Correlation and Path Coefficient Analysis for Yield Contributing and Quality Traits in Quality Protein Maize (Zea mays L.)

Ramesh Kumar*, R.B. Dubey, K.D. Ameta, Ram Kunwar, Rajani Verma and Prashant Bisen

Department of Plant Breeding and Genetics, Maharana Pratap University of Agriculture and Technology, Udaipur – 313001, Rajasthan, India

*Corresponding author

Abstract

Studies on genetic variability parameters were carried out in Quality Protein Maize (QPM) genotypes at AICRP on maize Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan and in kharif 2014 for 15 various traits like days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking interval, days to 50 per cent silking, anthesis silking interval, days to 75 per cent brown husk, plant height, ear height, ear length, 100-grain weight, grain yield per plant, harvest index, oil content, starch content, protein content, tryptophan content and lysine content in QPM genotypes. The experimental material consisting of 18 lines and 4 standard checks viz., Pratap QPM hybrid-1, Vivek QPM-9, HQPM-1 and HQPM-5 was raised in randomized block design in three replications. In the present investigation significant differences between the test entries were observed for all the yield and yield contributing traits and quality parameters. The grain yield per plant had highly significant and positive correlations both at genotypic and phenotypic levels with 100-grain weight (r_g=0.863, r_p=0.829), starch content (r_g=0.657, r_p=0.649), harvest index (r_g=0.529, r_p=0.504), lysine Content (r_g=0.518, r_p=0.486), ear length (r_g=0.476, r_p=0.463), tryptophan content (r_g=0.468, r_p=0.457) and ear height (r_g=0.351, r_p=0.339). The highest positive and direct effect was found for days to 50% tasseling (5.559) followed by lysine content (0.710) and starch content (0.439). The negative and direct effect was found for days to 50% silking (-5.774) and plant height (-0.331).

Keywords
Correlation, Path Coefficient, Quality Protein Maize, Grain yield.

Introduction

Maize (Zea mays L.) is the third important cereal crop globally after wheat and rice (FAO, 2014). Maize being a C_4 plant is physiologically more efficient, has higher grain yield and wider adaptation over wide range of environmental conditions which provides food, feed, fodder, fuel and severe as a source of basic raw material for a number of industrial products viz. protein, starch, oil, food sweeteners and bio-fuel etc. It grown over a range of agro climatic zones from 58° N to 40° S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (Downswell et al., 1996).

Because of very wide utilization of maize, the main goal of all maize breeding programs is to obtain new inbred and hybrids that will outperform the existing hybrids with respect to a number of traits. In working towards this goal, particular attention is paid to grain yield
as the most important agronomic characteristic (Pandey et al., 2017).

Grain yield is a complex quantitative trait that depends on plant genetics and its interaction with environmental conditions (Khatab et al., 2016). To determine such relationships, correlation analyses are used such that the values of two characters are analyzed on a paired basis, results of which may be either positive or negative (Akhtar et al., 2015).

Studies on correlation coefficients of different characters are useful criterion to identify desirable traits that may contribute to improve the grain yield in QPM. Path analysis is also equally beneficial since it is an efficient biometrical tool which indicates the direct contribution of characters and its influence through other traits in influencing the yield (Nataraj et al., 2014). Generally, this method provides more information among variables than do correlation coefficients since this analysis provides the direct effects of specific yield components on yield, and indirect effects via other yield components (Garcia et al., 2003). Present study aimed at understanding the genetic parameters which determine the relationship between maize yield and other traits.

Materials and Methods

Experimental material and experimental design

The present investigation was carried out in Quality protein maize (Zea mays L.)’ at Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, India during Kharif, 2014. The experimental material consisting of 22 genotypes presented in Table 1. In this experiment, 18 inbreds and 4 checks viz., Pratap QPM hybrid-1, Vivek QPM-9, HQPM-1 and HQPM-5 were evaluated in randomized block design with three replications during Kharif 2014. The experimental material were sown in randomized block design with three replications with a single row plot of four meter length, maintaining crop geometry of 60 x 25 cm.

Data collection

Observations for all traits (anthesis silking interval, plant height, ear height, ear length, 100-grain weight, grain yield per plant, harvest index, oil content, starch content, protein content, tryptophan content and lysine content) were recorded on five randomly selected competitive plants of each entry in each replication except for days to 50 per cent tasseling, days to 50 percent silking and days to 75 per cent brown husk where observations were recorded on plot basis.

Estimation of oil content, starch content and protein content were done as per method suggested by Soxhlet’s Ether Extraction method developed by A.O.A.C. (1965), Anthrone Reagent method and Micro kjeldahl’s method given by Lindner (1944), respectively. Tryptophan was estimated through calorimetric method designed by Hernandez and Bates (1969). Lysine was estimated according to the calorimetric method by Villegas and Mertz (1971).

Statistical analysis

The phenotypic ($r_p$), genotypic ($r_g$) and environmental ($r_e$) correlation coefficients for various characters were calculated by the method suggested by Panse and Sukhatme (1985). To establish a cause and effect relationship the first partition genotypic and phenotypic correlation coefficient into direct and indirect effects by path analysis as suggested by Dewey and Lu (1959) and developed by Wright (1921) than prepare path diagram based on cause and effect relationship.
Results and Discussion

In the present investigation significant differences between the test entries were observed for all the yield and yield contributing traits and quality parameters presented in Table 2. The grain yield per plant had highly significant and positive correlations both at genotypic and phenotypic levels with 100-grain weight \((r_g=0.863, r_p=0.829)\), starch content \((r_g=0.657, r_p=0.649)\), harvest index \((r_g=0.529, r_p=0.504)\), lysine Content \((r_g=0.518, r_p=0.486)\), ear length \((r_g=0.476, r_p=0.463)\), tryptophan content \((r_g=0.468, r_p=0.457)\) and ear height \((r_g=0.351, r_p=0.339)\) presented in Table 3. Whereas the anthesis silking interval \((r_g=-0.376, r_p=-0.256)\) had significant but negative correlation with seed yield at both the levels. Oil content \((r_g=-0.376, r_p=-0.256)\) had non-significant and negative correlation at both the levels. Days to 50% tasseling \((r_g=-0.121, r_p=-0.114)\), days to 75% brown husk \((r_g=-0.106, r_p=-0.102)\), days to 50% silking \((r_g=-0.065, r_p=-0.063)\), plant height \((r_g=-0.054, r_p=-0.046)\) and protein content \((r_g=-0.042, r_p=-0.043)\) had non-significant but positive correlation with seed yield per plant at both genotypic and phenotypic levels. Hence results were concluded that grain yield per plant had highly significant and positively correlated with 100-grain weight, starch content, harvest index, ear height and ear length, and negatively correlated with days to 50 per cent tasseling and days to 75 per cent brown husk at both genotypic and phenotypic levels. Anthesis silking interval had highly significant but negative association with tryptophan Content, lysine content and 100-grain weight. Plant height exhibited highly significant and positive association with ear height, ear length and lysine content. Ear height had highly significant and positive association with harvest index, tryptophan content and lysine content. Harvest index had significant and positive association with oil content and tryptophan content. Protein content exhibited highly significant and positive association with tryptophan content.

The estimation of correlation coefficients indicates only the nature and extent of association between yield and yield attributes, but does not show the direct and indirect effects of different yield contributing attributes 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 various components and grain yield.

The genotypic correlation coefficients calculated for different pairs of characters were subjected to path coefficient analysis for partitioning these values into direct and indirect effects. The highest positive and direct effect was found for days to 50 per cent tasseling \((5.559)\) followed by lysine content \((0.710)\) and starch content \((0.439)\). The negative and direct effect was found for days to 50 per cent silking \((-5.774)\) and plant height \((-0.331)\) presented in Table 4.
Table 1. Details of Inbred lines used

| S.N. | Symbol/Code | Pedigree | Origin |
|------|-------------|----------|--------|
| 1.   | L₁ (EIQ-115) | NP-06-07R-58-3-2-1-2-1 | AICRP on maize, Udaipur |
| 2.   | L₂ (EIQ-116) | NP-06-07R-58-3-2-1-3-1 | AICRP on maize, Udaipur |
| 3.   | L₃ (EIQ-117) | NP-06-07R-74-19-1-1-1 | AICRP on maize, Udaipur |
| 4.   | L₄ (EIQ-118) | NP-06-07R-76-11-3-2-1 | AICRP on maize, Udaipur |
| 5.   | L₅ (EIQ-119) | NP-06-07R-76-9-1-1-2-2 | AICRP on maize, Udaipur |
| 6.   | L₆ (EIQ-120) | NP-06-07R-74-2-2-1-1 | AICRP on maize, Udaipur |
| 7.   | L₇ (EIQ-121) | NP-06-07R-77-1-2 | AICRP on maize, Udaipur |
| 8.   | L₈ (EIQ-122) | NP-06-07R-74-3-1-2-1 | AICRP on maize, Udaipur |
| 9.   | L₉ (EIQ-123) | NP-06-07R-74-3-1-1-3-2 | AICRP on maize, Udaipur |
| 10.  | L₁₀ (EIQ-124) | NP-06-07R-16-3 | AICRP on maize, Udaipur |
| 11.  | L₁₁ (EIQ-125) | NP-06-07R-76-8-3-3-1-8-2 | AICRP on maize, Udaipur |
| 12.  | L₁₂ (EIQ-126) | NP-06-07R-80-16-1-1-1-1 | AICRP on maize, Udaipur |
| 13.  | L₁₃ (EIQ-127) | NP-06-07R-89-12-1-1-1-1 | AICRP on maize, Udaipur |
| 14.  | L₁₄ (EIQ-128) | HO6R-6136-64-1-2-1-1 | CIMMYT |
| 15.  | L₁₅ (EIQ-129) | HO6R-6136-4-1-1-2 | CIMMYT |
| 16.  | T₁ (EIQ-104) | NP-60 | AICRP on maize, Udaipur |
| 17.  | T₂ (EIQ-103) | NP-76 | AICRP on maize, Udaipur |
| 18.  | T₃ (EIQ-130) | NP-86 | AICRP on maize, Udaipur |
| 19.  | Pratap QPM | hybrid-1 | AICRP on maize, Udaipur |
| 20.  | Vivek QPM-9 | | VPKAS, Almora |
| 21.  | HQPM-1 | | CCS, HAU |
| 22.  | HQPM-5 | | CCS, HAU |

Where,  
AICRP - All India Coordinated Research Project  
CSS HAU - Chaudhary Charan Singh Haryana Agricultural University  
CIMMYT - International Wheat and Maize Improvement Centre  
VPKAS - Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora

Table 2. Analysis of variance for fifteen traits

| SN | Source | Replication | Genotype | Error |
|----|--------|-------------|----------|-------|
|    |        | [2]         | [21]     | [42]  |
| 1. | Days to 50% tasseling | 11.74** | 24.68** | 1.46  |
| 2. | Days to 50% silking   | 10.29** | 24.70** | 1.35  |
| 3. | Anthesis silking interval | 0.29   | 0.58** | 0.16  |
| 4. | Days to 75% brown husk | 14.02* | 41.16** | 3.46  |
| 5. | Plant height (cm)     | 70.47  | 390.80** | 30.95 |
| 6. | Ear height (cm)       | 171.92** | 981.06** | 23.78 |
| 7. | Ear length (cm)       | 0.50** | 4.16** | 0.08  |
| 8. | 100 Grain weight (g)  | 2.89   | 69.45** | 1.81  |
| 9. | Grain yield per plant (g) | 0.80 | 1442.80** | 3.08  |
| 10.| Harvest index (%)     | 0.42   | 20.63** | 0.51  |
| 11.| Oil content (%)       | 0.02   | 0.96** | 0.01  |
| 12.| Starch content (%)    | 0.05   | 21.67** | 0.14  |
| 13.| Protein (%)           | 0.01*  | 1.09** | 0.00  |
| 14.| Tryptophan Content (%)| 0.0039** | 0.03** | 0.00  |
| 15.| Lysine Content (%)    | 0.02   | 0.33** | 0.01  |
**Table 3** Genotypic (G) and phenotypic (P) correlation coefficients among yield and quantitative traits in maize

| Trait                      | Genotypic (G) Correlations | Phenotypic (P) Correlations |
|----------------------------|-----------------------------|-----------------------------|
| Grain yield per plant (g)  |                             |                             |
| Days to 50% tasseling      | G: 1.000                    | P: 1.000                    |
| Antthesis silking interval  |                             |                             |
| Days to 75% brown husk     | G: 1.000                    | P: 1.000                    |
| Plant height (cm)          | G: 1.000                    | P: 1.000                    |
| Ear height (cm)            | G: 1.000                    | P: 1.000                    |
| Ear length (cm)            | G: 1.000                    | P: 1.000                    |
| 100 Grain weight (g)       | G: 1.000                    | P: 1.000                    |
| Harvest index (%)          | G: 1.000                    | P: 1.000                    |
| Oil content (%)            | G: 1.000                    | P: 1.000                    |
| Starch content (%)         | G: 1.000                    | P: 1.000                    |
| Protein (%)                | G: 1.000                    | P: 1.000                    |
| Tryptophan Content (%)     | G: 1.000                    | P: 1.000                    |
| Lysine Content (%)         | G: 1.000                    | P: 1.000                    |
Table 4: Direct and indirect effect of characters on grain yield per plant (g) at genotypic level

|                          | Days to 50% tasseling | Days to 50% silking | Anthesis silking interval | Days to 75% brown husk | Plant height (cm) | Ear height (cm) | Ear length (cm) | 100 Grain weight (g) | Harvest index (%) | Oil content (%) | Starch content (%) | Protein (%) | Tryptophan Content (%) | Lysine Content (%) | Grain yield per plant (g) |
|--------------------------|-----------------------|---------------------|---------------------------|-------------------------|-------------------|----------------|-----------------|---------------------|----------------|---------------|---------------------|------------|-----------------------|--------------------|-------------------------|
| Days to 50% tasseling    | 5.559                 | 5.501               | 0.268                     | 4.691                   | -0.039            | -0.418         | 1.057           | 1.068               | 1.116           | -0.068        | 0.682               | 1.210      | 0.696                 | -0.373             | 0.121                   |
| Days to 50% silking      | -5.714                | -5.774              | -1.108                     | -4.764                  | 0.200             | 0.397          | -1.108          | -0.820              | -1.141           | -0.182        | 0.536               | -1.013     | 0.217                 | 0.598              | 0.065                   |
| Anthesis silking interval| 0.026                 | 0.105               | 0.549                      | 0.010                   | -0.119            | 0.040          | 0.046           | -0.168              | -0.033           | 0.103         | -0.101              | -0.176     | -0.367                | -0.376**            | -                      |
| Days to 75% brown husk   | 0.233                 | 0.228               | 0.005                      | 0.276                   | -0.017            | -0.014         | 0.043           | 0.034               | 0.006           | -0.074        | 0.045               | 0.014      | -0.034                | -0.105             | 0.106                   |
| Plant height (cm)        | 0.002                 | 0.012               | 0.072                      | 0.020                   | -0.331            | -0.137         | -0.117          | -0.065              | -0.037           | -0.032        | 0.022               | -0.042     | -0.113                | 0.054              | 0.351**                  |
| Ear height (cm)          | -0.028                | -0.026              | 0.027                      | -0.018                  | 0.153             | 0.372          | 0.203           | 0.226               | 0.027           | 0.113         | 0.191               | -0.032     | 0.098                 | 0.050              | 0.351**                  |
| Ear length (cm)          | 0.017                 | 0.017               | 0.008                      | 0.014                   | 0.032             | 0.049          | 0.089           | 0.047               | 0.045           | -0.004        | 0.006               | -0.026     | 0.019                 | 0.036              | 0.476**                  |
| 100 Grain weight (g)     | -0.043                | -0.032              | 0.069                      | -0.028                  | -0.044            | -0.137         | -0.119          | -0.225              | -0.092           | 0.011         | -0.159              | -0.025     | -0.133                | -0.141             | 0.863**                  |
| Harvest index (%)        | 0.059                 | 0.058               | -0.018                     | 0.006                   | 0.033             | 0.021          | 0.149           | 0.119               | 0.293           | 0.071         | 0.029               | 0.028      | 0.087                 | 0.170              | 0.529**                  |
| Oil content (%)          | 0.003                 | -0.007              | -0.043                     | 0.061                   | -0.022            | -0.070         | 0.010           | 0.011               | -0.056           | -0.230        | -0.014              | -0.036     | -0.028                | -0.031             | -0.175                   |
| Starch content (%)       | 0.054                 | 0.041               | -0.081                     | 0.071                   | 0.004             | 0.226          | 0.028           | 0.311               | 0.044           | 0.027         | 0.439               | 0.078      | 0.094                 | 0.064              | 0.657**                  |
| Protein (%)              | 0.030                 | 0.024               | -0.044                     | 0.007                   | -0.009            | -0.012         | -0.040          | 0.016               | 0.013           | 0.022         | 0.025               | 0.138      | 0.045                 | -0.013             | 0.042                   |
| Tryptophan Content (%)   | -0.029                | -0.009              | 0.153                      | 0.028                   | -0.029            | -0.061         | -0.050          | -0.135              | -0.068           | -0.028        | -0.049              | -0.075     | -0.229                | -0.154             | 0.468**                  |
| Lysine Content (%)       | -0.048                | -0.074              | -0.232                     | -0.269                  | 0.242             | 0.095          | 0.283           | 0.445               | 0.413           | 0.096         | 0.104               | -0.066     | 0.479                 | 0.710              | 0.518**                  |
The days to 50 per cent tasseling showed highly positive indirect effect for days to 50 per cent silking (5.501) followed by days to 75 per cent brown husk (4.691) and harvest index (1.116). Whereas, it has found negative indirect effect for ear height (-0.418) followed by lysine content (-0.373) and oil content (-0.068). The 100 grain weight showed positive indirect effect for anthesis silking interval (0.069) followed by oil content (0.011) and highly negative indirect effect was found for starch content (-0.159) followed by ear height (-0.137) and tryptophan content (-0.133).

These findings were in agreement with reports of Alok Kumar et al., (1999), Venugopal et al., (2003) for plant height and ear length; Kumar et al., (2006), Shakoor et al., (2007), Sofi and Rather (2007) and Saidaiah et al., (2008) for 100 grain weight; Venugopal (2003), Kumar et al., (2006) and Brar et al., (2008) for ear height and Kumar et al., (2006) for days to 50% tasseling.

The success of a breeding program depends upon the genetic variation in the materials at a hand. The high direct effects of these characters appeared to be the main reason for their strong association with grain yield. Hence, direct selection for these characters would be very effective. As such these results will be useful for choosing populations to be used in developing new maize populations with improved characters.

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