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# GENETIC DIVERSITY IN EGGPLANT GERMPLASM BY PRINCIPAL COMPONENT ANALYSIS

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## SUMMARY

Genetic divergence is a measure of selection of parents to produce potential hybrids and for isolation of transgressive segregants from hybrids in further filial generations. The objective of this study was to discriminate between 33 eggplant genotypes using multivariate analysis. The coefficient of variation was high for total phenols content and moderate in fruit yield per plant. Principal component analysis indicated that the first 6 components with an eigen value > 2 contributed about 80.61% of total variability. Magnitudes of the total variance attributable to the first 6 principal components were 32.74, 13.87, 10.68, 8.51, 5.52 and 4.79%, respectively. Flowering time, fruit circumference, fruit width, total phenols content, internodal length, leaf area index, fruit yield per plant and average fruit weight were traits contributing the most to the total variability. Fruit yield per plant, the most important economic trait, exhibited positive, significant, association with fruit circumference (0.557), fruit width, fruit borer infestation, total phenols content and average fruit weight. The distribution of genotypes from different geographical locations into 10 clusters was random, indicating geographical separation may not be the only factor causing genetic diversity. Cluster I contained the most genotypes (15) followed by cluster IX (5) and the minimum number of genotypes were in clusters II, V, VII and X. Intermating between genotypes of clusters I and IX would produce more desirable transgressive segregants for breeding.

**Key words:** *Solanum melongena*, multivariate analysis, association, selection, yield

**Key findings:** Genotypes EP 27 and EP 3 were better than all other genotypes and can be utilized for increasing fruit yield in eggplant. Fruit circumference, fruit width, fruit borer infestation, total phenols content and average fruit weight should be considered for improvement of fruit yield in eggplant.

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## INTRODUCTION

Eggplant (*Solanum melongena* L.) is a self-pollinated, annual herbaceous plant (Timmapur, 2007). Eggplant is consumed because of its low price (Lakshmi *et al.*, 2013). Eggplant fruit are a rich source of calcium, magnesium, potassium, iron, zinc and copper. It is also a fair source of fatty acids and may have medicinal properties (Shafeeq, 2005). Eggplant is an important vegetable in South Asia (Bangladesh, India, Nepal and Sri Lanka) and accounts for almost 50% of world area under cultivation. In India, eggplant cultivation is taken up in an area of 0.68 million hectares with an annual production of 12.98 million tonnes and productivity of 19.1 tonnes/ha during the year 2014-2015 (Anon, 2015). A large indigenous biodiversity exists in eggplant with variation in plant type, stem color, leaf size, leaf tip, midrib color, fruit size, fruit shape, fruit color, fruit yield, fruit quality, cooking quality, and tolerance to pests and diseases (Ullah *et al.,* 2014). Improvement in eggplant can be achieved by exploiting available sources of variability (Prabakaran, 2010).

Eggplant is an example of a crop grown in different macro-environments. For any breeding program information on the nature and magnitude of variability and genetic divergence among available germplasm is necessary for an efficient choice of parents for hybridization (Prakash *et al.,* 1990; Quamruzzaman *et al.,* 2009). Developing superior genotypes would be effective when existing variability in the chosen material is wide. Estimation of coefficient of variation helps to assess variability in the population.

To develop superior yielding genotypes it may not be always possible to select based on yield alone, because yield is a complex character and is collectively influenced by many component characters. The interrelationships between yield and yield contributing characters can be estimated by correlation analysis which provides information on nature, extent and direction of selection. Knowledge of genetic parameters is necessary to obtain improvement in crops.

Some related results have been reported in eggplant by Singh *et al.* (2006), Golani *et al.* (2007), Yadav (2008) and Roosevelt and Shanthi (2009). These studies did not cover any cultivars/ genotypes specific to the region of south Tamil Nadu. The effectiveness of multivariate analysis in the study of morphologically diverse individuals, and assessing the magnitude of divergence among different genotypes, has been studied (Ulaganathan and Nirmalakumari, 2015). Principal Component Analysis (PCA) is a technique that analyses data in which observations are designated by numerous inter-correlated quantitative dependent variables. Its aim is to: enable researchers to detect relationships within data, describe it as a set of new orthogonal variables (principal components), and define the pattern of similarity of observations as reported by Mahendran *et al.* (2015). Principal component analysis is a descriptive method that describes the pattern of variation of characters among individuals. It tends to reduce the dimension of multivariate data by removing inter-correlation among variables and allows a multi-dimensional relationship to be plotted on 2 or 3 principal axes (Nwangburuka *et al.,* 2011).

Cluster analysis is commonly used to study genetic diversity and for forming core subset for grouping accessions with similar characteristics into 1 homogenous category (Ulaganathan and Nirmalakumari, 2015). Clustering is also used to summarize information on relationships between objects by grouping similar units so that the relationship is easily understood. This investigation was undertaken in eggplant to identify, and classify variation in available germplasm on the basis of their genetic diversity.

## MATERIALS AND METHODS

The present experiment was conducted during the June to September (rainy season) of 2010-2011 at College Orchard, Agricultural College and Research Institute, Madurai, India, situated at 9°5' latitude and 78°5' longitude at an elevation of 147 m above MSL. Average temperature, relative humidity and light intensity during the cropping period were 34.20°C, 62.60% and 34044.45 respectively. Thirty-three eggplant germplasms, with a wide range of diversity and variability, were selected based on fruit shape, colour, size and evaluated under field conditions.

Seed were sown in raised nursery bed, covered by the thin layer of sand and watered daily. Plants in the nursery medium were protected against damping off by drenching with of an aqueous solution of 0.1% carbendazim. The well drained loamy soil in the field plot to which seedlings would be transplanted transplantation was brought to fine tilth by plowing and disking and the soil formed into ridges that were. Cow manure, 25 $t \cdot ha^{-1}$, was applied 20 days before transplanting. Thirty day-old seedlings from nursery beds were transplanted on the ridges adopting with 60×60 cm spacing. Each germplasm consisted of 60 plants in each replication. Cultural practices described in the Tamil Nadu Agricultural University Crop Production Guide (2005) were used.

The experiment was arranged in a completely randomized block design (CRBD) with 3 replications. Data were recorded for plant height, flowering time, number of primary branches, leaf area index, internodal length, fruit length, fruit weight, fruit pedicel length, fruit circumference, calyx length, number of fruit per plant, average fruit weight, fruit borer infestation, little leaf disease incidence, ascorbic acid content, total phenols content and fruit yield per plant.

Ascorbic acid content was estimated by a volumetric method (AOAC, 2001). The Folin-Ciocalteau reagent was used to estimate total phenols (Bray and Thrope, 1954). The assumption of null hypothesis was tested for differences among genotypes (Panse and Sukhatme, 1967). Phenotypic correlation coefficients were calculated using the formulae of Johnson *et al.* (1955). Principal component analysis was computed using SPSS (ver. 16.0, Chicago, IL) (Levesque, 2007). PCA axes with eigen values $\geq$ 0.8 were selected to define variation among accessions for agronomic and morphological traits. Mean values of 33 genotypes for 18 different traits were subjected to cluster analysis calculated using the software numerical taxonomy and multivariate analysis system (NTSYS) PC v2.02i (Rohlf, 1998).

## RESULTS AND DISCUSSION

The mean sum of square due to the germplasm was highly significant for all characters under study indicating presence of sufficient variability in the genotypes (Table 1). Considerable variation in eggplant germplasm has been reported in studies by Senapati et al. (2009), Shafeeq (2005) and Kushwa and Bandhyopadhya (2005). Data on range, mean, standard deviation and coefficient of variation for 17 traits in 33 eggplant genotypes varied (Table 2). Leaf area index, total phenols content, average fruit weight and fruit weight exhibited the widest range of mean values. Genotypes EP 27 and EP 3 were better than all other genotypes with respect to fruit yield per plant. 'Veerakkal Local' ('Sempatty Authur') had the least fruit yield. High marketable fruit yield per plant for these genotypes might be due to presence of round type fruit. These results may be useful for genetic improvement of eggplant through simple selection or through breeding for desirable traits. The highest coefficient of variation was for total phenols content. Consequently, there is the possibility to select genotypes with high phenols content and reduced incidence of fruit borer. Total phenols are directly related to resistance for fruit borer in eggplant (Praneetha, 2002). The response may also be viable for fruit yield per plant due to a moderate amount of co-efficient of variation.

**Table 1.** Analysis of variance for yield and quality characters.

| Source | df | PH[a] | DFF | NPB | LAI | INL | FL | FW | FPL | FC |
|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 1 | 4.306 | 0.310 | 60.134 | 6.7538 | 1.359 | 0.117 | 0.384 | 1.152 | 2.781 |
| Genotype | 32 | 305.19** | 7.850** | 13.404** | 6876.0** | 256.80** | 4.128** | 1.060 ** | 9.898 ** | 0.407** |
| Error | 32 | 4.283 | 0.119 | 1.230 | 2.163 | 3.718 | 0.640 | 0.204 | 2.918 | 0.138 |

| Source | df | CL | NFP | AFW | FBI | LLI | ACC | TPC | FYP |
|---|---|---|---|---|---|---|---|---|---|
| Replication | 1 | 1.046 | 6.40 | 3.892 | -0.0023 | -0.129 | 4.208 | 0.293 | 0.026 |
| Genotype | 32 | 0.439** | 782.90 ** | 111.83 ** | 4.486** | 4014.2** | 58.314** | 160.85** | 0.058 ** |
| Error | 32 | 0.222 | 2.880 | 4.610 | 0.0004 | 0.0060 | 19.944 | 36.066 | 0.014 |

**Significant at 1% level; [a] PH = plant height; DFF = flowering time; NPB = number of primary branches; LAI = leaf area index; INL = internodal length; FL = fruit length; FW = fruit weight; FPL = fruit pedicel length; FC = fruit circumference; CL = calyx length; NFP = number of fruit per plant; AFW = average fruit weight; FBI = fruit borer infestation; LLI = little leaf incidence; ACC = ascorbic acid content; TPC = total phenols content; FYP = fruit yield per plant.

**Table 2.** Estimates of variability in eggplant landraces.

| Characters | Mean | Maximum | Minimum | Difference | SD | CV % |
|---|---|---|---|---|---|---|
| PH[a] | 127.57 | 149.97 (Alavayal Local)[b] | 100.74 (SM 2) | 49.23 | 12.16 | 9.54 |
| DFF | 80.53 | 85.00 (EP 28) | 75.00 (Keerikai) | 10.00 | 2.55 | 3.17 |
| NPB | 7.55 | 10.90 (SM 3) | 4.55 (EP 9) | 6.35 | 1.95 | 25.82 |
| LAI | 131.01 | 311.81(EP 11) | 70.22 (70.22) | 241.59 | 57.74 | 44.07 |
| INL | 8.88 | 13.09 (EP 9) | 5.53 (Kariapatty Local) | 7.56 | 1.97 | 22.21 |
| FL | 7.36 | 12.64 (EP 29) | 5.32 (EP 5) | 7.32 | 1.41 | 19.22 |
| FW | 4.94 | 6.72 (EP 4) | 3.25 (Veerakkal Local) | 3.47 | 0.72 | 14.54 |
| FPL | 4.75 | 6.20 (EP 9) | 3.99 (EP 23) | 2.21 | 0.55 | 11.66 |
| FC | 15.86 | 20.31 (EP 4) | 10.39 (Veerakkal Local) | 9.92 | 2.19 | 13.81 |
| CL | 3.37 | 4.39 (EP 21) | 2.33 (EP 27) | 2.06 | 0.44 | 13.16 |
| NFP | 26.18 | 50.95 (SM 5) | 11.54 (EP 11) | 39.41 | 8.24 | 31.48 |
| AFW | 55.55 | 105.94 (EP 11) | 29.86 (Kariapatty Local) | 76.08 | 19.48 | 35.07 |
| FBI | 47.28 | 60.42 (SM 4) | 31.25 (Veerakkal Local) | 29.17 | 8.83 | 18.68 |
| LLI | 18.69 | 29.17 (EP 11) | 10.42 (Palamedu Local and EP 3) | 18.75 | 5.32 | 28.45 |
| ACC | 10.22 | 13.47 (Keerikai) | 7.38 (EP 30) | 6.09 | 1.47 | 14.42 |
| TPC | 83.52 | 198.44 (EP 28) | 29.32 (Alagarkovil Local) | 169.12 | 44.12 | 52.82 |
| FYP | 1.34 | 1.93 (EP 27) | 0.76 (Veerakkal Local) | 1.17 | 0.30 | 22.70 |

[a]PH = plant height; DFF = flowering time; NPB = number of primary branches; LAI = leaf area index; INL = internodal length; FL = fruit length; FW = fruit weight; FPL = fruit pedicel length; FC = fruit circumference; CL = calyx length; NFP = number of fruit per plant; AFW = average fruit weight; FBI = fruit borer infestation; LLI = little leaf incidence; ACC = ascorbic acid content; TPC = total phenols content; FYP = fruit yield per plant.
[b] Names in the parentheses are genotypes.

Eigen values represent the amount of variation accounted in each principal component and eigen vectors for traits for the 4 principle components varied (Table 3). Two of the 17 principal component axes had eigen values > 2 and together accounted for 51.11% of total variation. The PCA indicated the first 6 components with eigen value > 0.65 contributed about 80.61% of total variability in 33 genotypes involving all 17 traits studied.

Table 3. Eigen values, proportion of variation and total variation across axis.

| Component | Eigen value | % of variance | Cumulative % of variation |
|---|---|---|---|
| 1 | 6.33 | 37.24 | 37.24 |
| 2 | 2.35 | 13.87 | 51.11 |
| 3 | 1.81 | 10.68 | 61.79 |
| 4 | 1.44 | 8.51 | 70.30 |
| 5 | 0.93 | 5.52 | 75.82 |
| 6 | 0.81 | 4.79 | 80.61 |
| 7 | 0.69 | 4.10 | 84.71 |
| 8 | 0.66 | 3.93 | 88.64 |
| 9 | 0.51 | 3.04 | 91.68 |
| 10 | 0.42 | 2.47 | 94.15 |
| 11 | 0.31 | 1.83 | 95.98 |
| 12 | 0.21 | 1.24 | 97.22 |
| 13 | 0.16 | 0.98 | 98.20 |
| 14 | 0.14 | 0.82 | 99.02 |
| 15 | 0.09 | 0.55 | 99.57 |
| 16 | 0.04 | 0.28 | 99.85 |
| 17 | 0.02 | 0.15 | 100.00 |

The first principal component accounted for 37.24% of total variation in the population (Table 4). Flowering time contributed more to variation followed by fruit circumference, fruit width, total phenols content, internodal length, leaf area index, fruit yield per plant, average fruit weight and fruit pedicel length had the highest loadings in PC1 indicating significant importance for these components. These traits provided the highest contribution in divergence and supported the largest portion of its variability, while the characters fruit length, plant height, calyx length and number of fruit per plant had the lowest loadings in PC1. Little leaf incidence, fruit borer infestation, ascorbic acid content and number of primary branches contributed negative values to the first component.

**Table 4.** Principal components of eggplant germplasm - non-rotated loadings.

| Traits | Components (Eigen vector >8.0) | | | | | |
|---|---|---|---|---|---|---|
| | PC1 | PC2 | PC3 | PC4 | PC5 | PC6 |
| PH[a] | 0.089 | 0.243 | 0.300 | 0.696 | -0.301 | -0.064 |
| DFF | 0.838 | 0.027 | 0.002 | 0.111 | 0.017 | 0.241 |
| NPB | -0.747 | -0.317 | -0.003 | -0.282 | 0.219 | 0.022 |
| LAI | 0.408 | 0.788 | 0.173 | 0.106 | 0.08 | 0.068 |
| INL | 0.464 | 0.474 | -0.141 | 0.351 | -0.442 | -0.169 |
| FL | 0.179 | 0.068 | -0.091 | 0.075 | -0.038 | 0.947 |
| FW | 0.688 | 0.244 | 0.442 | 0.118 | 0.101 | -0.022 |
| FPL | 0.291 | 0.171 | -0.118 | 0.845 | 0.051 | 0.144 |
| FC | 0.701 | 0.166 | 0.44 | 0.179 | 0.137 | -0.057 |
| CL | 0.017 | 0.569 | -0.155 | 0.516 | 0.436 | 0.088 |
| NFP | 0.01 | -0.858 | 0.23 | -0.239 | -0.057 | 0.037 |
| AFW | 0.365 | 0.818 | 0.283 | 0.132 | 0.05 | 0.108 |
| FBI | -0.031 | 0.023 | 0.809 | -0.071 | 0.074 | -0.302 |
| LLI | -0.032 | 0.092 | -0.012 | -0.077 | 0.884 | -0.077 |
| ACC | -0.88 | -0.117 | 0.012 | 0.016 | 0.18 | -0.172 |
| TPC | 0.591 | 0.266 | 0.227 | 0.138 | 0.422 | 0.02 |
| FYP | 0.386 | -0.079 | 0.776 | 0.06 | -0.143 | 0.278 |

[a]PH = plant height; DFF = flowering time; NPB = number of primary branches; LAI = leaf area index; INL = internodal length; FL = fruit length; FW = fruit weight; FPL = fruit pedicel length; FC = fruit circumference; CL = calyx length; NFP = number of fruit per plant; AFW = average fruit weight; FBI = fruit borer infestation; LLI = little leaf incidence; ACC = ascorbic acid content; TPC = total phenols content; FYP = fruit yield per plant.

The PC2 contributed 13.87% of the total variation. Characters contributing to the second component include average fruit weight, leaf area index, calyx length, internodal length, total phenols content, fruit weight, plant height, fruit pedicel length and fruit circumference. The PC 3 accounted for 10.68% of the total variation in the population. Fruit borer infestation contributed the highest amount followed by fruit yield per plant, fruit circumference and fruit width; flowering time contributed less variation. Plant height, average fruit weight, number of fruit per plat, total phenol content and leaf area index varied (Table 5). All other characters negatively contributed towards divergence. The PC4 contributed 8.51% of total variation. Major characters contributing the most to variation were fruit pedicel length, plant height and calyx length. Internodal length, total phenol content, average fruit weight, fruit length and fruit width contributed little to variation. The contribution of number of primary branches, number of fruit per plant, fruit borer infestation and little leaf infestation were negative.

The PC5 contribution towards total variation was 5.52%. Characters contributing substantially to divergence are little leaf incidence, calyx length and total phenols content. Those with little contribution were numbers of primary branches per plant, ascorbic acid content, fruit circumference and fruit weight. The PC 6 accounted for 4.79% of variation. The characters that contributed substantially towards genetic divergence are fruit length and fruit yield per plant. Those with the least contribution was flowering time.

The first principal components had the maximum number of characters towards genetic diversity and these traits could be effectively used for further breeding to generate more variability. Solaiman et al. (2014) reported that fruit width, fruit weight and fruit yield per plant were important traits contributing towards divergence of the genotypes. While Ullah et al. (2014) concluded that in eggplant plant height, fruit length and fruit diameter should be kept average to obtain maximum fruit yield. The role of fruit yield in eggplant was more important towards genetic divergence (Quamruzzaman et al., 2009). The number of fruit per plant, fruit yield per plant and fruit width in both vectors was positive across 2 axes indicating they are important components of genetic divergence among these characters (Rahman et al., 2014). Selection would be worthwhile in the group of high mean and high variability, and if necessary in the groups of high mean and low variability, because these groups have potential to produce more transgressive segregants than other groups. High mean and high variability are capable of producing more transgressive segregants. In certain characters wherein low mean is desirable as in earliness, calyx length, pest and disease incidence, this group could be promising for selection of segregants.

The correlation analysis measure the degree of relationship between plant characters and this will help to select component characters during crop improvement through selection (Dhaka and Soni, 2014; Rekha and Celine, 2013; Nalini *et al.,* 2009). The genotypic correlations between different characters varied (Table 5). Correlation indicated that fruit yield per plant was significantly, and positively, correlated with fruit circumference (0.557) followed by fruit width (0.546), fruit borer infestation (0.434), total phenols content (0.383) and average fruit weight (0.363). A strong correlation between average fruit weight and fruit yield per plant was reported by Nalini et al. (2009) and Shinde et al. (2012) for fruit circumference and Praneetha (2002) for total phenols content. These indicate that maximum fruit circumference increased fruit width and fruit weight resulted in higher fruit yield per plant.

Plant height was negatively, and significantly, correlated with number of primary branches per plant. A strong positive correlation occurred between plant height and fruit pedicel length, internodal length and leaf area index. This indicates that tall plants might better synthesize growth promoting substances and increased internodal length and leaf area index.
Flowering time were significantly correlated with fruit width, fruit circumference, total phenols content, leaf area index, fruit pedicel length and fruit length. Numbers of primary branches per plant were not correlated with number of fruit per plant, little leaf incidence, fruit borer infestation fruit yield per plant, calyx length and fruit length. Most traits had significant, negative, correlation with number of primary branches per plant and a significant, positive correlation with ascorbic acid content.

Leaf area index was positively, and significantly, correlated with average fruit weight, internodal length, fruit width, calyx length, total phenols content, and fruit circumference. Higher leaf area index resulted in better accumulation of photosynthates in plants and ultimately plants produced heavier and larger fruit.

Internodal length had a positive, significant, correlation with average fruit weight, fruit pedicel length and fruit width but was not correlated with fruit width, fruit circumference, calyx length, total phenols content, fruit yield per plant and fruit length. There were significant, negative, correlations between internodal length and ascorbic acid content.

Fruit width had a significant, positive, correlation with fruit circumference, average fruit weight, fruit yield per plant and total phenols content. There were significant, positive, correlations between fruit pedicel length with calyx length and total phenols content. Fruit circumference had a strong, positive, correlation with average fruit weight and fruit yield per plant. This indicates that as fruit circumference increases there will be an increase in fruit weight with higher fruit yield.

**Table 5.** Correlation matrix of different traits.

| Traits | DFF | NPB | LAI | INL | FL | FW | FPL | FC | CL | NFP | AFW | FBI | LLI | ACC | TPC | FYP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PH[a] | 0.210 | -0.445* | 0.409* | 0.413* | 0.040 | 0.286 | 0.484* | 0.314 | 0.187 | -0.279 | 0.358 | 0.168 | -0.166 | -0.170 | 0.096 | 0.211 |
| DFF | | -0.566* | 0.445* | 0.296 | 0.365* | 0.570* | 0.391* | 0.541* | 0.083 | -0.110 | 0.341 | 0.005 | -0.060 | -0.807* | 0.478* | 0.314 |
| NPB | | | -0.594* | -0.664* | -0.194 | -0.551* | -0.425* | -0.601* | -0.239 | 0.249 | -0.543* | 0.067 | 0.168 | 0.677* | -0.489* | -0.311 |
| LAI | | | | 0.506* | 0.176 | 0.501* | 0.314 | 0.470* | 0.461* | -0.582* | 0.814* | 0.149 | 0.175 | -0.472* | 0.488* | 0.218 |
| INL | | | | | 0.026 | 0.375* | 0.492* | 0.296 | 0.296 | -0.433* | 0.508* | -0.117 | -0.322 | -0.529* | 0.256 | 0.162 |
| FL | | | | | | 0.117 | 0.242 | 0.061 | 0.133 | -0.063 | 0.168 | -0.338 | -0.070 | -0.336 | 0.093 | 0.218 |
| FW | | | | | | | 0.250 | 0.905* | 0.190 | -0.216 | 0.549* | 0.259 | 0.054 | -0.518* | 0.490* | 0.546* |
| FPL | | | | | | | | 0.278 | 0.504* | -0.418* | 0.381 | -0.133 | -0.057 | -0.310 | 0.381* | 0.109 |
| FC | | | | | | | | | 0.192 | -0.141 | 0.532* | 0.210 | 0.058 | -0.497* | 0.519* | 0.557* |
| CL | | | | | | | | | | -0.525* | 0.439* | -0.132 | 0.292 | -0.011 | 0.313 | -0.103 |
| NFP | | | | | | | | | | | -0.663* | 0.148 | -0.070 | 0.042 | -0.212 | 0.304 |
| AFW | | | | | | | | | | | | 0.160 | 0.068 | -0.435* | 0.600* | 0.363* |
| FBI | | | | | | | | | | | | | 0.080 | -0.015 | 0.196 | 0.434* |
| LLI | | | | | | | | | | | | | | 0.131 | 0.265 | -0.188 |
| ACC | | | | | | | | | | | | | | | -0.447* | -0.368* |
| TPC | | | | | | | | | | | | | | | | 0.383* |

*Significant at 5% level

[a]PH = plant height; DFF = flowering time; NPB = number of primary branches; LAI = leaf area index; INL = internodal length; FL = fruit length; FW = fruit weight; FPL = fruit pedicel length; FC = fruit circumference; CL = calyx length; NFP = number of fruit per plant; AFW = average fruit weight; FBI = fruit borer infestation; LLI = little leaf incidence; ACC = ascorbic acid content; TPC = total phenols content; FYP = fruit yield per plant.

**Table 6.** Clustering pattern of eggplant genotypes.

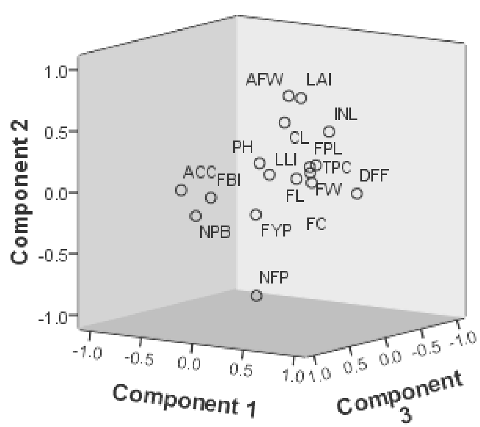
| Cluster | Number of genotypes | Constituent genotypes |
|---|---|---|
| I | 15 | Kariapatty Local, Sedapatty Local (Ramakkai Blue), Nilakottai Local, Sedapatty Local (Ramakkai Green), Alagarkovil Local, Singampunari Local 1, Singampunari Local 2, SM1, SM3, SM4, SM2, Alavayal Local, Melur Local, Kallampatty Local, Keerikai |
| II | 1 | SM5 |
| III | 2 | Palamedu Local, EP 3 |
| IV | 4 | EP 5, EP 7, EP 30, EP 27 |
| V | 1 | EP 23 |
| VI | 1 | Veerakkal Local (Sempatty Authur) |
| VII | 1 | EP 29 |
| VIII | 2 | EP 4, EP 28 |
| IX | 5 | EP 9, EP 17, EP 10, EP 20, EP 21 |
| X | 1 | EP11 |

Calyx length had a strong correlation with average fruit weight but was not correlated with total phenols content and little leaf incidence. Number of fruit per plant had a strong, negative, correlation with average fruit weight. Number of fruit per plant was not correlated with other traits.

Average fruit weight had a significant, positive, correlation with total phenols content and fruit yield per plant, but a significant, negative, correlation with ascorbic acid content. Fruit borer infestation had a strong correlation with fruit yield per plant but was not correlated with total phenols content and little leaf incidence. Ascorbic acid content and total phenols content exhibited significant, negative, and positive, correlations with fruit yield per plant, respectively. This may be due to high phenol content in fruit might result in less infestation of fruit borer contributing to higher fruit yield per plant.

Multivariate analysis is used to study morphologically complex individual and for measuring the degree of divergence between biological populations (Prabakaran, 2010). Cluster analysis is commonly used to study genetic diversity, and for forming core subsets for grouping accessions with similar characteristic into homogenous category. The genetic diversity varied widely as they formed 10 gene clusters (Table 6). Among clusters, cluster I had had the most genotypes followed by cluster IX which were from a different geographical location. Clustering patterns indicated that genotype did not resolve according to geographical origin. Geographic diversity, though appear to be an important factor it that it is not the only factor determining genetic divergence. Genotypes belonging to clusters I and IX could have greater genetic divergence and intermating between the genotypes belonging to them would give more transgressive segregates in advanced generations. Clusters II, V, VII and X had only 1 genotype; clusters III and VIII had 2 genotypes and cluster IV had 4 genotypes.

There was a wide range of diversity among the germplasm for quantitative traits (Figure 1). Phenotypic selection based on fruit circumference, fruit width, fruit borer infestation, total phenols content and average fruit weight should be considered for improvement of fruit yield in eggplant. Inter-genotypic crosses between members of clusters I and IX would exhibit high heterosis and is likely to produce new recombinants with desired traits. More emphasis should be given to cluster II and V in selecting inbreds for crossing in eggplant hybridization.




[a]PH = plant height; DFF = flowering time; NPB = number of primary branches; LAI = leaf area index; INL = internodal length; FL = fruit length; FW = fruit weight; FPL = fruit pedicel length; FC = fruit circumference; CL = calyx length; NFP = number of fruit per plant; AFW = average fruit weight; FBI = fruit borer infestation; LLI = little leaf incidence; ACC = ascorbic acid content; TPC = total phenols content; FYP = fruit yield per plant.

Figure 1. Tri-dimensional graph showing grouping of traits.

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