



Characterization of aonla (*Emblica officinalis*) varieties under zero irrigation semi-arid conditions

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Received: 27 December 2014; Accepted: 15 June 2015

ABSTRACT

A field study was conducted to differentiate the aonla (*Emblica officinalis* Gaertn) varieties for their vegetative and fruit characters under rainfed hot semi-arid ecosystem of western India during the years 2012-14. Among the cultivars, growth habit was observed upright spreading, tall upright, tall spreading, tall drooping and tall semi-spreading. The foliage was visualized as dense and sparse among all the cultivars. The leaflet colour (green to pale yellowish green), shape (oblong, oval oblong and elliptical), apex (obtuse and acute) also varied among the cultivars. The size of leaves in terms of length and breadth ranged between 1.25-1.47 cm and 0.23-0.37 cm, respectively. The time of fruit set and time of fruit maturity differed considerably among the varieties. The maximum fruit set (51.95%) and fruit retention (26.40%) were recorded in NA 7, whereas same was recorded minimum (36.21%) in Banarasi and Francis (11.34%). Variations in fruit shape, i.e. triangular, flattened oblong, flattened oval, and flattened round, whereas size of the fruit was observed as small large and medium among observed varieties. The highest fruit weight (33.90 g) and specific gravity (1.43) were found in Banarasi while these traits were recorded the lowest in Kanchan and Francis, respectively. The qualitative physico-chemical characters, viz. fruit juice content, acidity, pulp content, vitamin C content, TSS, TSS/acid ratio and stone weight ranged between 40.00-64.45%, 1.34-2.56%, 23.95- 31.95 g, 334.12-461.76 mg/100gm, 8.00-11.50% and 3.61- 6.74 g and 1.97-2.08 g, respectively. The stone of the fruit also varied with respect to its shape (triangular and oval round) and size (large, medium and small) under rainfed hot semi-arid environment of western India.

Key words: Aonla varieties, Fruit characters, Qualitative characters, Semi-arid, Vegetative characters

The Indian gooseberry or aonla (*Emblica officinalis* Gaertn) is an important fruit crop of 21st century and it has been regarded as 'Amritphal' in ancient literature and identified as an ideal plant for various kinds of wastelands, viz moisture stress, eroded, ravines, upland, riverbed and the areas with undulated topography (Korwar *et al.* 2006) possesses some specific characters like intensive and deeper root system, summer dormancy of zygote, reduced leaf area, synchronization of fruit growth and development with maximum moisture availability period and selective absorption of ions which enable it to grow in fragile agro-climatic conditions. Aonla fruit is very well known for its therapeutical properties as mentioned in literature of both *Ayurvedic* and *Unani* system of medicines. The fruit is the richest source of vitamin C next only to Barbados cherry. Owing to its hardiness, high productivity, suitability for growing under varied agro-climatic conditions and its utilization in cosmetic, pharmaceutical and processing

industry, attracts the growers for its cultivation under rainfed condition. Now its cultivation is becoming popular in rainfed areas of the country. Joshi *et al.* (1997) reported varietal diversity as an important ingredient in agriculture system which fulfills the varied needs of the farmers according to their physical environments. However, there is scanty of scientific information regarding distinct traits of aonla varieties and also for visualizing the prospects of this fruit under rainfed conditions. A study was undertaken to characterize aonla varieties for morphological differences under hot semi-arid region, so that these distinct characters could be used for further improvement of the crop.

MATERIALS AND METHODS

The location of the experiment was 113 m above msl on latitude 22° 41' 38" N and longitude 73° 33' 22" E and was characterized by hot semi-arid climate. The annual rainfall is mainly confined to three months (July-September) and actual mean precipitation is about 750 mm with number of rainy days average to about 32. The mean summer temperature is 32.90°C while the mean winter temperature is 21.30°C indicating that the area falls under hyperthermic soil regime. The mean annual maximum and minimum temperatures vary from 42 - 46°C (May) and 6 - 9°C

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(January), respectively. The soil was analyzed for organic carbon, EC, pH, N, P and K (Bhargava and Raghupati 1993) and soil bulk density and hydraulic conductivity (Page *et al.* 1982) before the initiation of the experiment. The experimental soil type was characterized with available N (150.25 kg/ha), P (8.23 kg/ha) and K (145.50 kg/ha) and organic carbon (0.31%), while EC and pH, bulk density and hydraulic conductivity of soil were 0.14 dS/m, 8.35, 1.43g/cc and 0.27 cm/hr, respectively. The soil depth of experimental field ranged from 0.65 to 0.75 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone followed by calcareous layers which falls under semi-arid hot climate.

A total nine varieties, viz. Banarasi, Krishna, Kanchan, Francis, Chakaiya, NA 7, NA-10, Anand 1 and Anand 2 were taken for study, which established through *in-situ* patch budding. The experiment was laid out in randomized block design (RBD) with four replications, considering two plants as unit of each treatment (variety). The uniform management practices were adopted for all the cultivars. To assess the growth parameters like tree habit, leaf size, inflorescence colour and different fruit characters, viz. time of fruit set, time of fruit maturity and fruit retention percentage were observed in all the varieties uniformly. Fruits were randomly selected from all the directions of the plant for quantitative attributes of fruit like fruit weight, length, width, girth, stone weight and stone shape. Chemical attributes of fruit like acidity, total soluble solids of pulp were determined by standard methods and for vitamin C (Ascorbic acid), phenols, total sugars, reducing as well as non reducing sugar were determined by the methods outlined in AOAC (1980). The pooled data were statistically analyzed as per method given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth attributing characters

Perusal of data presented in Table 1 shows that the

aonla varieties had considerable difference in tree habit which was observed upright spreading in Banarasi, Krishna, Chakaiya, tall upright in Anand 1 and Anand 2; tall spreading in NA 7, tall drooping in Francis and tall semi-spreading in Kanchan under rainfed conditions of western India. Plant height was maximum (5.67 m) in Anand 2 followed by Anand 1 (5.52 m) while it was found to be the minimum in Chakaiya (3.78 m) followed by Krishna (3.86 m). The foliage in Banarasi, Chakaiya, Krishna, Kanchan, Anand 1 and Anand 2 was sparse, whereas it was observed dense in Francis, NA 7 and NA 10. The tree trunk colour of different varieties was grey in Banarasi, Krishna, Francis, Chakaiya, Anand 1 and Anand 2, and whitish grey in Kanchan, NA 7 and NA 10. The inflorescence colour was deep pink in Banarasi and Krishna; yellowish green in Francis; pinkish green in Chakaiya and Kanchan; green to light pink in NA 7, NA 10 and Anand 1 while light green to pinkish colour was observed in Anand 2.

The leaf shape was oblong in Banarasi, Krishna, Chakaiya, NA 10, Anand 1 and Anand 2; oval oblong in Francis and Kanchan, and elliptical in NA 7. The leaf apex was mainly of two kinds, i.e. acute and obtuse. All the varieties had obtuse leaf apex excluding Chakaiya and Kanchan. The leaf length was observed maximum in Francis (1.47 cm) followed by Banarasi (1.44 cm) and NA 7 (1.40 cm) and the value of same trait was minimum in Chakaiya (1.24 cm) followed by Anand 2 (1.25 cm), Anand 2 (1.27 cm), NA-10 (1.28 cm) and Krishna (1.29 cm). The leaf width was measured maximum in Banarasi (0.37 cm) followed by Francis and Kanchan (0.32 cm), whereas same was recorded minimum in Anand 2 (0.23 cm) followed by Anand 1 (0.26 cm). Similar kinds of results were also obtained by Pareek and Nath (1996) in aonla cultivars under arid conditions of Bikaner, Rajasthan. However, variation in plant growth characters in different cultivars may be attributed to genetic features of the individual variety and soil condition (Dhandar and Shukla 2004).

Table 1 Growth attributes of different aonla varieties

Character	Banarasi	Krishna	Francis	Chakaiya	Kanchan	NA-7	NA-10	Anand-1	Anand-2	CD (P=0.05)
Tree habit	Upright	Upright	Tall	Upright	Tall	Tall	Semi tall	Tall	Tall	
Tree form	Spreading	Spreading	Drooping	Spreading	Spreading	Semi spreading	Semi spreading	Upright	Upright	
Tree height(m)	3.90	3.86	4. 21	3.78	4.59	4.03	3.89	5.52	5.67	0.42
Trunk colour	Grey	Grey	Grey	Grey	Whitish grey	Whitish green	Whitish grey	Grey	Grey	
Foliage	Sparse	Sparse	Dense	Sparse	Sparse	Dense	Dense	Sparse	Sparse	
Leaf length (cm)	1.44	1.29	1.47	1.24	1.29	1.40	1.28	1.27	1.25	0.12
Leaf width (cm)	0.37	0.31	0.32	0.30	0.32	0.30	0.30	0.26	0.23	0.02
Leaf shape	Oblong	Oblong	Oval oblong	Oblong	Oval oblong	Elliptical	Oblong	Oblong	Oblong	
Leaf apex	Obtuse	Obtuse	Obtuse	Acute	Acute	Obtuse	Obtuse	Obtuse	Obtuse	
Inflorescence colour	Deep pink	Deep pink	Yellowish green	Pinkish green	Pinkish green	Green to light pink	Green to light pink	Green to light pink	Light green to pinkish	

Fruit developing characters

The data presented in Table 2 shows that the time of fruit set was noticed during the 1st fortnight of March in Krishna, Francis, Chakaiya, Kanchan and 2nd fortnight of February in Banarasi, NA 7, and NA 10 whereas it was recorded in 2nd fortnight of March in Anand 1 and Anand 2. The percentage of fruit set (51.95) and fruit retention (26.40) were recorded the maximum in NA 7 followed by Krishna for fruit set (49.50%) and fruit retention (20.78%), and the minimum fruit set and fruit retention were recorded 36.21% and, 18.78% respectively in Banarasi followed by Francis (36.54% and 11.43%) among the varieties. The time of fruit maturity was last week of October in Banarasi, Francis, NA-10 and it was observed during mid to last week of November in Krishna, Chakaiya, Kanchan, Anand 1 and Anand 2. Days of maturity of different varieties ranged between 208 -220 days.

Physical characters of fruit

The data presented in Table 3 clearly indicate that the fruit shape had considerable variations among varieties. The fruit shape was triangular in Banarasi and Krishna,

flattened round in Francis, NA 7, Chakaiya, Kanchan and NA 10 and flattened oval in Anand 1 and Anand 2. Fruit colour of Banarasi and Kanchan was whitish green; light green in Krishna, Francis and Chakaiya; yellowish green in NA 7, NA 10 and Anand 2 and greenish yellow in Anand 1. Fruit stalk was observed short and thick in Banarasi, Krishna, NA-7 and NA-10 while short and thin was observed in Francis, Chakaiya, Kanchan, Anand 1 and Anand 2. Fruit stem end cavity was noticed shallow in Banarasi, Francis, Chakaiya, Kanchan, Anand 1 and Anand 2, whereas it was deep in Krishna, NA 7 and NA 10. Styler end was levelled in Banarasi, Francis, Chakaiya, Kanchan, and NA 10; prominent in Krishna and less prominent in NA 7, Anand-1 and Anand 2. Number of segments in all the varieties were six but in few varieties like Krishna and Kanchan 6-8 segments were also seen. Most of the varieties showed whitish green coloured flesh excluding Krishna which had light yellowish green colour under rainfed semi-arid environment of western India.

A peep of Table 3 revealed that the physical attributes in terms of fruit, viz. fruit weight ranged between 25.94-33.90 g being maximum in Banarasi (33.90 gm) followed by

Table 2 Fruit development characteristics of different aonla varieties

Character	Banarasi	Krishna	Francis	NA 7	Chakaiya	Kanchan	NA 10	Anand 1	Anand 2	CD (P=0.05)
Time of fruit set	2 nd fort night of February	1 st fort night of March	1 st fort night of March	2 nd fort night of February	1 st fort night of March	1 st fort night of March	2 nd fort night of February	2 nd fort night of March	2 nd fort night of March	
Time of fruit maturity	25-31 October	15-22 November	24-31 October	23-31 October	08-14 November	15-22 November	25-30 October	15-22 November	23-30 November	
Days to maturity	215 days	213 days	216 days	208 days	210 days	211days	213 days	219 days	220 days	
Fruit set (%)	36.21	49.50	36.56	51.95	41.24	39.78	40.81	37.88	37.13	4.12
Fruit retention(%)	18.78	20.78	11.43	26.40	20.67	19.89	20.38	18.98	18.65	1.70

Table 3 Physical characteristics of fruits of different aonla varieties

Character	Banarasi	Krishna	Francis	NA 7	Chakaiya	Kanchan	NA 10	Anand 1	Anand 2	CD (P=0.05)
Fruit shape	Triangular	Triangular	Flattened round	Flattened round	Flattened round	Flattened round	Flattened round	Flattened oval	Flattened oval	
Fruit colour	Whitish green	Light green	Light green	Yellowish green	Light green	Whitish green	Yellowish green	Greenish Yellow	Yellowish green	
Flesh colour	Whitish green	Pinkish to yellowish green	Whitish green	Whitish green	Whitish green	Whitish green	Whitish green	Whitish green	Whitish green	
Fruit stalk	Short and thick	Short and thick	Short and thin	Short and thick	Short and thin	Short and thin	Short and thick	Short and thin	Short and thin	
Fruit stem end cavity	Shallow	Deep	Shallow	Deep	Sallow	Shallow	Deep	Shallow	Shallow	
Styler end	Levelled	Prominent	Levelled	Less prominent	Levelled	Levelled	Levelled	Less prominent	Less prominent	
No. of segments in fruit	6	6-8	6	6	6	6-8	6	6	6	
Fruit length (cm)	3.73	3.70	3.07	3.62	3.35	3.82	3.39	3.10	3.12	0.31
Fruit width (cm)	4.37	3.93	3.40	4.00	4.00	3.99	3.98	3.45	3.41	0.35
Fruit weight (gm)	33.90	33.56	30.41	33.76	30.66	25.94	31.45	28.53	26.63	2.69

NA-7 (33.76 gm) and it was measured the minimum in Kanchan (25.94 gm). The fruit length ranged between 3.07-3.82 cm, whereas it was observed the maximum in Kanchan (3.82 cm) followed by Banarasi (3.73 cm) and Krishna (3.70 cm) and the same was observed the minimum in Francis (3.07 cm) followed by Anand 1 (3.10 cm) and Anand -2 (3.12 cm). Among the varieties, fruit width varied between 3.40-4.37 cm and the maximum width was observed in Banarasi (4.37 cm) followed by NA 7 and Chakaiya (4.00 cm), whereas it was minimum in Francis (3.40 cm) followed by Anand 2 (3.41 cm) and Anand -1 (3.45 cm) under hot semi arid ecosystem. Similar kind of results were also recorded in chironji by Singh *et al.* (2006).

Qualitative characters of fruits

Results of study on the qualitative attributes of different cultivars exhibited wide range of variability (Table 4). Among all the varieties, the maximum (64.45%) juice content was estimated in NA 7 followed by Krishna (61.60%) however, chakaiya had the minimum juice content (40.00%) followed by Banarasi (41.34%). The astringency level was highest in Krishna, Chakaiya and NA 10, and it was least in NA 7, but the rest of the varieties had medium astringency. The acidity ranged between 2.03-2.21% being the maximum in Banarasi (2.21%) followed by Krishna (2.16%), whereas it was recorded the minimum (2.03%) in Kanchan. The pulp content ranged between 23.95-31.91g/100 g of fruit and it was recorded the maximum in Banarasi (31.91 g) followed by NA 7 (31.79 g) and Krishna (31.51g) whereas the minimum pulp content was recorded in Kanchan (23.95 g) followed by Anand 2 (24.59 g) and Anand-1 (26.48 g). The estimated ascorbic acid content

among all the varieties ranged between 334.12- 453.20 mg/100gm. It was observed the maximum in NA-7 (453.20 mg/100gm) followed by Kanchan (427.27 mg/100g) and the same was found to be minimum in Banarasi (334.12mg/100g) followed by Francis (345.34 mg/100gm) and Krishna (352.45 mg/100g). The total soluble solids were recorded maximum in NA-7 (11.50⁰Brix) followed by Anand-1 (11.30⁰ Brix) and Anand 2 (10.25⁰ Brix) while Banarasi had the minimum value (8⁰Brix) followed by NA-10 (8.50⁰ Brix). The value of specific gravity ranged between 1.06 -1.43 being the highest in Banarasi (1.43) followed by Anand-1 (1.35) while it was least in Francis (1.06) followed by NA-7 (1.13). TSS/Acid ratio ranged between 3.61-6.74 being maximum in Krishna (6.74) followed by NA-7(5.60) and Anand-1(5.51), whereas the same was minimum in Banarasi (3.61) followed by NA-10 (4.00) and Francis (4.04). These results are in agreement with the findings as reported by Pathak *et al.* (1993) and Mishra *et al.* (2007) in aonla, Singh *et al.* (2012) in *Morinda* and Mahajan and Dhillon (2000) have reported variation in quality attributes of aonla varieties which may be due to genotypic dissimilarity.

Seed characters

A perusal of data presented in Table 5 showed wide variability on account of quantitative and qualitative seed characters in different varieties. Stone shape was observed triangular in Banarasi and Krishna; round in Chakaiya, Kanchan, Anand 1 and Anand 2; oval in Francis and NA 10; oval round in NA 7. Banarasi followed by Krishna and NA 7 enunciated large stone and seed size whereas it was small in Chakaiya, Kanchan, Anand 1 and Anand 2 while the rest of the varieties had medium stone size. The weight

Table 4 Fruit qualitative attributes of different aonla varieties

Character	Banarasi	Krishna	Francis	NA 7	Chakaiya	Kanchan	NA 10	Anand 1	Anand 2	CD (P=0.05)
Juice (%)	41.34	61.60	52.12	64.45	40.00	48.12	58.15	44.52	46.15	4.70
Astringency	Medium	High	Medium	Low	High	Medium	High	Medium	Medium	
Pulp (g/100 g of fruit)	31.91	31.51	28.33	31.79	28.64	23.95	29.46	26.48	24.59	2.54
TSS (%)	8.00	8.90	9.70	11.50	10.63	10.22	8.50	11.30	10.25	0.88
Acidity	2.21	2.16	2.04	2.05	2.10	2.03	2.12	2.05	2.04	0.19
Ascorbic acid	334.12	352.45	345.34	453.20	399.76	427.27	421.76	419.45	414.78	31.43
TSS/Acid ratio	3.61	6.74	4.04	5.60	5.06	5.03	4.00	5.51	5.02	0.46
Specific gravity	1.43	1.20	1.06	1.13	1.35	1.37	1.27	1.39	1.33	0.11

Table 5 Seed characters of different aonla varieties

Characters	Banarasi	Krishna	Francis	NA 7	Chakaiya	Kanchan	NA 10	Anand 1	Anand 2	CD (P=0.05)
Stone shape	Triangular	Triangular	Oval	Oval round	Round	Round	Oval	Round	Round	
Stone size	Large	Large	Medium	Large	Small	Small	Medium	Small	Small	
Stone weight (g)	1.99	2.05	2.08	1.97	2.02	1.99	1.99	2.05	2.04	0.18
Seed size	Large	Large	Medium	Large	Small	Small	Medium	Small	Small	

of the stone was exhibited maximum (2.08%) in Francis followed by Krishna and Anand 1(2.05 g) and it was minimum in NA 7 (1.97 g) followed by Kanchan and NA 10 (1.99 g). Similar kind of results was also obtained by Pathak *et al.* (1993) in different aonla seed characters.

From the above results, it may be inferred that the aonla varieties varied in their morphological and fruit quality characters which can be used to characterize the varieties and for further crop improvement.

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