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Variability in morphological and physico-chemical traits of aonla (*Emblica officinalis*) genotypes collected from north-eastern region of India

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ABSTRACT

Wild aonla (*Emblica officinalis* Gaertn.) is found growing throughout the north eastern region of India. An extensive survey was made to identify and collect the elite genotypes at different altitude to determine variability for physical and biochemical traits and find out the promising genotypes having good fruit quality from different regions of the north-eastern region of India, i.e. Manipur, Meghalaya, Asom and Nagaland during the year of 2014-15. A total of 39 fruit samples were collected and subjected to morphological and physico-chemical characters. Wide range of variability with respect to fruit weight (1.39 - 10.59 g), fruit length (1.26- 2.53 cm), fruit breadth (1.27-2.57 cm), fruit girth (4.16 to 8.10 cm), stone weight (0.28 to 1.50 g), specific gravity (1.00-1.42), TSS of juice (10.00-21.30 ^{o}Brix), pH of fruit juice (2.48-3.41), acidity (1.80-5.84), total sugar (7.50-13.68 %), vitamin C (375.00 -1428.50 mg/100 ml of fruit juice), phenol content (944.85-4969.50 mg/100g of juice) and TSS/acid ratio (2.64-9.72) were observed among the studied genotypes. The genotype T_{26} was found to superior with respect to fruit weight (10.59 g), fruit girth (8.10 cm), fruit length (2.30 cm) and breadth (2.57 cm), whereas $T_{12,}$ T_{14}, T_4 and T_{36} were found superior with their respective qualitative characters, i.e. vitamin C, total soluble solids and total sugar among the genotypes. A wide variation in physico-chemical characters of aonla genotypes indicated that the enormous scope of selection based on their quality characters and its genetic improvement.

Key words: *Emblica officinalis*, Genotype, Physico-chemical attributes, Variability

The aonla (*Emblica officinalis* Gaertn.) is one of the richest sources of vitamin C among fruits except Barbadoes cherry. It belongs to family Euphorbiaceae and was originated in tropical south-east Asia; the native of India, particularly in central and southern India (Firminger 1947). Aonla is credited with medicinal value such as antiscorbutic, diuretic, laxative and antibiotic. The fruit also possesses pronounced expectorant, antiviral, cardiotonic and hypoglycaemic activity (Mehta and Tomar 1979). Aonla is quite hardy, prolific bearer, highly remunerative even without much care under varied agro-climatic conditions. The fruits are mainly utilized as raw or used for preparation of different *Ayurvedic* and *Unani* medicines (Agarwal and Chopra 2004) , and various post-harvest products like pickle, candy, powder, *murrabba,* etc. India ranks first in the world with respect to area and production. So far, several improved cultivars was developed in the country, but still there is tremendous scope to identify and select elite genotypes having desirable horticultural traits. Owing to its seed propagation in wild form, its adaptability has reached to the maximum in marginal areas as well as its native place. A rich genetic diversity of aonla exists naturally in north eastern region of India particularly in lower Asom, Meghalaya and Tripura (Yadav *et al*. 2001). The naturally grown aonla abundantly found in the forest of Khasi and Garo hills of Meghalaya which is locally known as "Sohmylleng" (Pandey *et al*. 1993). The large numbers of wild elite germplasm available in the Himalayas, Chota Nagpur, Bihar, Odisha, West Bengal, North Circars, Deccan, and Karnataka and in Western Ghats (Rawat and Uniyal 2003).

Thus, genetic improvement of Indian gooseberry is confined only to selection of promising genotypes from seedling progenies. Introduction of novel quality traits into aonla through genetic transformation is possible only if suitable germplasm for development of promising cultivar is available. Keeping these facts in background, an exploration was carried out with the aim of effective utilization of genetic resources available in this region and also to identify elite genotypes rich in nutraceutical and therapeutical values from the existing population in the north eastern region.

MATERIALS AND METHODS

The states of north eastern region of the country, viz.

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Asom, Manipur, Meghalaya and Nagaland were explored and collected fruits of 39 selected aonla genotypes were collected during the winter season of the year of 2014-15. Fruits collected from different sites ranging elevations 750 to 1850 msl have been depicted in Table 2. The maximum average temperature ranges between 24 to 31°C and the minimum from 9 to 14°C. Fruits of aonla were randomly selected from each bulked fruit lot of the each genotype tree after discarding the damaged fruits. The bulk sample of all the parent trees for each site was then put into cotton bags and tagged by the location name from where they were collected (Table 1) and subjected to physicochemical analysis in laboratory. The observations on three replicates of samples, each consisting of 20 fruits, the physico-chemical and morphological characters in terms of fruit shape, colour, styler end, and stem end cavity and seed shape were observed. Fruit length, diameter and breadth were measured using vernier callipers. The vitamin C and total phenols content of fruit juice were estimated (mg/100 ml of juice). The fruit weight was taken on electric weighing balance. Total Soluble Solids (TSS) was determined by using a hand refractometer. Acidity was determined by titratating the fruit juice against 0.1N NaOH and expressed as per cent citric acid, whereas vitamin C was analyzed as per methods advocated by Sadashivam and Manickam (1990). Total phenolic content was analyzed as suggested by Ranganna (1986). Soluble sugar was determined by the standard method as described by AOAC (1950). The data were statistically analyzed as per method outlined by Gomez and Gomez (1984).

Table 1 Variation in fruit morphological characters from the north-eastern region of India.

Treatment	Name of area from where genotypes collected	Fruit shape	Fruit colour	Fruit styler end	Fruit stem end	Stone shape
T_1	Pungilong (Mon distt)	Round slightly flattened	Light green	Sunken	Depressed	Round triangular at apex
T_2	Tanshiqui (Mon)	Round spherical	Pale yellowish green	Smooth	Smooth	Flattened triangular
T_3	Jharnapani (Dimapur)	Round spherical	Pale yellowish green	Smooth	Slightly depressed	Flattened round
T_4	Photok (Longleng)	Round flattened	Light green	Slightly depressed	Smooth	Flattened triangular
T_5	Udalguri (Golaghat)	Round	Light green	Slightly depressed	Smooth	Flattened round
T_6	Tseminyu (Kohima)	Round spherical	Dark green	Depressed	slightly depressed	Round
T_7	Lunghar I (Manipur)	Round flattened	yellowish green	Slightly depressed	sunken	Flattened triangular
T_8	Longleng	Round spherical	yellowish green	Smooth	sunken	Flattened round
T_9	Kachai (Manipur)	Round flattened	Light green	Sunken	Depressed	Spherical round
T_{10}	Mokokchung (Nagaland)	Round spherical	yellowish green	Smooth	sunken	Flattened Triangular
T_{11}	Lunghar- II (Manipur)	Round flattened	Light green	Slightly depressed	Depressed	Flattened triangular
T_{12}	Chikilong (Wokha)	Round spherical	yellowish green	Slightly depressed	sunken	Spherical round
T_{13}	Longsachung Wokha	Round flattened	Dark green	Depressed	sunken	Spherical round
T_{14}	Lunghar-III(Manipur)	Round spherical	yellowish green	Smooth	Slightly depressed	Spherical round
T_{15}	Cachinmolong Mon (Nagaland)	Round flattened	Pale yellowish green	Slightly depressed	Slightly depressed	Round triangular at apex
T_{16}	Marshall Kirki (Kohima)	Round flattened	yellowish green	sunken	Deeply sunken	Flattened round
T_{17}	Tangkhul Hundung (Manipur)	Round flattened	Greenish yellow	Smooth	Sunken	Flattened triangular
T_{18}	Santipur (Jorhat, Asom)	Round spherical	yellowish green	smooth	Slightly depressed	Spherical round triangular at apex
T_{19}	Nirayo (Wokha)	Round flattened	yellowish green	Depressed	Deeply sunken	Spherical round
T_{20}	Aboi (Longleng)	Round spherical	Light green	Sunken	Slightly depressed	Flattened round
T_{21}	Totak (Mon)	Round flattened	Pale yellowish green	Smooth	Slightly depreesed	Spherical round
T_{22}	Kotok (Longleng)	Round flattened	Light green	Slightly depreesed	Slightly depressed	Spherical round triangular at apex
T_{23}	Alayong Mokokchung	Round spherical	Yellowish green	Depreesed	Sunken	Spherical round
T_{24}	Mookhan, Jaintia hills	Round flattened	Light green	Smooth	Slightly depressed	Spherical round

(Continued)

Table 1 *(Concluded)*

Treatment	Name of Area from where genotypes collected	Fruit shape	Fruit colour	Fruit styler end	Fruit stem end	Stone shape
T_{25}	Ribhoi district Mawkhana-1	Round	yellowish green	Slightly depreesed	Slightly depressed	Spherical round
T_{26}	Ribhoi district Mawkhana-2	Round flattened	Light green	Smooth	Slightly depreesed	Spherical round Triangular at apex
T_{27}	Manthansi-3, Jaintia hills	Round flattened	Light green	Smooth	Slightly depreesed	Spherical round Triangular at apex
T_{28}	Nongtyngur, Jaintia hills	Round flattened	Pale yellowish green	Smooth	sunken	Flattened round
T_{29}	Mihmyndtu, Jaintia hills	Round spherical	yellowish green	Slightly depreesed	Slightly depreesed	Flattened round
T_{30}	Nogstoin, Khasi hills	Round spherical	Light green	Smooth	sunken	Spherical round
T_{31}	Kunrud, Khasi hills	Round flattened	Pale yellowish green	Smooth	Sunken	Spherical round
T_{32}	Mawkyrwat, Khasi hills	Round spherical	yellowish green	Smooth	Deeply sunken	Spherical round triangular at apex
T_{33}	Mairang, Khasi hills	Round flattened	Pale yellowish green	Slightly depreesed	sunken	Flattened round
T_{34}	Manthani-2, Jaintia hills	Round	Pale yellowish green	Smooth	Slightly depreesed	Spherical round triangular at apex
T_{35}	Jowai-1, Jaintia hills	Round	Pale yellowish green	Smooth	Smooth	Spherical round triangular at apex
T_{36}	Mynrod-2, Jaintia hills	Round	Pale yellowish green	smooth	Slightly depressed	Spherical round triangular at apex
T_{37}	Mynrod-1, Jaintia hills	Round	Pale yellowish green	smooth	depressed	Spherical round triangular at apex
T_{38}	Kayanshi, Khasi hills	Round spherical	Light green	Slightly depreesed	depressed	Spherical round
T_{39}	Nonthaime, Jaintia hills	Round flattened	Pale yellowish green	Slightly depreesed	Slightly depressed	Spherical round triangular at apex

RESULTS AND DISCUSSION

Qualitative characters

Tha data of the physical variability in the fruits of the different aonla genotypes depicted in the Table 1 indicate that the fruits of different genotypes varied in their shape (round flattened, round spherical and round), fruit colour (light green, pale yellowish green, yellowish green, dark green). Various accessions exhibited variation in styler end (sunken, smooth, deeply sunken, slightly depressed and depressed) and fruit stem end cavity (smooth, slightly depressed and depressed) among the genotypes studied for their morphological characters. The stone shape was observed round triangular at apex (T_1 and T_{15}), flattened triangular (T_2, T_4, T_7, T_{10} and T_{11}) flattened round (T_3 T_5, T_{29} T_{28} and T_{33}) spherical round (T_9, T_{12}, T_{13}, T_{14}, T_{21}, T_{23}, T_{24}, T_{25}, T_{30}, T_{31} and T_{38}) and spherical round triangular at apex (T_{18}, T_{22}, T_{26}, T_{27}, T_{32}, T_{34}, T_{35}, T_{36}, T_{37} and T_{39}) in all the genotypes. These findings are in accordance with the results reported by Singh *et al*. (2012) in bael and Singh *et al*. (2014b) in *Morinda tomentosa* under rainfed conditions of western India.

Fruit physical attributes

Results of study on physical characters of the fruits depicted in Table 2 considerably varied with respect to size, weight, specific gravity and stone weight. The fruit weight ranged between 1.39-10.59 g being maximum in T_{26} (10.59 g) followed by T_{25} (8.67 g) and T_7 (6.78 g) whereas the same was found to be minimum in T_{18} (1.39 g) followed by T_6 (1.50 g) and T_{36} (1.88 g). The highest fruit length was observed in genotype T_{25} (2.53 cm) followed by T_{26} (2.30 cm), T_{13} (2.28 cm) and T_1 (2.10 cm), whereas it was lowest in T_{36} (1.26 cm) followed by T_6 (1.27 cm) and T_{18} (1.36 cm). The fruit breadth was observed the maximum in T_{26} (2.57 cm) closely followed by T_{25} (2.48 cm) and T_{13} (2.44 cm), whereas T_{18} exhibited the minimum value (1.27 cm) followed by T_6 (1.38 cm) and T_{36} (1.42 cm). The fruit girth was measured the highest in T_{26} (8.10 cm) followed by T_{25} (7.78 cm) and T_7 (7.22 cm) and it was least in T_{18} (4.16 cm)

Table 2 Variability in fruit physical attributes of different genotypes from the north-eastern region of India

Treatments	Fruit length (cm)	Fruit breadth (cm)	Fruit girth (cm)	Fruit weight (g)	Specific gravity	Stone weight/ fruit (g)
T_1	2.10	2.19	6.80	5.88	1.11	0.65
T_2	1.69	1.86	5.78	3.12	1.28	0.60
T_3	1.87	2.04	6.24	4.72	1.06	0.53
T_4	1.39	1.53	4.97	2.11	1.08	0.41
T_5	1.41	1.51	5.04	2.04	1.30	0.63
T_6	1.27	1.38	4.38	1.50	1.00	0.51
T_7	1.94	2.32	7.22	6.78	1.21	0.79
T_8	1.83	1.87	6.08	3.69	1.20	0.51
T_9	1.54	1.64	5.22	2.51	1.35	0.36
T_{10}	1.89	2.17	6.50	5.04	1.16	0.51
T_{11}	1.56	2.08	5.94	3.78	1.07	0.52
T_{12}	1.91	2.23	6.68	5.69	1.19	0.84
T_{13}	2.28	2.44	6.80	6.37	1.11	0.85
T_{14}	1.80	1.88	5.94	4.03	1.13	0.95
T_{15}	1.55	2.03	6.06	3.74	1.10	0.47
T_{16}	1.67	2.12	6.34	4.56	1.18	0.51
T_{17}	1.82	2.31	7.12	5.71	1.22	0.46
T_{18}	1.36	1.27	4.16	1.39	1.33	0.28
T_{19}	1.73	2.29	6.60	5.02	1.22	0.69
T_{20}	1.44	1.51	4.72	2.12	1.02	0.29
T_{21}	1.67	2.10	6.34	4.28	1.09	0.43
T_{22}	1.83	1.86	6.10	3.96	1.09	0.47
T_{23}	1.64	2.36	6.55	4.87	1.50	0.71
T_{24}	1.57	1.72	5.60	3.13	1.08	0.45
T_{25}	2.53	2.48	7.78	8.67	1.24	0.85
T_{26}	2.30	2.57	8.10	10.59	1.03	1.50
T_{27}	1.60	2.15	6.88	5.03	1.09	0.43
T_{28}	1.41	1.49	5.42	2.73	1.01	0.30
T_{29}	1.58	1.81	5.70	3.72	1.06	0.35
T_{30}	1.93	2.07	6.48	5.23	1.32	0.85
T_{31}	1.47	1.63	5.04	2.83	1.30	0.75
T_{32}	1.81	2.21	6.60	5.22	1.35	0.44
T_{33}	1.72	1.90	6.12	4.28	1.03	0.59
T_{34}	1.64	2.06	6.14	4.15	1.19	0.61
T_{35}	1.57	1.89	5.50	3.43	1.42	0.55
T_{36}	1.26	1.42	4.76	1.88	1.15	0.47
T_{37}	1.61	1.87	5.94	4.02	1.14	0.45
T_{38}	1.58	1.79	5.74	3.72	1.02	0.46
T_{39}	1.49	1.65	5.24	2.86	1.14	0.48
CD (P=0.05)	0.17	0.17	0.55	0.53	0.11	0.08

followed by T_6 (4.38 cm) and T_{20} (4.72 cm). The specific gravity ranged between 1.01- 1.42, whereas the maximum value of the same was recorded in T_{35} (1.42) and minimum in T_{28} (1.01) followed by $T_{20,}$ T_{38} (1.02) and T_{26} (1.03). The stone weight per fruit ranged between the 0.28 -1.50 g being the highest stone weight was recorded in theT_{26} (1.50g) followed by T_{14} (0.95 g) and it was recorded the lowest in T_{18} (0.28 g) followed by T_{20} (0.29 g). Variation in physical fruit characters of aonla may be due to differences in their genetic make up and prevailing agro-climatic conditions, i.e. nutrient, soil, light, water and altitude under which the plants are growing (Murali 1997). Variations in physical characteristics was reported in *bael* (Singh *et al*. 2012), *jamun* (Singh and Singh 2005a and 2012), *Morinda* (Singh *et al.* 2013), *mahua* (Singh and Singh 2005b, Singh *et al.* 2005) and tamarind (Singh and Singh 2005c). More or less similar kinds of variability in fruit physical characteristics were observed by Chandra *et al.* (2009) in aonla genotypes from the Garo hills of Meghalaya.

Fruit chemical attributes

The chemical attributes of different genotypes presented in Table 3 revealed significant variability among all the genotypes. The total soluble sugar ranged between 10-22.8°Brix. It was recorded the maximum in T_4 (21.30°Brix) followed by T_{36} 19.15 °Brix) and T_{34} (18.15 °Brix) and the minimum was exhibited in T_2 (10.0 °Brix) and T_1 (11.0). The pH among all the genotypes varied from 2.48 - 3.41. The fruits of T_{35} had maximum pH value (3.41) followed by T_{30} (3.32) and T_{23} (3.30), whereas it was recorded the minimum in T_{32} (2.48) followed by T_4 (2.53) and T_{17} (2.57). The maximum fruit acidity recorded in T_{33} (5.84%) followed by T_{34} (5.30%) and T_{36} (5.08%) among all the genotypes, while minimum acidity was estimated in T_{16} (1.80%) followed by T_{19} (1.94%) and T_{21} (2.00%).The fruits of genotype T_{36} had higher amount of total sugar (13.68%) followed by T_{12} (12.73 %), T_{35} (11.97%) and $T_{38.}$ (11.97 %) and it was exhibited least in T_2 (7.5%) followed by T_{27} (7.94%) among all the genotypes. The estimated value for vitamin C content was higher in genotype T_{12} (1 428.50 mg/100 ml of juice) subsequently by T_{28} (1 386.00 mg), T_{19} (1 366.00 mg), T_{16} (1 267.85 mg) and value of the same attribute was observed the minimum in genotype T_{20} (375.00 mg), T_{32} (439.4 mg) and T_7 (446.42 mg). Total phenol content was estimated to be maximum in genotype T_{26} (4 969.50 mg) followed by T_{16} (4 516.20 mg) T_{29} (4 007.85 mg) and least was found in the genotypes T_5 (944.85 mg) ,T_1(1 190.49 mg), T_4 (1 000.25 mg). The value for the TSS /acid ratio was maximum in T_{16} (9.72) followed by T_8 (7.44), T_{15} (7.24) and T_{14} (6.85) whereas the minimum value was obtained from the genotype T_{33} (2.64) followed by T_{31} (2.93), T_5 (3.03) and T_{12} (3.19). Significant variations have also been observed in the physio-chemical constituents of selected genotypes by the Kumar *et al.* (2013) and Bala *et al.* (2014) in northen region of India (UP) and Pandey *et al.* (2013) in aonla genotypes from Madhya Pradesh and in *M. tomentosa,* tamarind, bael, chironji and aonla under rainfed condition of western India by, (Singh *et al*. 2006a,b and Sharma *et al*. 2015), (Singh *et al*. 2014a,b), and (Singh *et al*. 2015), respectively.

Based on the observations on variability in qualitative characters among the aonla genotypes studied, it may be inferred from the study that the different genotypes exhibited wide range of variability with respect to the most of the physico-chemical attributes. Thus, an effective selection

Table 3 Variability in fruit chemical attributes of different genotypes from the north-eastern region of India

Treatment	TSS (°Brix)	pH of fruit juice	Acidity (%)	Total sugar (%)	Vitamin C mg/100 ml	Phenol mg/100 ml	TSS/acid ratio
T_1	11.00	3.05	2.94	08.75	732.13	1353.59	3.74
T_2	10.00	2.92	2.72	07.50	1267. 84	1190.49	3.67
T_3	18.00	2.82	2.89	11.42	665.56	1387.80	6.22
T_4	21.30	2.53	3.45	13.15	532.98	1000.25	6.17
T_5	11.00	3.08	3.63	8.82	467.98	0944.85	3.03
T_6	12.00	2.89	3.10	09.62	889.12	1439.50	3.87
T_7	14.00	2.75	3.62	8.55	446.42	1303.54	3.86
T_8	16.00	3.14	2.15	10.80	643.89	1742.72	7.44
T_9	13.15	2.75	3.32	10.43	785.67	1961.24	3.90
T_{10}	14.50	2.82	3.95	8.86	665.81	1434.45	3.60
T_{11}	13.50	2.87	3.20	10.14	794.54	1473.60	4.21
T_{12}	11.50	2.65	3.60	8.62	1428.50	1373.48	3.19
T_{13}	12.30	3.00	3.12	9.22	839.20	1942.54	3.94
T_{14}	17.00	2.81	2.48	12.73	755.89	2012.23	6.85
T_{15}	16.30	2.90	2.25	11.42	467.28	2913.47	7.24
T_{16}	17.50	2.83	1.80	11.25	1267.85	4516.20	9.72
T_{17}	14.70	2.57	2.50	8.62	651.78	1342.52	5.88
T_{18}	13.10	2.95	2.67	10.45	899.46	2312.15	4.90
T_{19}	12.20	2.84	1.94	8.15	1366.00	1621.80	6.28
T_{20}	15.20	3.27	2.85	10.51	375.00	1462.34	5.33
T_{21}	12.00	3.08	2.00	8.05	775.43	2045.16	6.00
T_{22}	16.20	2.79	3.00	9.42	1034.81	2842.45	5.40
T_{23}	14.00	3.30	2.52	9.23	661.98	2715.95	5.55
T_{24}	16.10	3.00	3.34	10.47	742.18	3848.45	4.82
T_{25}	14.75	3.00	4.18	8.71	830.78	2918.72	3.52
T_{26}	16.20	3.00	4.32	9.87	1054.68	4969.50	3.75
T_{27}	11.30	2.80	3.34	7.94	517.00	2749.12	3.38
T_{28}	17.00	3.25	3.40	10.58	1386.0	3615.47	5.00
T_{29}	15.23	3.10	3.34	9.74	917.96	4007.85	4.55
T_{30}	15.30	3.32	3.20	10.71	507.81	3028.89	4.78
T_{31}	14.20	3.10	4.84	8.94	625.78	3147.20	2.93
T_{32}	17.10	2.48	4.60	10.97	439.40	1416.42	3.71
T_{33}	15.30	2.80	5.84	8.71	664.06	2907.53	2.64
T_{34}	18.15	2.95	5.30	10.80	781.25	1201.80	3.83
T_{35}	17.10	3.41	3.97	11.97	634.76	2757.25	4.30
T_{36}	19.15	3.12	5.08	13.68	468.75	1662.43	4.48
T_{37}	18.00	3.20	4.08	10.47	625.00	1334.87	4.41
T_{38}	18.21	2.80	4.04	11.47	556.64	3135.00	4.50
T_{39}	17.80	2.95	4.32	11.26	751.00	1159.44	4.12
CD (P=0.05)	1.40	0.26	0.34	0.95	81.14	266.14	0.55

can be made based on qualitative characters for further improvement in aonla.

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