# Association and diversity studies for Yield and Its Attributing Traits in Maize (*Zea mays* L.)hybrids


## Abstract:

Present investigation was conducted in 144 maize hybrids of CIMMYT, Hyderabad along with 6 checks at ICRISAT, Hyderabad. The genotypes were evaluated for six quantitative traits that are plant height, ear height, anthesis days, silking days and grain yield. Correlation among the traits came to a conclusion that plant height and ear height are positively correlated with grain yield. Path analysis revealed there is highest direct association of plant height on grain yield and ear height had a highest indirect positive association with grain yield. Hence selection plant height and ear height days plays a vital role in increasing yield. Clustering of genotypes based on the six traits divide the germplasm into two clusters. 85 and 65 genotypes were found in each clusters. Clustering the genotypes based the quantitative traits revealed close relatedness between the genotypes. Knowledge on association and diversity identified in our study help in plant breeding process.


## Introduction:

Maize is one among the most important cereal crops. It is cultivated in 190mha in 165 countries (FAOSTAT, 2021). It is an important cereal crop as it is a main component of human feed, animal feed and industrial purpose. In India maize is grown in 9.9 mha and produce 28 m tones of maize with on an average 6t/ha (ANGRAU, 2021). Growing importance of maize has increased its demand. Hence increasing the production and productivity of maize is need of the hour. Hence its important analyse the association of traits and available diversity in the germplasm. Analysis of genetic diversity in the germplasm will help in development and utilisation of diverse parents in the hybrid development. Correlation and path analysis of the important yield attributing traits help in indirect selection of yield through the associated traits when the heritability of the yield trait is low as in stress conditions. Many studies have been conducted in maize hybrids to assess the diversity and association among the traits in hybrids(Rigon et al., 2015; Sabitha et al., 2022; Zaman, 2013). In present study we have attempted to analyse the diversity and association of traits in the CIMMYT maize hybrids to understand and utilise the results in future breeding programme.

## Material and methods:

144 maize hybrids from CIMMYT, Hyderabad with 6 checks were evaluated for yield and yield attributing traits at Attur, Tamilnadu in 2022 Rabi. 150 genotypes were evaluated for six quantitative traits i.e., plant height (PH)(cm), ear height (EH)(cm), days for 50% anthesis (AD), days for 50% silking (SD), ear per plant (EPP) and grain yield (GY)(t/ha). 150 genotypes are laid out in alpha lattice design with two replications. Suitable agronomic practices were carried out. The observations for plant height, ear height and ear per plant was taken on five plants per plot, whereas the grain yield was measured on plot the converted to tonnes per hectare. Genotypic and phenotypic correlations were done using the method by Searle(Searle, 1961).Path analysis study was carried out in METAN software in R studio(Olivoto, 2020). The cluster analysis using hierarchical clustering and ward.D method was done in R software using the factoextra and ggplot2 package (Kassambara, 2017; Wickham,2023).

## Results and Discussion:

### Correlation:

Yield is the prime most important character during selection and correlation studies provide a better understanding of this trait(Robinson et al., 1951 and Johnson et al., 1955). Correlation was worked out for all the five traits at genotypic and phenotypic levels (Table 1). Phenotypic correlation consists of both genotypic and phenotypic effects, it can be directly observed and are influenced by environmental factors. Inherent association between traits is studied through genotypic correlation it may be due to pleiotropic action of genes or due to linkage or more likely both (Mehra et al., 2016).Correlation studies in the present investigation revealed significant phenotypic and genotypic correlation of plant height, ear height and ear per plant with grain yield. Correlation of plant height with grain yield was also reported in earlier studies (Nemati et al., 2009; Yahaya et al., 2021). Ear height and plant height are significantly correlated. Since the plant height and ear height are significantly correlated with yield improving anyone of the trait will significantly improve the yield too. Anthesis and silking days both have perfect correlation with each other explaining the interdependency. But non-significant positive genotypic and negative phenotypic correlation was observed with grain yield, similar results were also obtained by other researchers (Akbar et al., 2008; Atnafua et al., 2013;Soumya and Kamatar, 2017). Ear per plant are significantly correlated with all the traits both phenotypically and genotypically.

Table 1: Phenotypic correlation among the traits

| Traits | GY | AD | SD | PH | EH |
|---|---|---|---|---|---|
| AD | -0.09 | | | | |
| SD | -0.1 | 0.97** | | | |
| PH | 0.52** | -0.14 | -0.15 | | |
| EH | 0.36** | 0.13 | 0.11 | 0.73** | |
| EPP | 0.24** | 0.28** | 0.24** | 0.19* | 0.21** |

*Significant at 5% level, ** Significant at 1% level

GY, grain yield; AD, anthesis days; SD, silking days; PH, plant height, EH, ear height; EPP ear per plant

Table 2: Genotypic correlation among the traits

| Traits | GYF | AD | SD | PH | EH |
|---|---|---|---|---|---|
| AD | 0.05 | | | | |
| SD | 0.03 | 1** | | | |
| PH | 0.79** | -0.14 | -0.16 | | |
| EH | 0.55** | 0.17* | 0.15 | 0.78** | |
| EPP | 0.22** | 0.77** | 0.78** | 0.61** | 0.47** |

*Significant at 5% level, ** Significant at 1% level

GY, grain yield; AD, anthesis days; SD, silking days; PH, plant height, EH, ear height; EPP ear per plant

### Path coefficient:

Multiple traits in correlation makes understanding the association between the traits more complex and doesn't have a meaningful interpretation. Hence partitioning the correlation to direct and indirect effects to specify the cause and their relative importance becomes important. Highest positive direct effect was by plant height (0.52) for grain yield followed by ear per plant (0.19) on grain yield(Table 3). Ear height was giving negative direct effect on grain yield. Significant association of plant height with grain yield was also observed in earlier studies (Patel et al., 2005; Soumya and Kamatar., 2017). Silking days was negatively associated with the grain yield (Kumar et al., 2006). Indirect effect was highest by ear height (0.42) on grain yield through plant height rest all the traits had negligible contribution of indirect effects. With the obtained results we can conclude that increase in grain yield can be obtained by increasing the plant height and ear height and decreasing the days to silking.

Table 3: Path coefficient study among five traits in maize hybrids

| | PH | EH | AD | SD | EPP |
|---|---|---|---|---|---|
| PH | **0.52** | -0.11 | -0.01 | 0.02 | 0.02 |
| EH | 0.42 | **-0.13** | -0.003 | 0.02 | 0.02 |
| AD | -0.10 | 0.01 | **0.03** | -0.08 | 0.04 |
| SD | -0.11 | 0.02 | 0.03 | **-0.08** | 0.03 |
| EPP | 0.04 | -0.01 | 0.01 | -0.01 | **0.19** |

*Bold numbers are direct effects

GY, grain yield; AD, anthesis days; SD, silking days; PH, plant height, EH, ear height; EPP ear per plant

**Clustering of genotypes:**

150 genotypes are divided at the height of 25 into two clusters. 65 genotypes are placed in one cluster and 85 genotypes are placed in other cluster(Figure 1). Cluster I has the genotypes with greater yield, plant height, ear height, lesser anthesis and silking days and cluster II has the genotypes opposite of cluster I (Table 4). Both the clusters have the similar ear per plant. Intra cluster distances are lower that inter cluster distance. Both the clusters had the similar intercluster distance (Table 5). Distribution of 150 maize hybrids into only two clusters suggest that the genotypes are closely related. Clustering of hybrids into two clusters say that these hybrids are divergent. This is an important observation as this knowledge would assist in developing inbreds. Similar kind of experiment was also conducted by various other researchers and they two obtained similar results(Rigon et al., 2015; Sabitha et al., 2022; Zaman, 2013).

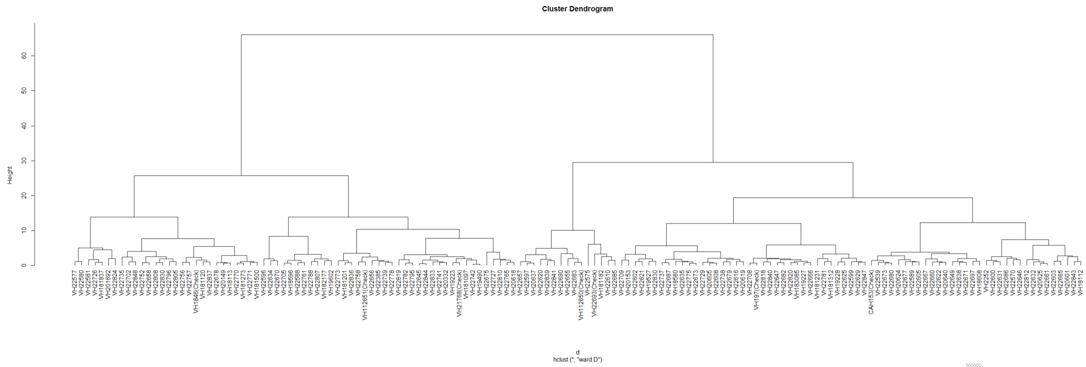


Figure 1: Dendrogram representing clustering of 150 maize hybrids

Table 4: Contribution of traits in each cluster

| Character | Cluster I | Cluster II |
|---|---|---|
| Grain yield | 10.09 | 8.92 |
| Ear height | 105.83 | 92.56 |
| Plant height | 211.10 | 188.66 |
| Anthesis days | 61.61 | 64.12 |
| Silking days | 63.35 | 66.30 |
| Ear per plant | 0.96 | 0.97 |

Table 5: Inter and intra cluster distance

| Cluster | I | II |
|---|---|---|
| I | **2.75** | 3.63 |
| II | | **2.80** |

**Reference:**

Akbar, M., Shabbir, S., AmerHussain and Mohammad, S. Evaluation of maize three way crosses through genetic variability, broad sense heritability, character association and path analysis. J. Agric. Res.,2008; 46(1): 39-45.

ANGRAU. Maize outlook report January to May 2021

Atnafua, B. and Nageshwar Rao. Estimates of heritability, genetic advance and correlation study for yield and it's attributes in maize (*Zea mays* L.). J. Pl. Sci.2014: 2(1): 1-4

FAO. World Food and Agriculture - Statistical Yearbook 2021. Rome.

Johnson, HW., Robinson, HF. and Comstock, RE. Estimates of genetic and environmental variability in soybean. Agron. J. 1955;47: 314-318.

Kassambara, A. and Mundt, F. Factoextra: Extract and Visualize the Results of Multivariate Data Analyses. 2020;R Package Version 1.0.7.

Kumar, S., Shashi, JP., Singh, J. and Singh, SP. Correlation and path analysis in early generation inbreds of maize (*Zeamays*L.). Crop Improv, 2006;33(2):156-160

Mehra, R. Tikle, AN. Saxena, A. Munjal A. Rekhakhandia. and Singh, M. Correlation, path-coefficient and genetic diversity inblackgram [*viginamungo*(l) hepper]. Int. Res. J. Pl. Sci., 2016;7(1): 001-011.

Nemati, A., Sedghi, M., Sharifi, R. S., and Seiedi, M. N. Investigation of correlation between traits and path analysis of corn (*Zea mays* L.) grain yield at the climate of Ardabil region (Northwest Iran). NotulaeBotanicae Horti.Agrobotanici Cluj-Napoca 2009; 37(1):194–198.

Olivoto T, Lúcio AD. "metan: An R package for multi□environment trial analysis." *Methods in Ecology and Evolution* 2020;11(6), 783-789.

Patel, DA., Patel, JS., Bhatt, MM. and Bhatt, HM. Correlation and path analysis in Forage maize (*Zea mays* L.). Res. Crops 2005;6(3): 502-504.

Rigon, J. P. G., Capuani, S., and Rigon, C. A. G. Genetic divergence among maize hybrids by morphological descriptors. Bragantia 2015; 74(2):156–160. https://doi.org/10.1590/1678-4499.0246

Robinson,HF.,Comstock, RE.And Harvey PH.Genotypicand phenotypiccorrelationsincornandtheirimplicationsinselection.Agron.J.1951;43:262-267.

Sabitha, N., Mohan Reddy, D., Lokanadha Reddy, D., Hemanth Kumar, M., Sudhakar, P., Ravindra Reddy, B., and Mallikarjuna, S. J. Genetic divergence analysis over seasons in single cross hybrids of maize (Zea mays L.). Acta Botanica Plantae. 2022; 1(2):12–18.

Searle, S. R. Phenotypic, Genetic and Environmental Correlations. Biometrics. 1961;17(3):474–480.

Soumya, H., and Kamatar, M. Correlation and path analysis for yield and yield components in single cross maize hybrids ( Zea mays L .). J. Farm Sci. 2017;30(2):153–156.

Wickham, H. ggplot2: Elegant Graphics for Data Analysis. 2016. Springer-Verlag New York,

Yahaya, M. S., Bello, I., and Unguwanrimi, A. Y. Correlation and path-coefficient analysis for grain yield and agronomic traits of maize (Zea mays L.). Science World Journal 2021;16(1):10–13.

Zaman, M. A. and A. A. A. Genetic diversity in exotic maize. Bangladesh J. Agril. Res. 2017;38(7):335–341.