Studies on Maize Yield under Drought Using Correlation and Path Coefficient Analysis

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A B S T R A C T

Yield being a complex character is governed by a large number of genes. To evaluate the relationship between yield and its components in maize through correlation and path studies a study was conducted. In present investigation, it was inferred that genotypic and phenotypic correlations among ten morpho-physiological and yield traits in maize lines were significant. The grain yield plot⁻¹ was positively correlated with 100-seed weight, ears plot⁻¹, chlorophyll content, plant height, ear height and number of kernels row⁻¹ indicating the importance of these traits in selection for yield. The influence of each character on yield could be known through correlation studies with a view to determine the extent and nature of relationships prevailing among yield and yield attributing characters. Path-coefficient analysis was studied at phenotypic level considering grain yield plot⁻¹ as dependent character. The independent characters were plant height (cm), ear height (cm), leaf relative water content (%), chlorophyll content at flowering, chlorophyll content at maturity, ears plant⁻¹, kernels row⁻¹, 100 grain weight (g), protein content (%). The highest positive and direct effect was found for chlorophyll content at flowering, kernels row⁻¹ followed by 100 grain weight and plant height. These traits contributed maximum to higher grain yield compared to other characters, thus, selection for these characters helps in selection of superior cross combinations for improvement of yield.

Keywords
Correlation, Yield, Zea mays L., Path, Drought

Introduction

Maize (Zea mays L.) is among the third most important cereal crops in India after rice and wheat meeting 50-60% of requirements of the people. It provides food, feed, fodder, fuel and serves as a raw material for many industrial products viz., starch, oil, and biofuel etc. It has wide adaptability to diverse agro-ecologies over latitude of 58N to 40S, and to a 3000 m altitude above mean sea level and thrives well in areas receiving rainfall ranging from 250 to 5000 mm (Downsell et al., 1996). Drought is one among the most important abiotic stress factors (Bruce et al., 2002), affecting growth and development of plants. The best option for good production, crop yield improvement and yield stability under drought stress conditions
is to develop drought tolerant crop varieties. One of the major goals of drought breeding programs is selection of the lines/cultivars/genotypes which are performing best under stress conditions. However, low heritability of drought tolerance and complex nature along with lack of effective selection procedures limit development of resistant crop cultivars to stress. Drought stress coinciding with flowering delays silking and results in an increase of anthesis-silking interval (Bolaão et al., 1993); this usually gets associated with reduction in grain number and yield. Grain yield being a complex quantitative character is governed by many genes.

The traits influencing yield are understood through correlation studies to determine the nature and extent of relationships between yield and other yield attributing traits. Yield improvement and stability is the primary objective of a plant breeder. Therefore, correlation analysis of a particular trait with other trait attributing to yield is of great importance for selecting lines for higher yield. Path coefficient analysis helps partitioning the correlation coefficient into its direct and indirect effects. This experiment was conducted to estimate the genotypic and phenotypic correlations and direct and indirect contributions of different traits to yield.

Materials and Methods

Study material comprised of 100 maize inbred lines available at AICRP (All India Coordinated Research Programme) Maize Srinagar Centre, collected from CIMMYT (International Maize and Wheat Improvement Centre) Mexico, AAU, Anand, IIMR, New Delhi, and MPUAT, Udaipur. These inbred lines were planted in a factorial randomized complete block design with two replications over two years. Each inbred line was planted in two row experimental plot of 1 metre length with inter and intra row spacing of 60 x 20 cm. The lines were evaluated under well watered and watered stressed conditions with two replications over two years. The data was recorded on plant height (cm), ear height (cm), leaf relative water content (%), chlorophyll content at flowering (SPAD units), chlorophyll content at maturity (SPAD units), ears plant\(^{-1}\), kernels row\(^{-1}\), 100 grain weight (g) and protein content (%). Observations were recorded on five randomly selected plants from each plot in each replication. Selected plants were tagged before tasseling.

Statistical analysis viz., correlation coefficient was carried out to understand the association and relationships between the traits, genotypic and phenotypic correlations coefficient were worked out by adopting method described by Singh and Chaudhary (1977). The genotypic and phenotypic correlation coefficient was partitioned into direct and indirect effects by path analysis to establish cause and effect association between the traits as suggested by Dewey and Lu (1959).

Results and Discussion

Genotypic and phenotypic correlations among ten morpho-physiological and yield traits in maize lines were computed. The data (Table 1) revealed that significant genotypic correlations and they were slightly higher in magnitude than phenotypic ones. This indicated that though there was a strong inherent association between characters studied, its expression was lessened due to the influence of environment. But, there was a general agreement in both sign and magnitude between the estimates of genotypic and phenotypic correlations. The grain yield plot\(^{-1}\) was positively correlated with 100-seed weight, ears plot\(^{-1}\), chlorophyll content, plant height, ear height and number of kernels row\(^{-1}\) indicating the importance of these traits in selection for yield.
### Table 1: Correlation coefficients for different traits in inbred lines of maize (pooled over years)

| Traits | PH   | EH   | LRWC | CCF   | CCM   | EPP   | KPR   | 100 GW | GYP   | PC    |
|--------|------|------|------|-------|-------|-------|-------|--------|-------|-------|
| PH     | 1.00 | 0.997** | 0.552** | 0.697** | 0.703** | 0.775** | 0.659** | 0.775** | 0.804** | 0.644** |
| EH     | 0.962** | 1.00 | 0.549** | 0.706** | 0.703** | 0.771** | 0.651** | 0.767** | 0.796** | 0.651** |
| LRWC   | 0.492** | 0.47** | 1.00 | 0.559** | 0.569** | 0.594** | 0.485** | 0.578** | 0.574** | 0.449** |
| CCF    | 0.644** | 0.626** | 0.548** | 1.00   | 0.934** | 0.781** | 0.625** | 0.729** | 0.805** | 0.609** |
| CCM    | 0.56**  | 0.541** | 0.572** | 0.895** | 1.00   | 0.893** | 0.832** | 0.812** | 0.776** | 0.562** |
| EPP    | 0.615** | 0.595** | 0.548** | 0.757** | 0.879** | 1.00   | 0.914** | 0.926** | 0.861** | 0.645** |
| KPR    | 0.475** | 0.452** | 0.502** | 0.621** | 0.878** | 0.887** | 1.00   | 0.846** | 0.719** | 0.486** |
| 100 GW | 0.675** | 0.647** | 0.579** | 0.742** | 0.832** | 0.902** | 0.848** | 1.00   | 0.912** | 0.677** |
| GYP    | 0.764** | 0.733** | 0.502** | 0.768** | 0.652** | 0.746** | 0.567** | 0.837** | 1.00   | 0.732** |
| PC     | 0.614** | 0.602** | 0.408** | 0.599** | 0.497** | 0.575** | 0.407** | 0.641** | 0.716** | 1.00   |

** Significant at 1 per cent level. Plant height (cm)= PH, Ear height (cm)= EH, Leaf relative water content (%)= LRWC, Chlorophyll content at flowering= CCF, Chlorophyll content at maturity= CCM, Ears plant\(^{-1}\)=EPP, Kernels row\(^{-1}\)=KPR, 100 Grain weight (g)= 100GW, Grain yield plot\(^{-1}\)= GYP, Protein content (%)= PC

### Table 2: Direct and indirect effects (genotypic level) of morphological, physiological yield attributing and quality traits on grain yield plot\(^{-1}\) (g) in inbred lines of maize (pooled over years)

| Traits | PH   | EH   | LRWC | CCF   | CCM   | EPP   | KPR   | 100 GW | PC    | GCC   |
|--------|------|------|------|-------|-------|-------|-------|--------|-------|-------|
| PH     | 0.4602 | -0.4218 | 0.0005 | 1.0337 | -1.1919 | 0.1426 | 0.3745 | 0.3893 | 0.0172 | 0.8042 |
| EH     | 0.4590 | **-0.4229** | 0.0005 | 1.0377 | -1.1908 | 0.1418 | 0.3691 | 0.3850 | 0.0174 | 0.7968 |
| LRWC   | 0.2543 | -0.2322 | **0.0009** | 0.8286 | -0.9642 | 0.1094 | 0.2755 | 0.2902 | 0.0120 | 0.5745 |
| CCF    | 0.3211 | -0.2963 | 0.0005 | **1.4811** | -1.5827 | 0.1438 | 0.3553 | 0.3661 | 0.0162 | 0.8052 |
| CCM    | 0.3238 | -0.2973 | 0.0005 | 1.3840 | **-1.6938** | 0.1643 | 0.4728 | 0.4067 | 0.0150 | 0.7760 |
| EPP    | 0.3567 | -0.3261 | 0.0006 | 1.1577 | -1.5131 | **0.1839** | 0.5193 | 0.4651 | 0.0171 | 0.8611 |
| KPR    | 0.3036 | -0.2749 | 0.0005 | 0.9269 | -1.4105 | 0.1682 | **0.5677** | 0.4251 | 0.0130 | 0.7195 |
| 100 GW | 0.3569 | -0.3244 | 0.0005 | 1.0804 | -1.3723 | 0.1704 | 0.4808 | **0.5019** | 0.0181 | 0.9123 |
| PC     | 0.2964 | -0.2755 | 0.0004 | 0.9020 | -0.9521 | 0.1178 | 0.2761 | 0.3403 | **0.0266** | 0.7321 |

Genotypic correlation coefficient =GCC, Residual effect=0.2093R\(^2\)=0.9562
These observations are in conformity with the findings of Kumar et al., (2006) and Pavan et al., (2011), Dar et al., (2015), Jakhar et al., (2017a). On studying association and interrelationships among the traits other than grain yield plot\(^1\) which might aid in understanding an idea of plant type it was revealed that plant height had highly significant positive correlation with ear height and grain yield plot\(^1\). Similar observations were reported by Bhole and Patil (1984) and Jakhar et al., (2017a). Chlorophyll content at maturity had good correlation with ears plot\(^1\).

Path-coefficient analysis was studied at phenotypic level considering grain yield plot\(^1\) as dependent character. The independent characters were plant height (cm), ear height (cm), leaf relative water content (%), chlorophyll content at flowering, chlorophyll content at maturity, ears plant\(^1\), kernels row\(^{-1}\), 100 grain weight (g), protein content (%). The phenotypic correlation was partitioned into direct and indirect effects on grain yield plot\(^1\) (Figure 1) and the data is presented in Table 2. Correlation coefficient estimates indicate only the extent and nature of association between yield and its attributes, but does not show the direct and indirect effects of different yield traits on yield per se.

Grain yield is dependent on several characters which are mutually associated; these will in turn impair the true association exiting between a component and grain yield. A change in any one component is likely to disturb the whole network of cause and effect. Thus, each component has two paths of action viz., the direct influence on grain yield, indirect effect through components which are
not revealed from the correlation studies. The highest positive and direct effect was found for chlorophyll content at flowering (1.4811), kernels per row (0.5677) followed by 100 grain weight (0.5019), plant height (0.4602). The negative and direct effect was found for days to chlorophyll content at maturity (-1.6938) and ear height (-0.4229). The plant height showed negative indirect effect for ear height (-0.42) followed by chlorophyll content at maturity (-1.19) with positive indirect effect for ears plot\(^{-1}\) (0.14), kernels row\(^{-1}\) (0.37) and 100 grain weight (0.38).

Ears plot\(^{-1}\) showed highly positive indirect effect for chlorophyll content at flowering (1.15), kernels row\(^{-1}\) (0.51) followed by 100 grain weight (0.46). The 100 grain weight showed highly positive indirect effect for chlorophyll content at flowering (1.08) followed by kernels row\(^{-1}\) (0.48) and highly negative indirect effect was found for chlorophyll content at maturity (-1.37) followed by ear height (-0.32). These findings were in agreement with reports of Venugopal et al., (2003), Sofi and Rather (2007), Brar et al., (2008) Saidaiah et al., (2008) and Jakhar et al., (2017b).

Based on the findings in this study, we concluded that traits viz., 100-seed weight, ears plot\(^{-1}\), chlorophyll content, plant height, ear height and number of kernels row\(^{-1}\) are highly correlated with grain yield plot\(^{-1}\) and need to be considered for selection. The conclusions revealed that there is scope for simultaneous improvement of these traits through selection. The highest positive and direct effects of chlorophyll content at flowering, kernels row\(^{-1}\) followed by 100 grain weight and plant height was revealed on grain yield plot\(^{-1}\). These traits contributed maximum to higher grain yield compared to other characters, thus, selection for these characters helps in selection of superior cross combinations for improvement of yield.

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