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Evaluation of Different Varieties and Genotypes of Aonla (*Emblica officinalis* Gaertn.) under Sodic Soil Condition of Eastern Uttar Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The purpose of this study was to assess the aonla (*Emblica officinalis* Gaertn.) varieties and genotypes for their growth and development of fruits (flowering and fruiting), physical attributes and yield under the sodic soil condition of Eastern Uttar Pradesh. The evaluated varieties and

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genotypes had a significant variation for the recorded parameters. The maximum flowering duration among the varieties was recorded in BSR-1 (27 days) whereas, the minimum duration of flowering was observed in NA-6 (23 days) and Chakaiya (23 days). Among the selected varieties and genotypes, fruit weight, fruit length, and diameter were recorded maximum in genotype NA-25, and the maximum fruit drop at the maturity stage was found in BSR-1 (80.60%). The maximum yield (kg/plant) was recorded in NA-26 (80.35 kg/plant). The maximum fruit volume was recorded in NA-25 (54.2) with the maximum pulp weight (55.02g) and the pulp: stone ratio was recorded highest in NA-25 (28.10). The maximum specific gravity was recorded in Anand-1 (1.07).

Keywords: Aonla; flowering duration; specific gravity; fruit volume and TSS.

1. INTRODUCTION

The aonla (*Phyllanthus Emblica* Gaertn.) fruit belongs to the family Phyllanthaceae or Euphorbiaceae and comprises about 350 [1]. to 500 species [2]. It is also known as Indian gooseberry, Amritphal, and is considered a "wonder fruit for health" because of its unique qualities [3]. It offers medicinal and nutritional qualities, as well as a high production potential and minimal maintenance costs. Therefore, it is predicted to be the "fruit of the 21st century" [4]. Being a subtropical plant, aonla needs a dry climate with 350–500 mm of rainfall each year. Its natural habitat is in central South India. Aonla cultivation has become very popular because of its higher production, good returns, and drought-tolerant capacity. It can be grown successfully in moderately alkaline soils and slightly acidic to sodic soils with a pH of 6.5 to 9.5 of soil [5]. however, well-drained and fertile soils are best for its cultivation.

Aonla is a naturally resilient plant that thrives in a variety of agroclimatic circumstances. On hills up to 1800 MSL, it is cultivated. During winter heavy frosts are bad for young plants but a mature tree can tolerate freezing as well as the high temperature of 46 ºC [6]. Warm temperature conducive for flower bud initiation. Aonla trees should be protected during May-June from hot winds by planting dense windbreaks.

Since it is one of the hardest native fruit species to grow naturally, it has a great deal of potential for use on degraded forest land, marginal, sodic, and wasteland land. These types of land are widely spread throughout India's rainfed, desert, and drought-prone regions. Aonla is one of the most nutritious fruits and the second richest source of vitamin C after Barbados cherry, the vitamin C content in aonla varies from 200-900 mg /100 g depending upon the variety and size of the fruit [7,8]. In addition, it contains reasonable amounts of minerals including iron, phosphorus, calcium, and magnesium as well as carotene, thiamine, riboflavin, and carbohydrates. It is made into high-quality culinary products or utilized in Ayurvedic treatment [9,10].

Aonla is commercially propagated by patch budding. May to September is the best time for patch budding in Aonla. Aonla is planted at a distance of 8m × 8m for vigorous cultivars. Aonla does not require pruning but it is necessary to give a strong framework and proper shape in the early years. Plants are trained on a modified leader system [11,12].

Aonla is cultivated commercially in India, with Uttar Pradesh being the top state and Pratapgarh being the top district in UP. The principal districts for aonla cultivation are Rai Bareilly, Varanasi, Jaunpur, Sultanpur, Kanpur, Agra, and Mathura. Besides U.P., aonla is commercially cultivated in Maharastra, Gujrat, Rajasthan, Haryana, Karnataka, Tamil Nadu, Punjab, Himachal Pradesh, and Aravali areas. India ranks first in the area (88,000 ha) and production (9, 72,000 MT) of aonla [13]. Globally, aonla is successfully grown in the West Indies, Cuba, Pakistan, Sri Lanka, Malaysia, and Java.

The Aonla tree has a deep root system and is deciduous. It starts shedding its determinate branches in mid-December and achieves complete defoliation by the end of January. Aonla flowers on determinate shoots appear in the spring season. The commencement of flowers opens from the last week of March and the blooming period lasts for 20 to 21 days. Clusters of male flowers appear on the leaf axile all over the branchlets at the same time female flowers are overlying the end of the few branchlets only. In aonla pollination is done by wind and honey bees. 120 to 130 days after fertilization fruits begin to grow with higher growth in September month and attain maturity by the last week of November.

The polyphenolic chemicals are found and it slow down the oxidation of vitamin C. Fruits have cooling, laxative, diuretic, acidic, and refrigerant properties. Chronic dysentery, diarrhoea, jaundice, diabetes, cough, dyspepsia, and anaemia can all be treated with dried fruits. It has been observed that aonla has antimicrobial, purgative, spasmolytic, expectorant, hypoglycemia neuroprotective, and hypolipidemic properties. Chayvanprash, Toffees, Barfi, Laddu, Triphala Powder, Candies, and Preservation are all made from Aonla fruits. [14].

2. MATERIALS AND METHODS

The present investigation entitled “Evaluation of different varieties and genotypes of aonla (*Emblica officinalis* Gaertn.) under sodic soil condition of Eastern Uttar Pradesh” was carried out on the orchard of Aonla at the main experimental station, Department of Fruit Science, Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) during the year 2021. Geographically, it is located in latitudes 26.47 ºN and longitudes 80.12 ºE, at an elevation of 113 meters above mean sea level. The location is amid the usual saline-alkaline soils of eastern Uttar Pradesh's Indo-Gangetic plains. The area has a sub-humid, subtropical climate with an average yearly rainfall of around 1000 mm, with the majority of that precipitation falling between mid-June and the end of September. The winter months were cold of dry and occasionally frost occurred during this period, hot weather starts from April and continues up to the onset of monsoon. The orchard was established by procuring uniform budded varieties of aonla viz. NA-6, NA-7, NA-10, NA-20, BSR-1, Anand-1, Chakaiya, CHES-1, NA-25, NA-26, and NA-27. In 2012, the trees were planted with an 8 m × 8 m spacing.

In February 2021, the experiment was conducted using a Randomized Block Design with three replications. The time of flower initiation was recorded by tagging five branches in each plant of every treatment from all directions and the date of first cyme (inflorescence) initiation was considered when five percent of flower buds were opened from all the tagged branches. The flowering duration was calculated from the date of the first cyme (inflorescence) initiation to the date of the end of flowering and the average time taken in the duration of flowering was expressed in days. The fruit drop was recorded by tagging four branches in each direction or quarter of the tree. These branches were monitored regularly to see the fruit drops. Using digital electric balance, the fruit yield per plant (kg) was determined at the time of fruit harvest. The five fruits in each replication were used to evaluate the physical properties of the fruits. The fruits were then weighed using a digital electric balance, and the average weight was given in grams, Vernier callipers were used to measure the diameter and length of fruits. Using the water displacement method, fruit volume was recorded. The average fruit volume was expressed in terms of cubic centimetres. The weight of the fruit is divided by its volume to get its specific gravity.

$$\text{Specific gravity} = \frac{\text{Weight of fruit (g)}}{\text{Volume of fruit (ml)}}$$

The pulp of individual fruit was separated from the stone. The average pulp weight of individual fruit was calculated and expressed in grams. Five pulp-free stones were weighed separately on digital balance and the average weight was taken as stone weight and expressed in grams. The pulp: stone ratio was calculated by dividing the pulp weight by the stone weight, Pulp weight was derived by subtracting the stone weight from the overall weight of the fruit.

3. RESULTS AND DISCUSSION

Aonla's varietal assessment, which included three genotypes and eight varieties **(**NA-6, NA-7, NA-10, NA-20, BSR-1, Anand-1, Chakaiya, NA-25, Na-26, and NA-27) was conducted to evaluate the relative performance of fruiting and blooming in Eastern Uttar Pradesh's sodic soil.

3.1 Flower Initiation (Days)

The cultivars displayed flowering from the second week of March and continuing through the last week of April. The initiation of flowering was recorded earliest in NA-6 and NA-25 (2nd week of March) than that of other varieties. Late flower initiation was observed in BSR-1 (1st week of April) in comparison to other varieties.

Similar, results were obtained by Aulakh et al [15]. The different varieties have non-significant variation in the duration of flowering in days. The maximum flowering duration among the varieties was recorded in BSR-1(27 days) followed by NA-25 (26.67 days), whereas the minimum duration of flowering was noted in NA-6 (23 days) and Chakaiya (23 days). Similar results were obtained by Bakshi et al [16].

3.2 Fruit Drop (%)

Significant differences were seen in the fruit drop at the maturity stage among the selected varieties. The maximum fruit drop at the maturity stage was found in BSR-1 (80.60%) followed by Anand-1 (79.22%). The minimum fruit drop at the maturity stage was recorded in NA-26 (65.25%) followed by NA-20 (66.69%). This result falls in line with the earlier reports of Bakshi et al [16].

3.3 Fruit Yield (kg/plant)

The yield (kg/plant) was noted as maximum in NA-26 (80.35 kg/plant) followed by NA-25 (40.66 kg/plant) whereas minimum yield (kg/plant) was recorded in BSR-1 (6.15 kg/plant) followed by NA-20 (7.15 kg/plant).

Similar findings were recorded by Dhaliwal et al [17]. The maximum yield (q/ha) was found in NA-26 (125.35 q/ha) followed by NA-25 (63.43 q/ha) whereas the minimum yield (q/ha) was found in BSR-1 (9.59 q/ha) followed by NA-20 (11.15 q/ha). The fruit weight was noted as maximum in NA-25 (56.98 g) followed by NA-20 (46.93 g), while the fruit weight was noted as minimum in BSR-1 (18.18 g).

3.4 Fruit Length and Diameter (cm)

The maximum fruit length was noted in NA-25 (4.93 cm) followed by NA-26 (3.83 cm). The minimum fruit length was noted in BSR-1 (2.56 cm) followed by NA-6 (2.92 cm). The maximum fruit diameter was noted in NA-25 (4.69 cm) followed by NA-26 (4.61 cm); however, the minimum fruit diameter was recorded in BSR-1 (2.86 cm) followed by NA-6 (3.51 cm). These findings are supported by Shukla et al [18].

3.5 Fruit Volume (cc)

In this study, the maximum fruit volume was recorded in NA-25 (54.20) followed by NA-20 (50.30) however the minimum volume was recorded in BSR-1 (17.20) followed by NA-6 (26.80). The recorded data were close in conformity with Killadi et al [19].

3.6 Specific Gravity (g/cc)

It was found that there was no significant difference in the average specific gravity of the different aonla fruit varieties and genotypes. The maximum specific gravity was recorded in Anand-1 (1.07) which was at par with the variety NA-10, NA-20 and BSR-1 (1.06) however the minimum specific gravity was recorded in NA-26 (1.02) closely followed by CHES-1 (1.03).

3.7 Pulp Weight and Stone Weight (g)

The maximum pulp weight was recorded in NA-25 (55.02 g) which was at par with variety NA-20 (44.67 g) compared to that, BSR-1 reported the lowest pulp weight (16.32 g) followed by NA-6 (26.78 g). The maximum stone weight was noted in Anand-1 (2.44 g) which is at par with variety NA-20 (2.26 g) whereas the minimum stone weight was recorded in CHES-1 (1.57 g) followed by NA-10 (1.76 g). This result is closely similar to Bakshi et al [16].

3.8 Pulp: Stone Ratio

The maximum pulp: stone ratio was recorded in NA-25 (28.10) which is at par with NA-26 (21.70) however the minimum pulp: stone ratio was noted in BSR-1 (8.80) followed by NA-7 (12.80). The recorded results confirm Kumar et al [20].

Table 1. Flowering, fruiting and yield attributes of different aonla varieties and genotypes

Treatments	Flower initiation time				Fruit drop at maturity stage (%)	Yield (kg/plant)	Yield (q/ha)
	Month	Week	Fortnight	Flowering Duration (days)			
T_1- NA-6	March	2nd	1st	23.00	73.24	20.00	31.20
T_2- NA-7	March	3rd	2nd	24.00	74.61	18.60	29.02
T_3- NA-10	March	3rd	2nd	25.67	69.82	13.50	21.06
T_4- NA-20	March	3rd	2nd	23.33	66.69	7.15	11.15
T_5- BSR-1	April	1st	1st	27.00	80.60	6.15	9.59
T_6- Anand-1	March	3rd	1st	23.67	79.22	8.20	12.79
T_7- Chakaiya	March	4th	2nd	23.00	68.52	13.50	21.06
T_8- CHES-1	March	3rd	2nd	25.00	67.15	12.50	19.50
T_9- NA-25	March	2nd	1st	26.67	77.20	40.66	63.43
T_{10}- NA-26	March	4th	2nd	23.67	65.25	80.35	125.35
T_{11}- NA-27	March	3rd	2nd	24.00	76.38	38.50	60.06
S. Em ±	**-**	**-**	**-**	**0.96**	**7.45**	**0.40**	**0.63**
CD at 5%	**-**	**-**	**-**	**NS**	**NS**	**1.18**	**1.85**

Table 2. Physical attributes of different aonla varieties and genotypes

Treatments	Fruit weight (g)	Fruit Length (cm)	Fruit diameter (cm)	Fruit volume (cc)	Specific gravity (g/cc)	Pulp weight (g)	Stone weight (g)	Pulp: Stone ratio
T_1-NA-6	28.55	2.92	3.51	26.80	1.06	26.78	1.77	15.20
T_2-NA-7	29.68	3.20	3.80	28.30	1.05	27.53	2.15	12.80
T_3-NA-10	37.78	3.47	3.86	36.40	1.04	36.02	1.76	20.60
T_4-NA-20	46.93	3.40	4.25	50.30	1.06	44.67	2.26	19.80
T_5- BSR-1	18.18	2.56	2.86	17.20	1.06	16.32	1.86	8.80
T_6- Anand-1	36.59	3.33	3.75	34.30	1.07	34.15	2.44	14.00
T_7 -Chakaiya	32.94	3.28	3.97	31.50	1.05	31.10	1.84	16.90
T_8-CHES-1	31.20	3.43	3.61	30.30	1.03	29.63	1.57	18.90
T_9-NA-25	56.98	4.93	4.69	54.20	1.05	55.02	1.96	28.10
T_{10}- NA-26	44.95	3.83	4.61	44.00	1.02	42.97	1.98	21.70
T_{11}-NA-27	28.85	3.37	3.66	27.80	1.04	26.98	1.87	14.40
S.Em±	**1.01**	**0.07**	**0.08**	**0.75**	**0.01**	**1.01**	**0.02**	**0.58**
CD at 5 %	**2.97**	**0.20**	**0.25**	**2.21**	**NS**	**2.99**	**0.05**	**1.72**

4. CONCLUSIONS

The present investigation was undertaken to perform the different aonla varieties for growth, flowering behaviour and yield attributes. There are eight varieties and three genotypes selected for the present investigation and they are found most productive and qualitative with lots of variations. However, based on growth and development in the present study, it is found that NA-26 is the best to other varieties. According to all the performance of the variety (performance regarding the highest yield and good physical attributes of fruits), it is concluded that Variety NA-26 is found to be the best followed by NA-25 and NA-20 among selected varieties under sodic soil conditions of eastern Uttar Pradesh.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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