# Genetic Divergence and Selection of Promising Types of Aonla (*Emblica officinalis* L.) from Seedling Population in Solan Area of Himachal Pradesh

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To assess the nature and magnitude of genetic divergence in *Emblica officinalis*, a survey was conducted during 2000 in Arki area of Himachal Pradesh and non-hierarchical Euclidean cluster analysis was performed for 66 seedling trees taking 15 fruit characters of each tree. Coefficient of variability ranged from 3.57% for pulp percentage (volume basis) to 39.26% for pulp volume. All the genotypes got clustered into 14 clusters which revealed that their distribution is in more than one cluster showing, non-parallelism between geographic and genetic diversity. Number of trees were minimum (1) in cluster 7 and 14 and maximum (12) in cluster 13. Mean value of most of the fruits was higher in cluster 14. Intra-cluster distance varied from 0 (cluster 7 and 14) to 1.81 (cluster 3). Maximum inter-cluster distance of 13.00 was observed between cluster 1 and 14. Based on various important fruit characters, four promising seedling trees will be propagated vegetatively for further testing and release in the growing area.

**Key Words: Aonla, *Emblica officinalis*, Genetic Divergence, Selection, Variability**

Aonla (*Emblica officinalis* L.) is an important fruit of family Euphorbiaceae. It is said to be indigenous to tropical South-East Asia, particularly in central and southern India (Firminger, 1947). Aonla is an important minor fruit crop of commercial significance. It is quite hardy, a prolific bearer and highly remunerative even without much care. The fruit is highly nutritive and is the richest source of vitamin C among fruits except Barbados cherry. The fruits are made into preserve, sauce, candy, dried chips, tablets, jellies, pickles, toffees and powder. In India, there is limited systematic plantation of aonla and mostly plants of seedling origin are grown. The seed-propagated trees exhibit a tremendous genetic divergence with respect to fruit and other characters, which in turn offers a great scope for selection of promising types. Earlier improvement work of aonla has taken place through selection only. Keeping in view the above importance the present survey was conducted in Arki area of district Solan in Himachal Pradesh.

## Materials and Methods

The present survey was conducted during 2000 in Arki area of district Solan in Himachal Pradesh which is situated at an elevation of 1000 to 1200 m above mean sea level. The microclimate of the survey area is subtropical to subtemperate. Hence, there is slight variation in the microclimate of the area from which the trees were sampled. In this area aonla was found growing in wild form in neglected areas and grasslands. Based on preliminary information from farmers, fruits were collected from 66 trees, out of a total population of 400 trees in the area. Twenty-five fruits from each tree were randomly harvested in mid December and were used for recording data on various fruit characters. Data were statistically analysed by using non-hierarchical Euclidean cluster analysis (Spark, 1973). The multivariate analysis was performed by using statistical package Spar-1. Based on various fruit characters like fruit weight, length, diameter, volume, pulp weight, pulp percentage and seed:pulp ratio, the promising types were selected and the fruits from selected types were subjected to chemical analysis following the methods suggested in AOAC (1975).

## Results and Discussion

Highest coefficient of variability was observed as 39.26 % for pulp volume followed by pulp weight (38.81%), fruit volume (36.44%), fruit weight (36.39%), seed:pulp ratio weight basis (35.60%), seed:pulp ratio volume basis (34.46%), seed weight (23.21), seed volume (21.43%), fruit diameter (12.53%), fruit length (11.52%), TSS (10.15%), seed length, (9.91%), seed diameter (8.93%), pulp percentage (3.61%) on the basis of weight and pulp percentage (3.57%) on the basis of volume (Table 1).

All 66 aonla genotypes got clustered into 14 clusters and distribution of genotypes from different areas into these clusters was apparently random. Number of genotypes in each cluster varied from 1 in cluster 7 and 14 to 12 in cluster 13. The number of trees in different clusters (1-14) were 4, 2, 9, 3, 8, 4, 1, 3, 2, 7, 7, 3, 12 and 1, respectively.

**Table 1. Range, mean, standard deviation and coefficient of variability for different fruit characters in seedling trees of aonla**

| Characters | Range | Mean | Standard deviation (SD) | Coefficient of variability (CV) |
|---|---|---|---|---|
| Fruit weight (g) | 2.30-12.50 | 6.10 | 2.22 | 36.39 |
| Fruit length (mm) | 14.69-14.62 | 19.45 | 2.24 | 11.52 |
| Fruit diameter (mm) | 15.73-29.05 | 22.18 | 2.78 | 12.53 |
| Fruit volume (cc) | 3.00-11.00 | 5.68 | 2.07 | 36.44 |
| Seed weight (g) | 0.230-0.855 | 0.56 | 0.13 | 23.21 |
| Seed length (mm) | 8.40-12.86 | 10.09 | 1.00 | 9.91 |
| Seed diameter (mm) | 8.16-12.61 | 10.08 | 0.90 | 8.93 |
| Pulp weight (g) | 1.756-11.640 | 5.54 | 2.15 | 38.81 |
| Pulp percentage (weight basis) | 76.35-95.57 | 89.98 | 3.25 | 3.61 |
| Seed:pulp ratio (weight basis) | 3.23-21.60 | 10.00 | 3.56 | 35.60 |
| TSS (°B) | 9.00-15.00 | 12.41 | 1.26 | 10.15 |
| Pulp volume (cc) | 1.625-10.250 | 5.123 | 2.041 | 39.26 |
| Seed volume (cc) | 0.250-0.750 | 0.56 | 0.12 | 21.43 |
| Pulp percentage (volume basis) | 83.33-95.02 | 89.27 | 3.19 | 3.57 |
| Seed:pulp ratio (volume basis) | 4.33-19.08 | 9.17 | 3.16 | 34.46 |

The mean fruit weight (12.50 g), fruit length (24.62 mm), fruit diameter (29.05 mm), fruit volume (11 cc), seed weight (0.86 g), seed length (11.43 mm), seed diameter (12.61), pulp weight (11.65 g), pulp volume (10.25 cc) and seed volume (0.75 cc) were highest in cluster 14 while cluster 7 had maximum pulp percentage (95.57%) and seed : pulp ratio (1:21. 60) on their weight basis. Similarly, cluster 7 had highest mean value (14.50° B) of TSS while cluster 14 had maximum pulp percentage (94.55%) and seed : pulp ratio (1:17.59) on volume basis (Table 2).

Minimum intra-cluster distance (0) was observed in cluster 7 and 14 while it was maximum (1.810) in cluster 3. Similarly inter-cluster distance varied from 0.046 between cluster 2 and 3 to 13.000 between cluster 1 and 14. Cluster 9 and 14 are separated from each other by a distance of 12.846 while 11.260 distance was recorded between cluster 7 and 14.

Different characters have different magnitude of percentage towards diversity. It ranged from 0.00% in pulp percentage seed : pulp ratio (volume basis) to 58.10% in fruit weight. Fruit weight (58.10 g), length (21.73 cm), diameter (5.94 cm), volume (4.85 cc), seed weight (4.12 g) and seed length (1.37 cm), thus explaining 96.10% variation.

Based on various characters like fruit weight, fruit length, fruit diameter, pulp weight, pulp percentage, seed: pulp ratio (weight and volume basis) and TSS, Tree No. 31, 59, 64 and 66 were found to be promising and were selected. Fruits from all these trees were green in colour. The various fruit characters of selected types are presented in Table 3. Acidity in selected types varied from 2.01 (Tree no. 59) to 2.48% (Tree No. 31), while ascorbic acid ranged from 305 to (Tree No. 59) to 515 mg/100 g of fruit (Tree No. 31). Similarly, total and reducing sugars varied from 8.62% (Tree No. 64) to 10.01% (Tree No. 59) and 5.23% (Tree No. 66) to 6.13% (Tree No. 59), respectively.

In the present investigation a great extent of genetic divergence was recorded from various fruit characters. Coefficients of variability in pulp volume, pulp weight and fruit weight as 39.26, 36.44 and 36.39%, respectively. Similar type of variation was also observed by Singh *et al.* (1987) and Chandra *et al.* (1998) in aonla varieties and seedling trees, respectively. All the 66 genotypes got clustered unsystematically into 14 clusters thus, cutting across geographic boundaries demonstrating that geographic isolation is not the only factor causing genetic diversity. Intra-cluster distance varied from 0 to 1.810. These relatively low values depicted the presence of narrow range of genetic diversity within a cluster. The 0 value of intra-cluster distance is due to the fact that only a single plant entered in this cluster. The inter-cluster distance varied from 0.04 between cluster 2 and 3 to 13.00 between cluster 1 and 14. The parents for hybridization could be selected on the basis of their large inter-cluster distance for isolating useful recombinants in the segregating generation. So to improve various fruit characters the members of cluster 1 and 14 can be used for hybridization programme as well as for introgressing their useful traits in commercial aonla cultivars. Aonla is a less exploited crop and mostly the improvement work was undertaken through selection. These four selected types

**Table 2. Cluster mean, standard deviation and coefficient of variability of 14 clusters for different fruit characters in seedling trees of aonla**

| Characters | Para-meters | Clusters | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Fruit weight | Mean | 3.10 | 8.10 | 4.37 | 8.47 | 5.66 | 9.93 | 7.30 | 6.87 | 2.80 | 6.86 | 5.74 | 10.62 | 4.84 | 12.50 |
| | SD | 0.48 | 0.14 | 0.41 | 0.49 | 0.46 | 0.66 | 0.00 | 0.59 | 0.71 | 0.47 | 0.68 | 0.48 | 0.91 | 0.00 |
| | CV | 15.48 | 1.73 | 9.38 | 5.79 | 8.13 | 6.65 | 0.00 | 8.59 | 25.36 | 6.85 | 11.85 | 4.52 | 18.80 | 0.00 |
| Fruit length | Mean | 15.90 | 21.72 | 18.13 | 21.52 | 19.31 | 22.66 | 17.24 | 22.56 | 15.67 | 20.02 | 19.05 | 23.25 | 18.28 | 24.62 |
| | SD | 0.43 | 0.37 | 0.92 | 0.99 | 0.75 | 0.30 | 0.00 | 0.48 | 1.39 | 0.61 | 1.64 | 1.14 | 0.93 | 0.00 |
| | CV | 2.70 | 1.70 | 5.07 | 4.60 | 3.88 | 1.32 | 0.00 | 2.13 | 8.87 | 3.05 | 8.61 | 4.90 | 5.09 | 0.00 |
| Fruit diameter | Mean | 18.12 | 24.44 | 20.42 | 24.33 | 21.95 | 26.69 | 18.57 | 23.10 | 16.77 | 23.91 | 20.87 | 27.11 | 21.49 | 29.05 |
| | SD | 0.79 | 0.18 | 1.08 | 1.82 | 0.80 | 0.75 | 0.00 | 0.75 | 1.48 | 0.96 | 1.79 | 0.87 | 1.27 | 0.00 |
| | CV | 4.36 | 0.74 | 5.29 | 7.48 | 3.64 | 2.81 | 0.00 | 3.25 | 8.83 | 4.02 | 8.58 | 3.21 | 5.91 | 0.00 |
| Fruit volume | Mean | 2.70 | 8.45 | 3.92 | 7.83 | 5.04 | 9.38 | 3.50 | 6.13 | 3.40 | 6.39 | 5.27 | 10.03 | 4.93 | 11.00 |
| | SD | 0.48 | 0.78 | 0.58 | 0.06 | 0.52 | 0.63 | 0.00 | 0.35 | 3.28 | 0.46 | 0.73 | 0.40 | 0.59 | 0.00 |
| | CV | 17.78 | 9.23 | 14.80 | 0.77 | 10.32 | 6.72 | 0.00 | 5.71 | 8.24 | 7.20 | 13.85 | 3.99 | 11.97 | 0.00 |
| Seed weight | Mean | 0.40 | 0.70 | 0.43 | 0.50 | 0.65 | 0.71 | 0.32 | 0.55 | 0.54 | 0.70 | 0.45 | 0.59 | 0.57 | 0.86 |
| | SD | 0.06 | 0.01 | 0.06 | 0.04 | 0.08 | 0.07 | 0.00 | 0.06 | 0.00 | 0.07 | 0.05 | 0.10 | 0.05 | 0.00 |
| | CV | 15.00 | 1.43 | 13.95 | 8.00 | 12.31 | 9.86 | 0.00 | 10.91 | 0.00 | 10.00 | 11.11 | 16.95 | 8.77 | 0.00 |
| Seed length | Mean | 8.73 | 10.70 | 9.43 | 10.57 | 10.56 | 11.12 | 8.60 | 11.19 | 10.00 | 10.33 | 9.39 | 9.28 | 10.46 | 11.43 |
| | SD | 0.29 | 0.26 | 0.56 | 1.08 | 1.08 | 0.72 | 0.00 | 0.70 | 0.15 | 0.78 | 0.95 | 0.71 | 0.75 | 0.00 |
| | CV | 3.32 | 2.43 | 5.94 | 10.22 | 10.23 | 6.47 | 0.00 | 6.26 | 1.50 | 7.55 | 10.12 | 7.65 | 7.21 | 0.00 |
| Seed diameter | Mean | 9.06 | 10.85 | 9.24 | 9.66 | 10.76 | 10.51 | 8.20 | 9.89 | 10.20 | 10.89 | 9.36 | 10.14 | 10.33 | 12.61 |
| | SD | 0.67 | 1.07 | 0.55 | 0.28 | 0.42 | 0.30 | 0.00 | 0.35 | 0.08 | 0.56 | 0.55 | 0.87 | 0.64 | 0.00 |
| | CV | 7.40 | 9.86 | 5.95 | 2.90 | 3.90 | 2.85 | 0.00 | 3.54 | 0.78 | 5.14 | 5.88 | 8.58 | 6.20 | 0.00 |
| Pulp weight | Mean | 2.70 | 7.40 | 3.94 | 7.96 | 5.01 | 9.22 | 6.98 | 6.32 | 2.26 | 6.16 | 5.29 | 10.03 | 4.27 | 11.65 |
| | SD | 0.44 | 0.13 | 0.38 | 0.47 | 0.47 | 0.59 | 0.00 | 0.59 | 0.71 | 0.45 | 0.67 | 0.39 | 0.91 | 0.00 |
| | CV | 16.30 | 1.76 | 9.64 | 5.90 | 9.38 | 6.46 | 0.00 | 9.34 | 31.42 | 7.31 | 12.67 | 3.89 | 21.31 | 0.00 |
| Pulp per cent age (weight basis) | Mean | 86.92 | 91.31 | 90.20 | 94.07 | 88.46 | 92.87 | 95.57 | 91.97 | 79.99 | 89.82 | 92.06 | 94.46 | 87.82 | 93.16 |
| | SD | 1.64 | 0.04 | 1.13 | 0.38 | 1.73 | 0.28 | 0.00 | 1.10 | 5.15 | 1.06 | 1.13 | 0.74 | 2.36 | 0.00 |
| | CV | 1.89 | 0.04 | 1.25 | 0.40 | 1.96 | 0.30 | 0.00 | 1.20 | 6.44 | 1.18 | 1.23 | 0.78 | 2.69 | 0.00 |
| Seed:pulp ratio (weight basis) | Mean | 6.75 | 10.52 | 9.33 | 15.91 | 7.84 | 13.05 | 21.60 | 11.62 | 4.17 | 8.91 | 11.83 | 17.27 | 7.49 | 13.62 |
| | SD | 1.09 | 0.03 | 1.17 | 1.09 | 1.38 | 0.56 | 0.00 | 1.87 | 1.33 | 0.94 | 1.90 | 2.62 | 1.61 | 0.00 |
| | CV | 16.15 | 0.29 | 12.54 | 6.85 | 17.60 | 4.29 | 0.00 | 16.09 | 31.89 | 10.55 | 16.06 | 15.17 | 21.50 | 0.00 |
| TSS (°B) | Mean | 11.50 | 12.50 | 11.33 | 12.17 | 12.27 | 13.25 | 14.00 | 14.50 | 10.25 | 12.29 | 12.50 | 13.17 | 12.79 | 14.00 |
| | SD | 1.35 | 0.00 | 1.32 | 0.29 | 1.24 | 0.65 | 0.00 | 0.50 | 1.77 | 0.70 | 1.29 | 0.29 | 0.81 | 0.00 |
| | CV | 11.74 | 0.00 | 11.65 | 2.38 | 10.11 | 4.91 | 0.00 | 3.45 | 17.27 | 5.70 | 10.32 | 2.20 | 6.33 | 0.00 |
| Pulp volume | Mean | 2.23 | 7.74 | 3.49 | 7.29 | 4.82 | 8.67 | 3.06 | 5.55 | 2.88 | 5.72 | 4.83 | 9.49 | 4.41 | 10.25 |
| | SD | 0.42 | 0.80 | 0.54 | 0.01 | 0.51 | 0.61 | 0.00 | 0.35 | 0.28 | 0.44 | 0.70 | 0.43 | 0.57 | 0.00 |
| | CV | 18.83 | 10.34 | 15.47 | 0.14 | 10.58 | 7.04 | 0.00 | 6.31 | 9.72 | 7.69 | 14.49 | 4.53 | 12.93 | 0.00 |
| Seed volume | Mean | 0.47 | 0.71 | 0.43 | 0.55 | 0.72 | 0.70 | 0.44 | 0.58 | 0.52 | 0.67 | 0.44 | 0.555 | 0.52 | 0.75 |
| | SD | 0.06 | 0.03 | 0.08 | 0.07 | 0.02 | 0.06 | 0.00 | 0.07 | 0.00 | 0.06 | 0.05 | 0.07 | 0.03 | 0.00 |
| | CV | 12.77 | 4.23 | 18.60 | 12.73 | 2.78 | 8.57 | 0.00 | 12.07 | 0.00 | 8.96 | 11.36 | 12.73 | 5.77 | 0.00 |
| Pulp per cent age (volume basis) | Mean | 82.51 | 91.59 | 88.92 | 93.03 | 85.62 | 92.48 | 87.49 | 90.47 | 84.51 | 89.51 | 91.60 | 94.55 | 89.30 | 93.18 |
| | SD | 1.01 | 1.08 | 2.00 | 0.82 | 1.71 | 0.67 | 0.00 | 1.29 | 1.29 | 0.99 | 0.87 | 0.80 | 0.99 | 0.00 |
| | CV | 1.22 | 1.18 | 2.25 | 0.88 | 2.00 | 0.72 | 0.00 | 1.43 | 1.53 | 1.11 | 0.95 | 0.85 | 1.11 | 0.00 |
| Seed:pulp ratio (volume basis) | Mean | 4.73 | 10.99 | 8.31 | 13.48 | 6.03 | 12.39 | 6.99 | 9.63 | 5.48 | 8.61 | 11.01 | 17.59 | 8.42 | 13.67 |
| | SD | 0.33 | 1.54 | 1.78 | 1.61 | 0.74 | 1.27 | 0.00 | 1.47 | 0.54 | 0.90 | 1.22 | 2.52 | 0.86 | 0.00 |
| | CV | 6.98 | 14.01 | 21.42 | 11.94 | 12.27 | 10.25 | 0.00 | 15.26 | 9.85 | 10.45 | 11.08 | 14.33 | 10.21 | 0.00 |

**Table 3. Fruit characters of some selected promising seedling trees**

| Characters | Tree Number | | | |
|---|---|---|---|---|
| | 31 | 59 | 64 | 66 |
| Fruit weight (g) | 10.10 | 11.05 | 10.90 | 12.50 |
| Fruit length (mm) | 23.15 | 24.44 | 22.56 | 24.62 |
| Fruit diameter (mm) | 26.22 | 27.95 | 27.81 | 29.05 |
| Fruit volume (cc) | 9.80 | 10.50 | 10.00 | 11.00 |
| Seed weight (g) | 0.475 | 0.643 | 0.801 | 0.855 |
| Seed length (mm) | 8.46 | 9.69 | 11.94 | 11.43 |
| Seed diameter (mm) | 9.27 | 11.01 | 10.65 | 12.61 |
| Pulp weight (g) | 9.625 | 10.407 | 10.099 | 11.645 |
| Pulp percentage (weight basis) | 95.23 | 94.18 | 92.65 | 93.16 |
| Seed:pulp ratio (weight basis) | 1:20.26 | 1:16.19 | 1:12.61 | 1:13.62 |
| TSS (°B) | 13.5 | 13.0 | 14.0 | 14.0 |
| Pulp volume (cc) | 9.312 | 9.975 | 9.250 | 10.25 |
| Seed volume (cc) | 0.488 | 0.525 | 0.750 | 0.750 |
| Pulp percentage (volume basis) | 95.02 | 95.00 | 92.50 | 93.18 |
| Seed:pulp ratio (volume basis) | 1:19.08 | 1:19.00 | 1:12.33 | 1:13.67 |
| Acidity (%) | 2.48 | 2.01 | 2.40 | 2.36 |
| Ascorbic acid (mg/100g of fruit) | 515 | 305 | 350 | 460 |
| Reducing sugar (%) | 6.04 | 6.13 | 5.34 | 5.23 |
| Total sugar (%) | 9.91 | 10.01 | 8.62 | 8.87 |

of aonla seem to be promising and to avoid adaptability problem of exotic types, these will be now multiplied vegetatively for further testing and release. Similar type of selection study was also conducted in Meghalaya (Chandra *et al.*, 1998) and three promising trees were selected.

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