# Collection, Characterization and Evaluation of Eggplant (*Solanum* spp.) Germplasm in Myanmar

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## ABSTRACT

In Myanmar, the specific attempt in collection and identification of eggplant germplasm was rarely found. To identify the morpho-physiological diversity of 40 germplasm, the experiment was conducted at Horticulture Section, Department of Agricultural Research (DAR), Yezin from May to October, 2016. Randomized Complete Block Design (RCBD) with three replications was used. Morpho-physiological divergence among 40 eggplant germplasm was estimated using cluster and principal component analysis (PCA). The germplams were grouped into four clusters. No clear association was observed between geographic origin and genetic diversity. Cluster I included 25 germplsm and scattered into this cluster, and which were early in days to first harvest. Cluster IV included only one germplasm and larger fruit size. The maximum inter-cluster distance was observed between cluster I and IV followed by that cluster I and II, suggesting a large distance between these clusters or groups of germplasm. From these findings, the germplasm of the cluster I and IV had the maximum common gene complexes and the magnitude of heterosis largely depended on the degree of genetic diversity in the germplasm. Populations with high scores for the first eigenvectors are leaf width, leaf length, fruit length, corolla color and fruit length/breadth ratio were the most important contributors towards diversity of the germplasm in PC1. The second eigenvector was mostly connected with scores of days to first harvest, fruit weight, fruit breadth and 100 seeds weight were the second most important contributors among the 31 traits for 40 germplasm. The first PC explained 17.071 % of variability and the second PC explained 13.532 %, totally 30.603% of the total variability among 40 germplasm based on 31 traits. Finally, the eggplant germplasm were separately isolated from the others and they were away from centroid. These results showed their uniqueness and divergence of the germplasm in respect to the measured 31 traits. Thus, discrimination of eggplant germplasm based on multiple traits by cluster analysis provided the insight of varietal evolution and adaptation.

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# INTRODUCTION

Brinjal or eggplant or aubergine (*Solanum melongena* L.) is indigenous to a vast area stretching from northeast India and Burma, to Northern Thailand, Laos, Vietnam and Southwest China and wild plants can still be found in these locations (Daunay and Janick, 2007). Eggplant was domesticated from wild forms in the Indo-Burma region with indications that it was cultivated in antiquity. Several Sanskrit documents, dated from as early as 300 BCE, mention this plant with various descriptive words, which suggest its wide popularity as food and medicine (Nadkarni, 1927). In the Ayurvedic, a Hindi system of medicine, white types were recommended for diabetic patients, and roots for the treatment of asthma (Khan, 1979).

Eggplant is widely cultivated as vegetable in both temperate and tropical areas, especially in Asia. Eggplant is a major fruit vegetable with world production exceeding 32 million tonnes (Mt). The world leading eggplant producers are China (18.2 Mt), India (15.6 Mt), Egypt (2.0 Mt), Turkey (1.3 Mt), Indonesia (0.7 Mt), Iraq (0.6 Mt) Japan (0.6 Mt) and Italy (0.5 Mt) (FAO, 2008). Eggplant is particularly favoured in Asia where it has been cultivated for millennia, and in India it is considered King of Vegetables (Ferdousi et al. 2013).

Information on genetic divergence among the available germplasm is vital to a plant breeder for an efficient choice of parents for hybridization. It is an established fact that genetically diverse parents are likely to contribute desirable segregants. It was also observed that the more diverse the parents, greater are the chances of obtaining high heterotic F1s and broad spectrum of variability in the segregating generation (Arunachalam, 1981). Improvement in yield and quality is normally achieved by selecting genotypes with desirable character combinations existing in the nature or by hybridization. Selection of parents identified on the basis of divergence analysis would be more promising for a hybridization programme. Some related results have been reported in eggplant by Kumar et al. (2000), Singh and Gapalakrishnan (1999), Chaudhary and Pathania (1998) and Tambe et al. (1993).

In Myanmar, there are number of local cultivars with a wide range of variability in size, shape and color of fruits available and for this easily fulfill the gap by developing high yielding hybrid variety. The yield, uses, and productivity of local genotypes were different. Though a fairly common crop, to-date there is only limited work has been done for evolving hybrids/hybrid derivatives of high yield potential and better quality in

Myanmar by using local germplasm. According to the origin country, in future, more and more genetic resources will be in danger situation due to various adverse factors. Furthermore, very limited attempt has been made for genetic improvement of available indigenous types in this crop.

These studies will not cover any Myanmar cultivars/genotypes and will be carried out in a different agro climate. Masud et al. (1995) reported in pumpkin, Alam et al. (2006) reported in hull- less barley and Habib et al. (2007) reported in rice in Bangladesh condition, while these did not cover the eggplant oriented. Haque et al. (2002) reported with 32 eggplant genotypes in Bangladesh condition, while maximum genotypes were exotic. In Myanmar context, information on the selection of local eggplant genotypes on the basis of diversity is inadequate. Therefore, the present investigation was undertaken to estimate the nature and magnitude of genetic diversity in some local eggplant genotypes in Myanmar condition. This type of study was useful for breeding eggplant varieties in the country.

## OBJECTIVES

Considering the above idea in mind the present investigation were undertaken with the following objectives:

(i) to study the quantitative, qualitative and some physiological traits of the collected germplasm

(ii) to identify higher potential and good quality using indigenous genotypes

## MATERIALS AND METHODS

### Germplasm collection

Germplasm collection was started from May to November, 2015. And total forty eggplant germplasm were collected from in and around the country having wider range of geographical conditions. And evaluated the variations under field condition for yield, quality, physiological and other desirable traits like resistance to shoot and fruit borer. Eleven were obtained from Seed Bank, Department of Agricultural Research (DAR), Yezin and twenty one germplasm were collected from some different growing regions of the country. The regions of 40 eggplant germplasm collection sites were shown in Figure 1.

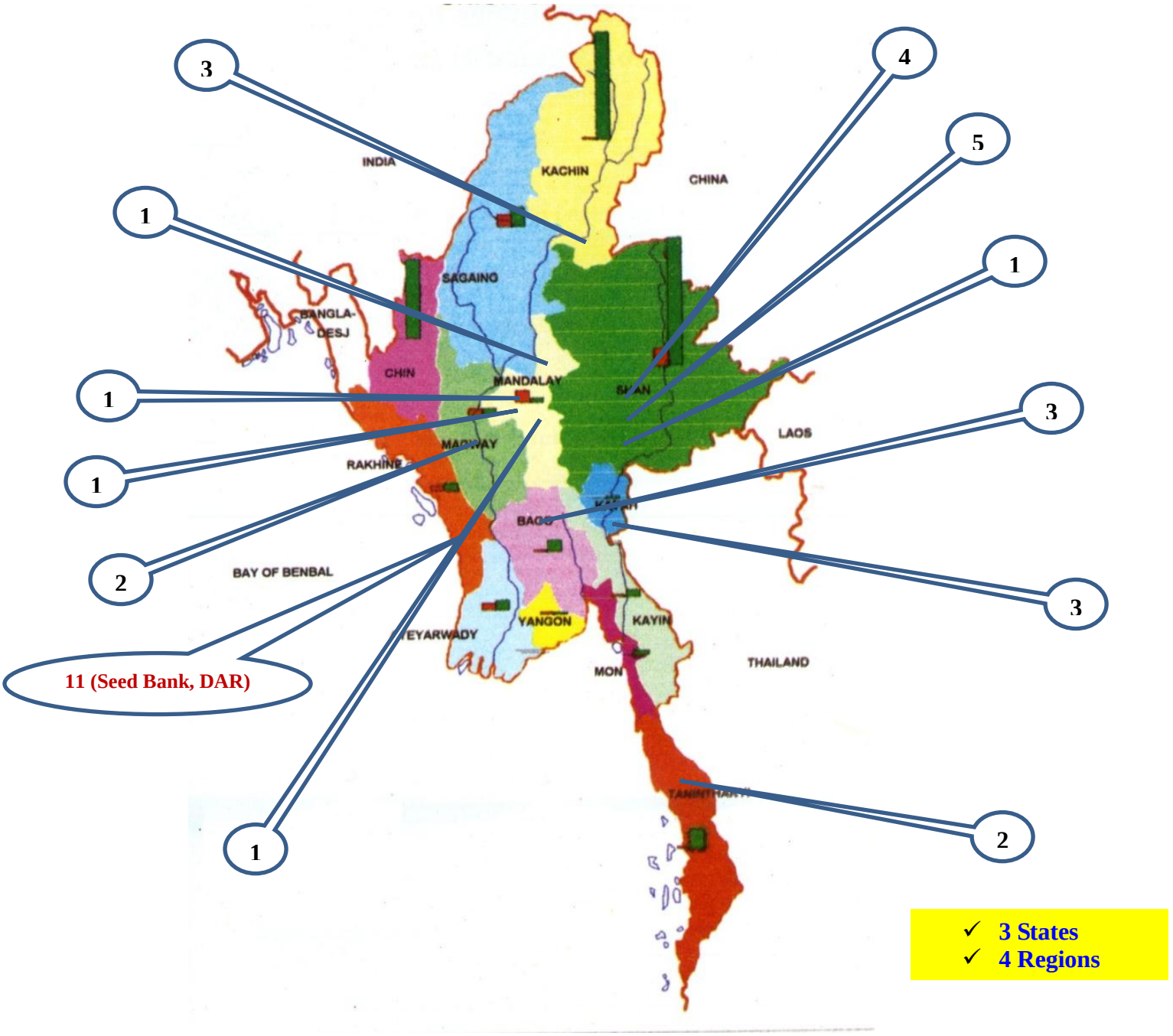


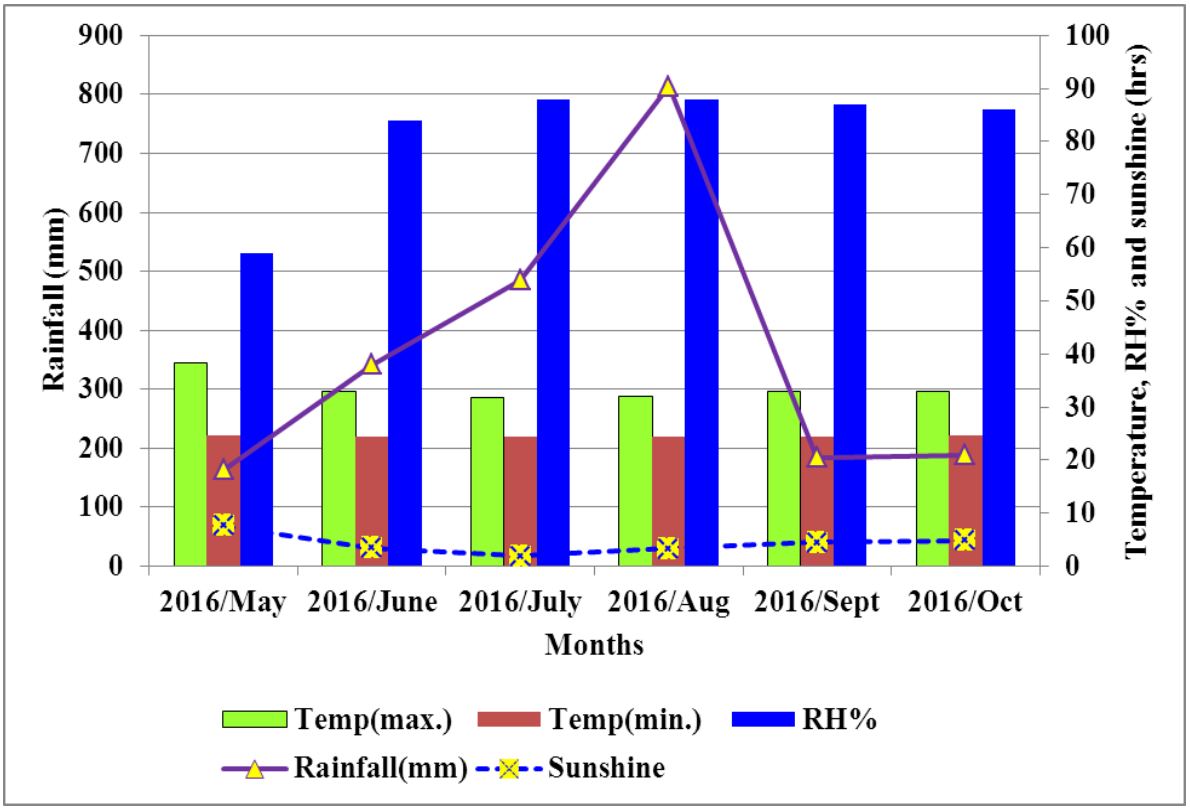

**Figure 1. The regions of 40 eggplant germplasm collection sites**

**The experimental site**

The experiment was started from 2015-2016 (Post-monsoon season) at Department of Agricultural Research (DAR), Horticulture Section Research Field, Yezin, Nay Pyi Taw, Myanmar situated at 9°5 latitude and 78°5 longitude and at an elevation of 147 meter above sea level (MSL). The soil type was sandy loam and soil pH was 6.7.

The minimum and maximum temperature, rainfall (cm) during the growing season of the experiment was shown in Table 1.

**Table 1. The minimum and maximum temperature (ºC), rainfall (mm), sunshine (hrs) and relative humidity (RH) % during the growing season**



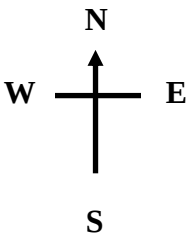

**Experimental design and layout**

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was (1 m x 9 m) and 9 plants were accommodated in a plot with a plant spacing of 90 cm maintaining a row distance of 90 cm. Experimental design and layout was shown in Figure 2.

**Nursery and cultivation aspects**

Twenty five to thirty days-old seedlings were raised in the nursery beds and they were transplanted on the ridges adopting a spacing of 60 x 60 cm. Recommended cultural practices were followed uniformly to all the genotypes. Observations were recorded in three randomly selected plants in each replication.

**Field Layout - (40 x 3) RCBD**




| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 9 | 16 | 36 | 40 | | | 1 | 38 | 19 | 40 | | | 39 | 8 | 4 | 37 | |
| | 32 | 39 | 38 | 3 | 13 | 11 | 32 | 27 | 16 | 3 | 13 | 36 | 12 | 11 | 13 | 32 | 36 | 15 |
| | 14 | 35 | 25 | 6 | 17 | 4 | 14 | 35 | 25 | 6 | 17 | 4 | 3 | 16 | 31 | 17 | 9 | 10 |
| | 2 | 19 | 31 | 19 | 10 | 29 | 2 | 9 | 31 | 39 | 10 | 29 | 1 | 21 | 5 | 2 | 29 | 6 |
| | 30 | 22 | 8 | 20 | 34 | 5 | 22 | 8 | 20 | 34 | 5 | 30 | 23 | 24 | 38 | 28 | 35 | 14 |
| | 21 | 7 | 26 | 28 | 27 | 24 | 21 | 37 | 7 | 28 | 18 | 12 | 27 | 18 | 22 | 20 | 25 | 30 |
| B | 18 | 33 | 12 | 23 | 15 | 1 | 26 | 33 | 23 | 24 | 15 | 11 | 33 | 26 | 34 | 7 | 40 | 19 | B |
| | RIII | | | | | | RII | | | | | | RI | | | | | |

**Figure 2. Experimental design and layout**

**Data Collection**

Data were recorded from three sub-sampling selected plants from each plot for quantitative traits.

**Quantitative Traits**

1. Plant height (cm) 2 weeks interval (PH)
2. Leaf numbers (2 weeks interval) (LNo.)
3. Leaf length (cm) (LLt)
4. Leaf width (cm) (LWdt)
5. Petiole length (cm) (PLt)
6. Fruit weight (g) (FWt)
7. Fruit length (cm) (FLt)
8. Fruit breadth (cm) (FBt)
9. Days to first flowering (DFF)
10. Days to first harvest (DFH)
11. 100 seeds weight (g) (100SWt)

**Physiological Traits**

1. Chlorophyll content (Chl)
2. Leaf temperature (LTem)
3. Fruit hardness (FHd)

**Qualitative Traits**

1. Leaf blade lobing (LBL)
2. Leaf blade tip angle (LBTA)
3. Leaf prickles (LP)
4. Plant growth habit (PGH)
5. Plant branching (PB)
6. Petiole colour (PtC)
7. Leaf blade colour (LBC)
8. Number of flowers per inflorescence (NFPI)
9. Corolla colour (CC)
10. Fruit length/breadth ratio (FLBR)
11. Fruit curvature (FC)
12. Fruit apex shape (FAS)
13. Fruit color (FCl)
14. Fruit color distribution (FCD)
15. Relative fruit calyx length (RFCL)
16. Fruit calyx prickles (FCP)
17. Brinjal shoot and fruit borer (BSFB)

Eleven quantitative and seventeen qualitative traits were measured according to Eggplant Crop Descriptor by IBPGR, 1990. Additional physiological traits like fruit hardness, chlorophyll content and leaf temperature were also measured.

**Statistical analysis**

Frequency distribution of the seventeen qualitative traits was analysed for 40 germplasm. Statistical parameters were analysed according to the procedure described by Gomez (1984) using CropStat (7.3.2). The selected multivariate methods were hierarchical cluster analysis and principal components analysis (PCA). Multivariate analysis of divergence among 40 eggplant germplasm morpho-physiological traits adjusted by using Ward's minimum variance clustering method to classify the accession into discrete clusters and were performed using XLSTAT (2016) procedure excel added in program (Ward, 1963).

Euclidean or straight-line measure of distance was calculated for estimating genetic distance (GD) between individuals (genotypes or germplasm or populations) by morpho-physiological data (Mohammadi, 2003). The data matrix of 40 germplasm and 31 traits was standardized/normalized (mean=0, std=1, var=1) and analyzed using PCA.

## RESULTS AND DISCUSSION

### Frequency distribution of qualitative traits

Frequency distribution of 17 qualitative traits was analysed. Table 2 and Figure 3 showed score/characteristics, number germplasm and relative frequencies (%) obtained from qualitative attributes. Variability was obtained in 17 out of 25 registered characteristics (68% of the descriptors). This pointed out a high degree of morphological polymorphism for the qualitative variables. Some of these characteristics were scarcely dependent on environmental conditions. Similar result was reported by Rosso et al. (2002) that there was wide qualitative variability the polymorphism in 26 out of 29 descriptors registered (89.7%) in the *Narino arracacha* (potato) collection and 31 out of 42 registered characteristics (73.81% of the descriptors) in green corn germplasm (Htwe Min Thant et al., 2006).

The relative frequencies of leaf blade lobbing was 50% strong leaf blade lobe for 20 germplasm, intermediate leaf blade tip angle was 55% for 22 germplasm, presence of leaf prickles was 2.5% for only one germplasm, intermediate plant growth habit occupied 67.50% for 27 germplasm, strong plant branching types was 30% for 12 germplasm, green petiole color occupied 30% for 12 germplasm, green leaf blade color was 50% for 20 germplasm, number of flowers per inflorescence was four and 35% for 14 germplasm, light violet corolla color was 42.50% for 17 germplasm, three times as long as broad fruit length/breadth ratio was 30% for 12 germplasm, straight fruit curvature was 62.50% for 25 germplasm, rounded fruit apex shape was 50% for 20 germplasm, uniform fruit color at commercial ripeness was 35% for 14 germplasm, green color for physiological ripeness of fruit was 47.50% for 19 germplasm, short fruit calyx length occupied was 57.50% for 23 germplasm, many fruit calyx prickles was 2.5% for only one germplasm and low susceptible of brinjal shoot and fruit borer (BSFB) was 2.5% for only one germplasm and high susceptible of BSFB was 40% for 16 germplasm among 40 germplsm respectively (Table 2).

The frequencies of qualitative traits were highly diverse among the germplasm (Htwe Min Thant et al. 2006). This may be due to different sources of germplsm which possessed various morphological traits. Brandolini and Brandolini (2001) reported that kernel type, kernel shape and size were also highly variable among 562 Italian maize accessions.

**Table 2. Frequency distribution for 17 qualitative traits in 40 eggplant germplasm**

| Variable | Categories | Frequencies | % |
|---|---|---|---|
| Leaf blade lobing | 1 | 0 | 0 |
| | 3 | 4 | 10.00 |
| | 5 | 16 | 40.00 |
| | 7 | 20 | 50.00 |
| | 9 | 0 | 0 |
| Leaf blade tip angle | 1 | 0 | 0 |
| | 3 | 16 | 40.00 |
| | 5 | 22 | 55.00 |
| | 7 | 2 | 5.00 |
| | 9 | 0 | 0 |
| Leaf prickles | 0 | 39 | 97.50 |
| | 1 | 1 | 2.50 |
| Plant growth habit | 3 | 4 | 10.00 |
| | 5 | 27 | 67.50 |
| | 7 | 9 | 22.50 |
| Branching type | 1 | 2 | 5.00 |
| | 3 | 11 | 27.50 |
| | 5 | 11 | 27.50 |
| | 7 | 12 | 30.00 |
| | 9 | 4 | 10.00 |
| Petiole color | 1 | 12 | 30.00 |
| | 3 | 11 | 27.50 |
| | 5 | 10 | 25.00 |
| | 7 | 7 | 17.50 |
| Leaf blade color | 3 | 20 | 50.00 |
| | 5 | 18 | 45.00 |
| | 7 | 2 | 5.00 |
| No. of flowers/inflorescence | 1 | 11 | 27.50 |
| | 2 | 4 | 10.00 |
| | 3 | 8 | 20.00 |
| | 4 | 14 | 35.00 |
| | 5 | 3 | 7.50 |

| Variable | Categories | Frequencies | % |
|---|---|---|---|
| Corolla color | 3 | 2 | 5.00 |
| | 5 | 10 | 25.00 |
| | 7 | 17 | 42.50 |
| | 9 | 11 | 27.50 |
| Fruit length/breadth ratio | 1 | 2 | 5.00 |
| | 3 | 8 | 20.00 |
| | 5 | 8 | 20.00 |
| | 7 | 4 | 10.00 |
| | 8 | 12 | 30.00 |
| | 9 | 6 | 15.00 |
| Fruit curvature | 1 | 25 | 62.50 |
| | 3 | 8 | 20.00 |
| | 5 | 7 | 17.50 |
| | 7 | 0 | 0 |
| | 9 | 0 | 0 |
| Fruit apex shape | 3 | 8 | 20.00 |
| | 5 | 20 | 50.00 |
| | 7 | 12 | 30.00 |
| Fruit color | 1 | 14 | 35.00 |
| | 2 | 7 | 17.50 |
| | 3 | 1 | 2.50 |
| | 4 | 0 | 0 |
| | 5 | 0 | 0 |
| | 6 | 0 | 0 |
| | 7 | 11 | 27.50 |
| | 8 | 7 | 17.50 |
| | 9 | 0 | 0 |
| Fruit color distribution | 1 | 19 | 47.50 |
| | 3 | 10 | 25.00 |
| | 5 | 0 | 0 |
| | 7 | 11 | 27.50 |
| Relative fruit calyx length | 1 | 11 | 27.50 |
| | 3 | 23 | 57.50 |
| | 5 | 5 | 12.50 |
| | 7 | 0 | 0 |
| Fruit calyx prickles | 1 | 1 | 2.50 |
| | 0 | 39 | 97.50 |
| Brinjal shoot and fruit borer | 1 | 1 | 2.50 |
| | 3 | 11 | 27.50 |
| | 5 | 16 | 40.00 |
| | 7 | 13 | 32.50 |

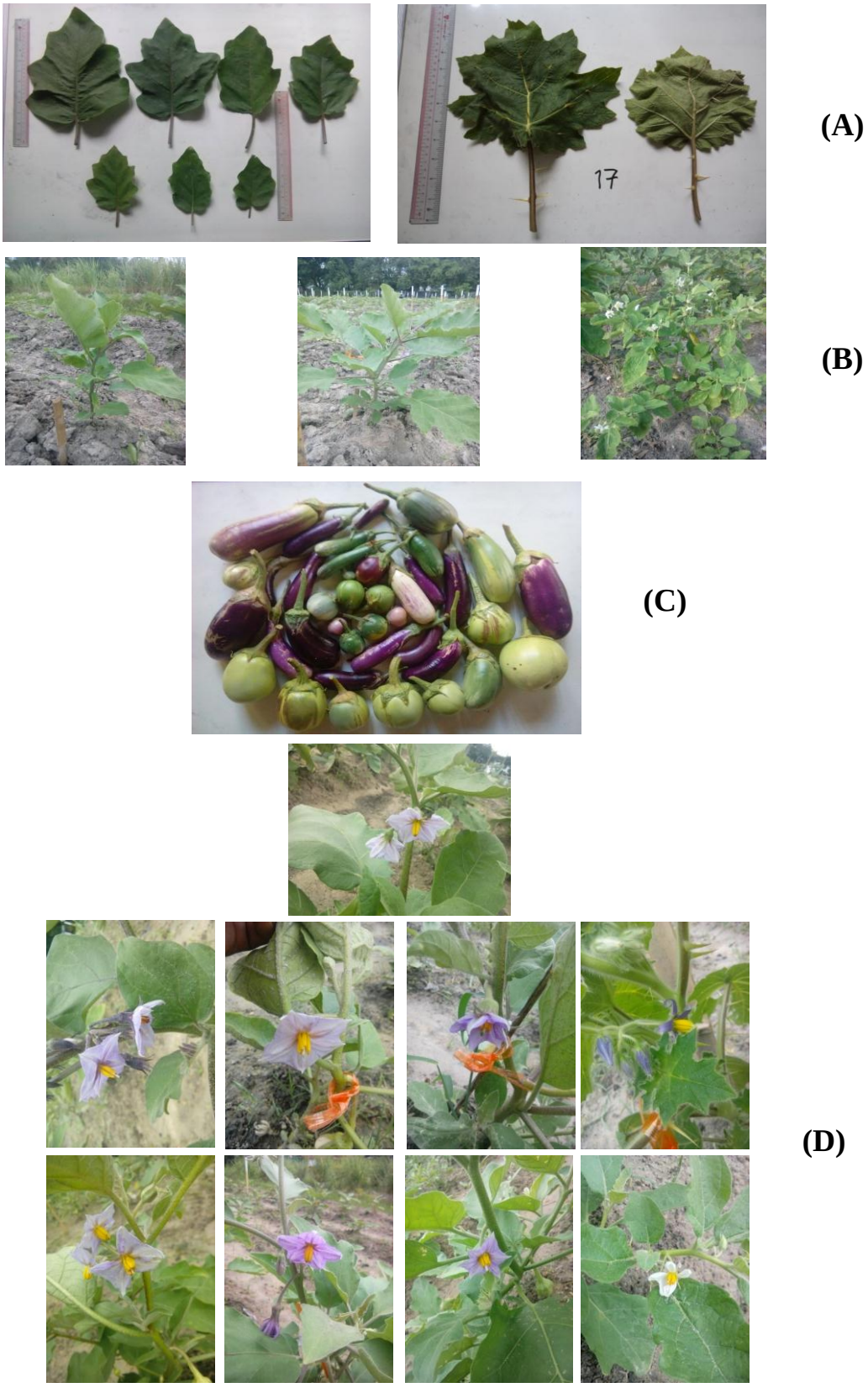



**Figure 3. Representative (A) leaves, (B) plant growth habit, (C) fruit color and shape and (D) flowers morphology of eggplant germplasm**

**Germplasm Distribution and Dendrogram**

**Qualitative traits**

The germplasm were grouped into 12 clusters based on 17 qualitative traits. Germplasm number MEG16-07, MEG16-12, MEG16-32, MEG16-23, MEG16-13, MEG16-12 were isolated in each clusters. These germplasm possessed their own distinct characteristic especially fruit color from other germplasm (Figure 4(a)).

**Quantitative/Qualitative traits**

Forty eggplant germplasm were grouped into four clusters based on 14 quantitative traits, 14 qualitative traits and 3 physiological traits using Ward's minimum variance clustering techniques. The dendrogram shown that the cluster I included 25 germplasm and number MEG16-01, MEG16-02, MEG16-03, MEG16-04, MEG16-11, MEG16-14, MEG16-17, MEG16-18, MEG16-20, MEG16-21, MEG16-23, MEG16-24, MEG16-25, MEG16-26, MEG16-27, MEG16-30, MEG16-31, MEG16-32, MEG16-33, MEG16-34, MEG16-35, MEG16-36, MEG16-37, MEG16-38 and MEG16-40 respectively. More of the germplasm were scattered into in this cluster. Cluster IV included only one germplasm, MEG16-10. Cluster II and III included 5 and 9 germplasm respectively (Table 3 and Figure 4(b) and 5).

These results were confirmed to the findings of Quamruzzaman et al. (2009), they observed nineteen genotypes were grouped into 5 clusters on the basis of cluster analysis in eggplants genotypes. Maximum 7 entries were grouped into cluster I, followed by 4 in cluster II and III. Cluster IV and V composed of only 2 of each.

The clustering pattern of the genotypes revealed that the genotypes collected from the same places did not form a single cluster. On the other hand, genotypes originating from different geographical locations formed a single cluster indicating there was no clear relationship between the clustering pattern of the genotypes and their geographic sources (Table 3.). This findings fully agree with those of Murty and Arunachalam (1966), Sangha (1973), Dasgupta and Das (1985), Nadaf et al. (1986), Ramana and Singh (1987) and Golakia and Makne (1992). Lack of true relationship between geographic and genetic diversity was explained by Murty and Arunachalam (1966) and Updhyya and Murty (1970) who pointed out that genetic drift and natural selection in different environments can cause high diversity among the races than geographic isolation in pearl millets. It must be noted that in breeding programmes, geographic diversity alone should not be considered as an index of genetic diversity for selection of parents. Htwe Min Thant et al.

(2006) reported that the germplasm within the same clusters were originated from different geographical regions of the country, which indicated the geographical distribution and genetic divergence did not follow the same trend in green corn germplasm. This may be due to continuous exchange of genetically material among the States and Divisions.

**Table 3. Distribution of different germplasm of eggplant for 31 traits**

| Cluster No. | Number | Germplasm | Sources |
|---|---|---|---|
| I | 25 | MEG16-01, MEG16-02, MEG16-03, MEG16-04, MEG16-11, MEG16-14, MEG16-17, MEG16-18, MEG16-20, MEG16-21, MEG16-23, MEG16-24, MEG16-25, MEG16-26, MEG16-27, MEG16-30, MEG16-31, MEG16-32, MEG16-33, MEG16-34, MEG16-35, MEG16-36, MEG16-37, MEG16-38, MEG16-40 | Pegu, Shan (South) Kayah, Thanintharyi, Kachin, Mandalay, Magway |
| II | 5 | MEG16-05, MEG16-07, MEG16-19, MEG16-22, MEG16-28 | Pegu, Shan (South) Kayah, Mandalay, Magway |
| III | 9 | MEG16-06, MEG16-08, MEG16-09, MEG16-12, MEG16-13, MEG16-15, MEG16-16, MEG16-29, MEG16-39 | Pegu, Shan (South) Kayah, Thanintharyi, Kachin, Mandalay, Magway |
| IV | 1 | MEG16-10 | Pegu |

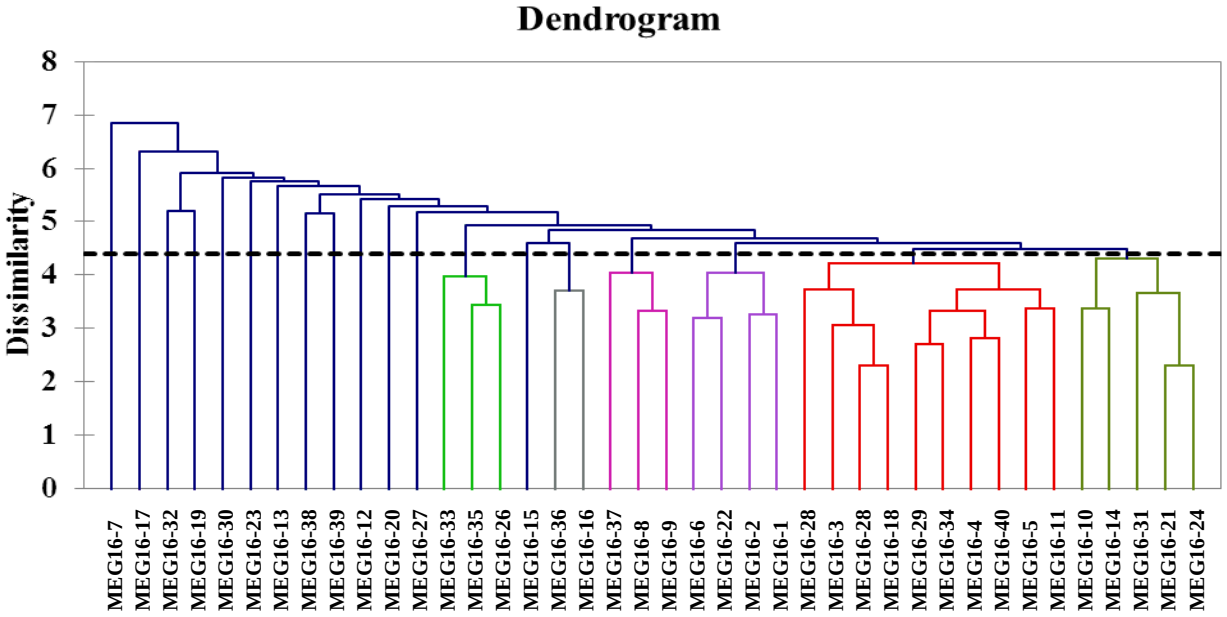



**Figure 4 (a). Cluster tree of 40 germplasm based on qualitative traits**

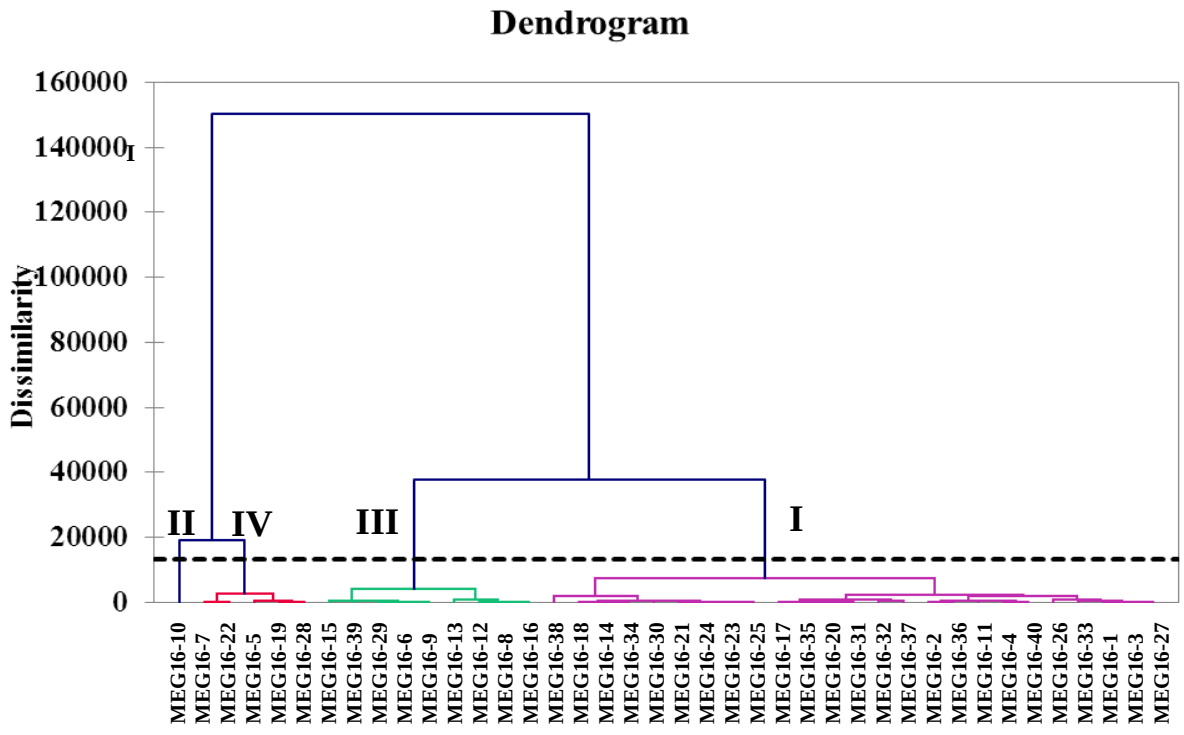



**Figure 4 (b). Cluster tree of 40 germplasm based on 31 traits**

**Figure 5. Representative fruit morphology and different cluster of eggplant germplasm**

**Principal component analysis (PCA)**

Principal component analysis was carried out by calculating the first two principal components which accounted for 30.60% of the total divergence (Figure 6). The first PC explained 17.07% of the total variability and the second PC explained only 13.53% of the variation among 40 eggplant germplasm. Thus, the present study was revealed that the first PC was more important than the second PC for explaining the variability among the germplasm based on 31morpho-physiological traits.

Ferdousi et al. (2013) observed that the first axes totally accounted for 20.07% variation among the genotype and accounted for 73.87% of the total variation among the 21 principal component axes describing 92 genotypes of eggplant. Htwe Min Thant et al. (2006) stated the plot of the first two principal components 1 and 2 for a group of Myanmar green corn germplasm and the first two principal components which accounted for 49% of the total divergence.

The eggplant germplasm such as MEG16-07, MEG16-10, MEG16-19, MEG16-22, MEG16-38, MEG16-30, MEG16-21, MEG16-14 and MEG16-01 etc., were separately isolated from the others and they were away from centroid. This result showed the uniqueness and divergence of the germplasm. Thus, discrimination of eggplant germplasm based on multiple traits by cluster analysis even provided the insight of

varietal evolution and adaptation. Similar result has been reported by Tin Htut (2006) who studied 10 soybean varieties. In this study, varieties number 1, 2, 9 and 10 largely segregated from others accessions. Htwe Min Thant et al. (2006) reported that the green corn germplasm such as G13, G31, G14, G20, G16, G6, G30 and G11 etc., were separately isolated from the others and they away from centroid and indicated that their uniqueness and divergence with respect to the measured traits.

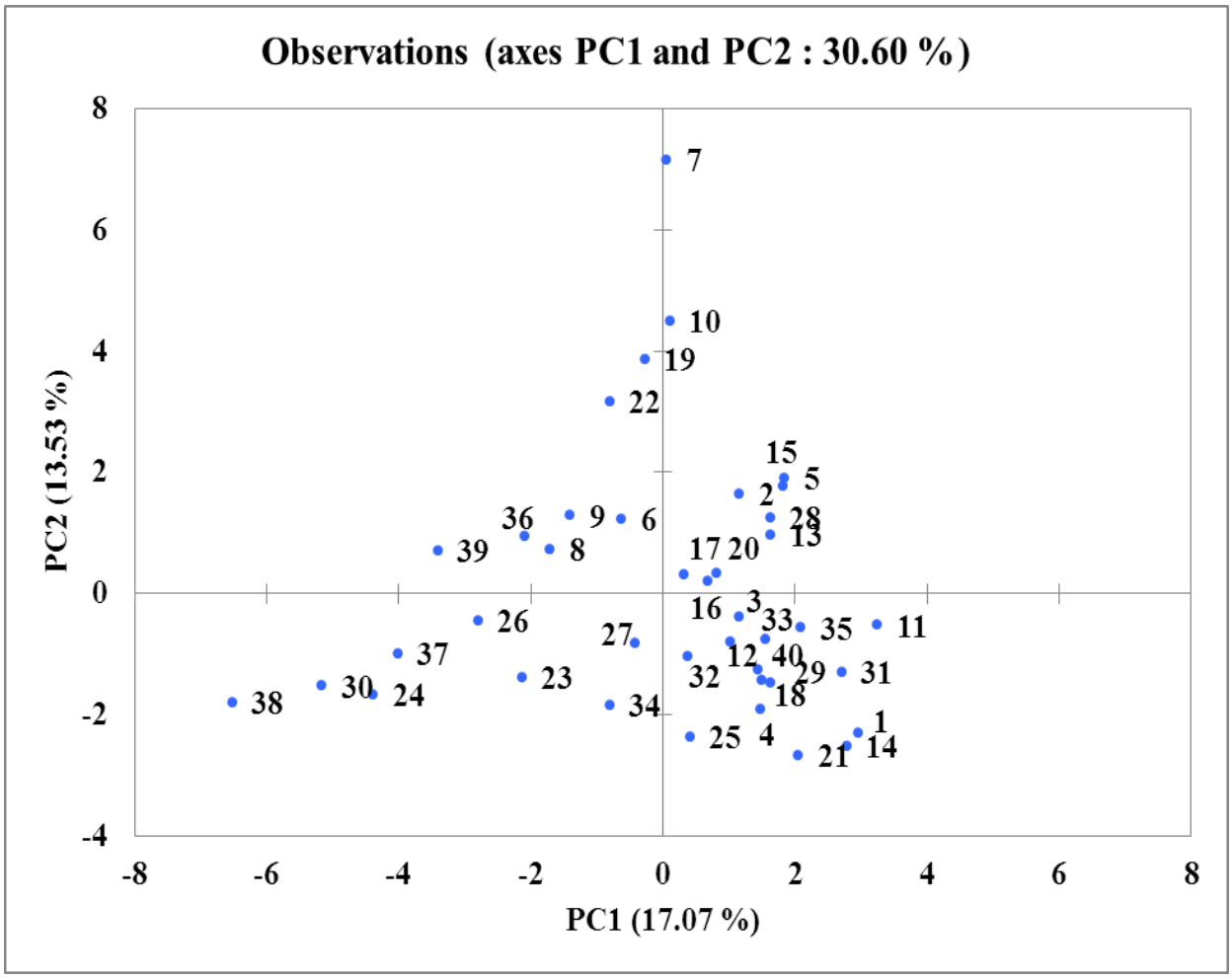



**Figure 6. The plot of the first two PCA 1 and 2 for a group of Myanmar eggplant germplsm**

**Cluster distance**

Euclidean distance for inter-cluster is presented in Table 4 The maximum inter-cluster distance was observed between cluster I and IV (317.30) followed by cluster I and II (166.59), suggesting a large distance between these clusters or groups of germplasm. On the other hand, the minimum distance between cluster I and III (75.63) indicates a close relationship. This finding indicated that cluster I and IV had the maximum common

gene complexes and the magnitude of heterosis largely depended on the degree of genetic diversity in the germplasm. The greater the distance between the two clusters, the wider is the genetic difference between the germplasm.

Quamruzzaman et al. (2009) found that the maximum inter-cluster distances were recorded between the cluster IV and V (10.75) followed by the distance between I and II (10.38) in eggplant genotypes. As the genetic variation is very distinct among the groups, genotypes from these four clusters if used in hybridization may produce a wide spectrum of segregating population. The lowest inter-cluster distance was observed between cluster I and III (5.53) followed by I and V (5.76) suggesting a close relationship among these three clusters. Htwe Min Thant et al. (2006) reported that the greater the distance between two clusters, the wider is the genetic difference between the green corn germplasm.

**Table 4. Cluster distance (Euclidean distance)**

| | **Cluster I** | **Cluster II** | **Cluster III** | **Cluster IV** |
|---|---|---|---|---|
| **Cluster I** | **0** | | | |
| **Cluster II** | 166.59 | **0** | | |
| **Cluster III** | **75.63** | 91.89 | **0** | |
| **Cluster IV** | **317.30** | 151.47 | 241.93 | **0** |

**Cluster mean value**

The maximum cluster mean value of vegetative growth were observed in Cluster II such as plant height (76.31 cm), leaf number (59.67), leaf length (18.50 cm) and leaf width (14.17 cm) respectively. Larger fruit weight and fruit breadth were observed in cluster IV, such as 364.12 g and 12.83 cm respectively. Days to first harvest was observed in cluster I (99.79 days) than other clusters (Table 5). Grouping of the germplasm to different clusters gives an opportunity to select genotypes to develop high yield and good quality varieties.

Similar results were observed by Htwe Min Thant et al. (2006), Sai Lin Kyaw Swar Hlaing et al. (2004), and Endang et al. (1971). They highlight that clustering pattern could be utilized in choosing parents for cross combination which likely to generate the highest possible variability for the effective selection of various economic traits.

**Eigen values and eigenvectors**

The eigenvalues and vectors of 31 traits for a PCA of important traits for the first sixth principal components in 40 Myanmar eggplant germplasm was shown in Table 7. Populations with high scores for the first eigenvectors are leaf width (0.240), leaf length

(0.242), fruit length (0.315), corolla color (0.278), and fruit length/breadth ratio (0.329) and these traits were the most important contributors towards diversity of the germplasm in PC1. The second eigenvector was mostly connected with scores of days to first harvest (0.244), fruit weight (0.384), fruit breadth (0.405) and 100 seeds weight (0.336) and also these traits were the second most important contributors among the 31 traits for 40 germplasm.

Quamruzzaman et al. (2009) reported that the results of the PCA revealed that in vector Z1, the important characters responsible for genetic divergence in the major axis of differentiations were number of fruits per plant (0.3367), infestation by EFSB (0.2631), prickle on pedicel (0.0375) and prickle on calyx (0.07 18). In vector Z2, plant height at last harvest (0.0219), number of branches (0.3101), fruit diameter (0.4518), individual fruit weight (0.3890), fruit yield (0.4443) and leaf pedicel length (0.0636) in eggplant genotypes played a major role, while rest of the characters in this second axis of differentiations might not have played any major role. The role of fruit yield in both the vectors was found to be more important towards genetic divergence.

**Table 5. Cluster mean value of different traits of eggplant germplasm**

| | PH | LNo. | LWdt | LLt | PLt | DFF | DFH | FHd | FWt | FLt | FBt | Chl | LTem | 100 SWt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cluster I** | 73.19 | 58.61 | 10.91 | 15.35 | 4.66 | 71.92 | **99.79** | **0.90** | 47.37 | 8.80 | 3.36 | 41.86 | 28.73 | 0.29 |
| **Cluster II** | **76.31** | **59.67** | **14.17** | **18.50** | 4.55 | 69.20 | 106.47 | 0.88 | 213.59 | 12.70 | 6.60 | 42.75 | 29.74 | **0.32** |
| **Cluster III** | 69.09 | 53.96 | 10.71 | 15.95 | **4.98** | 71.78 | 101.67 | 0.89 | 122.58 | 10.72 | 5.15 | 41.93 | **27.91** | 0.29 |
| **Cluster IV** | 69.00 | 48.00 | 11.80 | 17.47 | 4.87 | **67.00** | 109.33 | 0.87 | **364.12** | 11.17 | **12.83** | 39.67 | 29.00 | **0.32** |

**Table 6. Eigenvalues and vectors of 31 traits for a PCA of important traits for the first two PC in 40 Myanmar eggplant germplasm**

| Traits | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 |
|---|---|---|---|---|---|---|
| **PH** | 0.155 | 0.004 | 0.325 | -0.071 | 0.128 | 0.127 |
| **LNo** | -0.162 | -0.099 | 0.368 | -0.100 | -0.051 | 0.180 |
| **LWdt** | **0.240** | 0.186 | 0.272 | 0.043 | 0.194 | -0.164 |
| **LLt** | **0.242** | 0.171 | 0.276 | 0.030 | 0.104 | -0.173 |
| **PLt** | 0.234 | 0.030 | 0.176 | 0.034 | 0.289 | -0.269 |
| **DFF** | 0.160 | -0.057 | -0.197 | 0.019 | 0.314 | 0.346 |
| **DFH** | 0.129 | **0.244** | -0.151 | -0.117 | 0.252 | 0.168 |
| **FHd** | -0.234 | -0.108 | 0.060 | -0.208 | 0.185 | -0.006 |
| **FWt** | 0.067 | **0.384** | -0.050 | -0.245 | -0.106 | -0.058 |
| **FLt** | **0.315** | 0.064 | -0.087 | -0.122 | -0.209 | 0.125 |
| **FBt** | -0.037 | **0.405** | -0.034 | -0.199 | -0.021 | -0.064 |
| **Chl** | 0.018 | -0.005 | 0.347 | -0.156 | -0.009 | 0.322 |
| **LTem** | 0.142 | 0.109 | -0.152 | 0.243 | -0.109 | 0.160 |
| **100SWt** | 0.002 | **0.336** | 0.124 | -0.187 | -0.166 | -0.026 |
| **LBL** | 0.167 | -0.123 | -0.079 | 0.018 | -0.099 | -0.309 |
| **LBTA** | 0.008 | -0.010 | -0.016 | -0.137 | 0.117 | 0.193 |
| **LP** | 0.001 | 0.273 | 0.140 | 0.448 | -0.134 | 0.030 |
| **PGH** | -0.123 | -0.076 | 0.168 | -0.135 | -0.298 | -0.123 |
| **PB** | -0.155 | -0.095 | 0.361 | -0.016 | -0.209 | 0.201 |
| **PC** | 0.221 | -0.138 | 0.178 | -0.005 | -0.031 | 0.079 |
| **BC** | 0.169 | -0.124 | 0.237 | 0.187 | 0.245 | 0.034 |
| **NFPI** | -0.062 | -0.136 | 0.029 | 0.313 | -0.111 | -0.169 |
| **CC** | **0.278** | -0.064 | 0.060 | -0.202 | -0.068 | -0.185 |
| **FLBR** | **0.329** | -0.201 | -0.099 | 0.055 | -0.070 | 0.170 |
| **FC** | 0.231 | -0.118 | -0.120 | -0.002 | -0.307 | 0.045 |
| **FAS** | -0.195 | 0.157 | -0.017 | 0.001 | -0.166 | -0.018 |
| **FCl** | 0.202 | -0.200 | -0.014 | 0.049 | -0.156 | -0.121 |
| **FCD** | -0.060 | 0.104 | -0.057 | 0.223 | 0.043 | 0.396 |
| **RFCL** | -0.221 | 0.074 | -0.081 | 0.132 | 0.352 | -0.201 |
| **FCP** | 0.001 | 0.273 | 0.140 | 0.448 | -0.134 | 0.030 |
| **BSFB** | 0.195 | 0.199 | -0.105 | -0.070 | -0.106 | 0.132 |
| **Eigenvalue** | **5.292** | **4.195** | **3.789** | **2.289** | **2.131** | **1.829** |
| **Variability (%)** | **17.071** | **13.532** | **12.222** | **7.384** | **6.874** | **5.899** |
| **Cumulative %** | **17.071** | **30.603** | **42.825** | **50.209** | **57.083** | **62.982** |

## CONCLUSION

**T**here was wide qualitative variability among the germplasm, with polymorphism in 17 out of 25 descriptors registered (68%). It must be needed to collect the trait that exhibit the presence of prickles (only one germplasm) and zero frequencies for qualitative traits. Significant variation among the 40 germplasm for most of the quantitative traits indicated that the opportunity for further varietals development.

The clustering pattern of the genotypes revealed that the genotypes collected from the same places did not form a single cluster. On the other hand, genotypes originating from different geographical locations formed a single cluster indicating there was no clear relationship between the clustering pattern of the genotypes and their geographic sources.

The first PC explained 17.07% of the total variability and the second PC explained only 13.53% of the variation among 40 eggplant germplasm. Thus, the present study was revealed that the first PC was more important than the second PC for explaining the variability among the germplasm based on 31 morpho-physiological traits.

The eggplant germplasm such as MEG16-07, MEG16-10, MEG16-19, MEG16-22, MEG16-38, MEG16-30, MEG16-21, MEG16-14 and MEG16-01 etc., were separately isolated from the others and they were away from centroid. This result showed that such germplasm were indicated their uniqueness and divergence with respect to the measured 31 traits. Thus, discrimination of eggplant germplasm based on multiple traits by cluster analysis even provided the insight of varietal evolution and adaptation.

The maximum inter-cluster distance was observed between cluster I and IV (317.30) followed by that cluster I and II (166.59), suggesting a large distance between these clusters or groups of germplasm. From this findings, the germplasm of the cluster I and IV had the maximum common gene complexes and the magnitude of heterosis largely depended on the degree of genetic diversity in the germplasm. The greater the distance between the two clusters, the wider is the genetic difference between the germplasm. It can be suggested that the selection of parents for hybridization should be done from two clusters with wider inter-cluster distances in order to get more variability among the segregents.

The maximum cluster mean value of vegetative growth were observed in Cluster II. Larger fruit weight and fruit breadth were observed in cluster IV. Days to first harvest was observed in cluster I. Grouping of the germplasm to different clusters gives an opportunity to select genotypes to develop high yield and good quality varieties.

Populations with high scores for the first eigenvectors are leaf width (0.240), leaf length (0.242), fruit length (0.315), corolla color (0.278), and fruit length/breadth ratio (0.329) and these traits were the most important contributors towards diversity of the germplasm in PC1. The second eigenvector was mostly connected with scores of days to first harvest (0.244), fruit weight (0.384), fruit breadth (0.405) and 100 seeds weight (0.336) and also these traits were the second most important contributors among the 31 traits for 40 germplasm.

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