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THE CLUSTER AND PRINCIPAL COMPONENT ANALYSES OF MAIZE LANDRACES OF MANIPUR, INDIA

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ABSTRACT

The experiment comprises of 42 landraces accession of Manipur and were assessed for 28 quantitative morphological characters. These characters were evaluated by employing cluster and principle component analysis to obtain suitable parents. The analysis of variance revealed significant differences among the accessions for all the traits. The accession CAUCH 57 and CAUCH 69 has a maximum elucidation distance with the majority of accession collected indicating they are quite different from the rest of the collected landraces accession. Three broad clusters were formed in the dendogram produced by the morphological data. The principal component analysis of 28 morphological traits accounted for 80.47% of the total variation. The current study of maize landraces accounted for total eight principal components having eigen value greater than 1. The first principal component explained the highest 26.44% of the total variation. The results showed that the germplasm having a wide genetic diversity can be thus utilized for future breeding programme.

KEYWORDS: CAUCH, Cluster Analysis, Landraces & Principal Component Analysis and Quantitative Traits

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Original Article

INTRODUCTION

Maize (*Zea mays* L.) is the second most important cereal crops in north eastern Himalayan region of India including Manipur next to rice which plays an important role in ensuring food security and is grown under rainfed hilly upland conditions Ansari *et. al* (2015). Many of the Indian North eastern Hill landrace accessions are unique in their morphology and area(s) of adaptation, and have been conserved by the local farmers for several centuries due to their socio-cultural, aesthetic and economic value (Prasanna and Sharma, 2005). The genetic diversity is the base for crop improvement programs (Iqbal *et. al* 2014) which is elucidated through different marker systems such as agro-morphological, biochemical and molecular markers. Among these the agro-morphological characterization is considered as the initial step (Smith and Smith, 1989) for germplasm conservation. Classification tools like cluster analysis are used to better understand the relationships between various landraces. Knowledge of relationships and common characteristics of individuals can assist breeders and geneticists with identification of sets or groups of individuals which have potential utility for specific breeding or genetic purposes and for these cluster analysis is frequently used to classify maize accession Rincon *et. al* (1996). The principal component analysis (PCA) assigned each genotype to only one group and also reflects the significance of the largest contributor to the total variability at each axis of differentiation (Sharma, 1998). A combination of cluster analysis and principal component analysis has been used to classify maize accessions Crossa *et. aI* (1995). Principal component analysis and clustering are

considered the strong statistical tools to classify maize accession and to find out the component which contribute maximum variation among the collected landrace accessions to identify suitable parents for breeding programmes

MATERIAL AND METHODS

A total of 1208 accession of maize landraces were collected giving each a unique passport data from the villages of 9 districts of Manipur viz Imphal West, Imphal East, Bishnupur, Churachandpur, Tamenglong, Chandel, Thoubal, Senapati and Urkhrul. Unique accession code of the initials CAUCH followed by the collection number was assigned to each accession collected and CAUCH stands for Central Agricultural University Chuwang Hijam. In *Kharif* 2014 the collected accession was categorised into similar group *w.r.t.* Kernel shape, kernel color, kernel row arrangement and Local name. From each group comprising similar accessions, a single accession was selected to represent all the similar accession, the selected accession was planted and preliminary evaluation data as per IBPGR descriptors of maize (1991) were recorded from 10 representative plant and were self-pollinated in the experimental field of Plant Breeding and Genetics Department. The recorded data was analysed for their mean and those accession which are very similar in relation to the recorded character are considered as duplicate samples and one accession from similar group was selected while others are eliminated. Only 42 accessions were selected representing all the similar accession for further characterization and evaluation. In *Kharif* 2015, the 42 selected maize landraces accessions were shown in Randomised block design with 3 replication, plot size having (4 X 2) m^2 and spacing of 60 cm X 30 cm. Agronomic practices which is required for raising good crops was followed. The observations were recorded from ten randomly selected plants in each plots in each replication on following 28 quantitative characters *viz.* total number of leaves per plant, Leaf length, Leaf width, Venation index, Tassel length, Tassel peduncle length, Tassel branching space, Number of primary branches on tassel, Number of secondary branches on tassel, Number of tertiary branches on tassel, Growing Degree Units (GDU) to female flowering, GDU to male flowering, Plant height, Ear height, Number of leaves above the uppermost ear including ear leaf, Prolificacy index, Ear length, Peduncle length of ear, Ear diameter, Cob diameter, Rachis diameter, Number of bracts, Number of kernels per row, Number of Kernel rows, Kernel length, Kernel width, Kernel thickness and 100 kernel weight as per Descriptors for Maize, IBPGR (1991). The data collected were subjected to analysis of variance, cluster analysis and principal component analysis (PCA) using statistical software packages of SAS 9.3, Microsoft Excel and IBM SPSS 22.0 Software packaged and dendogram was produced by using average linkage (Between groups).

RESULTS AND DISCUSSIONS

Landraces were evaluated for 28 quantitative characters. The maximum, minimum, range, average value and standard deviation for the quantitative traits are shown in table 1. The highest Standard deviation were recorded for Plant height (45.48), GDU male flowering (35.29) and ear height (32.14) while the lowest Standard deviation was recorded in number of tertiary branches of tassel (0.24), cob diameter (0.32), rachis diameter (0.32) and venation index (0.46). Means that were calculated for each trait showed considerable diversity among the maize landraces.

Table 1: Descriptive Statistics of 28 Quantitative Traits

Quantitative Characters	Maximum	Minimum	Range	Mean	Std. Deviation
100 kernel weight	42.31	12.09	30.22	25.26	5.45
Cob diameter [cm]	3.79	1.86	1.93	2.48	0.32
Ear diameter [cm]	4.94	1.96	2.98	3.71	0.49
Ear length [cm]	18.85	8.69	10.17	13.78	2.59
Kernel length [mm	11.43	6.29	5.14	8.70	1.14
Kernel thickness [mm]	5.81	3.24	2.57	4.46	0.67
Kernel width [mm]	11.19	4.83	6.36	7.92	1.01
Number of kernels per row	38.49	17.16	21.33	26.96	5.56
Number of Kernel rows	19.81	8.81	11.00	13.55	1.97
Number of bracts	17.41	7.41	10.00	11.92	2.33
Tassel peduncle length [cm]	16.44	3.72	12.72	8.18	3.47
Rachis diameter [cm]	2.63	1.15	1.48	1.72	0.32
Ear height (cm)	177.96	58.70	119.26	127.16	32.14
GDU to female flowering	1125.48	992.85	132.63	1016.62	23.55
GDU to male flowering	1095.85	870.22	225.63	962.58	35.29
Leaf width [cm]	100.27	56.03	44.24	79.56	12.07
Leaf length [cm]	10.79	5.39	5.41	8.11	1.15
Number of leaves above the uppermost ear including ear leaf	7.83	4.83	3.00	6.62	0.56
Number of primary branches on tassel	33.66	6.96	26.70	20.32	5.42
Number of secondary branches on tassel	9.53	0.73	8.80	5.16	2.48
Number of tertiary branches on tassel	1.04	0.00	1.04	0.13	0.24
Peduncle length of ear [cm]	30.17	7.58	22.60	19.23	4.46
Plant height (cm)	281.13	97.22	183.91	218.24	45.48
Prolificacy index	3.10	1.10	2.00	1.51	0.37
Tassel branching space [cm]	21.15	7.84	13.31	14.37	3.35
Tassel length [cm]	48.97	21.32	27.65	34.91	6.31
Total number of leaves per plant	20.23	11.90	8.32	14.64	1.48
Venation index	4.40	2.29	2.11	3.25	0.46

Anova

The analysis of variance was performed to test the difference between all sets of collected landraces included in the studied characters and are presented in table 2. From the table it was revealed that the maize landraces accession differed highly significantly for all the characters under study. Significant ANOVA of different characters of maize were also found by Sofi and Rather (2006) and Samanthi *et al*. (2014)

Table 2: Analysis of Variance for 28 Quantitative Characters in Landrace of Manipur

Sl. No.	Character	F Value		Pr > F Value	
		Treatment	Replication	Treatment	Replication
1	100 Kernel weight(g)	162.73	39.12	<0.01**	<0.01**
2	Cob Diameter(cm)	112.62	29.45	<0.01**	<0.01**
3	Ear Diameter(cm)	14.17	13.63	<0.01**	<0.01**
4	Ear Length(cm)	543.14	19.18	<0.01**	<0.01**
5	Kernel length(mm)	76.67	32.18	<0.01**	<0.01**
6	Kernel thickness(mm)	103.58	330.84	<0.01**	<0.01**
7	Kernel width(mm)	108.97	25.52	<0.01**	<0.01**
8	No. of kernel per rows	789.33	1061.59	<0.01**	<0.01**
9	No. of kernel rows	69.59	156.18	<0.01**	<0.01**
10	No. of bracts	84.69	36.09	<0.01**	<0.01**

Table 2: Contd.,					
11	Tassel peduncle length(cm)	59.48	10.52	<0.01**	<0.01**
12	Rachis diameter(cm)	657.58	608.34	<0.01**	<0.01**
13	Ear height(cm)	390.10	22.63	<0.01**	<0.01**
14	GDU to female flowering	27.60	0.41	<0.01**	<0.01**
15	GDU to male flowering	7.89	0.73	<0.01**	<0.01**
16	Leaf width(cm)	53.43	8.50	<0.01**	0.01**
17	Leaf length(cm)	176.20	33.25	<0.01**	<0.01**
18	No. of leaves above the uppermost ear including ear leaf	8.09	12.33	<0.01**	<0.01**
19	No. of primary branches of the tassel	76.54	30.78	<0.01**	<0.01**
20	No. of secondary branches of the tassel	103.12	3.53	<0.01**	0.35*
21	No. of tertiary branches of the tassel	221.50	0.43	<0.01**	0.68
22	Peduncle length of the ear(cm)	1633.52	27.76	<0.01**	<0.01**
23	Plant Height(cm)	264.06	20.36	<0.01**	<0.01**
24	Prolificacy Index	23.78	44.27	<0.01**	<0.01**
25	Tassel branching space(cm)	88.22	1.69	<0.01**	0.19*
26	Tassel length(cm)	150.97	2.17	<0.01**	0.12*
27	Total number of leaves per plant	25.57	27.96	<0.01**	<0.01**
28	Venation index	45.35	11.62	<0.01**	<0.01**

*** and ** indicate significant *F*-values at $P < 0.05$ and $P < 0.01$.**

Cluster Analysis

The maximum ten elucidation distance between the landraces are shown in table 3 and it shows that CAUCH57-CAUCH1003 (14.84), CAUCH76-CAUCH57 (14.52) and CAUCH69- CAUCH57 (14.00) had the largest squared Euclidean distance therefore there is a maximum difference between these accessions. The accession CAUCH 57 and CAUCH 1003 has a maximum elucidation distance with the majority of accessions collected which indicates that they are quite different from the rest of the collected landrace accessions. Similar method for grouping landraces was also used by many researcher like Ruiz and Alvarez (2001).

Table 3: The Maximum ten Elucidation Distance between the Landraces Collected

Sl. No.	Accession Code	Elucidation Distance
1	CAUCH57-CAUCH1003	14.84
2	CAUCH76-CAUCH57	14.52
3	CAUCH69- CAUCH57	14.00
4	CAUCH57- CAUCH92	13.48
5	CAUCH57- CAUCH70	12.83
6	CAUCH76- CAUCH81	12.73
7	CAUCH76- CAUCH87 and CAUCH38- CAUCH57	12.47
8	CAUCH57- CAUCH19	12.17
9	CAUCH78- CAUCH57	12.09
10	CAUCH1000- CAUCH57	12.05

The cluster analysis of the studied landraces produced three different clusters with the forty number of genotype in the first cluster and one landrace each *i.e* (CAUCH 69) and (CAUCH 57) in other two clusters as shown in the dendogram of figure 1 which signifies that the collection is very diverse and these clusters contain distinct characters from each other which is similar with results obtained by Beyene *et al*. (2005) and Khodarahmpour (2012) on maize. The predominant cluster with one of the few landraces signifies diversity within a collection. However these results do not support those obtained by Manyasa *et al.* (2009), Subramanian and Subbaraman (2010), Tanavar *et al.* (2014), Ali *et al.*

(2015) and Mustafa *et al.* (2015), who found four clusters on wheat, pigeon pea, maize, and sorghum. Contrasting findings could be due to their clustering depend in extend of diversity they collected and different populations used by them.

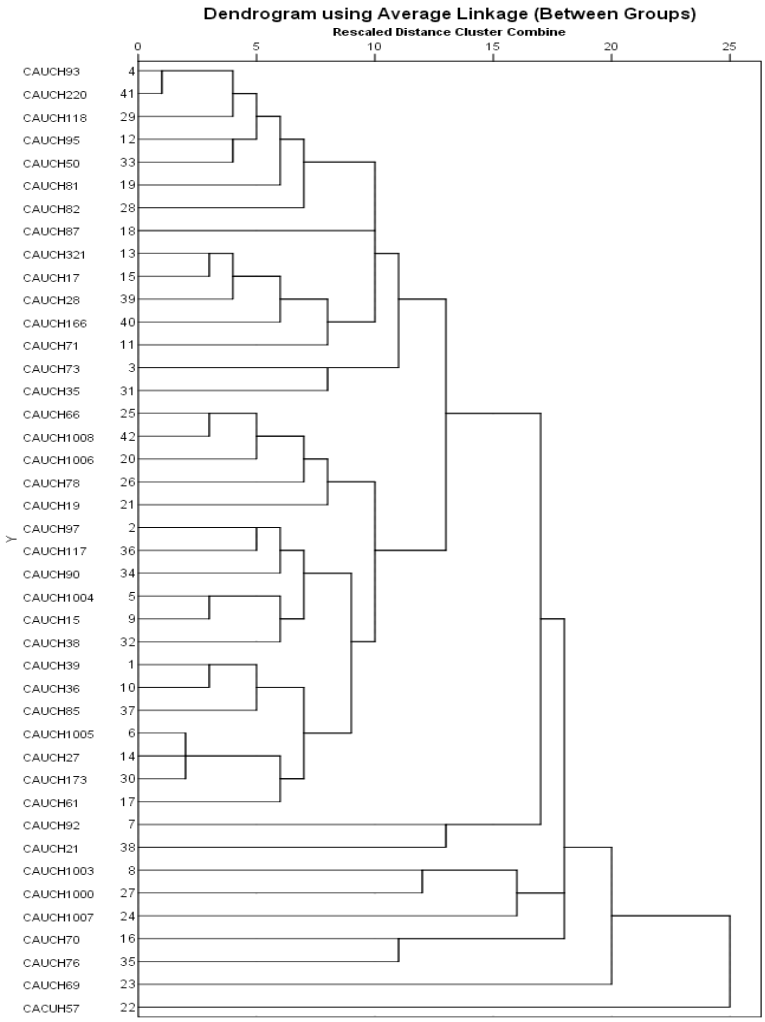

Figure 1: Dendogram Produced from Cluster Analysis of Maize Landraces Using Morphological Traits

Principal Component Analysis

The PCA analysis shown in table 4 depicts that the current study of maize landraces accounted for 80.47% of the total variation which is similar with the results obtained by Micic *et al.* (2008) of (80.86%) on maize landraces of Yugoslavia. The first principal component explained the highest 26.44% of the total variation. Maximum influence was given by Ear height (0.90), Number of secondary branches of tassel (0.85), tassel branching space (0.83), Number of primary branches of tassel (0.75), Plant height (0.70), total number of leaves per plant (0.68) and tassel length (0.61). In first component maximum numbers of traits influence the principal component with high to medium magnitude as compared to other seven principal components although medium magnitude and minimum numbers of traits take major role in the principal component. Out of the 28 characters ear height, number of secondary branches of tassel, tassel branching space, number of primary branches of tassel, plant height, total number of leaves per plant and tassel length take the major contribution in expressing all the eight principal component analysis. The studied maize landraces accounted for total eight principal component having eigen value>1 while Six principal components were obtained by Ali *et al*. (2015) on

wheat. Manyasa *et al*. (2009) and Ndiso *et al*. (2013) found two principal components for maize and pigeon pea. Beyene *et al*. (2005), Tanavar *et al*. (2014) and Mustafa *et al*. (2015) reported four principal components from a study on maize. Contrasting findings could be due to populations used and studying of a huge number of traits at a time.

Table 4: Factor Loadings and Eigenvalue for Component Traits in Principle Component 1-8

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8
100 kernel weight	0.12	0.77	0.35	0.06	0.21	0.03	0.02	0.34
Cob diameter [cm]	0.01	0.27	0.90	-0.03	0.04	0.02	0.07	-0.07
Ear diameter [cm]	0.07	0.26	0.72	0.19	0.28	-0.09	0.36	0.18
Ear length [cm]	0.17	0.66	-0.06	-0.34	0.10	0.36	0.43	-0.06
Kernel length [mm]	0.07	0.08	-0.10	-0.05	0.02	0.05	0.09	0.90
Kernel thickness [mm]	-0.06	0.24	-0.05	0.13	-0.03	0.01	-0.85	-0.21
Kernel width [mm]	0.00	0.85	0.26	0.02	0.19	-0.19	-0.04	0.03
Number of kernels per row	0.29	0.27	0.12	-0.23	0.09	0.07	0.78	-0.08
Number of Kernel rows	0.13	-0.54	0.32	0.01	-0.19	0.31	0.35	-0.13
Number of bracts	0.12	0.18	0.41	-0.29	0.40	0.18	0.31	-0.04
Tassel peduncle length [cm]	0.19	0.70	0.22	-0.47	-0.04	0.16	-0.05	-0.06
Rachis diameter [cm]	-0.01	-0.01	0.88	-0.03	0.00	-0.19	-0.09	-0.10
Ear height (cm)	0.90	0.12	-0.01	0.15	0.03	-0.09	0.00	0.17
GDU to female flowering	0.13	-0.02	0.01	0.91	0.01	0.11	-0.06	-0.10
GDU to male flowering	0.02	-0.02	0.03	0.89	-0.02	0.01	-0.18	-0.02
Leaf length [cm]	0.39	0.44	0.13	-0.11	0.58	-0.14	0.03	0.05
Leaf width [cm]	-0.05	0.38	0.14	-0.24	0.53	-0.49	0.04	-0.23
Number of leaves above the uppermost ear	0.08	0.06	0.05	0.14	0.89	0.03	0.22	-0.01
Number of primary branches on tassel	0.75	-0.23	0.00	0.15	-0.07	0.02	0.26	0.09
Number of secondary branches on tassel	0.85	0.00	0.20	-0.16	0.25	0.02	0.01	-0.06
Number of tertiary branches on tassel	0.31	0.09	0.03	-0.17	0.71	0.15	-0.26	0.12
Peduncle length of ear [cm]	0.33	0.25	0.18	-0.25	0.00	-0.59	-0.09	0.11
Plant height (cm)	0.70	0.27	0.03	-0.08	0.26	-0.28	0.12	0.28
Prolificacy index	-0.13	0.09	-0.05	0.02	0.08	0.86	0.04	0.06
Tassel branching space [cm]	0.83	0.24	0.03	0.07	0.10	-0.21	0.15	-0.01
Tassel length [cm]	0.61	0.54	0.10	0.02	0.09	-0.36	0.10	-0.15
Total number of leaves per plant	0.68	-0.12	-0.30	0.09	0.08	0.24	-0.06	-0.34
Venation index	0.17	-0.32	-0.01	0.58	-0.38	0.31	-0.08	0.12
Eigen value	**7.40**	**3.92**	**2.65**	**2.49**	**1.97**	**1.59**	**1.43**	**1.08**
Percentage	**26.44**	**13.99**	**9.45**	**8.88**	**7.05**	**5.69**	**5.11**	**3.85**
Cumulative percentage	**26.44**	**40.44**	**48.89**	**58.77**	**65.82**	**71.51**	**76.62**	**80.47**

CONCLUSIONS

Principal component analysis and cluster analysis in the studied set of the experiment material gives a detailed information in the classification of genotypes and indicates the presence of potential genes in the maize landraces particularly in North Eastern part of India which can be used in further maize crop improvement programmes.

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