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Research Note

Factor analysis for yield contributing traits in maize (*Zea mays* L.)

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Abstract
Data collected on 17 traits from 144 inbred lines derived using 4 different base populations of unknown pedigree were subjected to factor analysis. Sixteen factors were extracted using principal component analysis as extraction method. Out of 16, only 5 factors had eigen value greater than one and these factors alone accounted for 78.3% of total variance. The loadings of each variable onto each factor was analysed from the rotated factor matrix obtained through varimax rotation. First factor accounted for 22.93% of the total variation and showed significant associations of traits related to duration namely days to 50% tasseling, days to 50% silking, anthesis silking interval and days to maturity. Second factor with 19.22% of total variation had higher loadings of plant height and ear height which are the important growth traits in maize. Factor 3 with a contribution of 17.91% to total variation was found to be significantly associated with the important yield traits *viz.* cob yield/plant, grain yield/plant and ear girth. Factor 4 (9.99% variance) and factor 5 (8.33% variance) were loaded mainly with hundred seed weight and grain setting length respectively.

Key words
Maize, Factor analysis, Principal components and varimax rotation

Maize is the third most important food crop in India next to rice and wheat (Parihar *et al.* 2011). During the initial years of maize improvement, emphasis was on development of Composites, Double and Three Way Cross Hybrids. After realization of the advantages of single cross hybrids, major thrust has been on this direction. Success of single cross hybrid development largely relies on the diversity and yield attributes of the parental inbreds. Analysis using univariate statistical techniques ignore the correlation among the variables and sometimes the conclusion may be misleading. The multivariate techniques take into account the inter dependence and relative importance of various characters involved and yield more meaningful genetic information (Mohar singh *et al.* 2011). Hence, an effort was made to study the inter dependence of important growth and yield parameters of maize inbreds derived from unknown pedigree using factor analysis.

The materials for the study consisted of 144 inbred lines derived from 4 different populations of unknown pedigree *viz.* segregating populations of single cross and three way cross hybrids, hybrid mixtures and composites. These inbreds were tested in a square lattice design with 2 replications at FCS research farm, Attur, Tamilnadu. Data were recorded in 5 competitive plants on 17 characters *viz.* Days to 50% tasseling, days to 50% silking, anthesis silking interval, days to maturity, plant height (cm), ear height (cm), number of leaves, leaf length (cm), leaf width (cm), number of tassel branches, ear length (cm), grain setting length (cm), ear girth (cm), number of kernels/ear, 100 seed weight (g), cob yield/plant (g) and grain yield/plant (g). The suitability of the data for factor analysis was tested using Kaiser-Meyer-Olkin measure of sampling adequacy. The factor extraction was done using principal component method and the criterion of eigen value (>=1) or characteristic root was utilized for deciding the number of factors to be retained (Kaiser 1960). The varimax rotation was used to make each factor uniquely defined as a distinct cluster of inter correlated variables. The calculations were performed using SPSS software.

The value of Kaiser-Meyer-Olkin measure of sampling adequacy for the data was 0.711. Kaiser (1974) has recommended a value greater than 0.5 as acceptable for factor analysis. Further values between 0.7 and 0.8 were classified as good. In total 16 factors were extracted through principal component analysis and only 5 factors (duration, growth, yield, test weight and grain setting) with eigen value greater than 1 which jointly attributed to 78.36% of total variance were retained for further analysis (table 1). Ashofteh Beiragi *et al.* (2012) identified 12 factors out of which only four were extracted which together explained 67.8% of total variance among the entries. The principal factor matrix obtained after orthogonal rotation by varimax and the communalities of each variable are given in table 2. Factor 1 with eigen value of 3.897 explained 22.93% of total variance. The characters days to 50% tasseling, days to 50% silking, anthesis silking interval and days to maturity showed significant loadings in factor 1 with values of 0.962, 0.962, 0.976 and 0.723 respectively. It was evident that the first factor was associated with traits related to duration. Second factor showed higher factor loadings of plant height (0.867) and ear height (0.872) which are the important growth traits in maize. This factor had eigen value of 3.267 which contributed to 19.22%

of the total variance. Third factor with an eigen value of 3.044 explaining 17.91% of the total variance was loaded with the important yield traits in maize namely cob yield/plant (0.809), grain yield/plant (0.809) and ear girth (0.752). Khayatnezhad *et al*. (2011) have reported higher loadings of grain number/row, number of grains per ear and grain weight on a factor having 62.36% of total variation. The fourth and fifth factors with eigen value of 1.697 and 1.416 explained 9.98% and 8.33% of total variance respectively. The fourth and fifth factors showed high loading for only one trait *viz.* hundred seed weight (0.866) and Grain setting length (0.791) respectively. Houman Homayoun (2011) obtained factor with high loadings of kernels/ear, ear length and 500 kernel weight which justified 71.53% of data changes. The communalities after extraction represent the amount of variance in each variable that are being shared by all other variables in commonality. Among the variables, leaf length had the lowest communality of 0.418.

From the study, it is evident that extracted factors showed a high positive loading with duration, growth, yield, test weight and grain setting traits. These factors can be very well utilized for choosing the inbreds for hybrid development and other breeding programs based on the objectives. Leaf characters like number of leaves, leaf length and leaf width and number of tassel branches have low significance in the extracted factors which indicates the limited importance of these characters in further breeding programs.

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Table 1. Eigen value and the total variance explained for each factor based on 17 characters used in the study.

Factor	Initial Eigen values			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.010	35.35	35.35	3.897	22.93	22.93
2	2.775	16.32	51.68	3.267	19.22	42.14
3	1.850	10.88	62.56	3.044	17.91	60.05
4	1.543	9.08	71.64	1.697	9.98	70.03
5	1.144	6.73	78.36	1.416	8.33	78.36
6	0.808	4.75	83.12			
7	0.691	4.06	87.18			
8	0.563	3.31	90.49			
9	0.465	2.74	93.23			
10	0.413	2.43	95.65			
11	0.266	1.57	97.22			
12	0.197	1.16	98.38			
13	0.130	0.76	99.14			
14	0.080	0.47	99.61			
15	0.051	0.30	99.91			
16	0.015	0.09	100.00			

Table 2. Principal factor matrix after varimax rotation for 17 characters with communalities

Characters	Factor					Communalities
	1	2	3	4	5	
Days to 50% tasseling	0.962	0.093	0.060	-0.053	-0.010	0.941
days to 50% silking	0.962	0.119	0.099	-0.029	-0.022	0.950
Anthesis silking interval	0.976	0.109	0.082	-0.042	-0.016	0.973
Days to maturity	0.723	0.194	0.161	0.324	0.218	0.738
Plant height (cm)	0.191	0.867	-0.026	0.234	0.120	0.858
Ear height (cm)	0.187	0.872	0.085	0.105	0.068	0.817
Number of leaves	-0.020	0.697	0.271	-0.238	-0.124	0.632
Leaf length (cm)	0.393	0.390	0.265	0.022	0.200	0.418
Leaf width (cm)	0.389	-0.039	0.599	-0.228	-0.185	0.597
No. of tassel branches	0.237	0.407	0.170	-0.466	-0.425	0.649
Ear length (cm)	0.194	0.586	0.363	-0.103	0.469	0.744
Grain setting length (cm)	0.063	0.090	0.027	-0.001	0.791	0.638
Ear girth (cm)	0.259	-0.092	0.752	0.242	-0.224	0.750
Number of grains/ear	0.114	0.226	0.623	-0.596	0.270	0.879
100 seed weight (g)	0.123	0.237	0.253	0.866	0.015	0.885
Cob yield/plant (g)	0.003	0.468	0.809	0.114	0.232	0.940
Grain yield/plant (g)	-0.048	0.437	0.809	0.088	0.237	0.912