Principal component (PCA) and cluster analyses for plant nutrient traits in baby corn (Zea mays L.)

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ABSTRACT
The present study was conducted to evaluate the plant nutrient traits in 12 baby corn genotypes by using Principal component analysis and cluster analysis during rabi 2017. Analysis of variance depicted the genotypes differed significantly among themselves for all the traits except sugar content. Variability studies revealed that PCV was observed maximum for all the traits. Maximum GCV and PCV were recorded for yield without husk followed by iron content and sugar content. Medium heritability was observed for all the traits except sugar content. Calcium content and iron content was recorded for highest genetic advance. Principal component analysis revealed that the first three principal components together accounted for 87.49 % of variability. The principal components (PC1, PC2) were highly positively influenced by sugar and iron contents, respectively. PC3 was negatively influenced by yield without husk. The 12 genotypes were grouped into three distinct clusters. The cluster-I were the largest cluster comprising of five genotypes and followed by Cluster-II (4 genotypes) and cluster-III (3 genotypes). The genotypes in cluster-I has higher iron content and yield without husk, while the genotypes in cluster-II having higher potassium, phosphorous and calcium contents. The genotypes in cluster-III exhibiting higher means for sugar and phosphorous contents.

Key words: Baby corn, Cluster, Eigen value, Heritability, PCA.

INTRODUCTION
Maize (Zea mays L.) is one of the most important cereal crops in global agriculture after wheat and rice. It belongs to the family poaceae and it is highly cross pollinated crop. Specialty corns (Baby corn, Sweet corn, pop corn) assume tremendous market potential in India and international market (Venkatesh et al., 2003). Baby corn is not a separate type of corn like sweet corn or pop corn and that any corn type can be used as baby corn. Baby corn is dehusked maize ear, harvested young especially when the silk have either not emerged or just emerged and no fertilization has taken place or we can say the shank with unpollinated silk is baby corn. The economic product is harvested within 1-3 days of silk emergence. The quality of baby corn measured at international level the ear length should be 4-9 cm, ear diameter has to be 1-1.5 cm and most preferred colour for export and consumer preference is creamy yellow and the cobs should be straight and arrangement of the ovules will be regular without splitting (Engineers India Research Institute, New Delhi). Baby corn is a highly nutritive vegetable than the seasonal vegetables. Besides vitamins, carbohydrate, protein it is a rich source of phosphorous, calcium, riboflavin, rhiamine and folic acid and also it is an attractive low calorie vegetable, high in fiber without cholesterol (Engineers India Research Institute, New Delhi). It is also free from residual effect of pesticide, as the young cobs are wrapped up within the husk and well protected from diseases, insects, insecticide and fungicide (Dass et al., 2007). The present study was conducted to evaluate a set of maize genotypes for nutritional composition of baby corn.

MATERIALS AND METHODS
Twelve randomly selected maize genotypes were evaluated in randomized block design (RBD) with three replications at college research farm, Central Agricultural University, Imphal during rabi 2017. Each experimental plot consisted of two rows with 60 x 20 cm spacing. The plants were detassled to avoid pollination and fresh cobs were harvested immediately 2-3 days after silk emergence. A random sample of five plants was taken per plot. The cobs from these sampled plants were harvested and weighed after removing the husk to get the yield without husk (gm) per plant. The sugar content was estimated using the hand refractrometer from the sample obtained from the sap of the freshly harvested cobs. The cobs were then air dried followed by oven drying (60°C for 12 hrs). The oven dried cobs were ground and the ground sample was used for the estimation of phosphorus, potassium, calcium and iron contents.

Phosphorous, Potassium, Calcium, Iron contents were determined from the aqueous solution which is obtained by di-acid digestion (Gupta, 2000) of the dry matter obtained...
from the cobs as detailed above. Phosphorous content was estimated by using vanadate molybdate method. Potassium was estimated by using flame photo meter. Calcium content was estimated by versene titration method and Iron content was estimated by using AAS (Gupta, 2000). Appropriate statistical analyses were applied to analyze the ANOVA. The principal component analysis was done using the STAR (ver 2.0.1.0) software of IRRI, Philippines. The clustering was done using ward minimum variance method.

RESULTS AND DISCUSSION

Mean performances: Analysis of variance was carried out to partition the variances into its components. ANOVA exhibited that the genotypes differed significantly among themselves for the traits studied except the sugar content (Table 1). The means for plant nutrients and yield are presented in Table 2. Sugar content (TSS) ranged from 6.41 (AH-7043) to 8.81 (GA(YMH-1) degree brix which is contrast to the results of Shobha et. al., (2010) who have reported a narrower range in sugar content. In general 60% of the genotypes had values higher than general mean of the character for sugar and potassium contents, while for rest of the characters, 40% of the genotypes exceeded the general mean of the trait(s). Phosphorous content ranged from 0.46% (GAYMH-1) to 1.06% (BVM-2) similar to the reports of Anonymous (2016b) and Singh et. al., (2006). Potassium content ranged between 0.09% (GAYMH-1) to 0.26% (AH-7043) which was lower in comparison to the report of Anonymous (2016a). Calcium content ranged from 0.107% (IMHB 1537, IMHB 1539 and HM-4) to 0.293% (IMHB 1538) which is lower in comparison to the reports of (Anonymous 2016b). Iron content ranged 0.62 % (AH-5021) to 1.82 % (AH-7043). Yield without husk was ranged between 13.85g (IMHB 1525) to 1537 (26.05g).

Genetic variability: In the present study, PCV was observed more than GCV for all the traits (Table 3). It shows the presence of environmental influence on genotypes for these traits. Medium heritability coupled with medium to high genetic advance indicating the scope for improvement of maize genotypes through selection. Selection of characters with high heritability coupled with high genetic advance is helpful for the gain under selection than the heritability alone. However it is not necessary that a character showing high heritability should always show high genetic advance (Johnson et. al., 1955). Medium heritability was observed for yield without husk (49.00) followed by calcium content (38.96), iron content (38.54). GA (as percent of mean) was observed high for calcium content (34.53) followed by iron content (32.83), yield without husk (28.56), phosphorous content (23.49). Low heritability with low genetic advance was observed for sugar content.

PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) reflects the importance of the largest contributor to the total variation at each axis of differentiation (Sharma, 1998). Principal component is a linear combination of simplifying complex

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**Table 1:** Analysis of variance for five biochemical traits in 12 baby corn genotypes.

| Source of variance | d.f. | Sugar content | Potassium content | Phosphorous content | Calcium content | Iron content | Yield without husk |
|--------------------|------|---------------|-------------------|--------------------|----------------|--------------|-------------------|
| Replications       | 2    | 0.85          | 0.005             | 0.13               | 0.02           | 0.32         | 40.69             |
| Genotypes          | 11   | 1.24          | 0.01**            | 0.09**             | 0.01**         | 0.36**       | 53.47**           |
| Error              | 22   | 0.58          | 0.001             | 0.03               | 0.003          | 0.13         | 13.77             |

** ** 1% level of significance * 5 % level of significance

**Table 2:** Mean performances of biochemical traits for 12 baby corn genotypes.

| Characters | Sugar content | Potassium content | Phosphorous content | Calcium Content | Iron content | Yield without husk |
|------------|---------------|-------------------|--------------------|-----------------|--------------|-------------------|
| IMHB 1538  | 7.053         | 0.228             | 0.792              | 0.293           | 0.701        | 14.75             |
| IMHB 1525  | 7.693         | 0.158             | 0.777              | 0.133           | 1.276        | 13.85             |
| IMHB 1531  | 7.767         | 0.201             | 0.809              | 0.213           | 0.73         | 18.58             |
| AH-7043    | 6.407         | 0.257             | 0.965              | 0.187           | 1.822        | 18.49             |
| IMHB 1539  | 8.300         | 0.167             | 0.773              | 0.107           | 1.071        | 14.03             |
| AH 5021    | 8.113         | 0.207             | 0.872              | 0.187           | 0.621        | 19.07             |
| IMHB 1537  | 7.927         | 0.197             | 0.795              | 0.107           | 0.862        | 26.05             |
| GAYMH-1    | 8.807         | 0.094             | 0.462              | 0.133           | 1.075        | 19.63             |
| IMHB 1532  | 8.153         | 0.142             | 0.570              | 0.16            | 1.324        | 24.51             |
| BVM-2      | 7.067         | 0.212             | 1.059              | 0.16            | 0.971        | 22.34             |
| DMRHB 1305 | 7.913         | 0.196             | 0.765              | 0.187           | 1.376        | 14.65             |
| HM 4       | 7.847         | 0.173             | 0.554              | 0.107           | 1.344        | 14.47             |
| MEAN       | 7.754         | 0.186             | 0.766              | 0.164           | 1.098        | 18.37             |
| CD         | 0.743         | 0.031             | 0.169              | 0.053           | 0.352        | 3.621             |
Table 4: Correlation among the five biochemical traits for 12 baby corn genotypes.

| Character                  | Sugar content | Potassium content | Phosphorous content | Calcium content | Iron content | Yield without husk |
|----------------------------|---------------|-------------------|---------------------|-----------------|--------------|-------------------|
| Sugar content              | 1.000         |                   |                     |                 |              |                   |
| Potassium content          | -0.848 ***    | 1.000             |                     |                 |              |                   |
| Phosphorous content        | -0.717 ***    | 0.815 **          | 1.000               |                 |              |                   |
| Calcium content            | -0.482        | 0.529             | 0.308               | 1.000           |              |                   |
| Iron content               | -0.292        | 0.003             | -0.099              | -0.295          | 1.000        |                   |
| Yield without husk         | 18.37         | 26.05             | 13.85               | 19.81           | 28.29        | 49.00             |

** 1% Level of significance.

Table 5: Principal component analysis for five biochemical traits in 12 baby corn genotypes.

| Characters          | PC1       | PC2       | PC3       | PC4       | PC5       | PC6       |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Sugar content       | 0.5370    | -0.2480   | 0.0997    | 0.1800    | -0.0707   | 0.7764    |
| PotassiumContent    | -0.5609   | 0.0079    | -0.0606   | 0.1020    | 0.6926    | 0.4377    |
| PhosphorousContent  | -0.5020   | -0.0787   | -0.2543   | 0.5141    | -0.6169   | 0.1795    |
| CalciumContent      | -0.3776   | -0.3127   | 0.4646    | -0.6329   | -0.3076   | 0.2204    |
| Iron content        | -0.0026   | 0.8378    | -0.1772   | -0.3238   | -0.2000   | 0.3490    |
| Yield without husk  | 0.0489    | -0.3640   | -0.8213   | -0.4331   | 0.0005    | 0.0558    |
| Proportion of variance | 48.37   | 21.23     | 17.89     | 8.89      | 2.07      | 1.55      |
| Cumulative variance  | 48.37     | 69.60     | 87.49     | 96.38     | 98.45     | 100.00    |
| Eigen value         | 2.9023    | 1.2737    | 1.0735    | 0.5332    | 0.1244    | 0.0930    |
PC1 and PC2 in Fig 1. As can be seen the characters can be grouped into 4 distinct groups, potassium, phosphorus and calcium contents forming one group, iron the second group, sugar content the third group and the yield forming the fourth group. Similarly the genotypes also formed distinct groups. Genotype 4 forming a single group, while genotypes 12, 2, 5 and 9 forming a second group while 7 in third group and the rest forming the last group. Genotype 4 is best suited for high potassium, phosphorus and calcium contents, 7 has highest yield, 8 followed by 9 has the highest sugar content. While 12 followed by 2 and 11 had high iron contents.

CLUSTER ANALYSIS

Clustering of the genotypes was done according to Ward’s minimum variance method. The dendrogram obtained from the analysis is presented in Fig 2. As can be seen all the genotypes grouped into three distinct clusters.

The cluster-I was largest with 5 genotypes, IMHB 1538, IMHB 1525, IMHB 1539, DMRHB 1305, HM-4 has maximum for iron content and yield without husk. The cluster - II contain 4 genotypes it include IMHB 1531, AH 5021, GAYMH -1, AH-7043 has maximum for potassium content, phosphorous content and calcium content. The cluster-III was the smallest with 3 genotypes, IMHB 1537, IMHB 1532, BVM-2 were higher for sugar content and phosphorous content. Among the clusters, cluster-II has the more desirable genotypes as the genotypes with higher values emerge.

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