



Evaluation of different aonla (*Emblica officinalis*) cultivars under rainfed conditions of lower shivalik foothills of Himalayas

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ABSTRACT

Six cultivars of aonla (*Emblica officinalis* Gaertn), viz. Banarasi, Chakaiya, Neelam, Francis, Kanchan and Desi were evaluated for growth, yield and quality parameters. In all the cultivars of aonla, flowering started in the month of April. The cultivar Desi flowered early (1st week of April), whereas Kanchan and Neelam were found to be late in flowering (2nd week of April). The cultivar Banarasi had longest flowered period (24 days) while Neelam and Kanchan had shortest (20 days). The total number of flowers was higher in cultivars Banarasi (816) and Desi (842). The lowest sex ratio was recorded in Neelam (79.40:1) followed by Chakaiya (95.84:1) and highest in Desi (186.10:1) owing to higher percentage of female flowers in Neelam (1.25%) and minimum in Desi (0.53%). Maximum fruit setting of 51.86% was found in Neelam and minimum (20.16%) in Desi. Among the different cultivars studied, minimum fruit drop of 48.14% was recorded in Neelam and maximum (79.84%) in Desi cultivar. The study revealed that cultivar Neelam was superior to all other cultivars in terms of yield attributes as it registered highest average yield of 72.77 kg/plant. From the various physical characteristics studied, cultivar Neelam showed significantly maximum fruit weight (41.46 g), fruit length (3.73 cm), fruit diameter (4.42 cm), fruit volume (39.80 cm³), pulp weight (39.57 g), stone weight (1.89 g) and pulp:stone ratio of 20.94. The cultivar Neelam was found superior in terms of chemical characteristics of fruit such as vitamin-C (596.03 mg/100g pulp), total sugars (5.71%), reducing sugars (3.41%), non-reducing sugars (2.19%), TSS:acid ratio (6.54). Specific gravity of 1.13, TSS (12.20⁰B) and acidity of 2.08 was found maximum in Desi aonla. From the present investigation it can be concluded that Neelam cultivar of aonla is most superior under the rainfed conditions.

Key words: Anthesis, Aonla, Flowering, Fruit drop, Fruit set, Quality, Yield

In India, aonla (*Emblica officinalis* Gaertn) is cultivated on a commercial scale in Uttar Pradesh, Maharashtra and Gujarat (Radha and Mathew 2007). It is highly nutritious and claimed to be the 2nd richest source of vitamin-C (Anonymous 1988). Aonla fruits are used in traditional Indian system of medicines, like ayurvedic and unani, due to its therapeutic values (Agarwal and Chopra 2004). The aonla fruits are used in medicines to treat common cold, gastric troubles, headache, constipation, enlarged liver, etc. The fruit, due to its sour and astringent taste, has very limited table value. However, aonla fruits are processed into a number of products like preserve, candy, pickle, juice, shreds, RTS beverages, dried powder, etc. Dried fruits are used for treatment of bronchitis, diabetes, fever, diarrhea, anemia, jaundice, dyspepsia, hemorrhages and cough. It is

also used for the preparation of various health care products like hair oil, dye, shampoo, face cream and tooth powder. The plant parts, fruits and leaves have uses in tanning and dyeing industries.

Owing to better prospects of aonla in semi arid regions due to hardy nature of plants, high medicinal and nutritional values, there is a possibility that it will be one of the most important fruit of the future. Therefore, it was felt necessary to evaluate aonla cultivars in rainfed conditions of Jammu region. Hence, the present study was conducted to evaluate commercially important aonla cultivars on the basis of their flowering, yield and quality under rainfed conditions.

MATERIALS AND METHODS

The present investigation was carried out at Rainfed Research Sub-Station for Sub-tropical fruits, Raya, Jammu and Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu during 2012 and 2013. The experimental field is situated at an elevation of 332 m above mean sea level and lies between 32°39' North latitude and 74°53' East longitude. The climate of experimental site is sub-tropical with hot and dry summer,

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hot and humid, rainy season and cold winter months. The maximum temperature rises up to 45°C during summer and minimum temperature falls to 3.16°C during winter. The mean annual rainfall is about 1000-1200 mm. Soil of the experimental field was sandy clay in texture, having pH: 6.50, organic carbon: 0.50%, available N: 174.50 kg/ha, available P: 15.80 kg/ha and available K: 140.00 kg/ha.

The study was conducted with six commercially important aonla cultivars, viz. Banarasi, Chakaiya, Neelam, Francis, Kanchan and Desi. The experiment was conducted on the layout of randomized block design, wherein one tree each of the six cultivars form one replication and there were three replications per cultivar. The observations on each of 2 sample trees within each cultivar and replication were recorded. Observations on flowering period and duration of flowering, time of maturity, fruit yield and quality parameters of all the six cultivars were made on date of opening of the first flower, date of full bloom, date of opening of the last flower and flowering duration. The flower density was calculated by counting the flowers of both sexes separately, in different parts of the branch. After counting, the flowers were removed to avoid recounting. The sex ratio (female: male) and percentage of female flower for each variety were worked out accordingly. Per cent fruit set and fruit drop were computed by using following formula:

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set}}{\text{Number of female flowers}} \times 100$$

$$\text{Fruit drop (\%)} = \frac{\text{Initial fruit set} - \text{Final fruit retention}}{\text{Initial fruit set}} \times 100$$

The length and diameter of fruits were taken with the help of vernier callipers. The fruit weight, pulp weight and stone weight were taken separately on electronic balance. The volume of aonla fruits were determined by water displacement method. Specific gravity of fruits was determined by weighing the fruits in air and then determining its volume in water. Chemical analysis such as total soluble solids (TSS) of aonla fruits were determined with the help of hand refractometer. The acidity of the aonla fruits was determined by the procedure given by (Ranganna 2003). Total acid content was estimated by titrating sample against 0.1 N NaOH using phenolphthalein as an indicator. Sugars were determined by the method of Lane and Eynon as described by (Ranganna 2003). The ascorbic acid content was determined by the procedure given by (Srivastava and Sanjeev 2006). The data were subjected to statistical analysis as per the method of Gomez and Gomez (1996).

RESULTS AND DISCUSSION

Time and Duration of flowering

The data presented in Table 1 revealed that flowering in all the aonla cultivars occurred in the month of April. Dhandar *et al.* (2007) also found that the flowering in aonla occurred during March-April on newly emerged determinate shoots. Flower initiation started on 2 April and continued up

Table 1 Time and duration of flowering in different aonla cultivars

Cultivars	Time of flower initiation	Time of full bloom	Time of end of flowering	Duration of flowering (days)
Banarasi	5 April	15 April	29 April	24
Chakaiya	7 April	16 April	28 April	20
Neelam	11 April	18 April	1 May	20
Francis	8 April	17 April	27 April	21
Kanchan	12 April	21 April	2 May	20
Desi	2 April	12 April	24 April	22

to 12 April depending on varieties. In Desi, flower initiation takes place in first week of April (2 April) and was completed in the last of April (24 April). In case of Banarasi and Chakaiya, flowering was started on 5 and 7 April and continued up to last week of April (29 and 28 April) with the peak full bloom on 15 and 16 April, respectively. In cultivars Neelam and Kanchan, flowering initiation was little late, i.e. on 11 and 12 April and it completed in the first week of May (1 and 2 May) with full bloom on 18 and 21 April, respectively. These observations are in conformity with Kester (1965) where in he has suggested that the variability in the time of flowering and period of bloom seems to be a varietal feature and may be genetically controlled. Regarding duration of flowering, it was found that maximum days were taken by Banarasi (24 days) followed by Desi (22 days) and Francis (21 days) and, whereas minimum in cultivar Chakaiya, Neelam and Kanchan (20 days each). Thus the time of flower initiation, full bloom, time of end of flowering and duration of flowering in the different cultivars of aonla under study were comparable with those reported by Bajpai (1965), Ram (1971) and Jamwal (2000), who also reported that any variation in the time of flower initiation and bloom period was variety dependent.

Flower density, sex ratio and percentage of female flowers

The data in Table 2 depicted higher flower density of 842 flowers/m branchlet in Desi followed by Banarasi (816 flowers/metmr branchlet) and minimum in Kanchan (617 flowers/metmr branchlet). The data in Table 2 further depicted higher proportion of male than female flowers in all the cultivars. The maximum number of male flowers were in Desi (837.50 flowers/m) and female flowers in Neelam (9.00 flowers/m), whereas minimum number of male flowers were found in Kanchan (611.00 flowers/m) and female flowers in Desi (4.50 flowers per m). Pathak (2003) also observed that the percentage of determinate shoots bearing both male and female flowers may be 14 to 17 and male flowers were many times more than the female flowers. The perusal of data in Table 2 revealed that sex ratio (male: female flower ratio) in these commercial varieties varied from 79.40:1 to 186.10:1. However, it was found maximum in Desi (186.10:1) followed by Kanchan (101.83:1) and Banarasi (101.00:1), whereas ratio was

Table 2 Total number of male and female flowers per meter shoot length in different aonla cultivars (Pooled data of 2 years)

Cultivar	Total no. of flowers	Number of male flowers	Number of female flowers	Percent female flowers	Male: female flower ratio
Banarasi	816	808.00	8.00	0.99	101.00:1
Chakaiya	736	728.40	7.60	1.04	95.84:1
Neelam	724	715.00	9.00	1.25	79.40:1
Francis	730	722.80	7.20	0.99	100.39:1
Kanchan	617	611.00	6.00	0.98	101.83:1
Desi	842	837.50	4.50	0.53	186.10:1

reported to be minimum in Neelam (79.40:1). With respect to percentage of female flowers, the maximum was noted in Kanchan (1.25%) followed by Chakaiya (1.04%) and Francis (0.99%) and minimum was recorded in Desi (0.53%). The present study is more or less in conformity with those of Karale *et al.* (1991) and Jamwal (2000). Srivastava and Pathak (1993) also reported almost similar trend of sex ratio in different cultivars of aonla.

Maturity period and fruiting behaviour

The data presented in Table 3 showed that fruits of Banarasi were earliest to mature (27 November) followed by Desi (29 November), Kanchan (1 December), Chakaiya (2 December) and Francis (3 December). Fruits of Neelam matured at the last (15 December) and took 12-15 days more than the other cultivars to mature. These results are in accordance with the findings of Singh *et al.* (1989) who also reported that the best time of harvesting in Banarasi and Chakaiya is first week of December. Data regarding the number of days required from fruit set to maturity of fruits indicated that maximum days were taken for maturity in Neelam (241 days) followed by Desi (231 days), whereas minimum days were taken for maturity in Kanchan (224 days) followed by Banarasi (226 days). These findings are in agreement with those of Pathak *et al.* (1990) and Singh *et al.* (1994). Evaluation of flowering behaviour reveals that Banarasi is an early variety while, Chakaiya, Kanchan and

Table 3 Variability in time of maturity and fruiting behaviour of different aonla cultivars (Pooled data of 2 years)

Cultivar	Date of maturity	Time taken from full bloom to maturity (days)	Percent fruit set	Percent fruit drop	Yield (kg/plant)
Banarasi	27 November	226	26.41	73.59	70.04
Chakaiya	2 December	230	32.09	67.91	53.54
Neelam	15 December	241	51.86	48.14	72.77
Francis	3 December	230	48.82	51.18	56.41
Kanchan	1 December	224	41.32	58.68	61.00
Desi	29 November	231	20.16	79.84	44.13
CD (P=0.05)			4.85	5.28	4.70

Francis are mid season varieties. However, Neelam is a late season variety under rainfed sub-tropical conditions. Fruit setting in different aonla cultivars is presented in Table 3. The data showed that maximum fruit setting (51.86%) was found in Neelam though at par with Francis (48.82%). However, significantly lower fruit set of 20.16% was recorded in Desi. As for fruit dropping, the highest fruit drop (79.84%) was recorded in Desi followed by Banarasi (73.59%). The minimum fruit drop (48.14%) was observed in Neelam which was at par with Francis (51.18%). These variations in per cent fruit set and fruit drop might be due to genetic makeup of the plant. The environmental conditions especially temperature and relative humidity also affected the per cent fruit retention and fruit drop. These results are in conformity with the findings of (Mishra and Bajpai 1975). The perusal of the data presented in Table 3 indicated that the cultivars expressed their yield potential at different magnitude in the present agro-climatic situation. All the cultivars, taken for the study reported to have good yield potentiality (Singh *et al.* 1994). The highest average yield (72.77 kg/plant) was recorded from Neelam followed by Banarasi (70.04 kg/plant) and lowest yield was in Desi (44.13 kg/plant).

Physical characteristics

The perusal of data in Table 4 on average fruit weight of different aonla cultivars indicates that cultivar Neelam had maximum fruit weight of 41.46 g followed by Banarasi (36.42 g) while Desi aonla had a minimum weight of 13.6 g. Similar findings were reported by Pathak and Drivadi (1995) and Jamwal (2000). Increase in fruit weight in Neelam may be due to more activeness of monocarp cells which enlarge during fruit development (Balasubramanyan and Bangarusamy 1998). A wide variation (Table 5) in the length and diameter were found under different varieties, where it ranged from 2.64 to 3.73 cm and 2.84 to 4.42 cm, respectively in Desi to Neelam varieties. The minimum fruit length and diameter were found in variety Desi. These observations are in line with (Ghosh *et al.* 2013). The fruits of cultivar Neelam showed significantly maximum volume of 39.80 m³, whereas it was minimum in Desi (12.01 m³).

Table 4 Fruit weight, fruit length, fruit diameter, fruit volume and specific gravity of different aonla cultivars (Pooled data of 2 years)

Cultivar	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (m ³)	Specific gravity
Banarasi	36.42	3.62	4.34	34.82	1.06
Chakaiya	31.00	3.48	4.22	29.40	1.03
Neelam	41.46	3.73	4.42	39.80	1.04
Francis	33.12	3.54	4.27	31.52	1.05
Kanchan	35.14	3.58	4.31	33.54	1.05
Desi	13.61	2.64	2.84	12.01	1.13
CD (P=0.05)	3.85	0.27	0.12	1.27	0.02

Table 5 Pulp weight, stone weight and pulp:stone ratio of different aonla cultivars (Pooled data of 2 years)

Cultivar	Pulp weight (g)	Stone weight (g)	Pulp: stone ratio
Banarasi	34.68	1.74	19.93
Chakaiya	29.36	1.64	17.90
Neelam	39.57	1.89	20.94
Francis	31.45	1.67	18.83
Kanchan	33.43	1.71	19.54
Desi	12.57	1.04	12.08
CD (P=0.05)	2.41	0.14	0.94

of 480.20 mg/100g was recorded in Desi. The results of the present investigation were in agreement with the findings of (Teotia *et al.* 1968, Singh *et al.* 1984, Singh *et al.* 1989, Srivastava and Singh 1997). The Neelam cultivar resulted in higher total sugars (5.71%), reducing sugars (3.41%) and non-reducing sugars (2.19%) followed by Banarasi (5.69% total sugars, 3.37% reducing sugars and 2.14% non-reducing sugars). The least total sugars (5.38%), reducing sugars (3.07%) and non-reducing sugars (1.78%) were recorded in fruits of Desi cultivar. The results of the present study are in agreement with the findings of Sharma *et al.* (1989) in cultivar Banarasi, Chakaiya and Desi aonla.

Table 6 Quality characteristics of different aonla cultivars (Pooled data of 2 years)

Cultivar	TSS	Acidity (%)	TSS: acid ratio	Vitamin-C mg/100g fruit	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)
Banarasi	10.69	1.78	6.01	584.00	5.69	3.37	2.14
Chakaiya	9.90	1.98	5.00	563.45	5.49	3.19	1.92
Neelam	10.73	1.64	6.54	596.03	5.71	3.41	2.19
Francis	10.19	1.95	5.22	571.15	5.54	3.25	2.01
Kanchan	10.42	1.90	5.48	580.13	5.61	3.31	2.09
Desi	12.20	2.08	5.86	480.20	5.38	3.07	1.78
CD (P=0.05)	0.32	0.16	1.21	2.16	0.13	0.15	0.27

However, specific gravity of 1.13 was found in Desi variety followed by Banarasi (1.06), whereas it was minimum in variety Chakaiya (1.03).

The perusal of the data given in Table 5 showed that the maximum pulp content/fruit (39.57 g) was recorded in Neelam variety followed by Banarasi, Kanchan, Francis and Chakaiya. The minimum pulp content in aonla fruit was found in Desi (12.57 g). The Neelam had maximum stone weight (1.89 g), whereas minimum stone weight (1.04 g) was obtained in Desi aonla. The cultivar Neelam exhibited the maximum pulp to stone ratio of 20.94, while minimum value of 12.08 was recorded in variety Desi. Similar results were also reported by Supe *et al.* (1997) and Jamwal (2000).

Quality characteristics

The data given in Table 6 showed the highest TSS of 12.20⁰B followed by Neelam (10.73⁰B) and lowest TSS of 9.90⁰B was noted in Chakaiya variety. Significantly higher acid content was observed in cultivar Desi (2.08%), whereas it was lowest in Neelam (1.64%). The present findings are in accordance with those of Singh *et al.* (1984), Singh *et al.* (1989), Srivastava and Singh (1997). The maximum TSS: acid ratio was obtained in cultivar Neelam (6.54) and minimum in Chakaiya (5.00). The vitamin-C content of aonla cultivar varied from 480.20 to 596.03 mg/100g pulp. The maximum vitamin-C content was recorded in Neelam (596.03 mg/100g) and it was significantly higher than all other cultivars. It was followed by Banarasi and Kanchan which recorded vitamin-C content of 584.00 mg/100g and 580.13 mg/100g, respectively. Minimum vitamin-C content

From the present study, it can be concluded that Neelam (NA-7) cultivar of aonla showed a promise under rainfed conditions of Jammu region as it had maximum percentage of female flowers with minimum female: male flower ratio, maximum fruit set and minimum fruit drop, good fruit size, fruit weight, pulp weight. Stone weight, pulp: stone ratio, TSS, vitamin-C, total sugars, reducing sugars and non-reducing sugars also showed good yield performance.

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