PCV and GCV indicating a low influence of environment on the expression of these traits. However, traits like leaf width (3.61), dry weight (2.17) showed wide differences in PCV and GCV suggesting a considerably higher environmental influence on these traits. For all the trait, phenotypic coefficient of variation was higher than the genotypic coefficient of variation indicating that the performance of these characters is influenced by the environment. Based on the above findings it can be concluded that there is an adequate amount of variability among the genotypes making direct selection effective for improving these traits. According to Deshmukh *et al.* (1986); GCV and PCV values are classified as high (>20%), medium (10-20%) and low (<10%) the above readings. The maximum value of PCV for grain yield per plant was previously confirmed by Reddy *et al*. (2012) and for plant height by Ghosh *et al*. (2014); Maruthi and Jhansi (2015).

**Heritability.** In our findings, we found that heritability ranged from 95.7% in grain yield per plant to 36.17 in days to 50% tasseling. The heritability was calculated as high (more than 60%), moderate (30 –60%) and low (less than 30%) as studied by Johnson *et al.,* (1955). Similarly high heritability estimates were found in grain yield per plant (95.7%), number of cobs per plant (94.09%), anthesis to silking interval (93.42 %), weight of cob (90.86%), 100 seed weight (90.7%), days to 50% tasseling, cob length (68.93%), cob diameter (54.95%) and moderate for days to 50% silking (36.17%), number of kernels per row (55.2%) and biological yield (60.48%). Low heritability was found in days to 50 % silking (36.1), days to 50% tasseling (36.04), plant height (36.19), days to maturity (35.18). The presence of high heritability for several traits indicated less influence of the environment on these traits. Thus, selecting these genotypes on phenotypic performance will be effective for further improvement of these characters whereas improving low heritable traits through selection is difficult.

*C. Phenotypic and Genotypic coefficient of Correlation for qualitative characters in maize*

Association analyses were conducted to examine the correlation between various morphology and physiological traits at both phenotypic and genotypic levels. The results showed that genotypic correlation coefficients were generally higher than phenotypic coefficient of correlations, indicating that the strong intrinsic association is reduced at the phenotypic level due to environmental effects. his findings is consistent with a study by Bhiusal *et al*. (2017) in Table 3. In terms of phenotypic correlation Grain yield per plant was significant and positively associated with Weight of cob (0.95**) and Biological yield (0.75**), Leaf width (0.376*), Number of cobs per plant (0.387*), Number of kernel rows per cob (0.492*), Shank weight (0.29*), Fresh weight (0.295*), Dry weight (0.299**). On other hand 100 seed weight (0.74) and anthesis silking interval (0.207) showed positive and non-significant association .Days to 50% tasseling (-0.21), Days to 50% silking (-0.17), Plant height (-0.14) Number of leaves per plant (-0.04), Leaf length (-0.03), Days to maturity (-0.11), Cob length (-0.05) and Number of grains per row (-0.03) were non-significantly and negatively association with plant grain yield. These findings align with the previous studies on 100-seed weight (Kumar *et al.,* 2006; Pavan *et al.,* 2011) plant height (Jayakumar *et al*., 2007), number of kernel rows per ear (Ravi *et al*., 2012). Estimates of the genotypic correlation for traits are shown in (Table 4). It was observed that plants grain yield shows significant and positive association at genotypic level with), Weight of cob (g) (0.97**), Biological yield (0.95**), 100 seed weight (g) (0.79**) and Number of kernels per row (0.59**), positive and non- significance was showed by Anthesis to silking interval (0.247), Leaf width (0.57). Cob diameter (0.24), While Days to 50% tasseling (-0.30*), Plant height (-0.36*) is significant and negative association with grain yield negative and non-significance with grain yield was showed by Day to 50% silking (-0.27), Leaf length (-0.06), Cob length (0.057), Cob diameter (-0.26), Number of leaves (-0.06), Days to maturity (-0.23), Cob length (0.05), Number of grains per row (-0.26) were non-significant and negative association with grain yield. These observations are in conformity with the findings of 100-seed weight (Kumar *et al.*, 2006; Pavan *et al.,* 2011), number of kernels per row (Sadek *et al*., 2006) and days to maturity were negatively correlated with grain yield per plant and are similar to the results reported by Umakanth and Sunil (2000); Pavan *et al.* (2011). The Genetic association among grain yield and yield components suggest that each trait could be indirectly selected for grain yield improvement. These traits are of great economic important to maize breeders and are considered during the selection process for grain improvement. similar findings have been reported Kumar *et al*. (2006); Pavan *et al*. (2011) regarding the phenotypic and genotypic effect-on quantitative traits in maize.

*D. Direct and Indirect Effect of Quantitative Traits Attaining to Grain Yield in Maize at Phenotypic level and genotypic level*

According to Table 6 the phenotypic correlation coefficient of different characters with grain yield was portioned into their direct and indirect effect. At phenotypic level, a positive direct effect on grain yield was found for weight of cob (gms) (0.95), 100 seed weight (0.74), biological yield (0.75) and number of kernels per row (0.43), anthesis to silking interval

(0.20), leaf width (0.37*), number of cobs per plant (0.387*), cob diameter (0.18*), number of kernel rows per cob (0.429*), shank weight (0.745*), dry weight (0.299*), fresh weight (0.295*) also showed appositive direct effect. On other hand, number of grains per row (-0.23), days to 50% tasseling (-0.21), days to 50% silking (-0.17), plant height (-0.14) days to maturity (-0.11), number of leaves per plant (-0.04), leaf length (-0.02) exhibited a negative direct effect on grain yield. In Table 7 genotypic correlation coefficient of different characters with grain yield was also partioned into their direct and indirect effect. At the genotypic level, a positive direct effect on grain yield was found for anthesis to silking interval (0.24), leaf width (0.572**), number of cobs per plant (0.402**), cob diameter (0.24), weight of cob (0.97), 100 seed weight (0.78) and number of kernel rows per cob (0.59), shank weight (0.786**), and fresh weight (0.346*), biological yield (0.949**) also showed a positive direct effect. conversely number of grains per row (-0.26), days to 50% tasseling (-0.30*), days to 50% silking (-0.27), plant height (-0.36*), days to maturity (-0.23), number of leaves per plant (- 0.048), leaf length (-0.0623), cob length (-0.057),and number of grains per row (-0.26) exhibited a negative direct effect on grain yield.

According to Table 6 the Phenotypic correlation coefficient of different characters with grain yield was also partioned into their direct and indirect effect at the genotypic level. At the phenotypic level, a positive direct effect on grain yield was found for weight of cob (0.974), biological yield ( 0.95**), 100 seed weight(0.78**), leaf width (0.572*), number of cobs per plant (0.40**) and cob diameter (0.24) on other hand days to 50% tasseling (- 0.307*), plant height (-0.36*) and number of grain per row (-0.27) showed a negative direct effect on grain yield. These observations are in conformity with the findings of others related to days to 50 percent tasseling (Venugopal *et al*., 2003) 100-seed weight (Kumar *et al*., 2006), cob length (Pavan *et al.*, 2011), number of kernels per row (Raghu *et al*., 2011), cob height (Raghu *et al.*, 2011), number of kernel rows per cob (Devi *et al.*, 2001), and plant height (Kumar *et al*., 2006). The high direct effects of these traits appeared to be the main reason for their strong association with grain yield. Hence, selection can be done directly for these traits which would be more effective. Days to 50 percent silking exhibited negative direct effect on grain yield and indicated that selection for high yield can be done by indirect selection through yield components.

**Table 1: ANOVA for various Quantitative Character of Maize.**

| Sr. No. | Character | Mean sum of square | | |
|---|---|---|---|---|
| | Source | **Replication** | **Treatment** | **Error** |
| | Degrees of freedom | 2 | 15 | 30 |
| 1. | Days to fifty percent tasselling | 10.1160 | 32.043* | 11.911 |
| 2. | Days to fifty percent silking | 19.7030 | 26.644** | 9.867 |
| 3. | Anthesis to silking Interval | 0.0250 | 0.556** | 0.013 |
| 4. | Plant height | 37.90 | 51.266** | 18.977 |
| 5. | Number of leaves per plant | 0.7560 | 1.088** | 0.379 |
| 6. | Leaf length | 7.8730 | 393.939** | 25.06 |
| 7. | Leaf width | 0.9320 | 1.673** | 0.495 |
| 8. | Number of cobs per plant | 0.0210 | 1.017** | 0.021 |
| 9. | Days to Maturity | 10.2680 | 13.867** | 5.135 |
| 10. | Cob length | 4.8420 | 12.905** | 1.686 |
| 11. | Cob Diameter | 2.7680 | 6.46** | 1.387 |
| 12. | Number of grains per row | 1.6670 | 37.347** | 2.32 |
| 13. | Number of Kernels rows per cob | 1.5980 | 3.765** | 0.801 |
| 14. | Weight of cob | 254.6430 | 4188.398** | 81.796 |
| 15. | Shank weight | 19.1920 | 296.357** | 9.614 |
| 16. | Grain yield per plant | 95.8830 | 3264.191** | 48.051 |
| 17. | 100 seed weight | 0.6510 | 106.533** | 3.481 |
| 18. | Dry weight | 3.8220 | 699.918** | 83.841 |
| 19. | Fresh weight of plant | 3.8220 | 699.918** | 100.148 |
| 20. | Biological yield | 152.7110 | 1306.496** | 233.639 |

*significant at 5% level ; **significant at 1% level

## Table 2: Genetic Variability Parameters of Quantitative Characters in Maize.

| Characters | ECV | Var Genotypical | GCV | Var Phenotypical | PCV | $h^2$ (Broad Sense) | Genetic Advancement 5% | Genetic Advance as % of Mean 5% |
|---|---|---|---|---|---|---|---|---|
| **Days to fifty percent tasseling** | 3.068 | 6.71 | 2.30 | 18.62 | 3.84 | 36.04 | 3.20 | 2.85 |
| **Days to fifty percent silking** | 2.76 | 5.59 | 2.08 | 15.46 | 3.45 | 36.17 | 2.93 | 2.57 |
| **Anthesis to silking Interval** | 6.45 | 0.18 | 24.31 | 0.19 | 25.15 | 93.42 | 0.85 | 48.39 |
| **Plant height** | 2.08 | 10.76 | 1.57 | 29.7 | 2.61 | 36.19 | 4.07 | 1.94 |
| **Number of leaves per Plant** | 4.8 | 0.24 | 3.83 | 0.62 | 6.18 | 38.39 | 0.62 | 4.88 |
| **Leaf length** | 5.70 | 122.96 | 12.63 | 148.02 | 13.86 | 83.07 | 20.82 | 23.71 |
| **Leaf width** | 8.05 | 0.39 | 7.17 | 0.89 | 10.78 | 44.24 | 0.859 | 9.83 |
| **Number of cobs per Plant** | 7.37 | 0.33 | 29.42 | 0.35 | 30.33 | 94.09 | 1.15 | 58.78 |
| **Days to Maturity** | 1.49 | 2.91 | 1.13 | 8.046 | 1.87 | 36.18 | 2.12 | 1.39 |
| **Cob length** | 7.49 | 3.74 | 11.17 | 5.43 | 13.45 | 68.93 | 3.30 | 19.10 |
| **Cob Diameter** | 7.90 | 1.69 | 8.73 | 3.07 | 11.78 | 54.95 | 1.99 | 13.33 |
| **Number of grains per Row** | 5.80 | 11.68 | 13.01 | 13.99 | 14.25 | 83.42 | 6.43 | 24.49 |
| **Number of Kernels rows per cob** | 6.42 | 0.99 | 7.13 | 1.79 | 9.59 | 55.22 | 1.52 | 10.92 |
| **Weight of cob** | 6.41 | 1368.87 | 26.20 | 1450.66 | 26.97 | 94.36 | 74.04 | 52.44 |
| **Shank weight** | 6.82 | 95.58 | 21.49 | 105.19 | 22.55 | 90.86 | 19.19 | 42.21 |
| **Grain yield per plant** | 7.25 | 1072.05 | 34.25 | 1120.09 | 35.01 | 95.71 | 65.99 | 69.02 |
| **100 seed weight** | 6.36 | 34.35 | 19.98 | 37.83 | 20.96 | 90.79 | 11.51 | 39.21 |
| **Dry weight** | 7.11 | 205.36 | 11.12 | 289.2 | 13.19 | 71.01 | 24.88 | 19.31 |
| **Fresh weight of plant** | 7.21 | 199.92 | 10.18 | 300.07 | 12.47 | 66.63 | 23.76 | 17.12 |
| **Biological yield** | 7.31 | 357.62 | 9.04 | 591.25 | 11.62 | 60.48 | 30.29 | 14.48 |

## Table 3: Phenotypic correlation coefficients among yield and yield components of rabi maize in eastern U.P region.

| Characters | DT50 | DS50 | ASI | PH | NLP | LL | LW | NCP | DM | CL | CD | NGR | NKP | WC | SW | SW(100g) | DW | FW | BY | GY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DT 50** | 1.0000 | 0.752** | -0.1508 | -0.0571 | -0.0111 | 0.314* | -0.0122 | -0.368* | 0.0643 | -0.0366 | -0.2312 | 0.2575 | 0.0389 | -0.287* | -0.314* | -0.0413 | -0.1376 | -0.1302 | -0.1870 | -0.2140 |
| **DS50** | | 1.0000 | -0.0427 | -0.2037 | -0.0261 | 0.338* | 0.0663 | -0.383* | 0.0621 | -0.0138 | -0.2115 | 0.2415 | 0.0098 | -0.2330 | -0.313* | -0.0635 | -0.2644 | -0.2646 | -0.1198 | -0.1713 |
| **ASI** | | | 1.0000 | -0.2635 | -0.0561 | 0.2280 | 0.0193 | -0.1138 | -0.1701 | -0.2078 | 0.1779 | 0.321* | 0.1022 | 0.2258 | 0.1399 | 0.432* | 0.352* | 0.344* | 0.1523 | 0.2073 |
| **PH** | | | | 1.0000 | 0.2296 | -0.1995 | 0.1120 | -0.0488 | -0.0103 | 0.1252 | -0.1381 | -0.426* | -0.2647 | -0.1120 | 0.0856 | -0.2823 | -0.0582 | -0.0512 | -0.1570 | -0.1407 |
| **NLP** | | | | | 1.0000 | -0.0313 | 0.1573 | -0.316* | -0.2652 | -0.304* | -0.0345 | -0.0001 | -0.1784 | -0.0173 | 0.0469 | -0.1532 | -0.0234 | -0.0180 | 0.1927 | -0.0449 |
| **LL** | | | | | | 1.0000 | -0.0294 | -0.0465 | -0.1067 | -0.309* | -0.2233 | 0.355* | 0.2721 | -0.0841 | -0.2222 | 0.2104 | 0.0000 | 0.0009 | -0.1350 | -0.0276 |
| **LW** | | | | | | | 1.0000 | 0.1772 | -0.0372 | 0.0140 | 0.0643 | -0.0928 | 0.2514 | 0.317* | -0.0713 | 0.2553 | 0.1643 | 0.1639 | 0.2285 | 0.376* |
| **NCP** | | | | | | | | 1.0000 | 0.292* | 0.401* | -0.0113 | -0.1196 | -0.0148 | 0.409* | 0.2539 | 0.310* | 0.0907 | 0.0914 | 0.1791 | 0.387* |
| **DM** | | | | | | | | | 1.0000 | 0.317* | -0.0229 | 0.1283 | -0.2243 | -0.0733 | 0.1599 | -0.0152 | 0.0179 | 0.0180 | -0.0656 | -0.1122 |
| **CL** | | | | | | | | | | 1.0000 | -0.1338 | -0.2755 | -0.0169 | 0.0590 | 0.319* | 0.0208 | -0.2665 | -0.2614 | -0.1549 | -0.0504 |
| **CD** | | | | | | | | | | | 1.0000 | -0.0456 | 0.1826 | 0.1087 | -0.2087 | 0.0787 | 0.0936 | 0.0883 | 0.1996 | 0.1843 |
| **NGR** | | | | | | | | | | | | 1.0000 | -0.1516 | -0.2364 | -0.0841 | 0.0028 | 0.1469 | 0.1477 | -0.0967 | -0.2335 |
| **NKP** | | | | | | | | | | | | | 1.0000 | 0.359* | -0.0840 | 0.508** | 0.347* | 0.344* | 0.2541 | 0.429* |
| **WC** | | | | | | | | | | | | | | 1.0000 | 0.546** | 0.739** | 0.2809 | 0.2749 | 0.729** | 0.952** |
| **SW** | | | | | | | | | | | | | | | 1.0000 | 0.295* | 0.1036 | 0.0994 | 0.2433 | 0.286* |
| **SW( 100g)** | | | | | | | | | | | | | | | | 1.0000 | 0.518** | 0.507** | 0.435* | 0.745** |
| **DW** | | | | | | | | | | | | | | | | | 1.0000 | 0.824** | 0.395* | 0.299* |
| **FWP** | | | | | | | | | | | | | | | | | | 1.0000 | 0.402* | 0.295* |
| **BG)** | | | | | | | | | | | | | | | | | | | 1.0000 | 0.757** |
| **GYP** | | | | | | | | | | | | | | | | | | | | 1.0000 |

KEY- *=Significant at 0.05 probability level DT50 (Days to first tassel emergence [50%]); DS 50 (Days to first silk emergence [50%]); ASI (Anthesis Silking Interval); PH (Plant height); NLP (Number of leaf per plant); LL (leaf length ); LW (leaf width); NCP (number of cobs per plant); DM (days to maturity); CL (cob length ); CD (cob diameter); NGR (number of grains per row); NKP (number of kernel per plant); WC (weight of cob); SW shank weight; SW100g (Seed weight 100g); DW ( Dry weight); FWP (fresh weight of plant); BG (biological weight); GYP (grain yield per plant)

## Table 4: Genotypic correlation coefficients among yield and yield components of rabi maize in eastern U.P region.

| Character | DT50 | DS50 | ASI | PH | NLP | LL | LW | NCP | DM | CL | CD | NGR | NKP | WC | SW | SW(100g) | DW | FWP | BG | GYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DT 50** | 1.000 | 0.821** | -0.2514 | -0.0946 | 0.1904 | 0.531** | 0.2054 | -0.650** | -0.0226 | -0.0333 | 0.489** | 0.450* | 0.1510 | -0.368* | -0.392* | -0.1491 | -0.445* | -0.456* | -0.443* | -0.307* |
| **DS50** | | 1.0000 | -0.0842 | -0.1331 | 0.1549 | 0.562** | 0.2466 | -0.660** | -0.1146 | -0.1711 | -0.362* | 0.553** | 0.1664 | -0.382* | -0.501** | -0.1595 | -0.397* | -0.397* | -0.408* | -0.2720 |
| **ASI** | | | 1.0000 | -0.377* | -0.0042 | 0.2654 | 0.1459 | -0.1247 | -0.1700 | -0.2502 | 0.2359 | 0.365* | 0.1943 | 0.2569 | 0.1457 | 0.493** | 0.451* | 0.457* | 0.2616 | 0.2474 |
| **PH** | | | | 1.0000 | 0.917** | -0.523** | 0.370* | -0.1515 | -0.295* | 0.460* | -0.1867 | 0.790** | -0.307* | -0.2843 | 0.0896 | -0.397* | -0.2636 | -0.2734 | -0.411* | -0.360* |
| **NLP** | | | | | 1.0000 | -0.0571 | 0.424* | -0.486** | -0.2339 | -0.552** | 0.0261 | -0.1282 | -0.405* | -0.0458 | 0.0422 | -0.2170 | -0.2026 | -0.2103 | 0.0247 | -0.0481 |
| **LL** | | | | | | 1.0000 | 0.0752 | -0.0487 | -0.1846 | -0.321* | -0.304* | 0.457* | 0.438* | -0.1255 | -0.2790 | 0.2642 | -0.0146 | -0.0153 | -0.2804 | -0.0623 |
| **LW** | | | | | | | 1.0000 | 0.2182 | -0.0181 | -0.1782 | 0.2635 | -0.2236 | 0.1813 | 0.478** | -0.0910 | 0.328* | 0.1862 | 0.1863 | 0.373* | 0.572** |
| **NCP** | | | | | | | | 1.0000 | 0.507** | 0.497** | 0.0596 | -0.1774 | 0.0065 | 0.440* | 0.289* | 0.344* | 0.0659 | 0.0653 | 0.1811 | 0.402* |
| **DM** | | | | | | | | | 1.0000 | 0.511** | 0.2190 | 0.537** | -0.619** | -0.0960 | 0.371* | -0.0350 | 0.0234 | 0.0233 | -0.1374 | -0.2383 |
| **CL** | | | | | | | | | | 1.0000 | -0.0883 | -0.357* | -0.2519 | 0.0365 | 0.354* | -0.0718 | -0.400* | -0.405* | -0.1896 | -0.0577 |
| **CD** | | | | | | | | | | | 1.000 | -0.1280 | 0.1499 | 0.1242 | -0.328* | 0.1232 | 0.2679 | 0.2745 | 0.608** | 0.2419 |
| **NGR** | | | | | | | | | | | | 1.0000 | -0.2414 | -0.2517 | -0.0698 | -0.0092 | 0.1235 | 0.1228 | -0.1519 | -0.2650 |
| **NKP** | | | | | | | | | | | | | 1.0000 | 0.498** | -0.1158 | 0.689** | 0.465** | 0.468** | 0.456* | 0.590** |
| **WC** | | | | | | | | | | | | | | 1.0000 | 0.526** | 0.798** | 0.365* | 0.371* | 0.931** | 0.974** |
| **SW** | | | | | | | | | | | | | | | 1.0000 | 0.351* | 0.1803 | 0.1842 | 0.333* | 0.306* |
| **SW( 100g)** | | | | | | | | | | | | | | | | 1.0000 | 0.652** | 0.662** | 0.617** | 0.786** |
| **DW** | | | | | | | | | | | | | | | | | 1.0000 | 0.855** | 0.2433 | 0.343* |
| **FWP** | | | | | | | | | | | | | | | | | | 1.0000 | 0.2356 | 0.346* |
| **BG)** | | | | | | | | | | | | | | | | | | | 1.0000 | 0.949** |
| **GYP** | | | | | | | | | | | | | | | | | | | | 1.0000 |

KEY- *=Significant at 0.05 probability level DT50 (Days to first tassel emergence [50%]); DS 50 (Days to first silk emergence [50%]); ASI (Anthesis Silking Interval); PH (Plant height); NLP (Number of leaf per plant); LL (leaf length ); LW (leaf width); NCP (number of cobs per plant); DM (days to maturity); CL (cob length ); CD (cob diameter); NGR (number of grains per row); NKP (number of kernel per plant); WC (weight of cob); SW shank weight; SW100g (Seed weight 100g); DW ( Dry weight); FWP (fresh weight of plant); BG (biological weight); GYP (grain yield per plant)

**Table 5: Direct and Indirect Effect of component Traits Attaining to Grain Yield in maize at Phenotypic Level.**

| Character | DT50 | DS50 | ASI | PH | NLP | LL | LW | NCP | BM | CL | CD | NGR | NKP | WC | SW | SW (100G) | DW | FPW | BG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DT 50 | -0.0028 | -0.0021 | 0.0004 | 0.0002 | 0.0000 | -0.0009 | 0.0000 | 0.0010 | -0.0002 | 0.0001 | 0.0007 | -0.0007 | -0.0001 | 0.0008 | 0.0009 | 0.0001 | 0.0004 | 0.0004 | 0.0005 |
| DS50 | -0.0013 | -0.0017 | 0.0001 | 0.0003 | 0.0000 | -0.0006 | -0.0001 | 0.0006 | -0.0001 | 0.0000 | 0.0004 | -0.0004 | 0.0000 | 0.0004 | 0.0005 | 0.0001 | 0.0004 | 0.0004 | 0.0002 |
| ASI | -0.0017 | -0.0005 | 0.0114 | -0.0030 | -0.0006 | 0.0026 | 0.0002 | -0.0013 | -0.0019 | -0.0024 | 0.0020 | 0.0036 | 0.0012 | 0.0026 | 0.0016 | 0.0049 | 0.0040 | 0.0039 | 0.0017 |
| PH | -0.0023 | -0.0083 | -0.0108 | 0.0410 | 0.0094 | -0.0082 | 0.0046 | -0.0020 | -0.0004 | 0.0051 | -0.0057 | -0.0175 | -0.0108 | -0.0046 | 0.0035 | -0.0116 | -0.0024 | -0.0021 | -0.0064 |
| NLP | 0.0003 | 0.0006 | 0.0013 | -0.0054 | -0.0234 | 0.0007 | -0.0037 | 0.0074 | 0.0062 | 0.0071 | 0.0008 | 0.0000 | 0.0042 | 0.0004 | -0.0011 | 0.0036 | 0.0005 | 0.0004 | -0.0045 |
| LL | -0.0180 | -0.0194 | -0.0130 | 0.0114 | 0.0018 | -0.0572 | 0.0017 | 0.0027 | 0.0061 | 0.0176 | 0.0128 | -0.0203 | -0.0156 | 0.0048 | 0.0127 | -0.0120 | 0.0000 | 0.0000 | 0.0077 |
| LW | 0.0001 | -0.0006 | -0.0002 | -0.0011 | -0.0015 | 0.0003 | -0.0098 | -0.0017 | 0.0004 | -0.0001 | -0.0006 | 0.0009 | -0.0025 | -0.0031 | 0.0007 | -0.0025 | -0.002 | -0.0016 | -0.0022 |
| NCP | -0.0092 | -0.0096 | -0.0029 | -0.0012 | -0.0079 | -0.0012 | 0.0044 | 0.0251 | 0.0073 | 0.0101 | -0.0003 | -0.0030 | -0.0004 | 0.0103 | 0.0064 | 0.0078 | 0.0023 | 0.0023 | 0.0045 |
| DM | 0.0020 | 0.0019 | -0.0053 | -0.0003 | -0.0083 | -0.0033 | -0.0012 | 0.0091 | 0.0311 | 0.0099 | -0.0007 | 0.0040 | -0.0070 | -0.0023 | 0.0050 | -0.0005 | 0.0006 | 0.0006 | -0.0020 |
| CL | 0.0028 | 0.0011 | 0.0159 | -0.0096 | 0.0233 | 0.0236 | -0.0011 | -0.0307 | -0.0243 | -0.0766 | 0.0102 | 0.0211 | 0.0013 | -0.0045 | -0.0245 | -0.0016 | 0.0204 | 0.0200 | 0.0119 |
| CD | 0.0048 | 0.0044 | -0.0037 | 0.0029 | 0.0007 | 0.0046 | -0.0013 | 0.0002 | 0.0005 | 0.0028 | -0.0208 | 0.0009 | -0.0038 | -0.0023 | 0.0043 | -0.0016 | 0.0019 | -0.0018 | -0.0041 |
| NGR | 0.0037 | 0.0034 | 0.0046 | -0.0060 | 0.0000 | 0.0050 | -0.0013 | -0.0017 | 0.0018 | -0.0039 | -0.0006 | 0.0142 | -0.0022 | -0.0034 | -0.0012 | 0.0000 | 0.0021 | 0.0021 | -0.0014 |
| NKP | 0.0012 | 0.0003 | 0.0032 | -0.0083 | -0.0056 | 0.0086 | 0.0079 | -0.0005 | -0.0071 | -0.0005 | 0.0058 | -0.0048 | 0.0315 | 0.0113 | -0.0026 | 0.0160 | 0.0109 | 0.0108 | 0.0080 |
| WC | -0.3020 | -0.2452 | 0.2377 | -0.1178 | -0.0182 | -0.0885 | 0.3331 | 0.4304 | -0.0771 | 0.0621 | 0.1144 | -0.2488 | 0.3774 | 1.0526 | 0.5747 | 0.7773 | 0.2957 | 0.2893 | 0.7669 |
| SW | 0.0995 | 0.0990 | -0.0443 | -0.0271 | -0.0149 | 0.0704 | 0.0226 | -0.0804 | -0.0506 | -0.1011 | 0.0661 | 0.0266 | 0.0266 | -0.1729 | -0.3167 | 0.0933 | 0.0328 | -0.0315 | -0.0770 |
| SW( 100g) | -0.0037 | -0.0057 | 0.0386 | -0.0253 | -0.0137 | 0.0188 | 0.0228 | 0.0277 | -0.0014 | 0.0019 | 0.0070 | 0.0002 | 0.0454 | 0.0661 | 0.0264 | 0.0895 | 0.0463 | 0.0454 | 0.0389 |
| DW | 0.1982 | 0.3810 | -0.5069 | 0.0838 | 0.0338 | 0.0000 | -0.2368 | -0.1307 | -0.0257 | 0.3840 | -0.1348 | -0.2117 | -0.5000 | -0.4048 | -0.1493 | 0.7459 | -1.441 | -1.4402 | -0.5688 |
| FWP | -0.1805 | -0.3667 | 0.4771 | -0.0709 | -0.0250 | 0.0012 | 0.2271 | 0.1267 | 0.0249 | -0.3623 | 0.1223 | 0.2047 | 0.4768 | 0.3810 | 0.1378 | 0.7030 | 1.3850 | 1.3859 | 0.5564 |
| BG) | -0.0050 | -0.0032 | 0.0041 | -0.0042 | 0.0052 | -0.0036 | 0.0061 | 0.0048 | -0.0018 | -0.0042 | 0.0054 | -0.0026 | 0.0068 | 0.0196 | 0.0065 | 0.0117 | 0.0106 | 0108 | 0.0269 |
| GYP | -0.2140 | -0.1713 | 0.2073 | -0.1407 | -0.0449 | -0.0276 | 0.376* | 0.387* | -0.1122 | -0.0504 | 0.1843 | -0.2335 | 0.429* | 0.952** | 0.286* | 0.745** | 0.299* | 0.295* | 0.757** |
| Partial $R^2$ | 0.0006 | 0.0003 | 0.0024 | -0.0058 | 0.0011 | 0.0016 | -0.0037 | 0.0097 | -0.0035 | 0.0039 | -0.0038 | -0.0033 | 0.0135 | 1.0019 | -0.0905 | 0.0667 | -0.4313 | 0.4090 | 0.0204 |

KEY- *=Significant at 0.05 probability level; **=Significant at 0.01 probability level; DT50 (Days to first tassel emergence [50%]); DS 50 (Days to first silk emergence [50%]); ASI (Anthesis Silking Interval); PH (Plant height); NLP (Number of leaf per plant); LL (leaf length); LW (leaf width); NCP (number of cobs per plant); DM (days to maturity); CL( cob length); CD (cob diameter); NGR (number of grains per row); NKP (number of kernel per plant); WC (weight of cob); SW shank weight; SW100g (Seed weight 100g); DW (Dry weight); FWP (fresh weight of plant); BG (biological weight); GYP (grain yield per plant)

**Table 6: Direct and Indirect Effect of component Traits Attaining to Grain Yield in maize at Genotypic Level.**

| Character | DT50 | DS50 | ASI | PH | NLP | LL | LW | NCP | DM | CL | CD | NGR | NKP | WC | SW | SW100g) | DW | FWP | BG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DT 50 | 0.0171 | 0.0218 | -0.0043 | -0.0016 | 0.0032 | 0.0091 | 0.0035 | -0.0111 | -0.0004 | -0.0006 | -0.0083 | 0.0077 | 0.0026 | -0.0063 | -0.0067 | -0.0025 | -0.0076 | -0.0078 | -0.0076 |
| DS50 | -0.0089 | -0.0070 | 0.0006 | 0.0009 | -0.0011 | -0.0039 | -0.0017 | 0.0046 | 0.0008 | 0.0012 | 0.0025 | -0.0039 | -0.0012 | 0.0027 | 0.0035 | 0.0011 | 0.0028 | 0.0028 | 0.0029 |
| ASI | -0.0123 | -0.0041 | 0.0488 | -0.0184 | -0.0002 | 0.0130 | 0.0071 | -0.0061 | -0.0083 | -0.0122 | 0.0115 | 0.0178 | 0.0095 | 0.0125 | 0.0071 | 0.0241 | 0.0220 | 0.0223 | 0.0128 |
| PH | -0.0038 | -0.0053 | -0.0151 | 0.0399 | 0.0366 | -0.0209 | 0.0148 | -0.0061 | -0.0118 | 0.0184 | -0.0075 | -0.0316 | -0.0123 | -0.0114 | 0.0036 | -0.0158 | -0.0105 | -0.0109 | -0.0164 |
| NLP | -0.0030 | -0.0024 | 0.0001 | -0.0142 | -0.0155 | 0.0009 | -0.0066 | 0.0075 | 0.0036 | 0.0086 | -0.0004 | 0.0020 | 0.0063 | 0.0007 | -0.0007 | 0.0034 | 0.0031 | 0.0033 | -0.0004 |
| LL | -0.0260 | -0.0275 | -0.0130 | 0.0256 | 0.0028 | -0.0490 | -0.0037 | 0.0024 | 0.0090 | 0.0157 | 0.0149 | -0.0224 | -0.0215 | 0.0062 | 0.0137 | -0.0129 | 0.0007 | 0.0008 | 0.0137 |
| LW | 0.0029 | 0.0034 | 0.0020 | 0.0052 | 0.0059 | 0.0011 | 0.0140 | 0.0030 | -0.0003 | -0.0025 | 0.0037 | -0.0031 | 0.0025 | 0.0067 | -0.0013 | 0.0046 | 0.0026 | 0.0026 | 0.0052 |
| NCP | -0.0331 | -0.0336 | -0.0063 | -0.0077 | -0.0248 | -0.0025 | 0.0111 | 0.0509 | 0.0258 | 0.0253 | 0.0030 | -0.0090 | 0.0003 | 0.0224 | 0.0147 | 0.0175 | 0.0034 | 0.0033 | 0.0092 |
| DM | -0.0004 | -0.0022 | -0.0033 | -0.0057 | -0.0045 | -0.0036 | -0.0004 | 0.0098 | 0.0194 | 0.0099 | 0.0043 | 0.0104 | -0.0120 | -0.0019 | 0.0072 | -0.0007 | 0.0005 | 0.0005 | -0.0027 |
| CL | 0.0018 | 0.0092 | 0.0135 | -0.0249 | 0.0298 | 0.0173 | 0.0096 | -0.0269 | -0.0276 | -0.0540 | 0.0048 | 0.0193 | 0.0136 | -0.0020 | -0.0191 | 0.0039 | 0.0216 | 0.0219 | 0.0102 |
| CD | 0.0115 | 0.0085 | -0.0056 | 0.0044 | -0.0006 | 0.0072 | -0.0062 | -0.0014 | -0.0052 | 0.0021 | -0.0236 | 0.0030 | -0.0035 | -0.0029 | 0.0078 | -0.0029 | -0.0063 | -0.0065 | -0.0144 |
| NGR | 0.0116 | 0.0143 | 0.0094 | -0.0205 | -0.0033 | 0.0118 | -0.0058 | -0.0046 | 0.0139 | -0.0092 | -0.0033 | 0.0259 | -0.0063 | -0.0065 | -0.0018 | -0.0002 | 0.0032 | 0.0032 | -0.0039 |
| NKP | 0.0132 | 0.0145 | 0.0170 | -0.0268 | -0.0354 | 0.0383 | 0.0158 | 0.0006 | -0.0541 | -0.0220 | 0.0131 | -0.0211 | 0.0874 | 0.0435 | -0.0101 | 0.0602 | 0.0406 | 0.0409 | 0.0399 |
| WC | -0.3842 | -0.3996 | 0.2686 | -0.2972 | -0.0478 | -0.1312 | 0.5002 | 0.4599 | -0.1004 | 0.0382 | 0.1299 | -0.2631 | 0.5203 | 1.0454 | 0.5502 | 0.8341 | 0.3817 | 0.3875 | 0.9738 |
| SW | 0.1013 | 0.1294 | -0.0376 | -0.0231 | -0.0109 | 0.0720 | 0.0235 | -0.0745 | -0.0957 | -0.0914 | 0.0847 | 0.0180 | 0.0299 | -0.1359 | -0.2582 | -0.0907 | -0.0465 | -0.0475 | -0.0860 |
| SW(100g) | 0.0048 | 0.0051 | -0.0157 | 0.0127 | 0.0069 | -0.0084 | -0.0105 | -0.0110 | 0.0011 | 0.0023 | -0.0039 | 0.0003 | -0.0220 | -0.0255 | -0.0112 | -0.0319 | -0.0208 | -0.0211 | -0.0197 |
| DW | 0.1818 | 0.1623 | -0.1840 | 0.1077 | 0.0828 | 0.0059 | -0.0761 | -0.0269 | -0.0095 | 0.1633 | -0.1095 | -0.0504 | -0.1898 | -0.1492 | -0.0737 | -0.2665 | -0.4085 | -0.4088 | -0.0994 |
| FWP | -0.1588 | -0.1384 | 0.1593 | -0.0952 | -0.0733 | -0.0053 | 0.0649 | 0.0227 | 0.0081 | -0.1412 | 0.0956 | 0.0428 | 0.1630 | 0.1291 | 0.0642 | 0.2306 | 0.3486 | 0.3484 | 0.0821 |
| BG) | -0.0221 | -0.0204 | 0.0131 | -0.0205 | 0.0012 | -0.0140 | 0.0186 | 0.0091 | -0.0069 | -0.0095 | 0.0304 | -0.0076 | 0.0228 | 0.0466 | 0.0167 | 0.0308 | 0.0122 | 0.0118 | 0.0500 |
| GYP | -0.307* | -0.2720 | 0.2474 | -0.360* | -0.0481 | -0.0623 | 0.572** | 0.402* | -0.2383 | -0.0577 | 0.2419 | -0.2650 | 0.590** | 0.974** | 0.306* | 0.786** | 0.343* | 0.346* | 0.949** |
| Partial $R^2$ | -0.0052 | 0.0019 | 0.0121 | -0.0144 | 0.0007 | 0.0031 | 0.0080 | 0.0205 | -0.0046 | 0.0031 | -0.0057 | -0.0069 | 0.0515 | 1.0186 | -0.0790 | -0.0251 | -0.1399 | 0.1207 | 0.0475 |

KEY- *=Significant at 0.05 probability level; **=Significant at 0.01 probability level DT50 (Days to first tassel emergence [50%]); DS 50 (Days to first silk emergence [50%]); ASI (Anthesis Silking Interval); PH (Plant height); NLP (Number of leaf per plant); LL (leaf length); LW (leaf width); NCP (number of cobs per plant); DM (days to maturity); CL (cob length); CD (cob diameter); NGR (number of grains per row); NKP (number of kernel per plant); WC (weight of cob); SW shank weight; SW100g (Seed weight 100g); DW (Dry weight); FWP (fresh weight of plant); BG (biological weight); GYP (grain yield per plant).

## CONCLUSIONS

Analysis of variance was conducted for l twenty quantitative characters and it was found that treatment differences were highly significant at 1% level of significance except for days to 50% tasseling. The remaining characters showed significance at a 5% level. The values of PCV were higher than GCV values for all the characters and there was a large difference between the values of PCV and GCV particularly in the number of leaves this indicates that environmental factors significantly influenced the expression of these traits. All the studied traits had higher heritability and genetic advance at a 5% selection intensity. The genetic advance as a percent of mean was also high, and highest was expected heritability was found in the number of cobs per plant. The higher genetic advance was found in weight of cob. Correlation studies suggest that selection based on the weight of cob and 100 seed weight had a positive correlation and direct effects with grain yield per plant at the phenotypic level. Biological yield (g), weight of the cob (g), Seed index (100 seed weight (g) ), number of kernels per row and leaf width had the highest positive and significant correlation at genotypic level. Based on these findings it is concluded that effective selection should be attempted for these traits in order to improve grain yield in maize genotypes suitable for the eastern U.P condition in northern India. The genotypes MZ1908, MZ1914 and NBPGR36548 exhibited highest grain yield.

## FUTURE SCOPE

for effective improvement of genotypes used in the above experiment for the north eastern Uttar Pradesh region, it is recommended to carry out effective selection for the number of cobs per plant, cob weight, number of kernels per row, ear height, shank weight, number of kernel rows per cob, number of kernels per cob, cob girth and cob length should be carried out during a breeding programme.

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**Conflict of Interest.** None.

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