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Evaluation of Aonla Varieties Under Semi-Arid Conditions of Haryana

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ABSTRACT

The farmers or orchardist are trying different varieties/germplasm for growing as a commercial orchard without having knowledge about the performance of these varieties/germplasm. The experiment on varietal evaluation of on aonla comprising of nine promising cultivars (NA 6, NA 7, NA 10, NA 20, Krishna, BSR 1, Gujarat 1, Chakaiya and CHES 1) released from the different parts of the country was carried out to study the variation among different varieties on qualitative as well as quantitative basis and observed the performance of growth, physicochemical characters and yield during 2017-18, 2018-19, 2019-20 under semi-arid conditions to recommend the suitable variety. Plant shape was observed as spreading (CHES 1, Chakaiya, Krishna, NA 6, NA 7, NA 10, BSR 1); drooping (NA 20) and upright (G1) in different cultivars of aonla. The range of variability among different parameters such as plant height (4.90-6.70 m), plant spread-EW (4.47-7.15 m), plant spread-NS (4.44-7.53 m) , stem girth (46.45-95.37 cm), plant volume (86.8-283.9 m^3), plant canopy area (15.59-42.35 m^2), total soluble solids,TSS (9.17-18.32 °B), acidity (1.92-2.63%), TSS : acidity ratio (4.09-7.71), ascorbic acid (323-567 mg/100 g pulp), fruit weight (5.89-55.43 g), fruit length (1.87-3.33 cm), fruit breadth (2.28-3.70 cm), yield (36-102 kg/plant and 10.00-28.34 MT/ha). Fruit shape was observed as flattened round (CHES 1, Chakaiya, NA 6, NA 10, G 1, BSR 1), triangular (Krishna), oval (NA 7) and round (NA 20). Free base (cavity at stem end) was observed as absent (CHES 1), shallow (Chakaiya, NA 6, NA 20, G 1), deep (Krishna), flat (NA 7, NA 10, BSR 1) and fruit apex was observed as flat (CHES 1, Chakaiya, Krishna, NA 7, NA 10, NA 20), papillate(NA 6, BSR 1), depressed (G 1).

Keywords: Aonla or Indian gooseberry (*Phyllanthus emblica*), varieties, growth, yield and quality, plant volume, fruit shape, variability

Introduction

The aonla or Indian gooseberry (*Phyllanthus emblica* Linn.) belongs to family Phyllanthaceae and subfamily Phyllanthoidae. It is a subtropical plant and prefers dry subtropical climate and can be grown with an annual rainfall of 350-500 mm. It is indigenous meditational and minor fruit crop grown in tropical South-East Asia, particularly central and southern India. It also has a tremendous export potential due to its medicinal and therapeutic and high nutritive value, it has been recognized as *Amrit Phal* (life-giving fruit). The fruit is highly nutritive and second richest source of vitamin C after barbados cherry. It is a fair source of thiamine (vitamin B_1), riboflavin (vitamin B_2), and a rich source of pectin and minerals (iron, calcium and phosphorus). The ascorbic acid and other constituents are well retained in dried/processed aonla fruits. The fruits are processed into chutney, candy, preserves (*murabba*), sauce, candy, dried chips, tablets, jellies, pickles, powder *etc.*(Kumar et al., 2013). It is also used in shampoos, hair dyes and ink industries. *Trifla* and *chavanprash* are well-known indigenous products of aonla. Besides fruits, leaves, bark and even seeds are being used for various purposes.

Aonla fruit due to its nutritional security, high medicinal value and high productivity (15-20 t/ha) has the immense possibility for commercial growing in the arid zone and marginal soils, where only a few fruits can be grown (Chadha, 2013). It is gaining popularity because of its high yield, good returns, hardy nature, drought tolerant, prolific bearer and being a hardy plant, it can be grown successfully in marginal soils, moderately alkaline soils and slightly acidic to saline/sodic (pH 6.5-9.5) conditions (Chadha, 2013). However, well-drained fertile loamy soils are best.

Deep root system, reduced foliage and dormancy of fruitlets during dry weather (April-June) make it an ideal plant for growing in arid and semi-arid conditions. However, heavy frost during winter is not conducive to young plants but a mature plant can tolerate freezing as well as the high temperature of 46ºC (Bose and Mitra, 2001). Warm temperature seems to be conducive for the initiation of floral buds and ample humidity is essential for initiation of growth of dormant fruitlets during July-August. Dry spells during this period result in heavy fruit drop and delay in initiation of fruit growth.

Aonla gene pool is spread over different parts of the country and has enormous variability with respect to qualitative as well as quantitative characters due to old age practice of seed propagation. A large number of varieties, mostly from selection have been released for commercial cultivation from different institutes, but their adaptability has not been studied for semi-arid region of Haryana. Farmers are experiencing the challenges of identifying the suitable cultivars, as they are unfamiliar with the characteristics of varieties with respect to adaptability and fruit characters. Identification of suitable genotype for the region is necessary for promoting its productivity, production and quality of the fruits under semi-arid conditions (Nagar et al. 2017). In order to identify distinct characters of various aonla cultivars, the morphological characters are also equally important to the fruit characters. On the basis of growth, yield and quality performance of different germplasm, the emphasis has been made to find out the suitable cultivar(s) for the semi-arid region of Haryana. This will also help the growers in the selection of suitable cultivar(s) of this underutilized crop for large-scale cultivation to get higher yield and good quality fruits suitable for processing as well as medicinal formulation preparations. Unproductive land of the arid and semi-arid region could be utilized properly by growing such a hardy fruit crop, which holds promise for nutritional security and also helpful in generating income.

Materials and Methods

The present study was carried out at experimental orchard at Regional Research Station, Bawal (Rewari), situated at an altitude of 266 m above mean sea level with coordinates of 28º10´N latitude and 76º50´E longitudes in South-West zone of Haryana having typical semi-arid climatic zone with hot and dry summer and extremely cold winter. It shows a wide range of fluctuations in temperature (maximum and minimum) and rainfall. During May to June, the temperature reaches to maximum of around 44°C, while during December and January it remains as low as freezing point accompanied by frost is also quite common. The rainfall is highly erratic with 20-30 per cent annual and 30-50 per cent seasonal variations. Large variations occur for total rainfall and its distribution, about 80-85 per cent received during monsoon season, while during winter and spring seasons some rains occurs due to the western disturbances. A long term field experiment was conducted on aonla plants planted during 2007 at 6 × 6 m spacing in a randomized block design with three replications and two plants per replications in a loamy sand soil having low level of organic carbon and available phosphorus. The observations on all the genotypes were recorded during 2017-18, 2018-19, 2019-20. Plants were selected randomly and maintained under uniform conditions during the study period, where, all the agronomic practices were carried out as per recommended package of practices.

Plant shape was observed visually at pea size fruit stage in the month of August every year as upright, spreading and drooping; and mature fruit shape mature fruit was observed visually as oval, round, oblong or flattened-round and triangular (slightly conical at apex) as recommended in the descriptor of NBPGR (Mahajan et al. 2002), and guidelines for DUS testing of PPV and FRA (Anonymous, 2016). Plant height was measured with the help of a graduated measuring pole from ground level to the tip of the highest shoot and expressed in meters. Observation for stem circumference (girth) was measured with the help of measuring tape at 15 cm above the bud union of the plants. The average stem girth was calculated and expressed in centimeters. Plant spread was measured in both directions, *i.e.,* north to south and east to west, with the help of a graduated measuring tape. Average plant spread was calculated from both directions separately and expressed in meters. Plant volume was calculated using the formula $л\ r^2\ h$, where r = (plant spread NS, North-South + plant spread EW, East-West)/4); h = height of plant, it was expressed in m^3. Plant canopy cover area was calculated by using the formula $л\ r^2$.

Physical characteristics of the fruits were estimated from the five randomly selected fruits plucked from each quarter of a plant, fruits were weighed on the digital electric balance and average fruit weight was expressed in grams, their length was measured from distal to proximal end with the help of digital vernier callipers and their average value was taken and expressed in cm, fruit breadth was measured with the help of digital vernier callipers and the average value was taken and expressed in cm.

Physiochemical characteristics were estimated from the five fruits selected randomly from tagged branch of each quarter of plant and their pulp was crushed to extract juice. Morphological characteristics such as fruit shape, fruit base (cavity at stem end) and fruit apex were observed by matching the fresh fruit with the shapes of the fruits available in the descriptor of NBPGR (Mahajan et al. 2002), and guidelines for DUS testing of PPV and FRA (Anonymous, 2016).

The TSS of fresh fruits were determined at room temperature using hand refractometer having a range of 0 to 32 °Brix (ERMA made) by putting a drop of fresh fruit juice on the screen and recorded the readings. The refractrometer was calibrated with distilled water after every use and the values were expressed in degree Brix (°B). The method suggested by A.O.A.C. (2000) was followed for estimation of titratable acidity. Diluted aonla extract was titrated against 0.1 N sodium hydroxide using phenolphathlein indicator. The TSS: acid ratio was calculated by dividing total soluble solids with percentage acidity. Fresh aonla juice was diluted with equal amount of meta-phosphoric acid and titrated rapidly with indo-phenol dye to estimate the ascorbic acid content. Similarly standard ascorbic acid solution and meta-phosphoric acid (blank) solution titrated against the indo-phenol dye (A.O.A.C., 2000). To calculate total fruit yield, the harvested fruits were weighed on the digital electric balance for each replication and the value was expressed in kilograms (kg/plant). Total yield per plant was divided by area or volume of the plant to calculate the yield per unit canopy area or volume.

The data presented in this manuscript are the average values of different parameters. The statistical method described by Panse and Sukhatme (1985) was followed for analysis and interpretation of the experimental results. In order to evaluate comparative performance of the various treatments, the data were analyzed by the technique of analysis of variance described by Fisher (1958). All the tests of significance were made at 5 per cent level of the significance. The data has been analysed using the statistical tool/ programme "*opstat*" developed by Sheoran et al. (1998), CCS HAU, Hisar. This tool is open for all and available on official website of CCS HAU, Hisar (www.hau.ac.in).

Results and Discussion

Varietal evaluation of aonla comprising of nine cultivars (NA 6, NA 7, NA 10, NA 20, Krishna, BSR 1, Gujarat 1, Chakaiya and CHES 1) was carried out for assessing the comparative performance of cultivar for growth and physicochemical characters under semi-arid conditions. Plant shape was observed as spreading (CHES 1, Chakaiya, Krishna, NA 6, NA 7, NA 10, BSR 1); drooping (NA 20) and upright (G1) in different cultivars of aonla. The maximum plant height (6.70 m), plant spread EW (7.15 m) and SW (7.53 m) and stem girth (95.37 cm) were recorded in Gujrat-1; followed by NA 6 with plant height (6.32 m) and Krishna with plant spread EW (6.58 m) and plant spread NS (6.46 m). Plant height was found minimum in Chakaiya (4.90 m). Minimum plant spread EW (4.47 m) and NS (4.44 m) was found in NA 7, whereas; stem girth (46.45 cm) in CHES 1. Maximum plant volume (283.9 m^3) was observed in G1, followed by Krishna (191.1 m^3) and minimum (86.8 kg/m^3) in NA 7. Plant canopy area was observes maximum (42.35 m^2) in G1 and minimum (15.98 m^2) in CHES 1. The variation in growth parameters such as plant shape, plant height, plant spread (EW &NS), stem girth, plant volume and plant canopy area might be due to the specific climatic requirement of the variety and the genetic makeup of the cultivar. Similar findings were recorded by Kumar et al. (2011).

Fruit shape was observed as flattened round (CHES 1, Chakaiya, NA 6, NA 10, G 1, BSR 1), triangular (Krishna), oval (NA 7) and round (NA 20). Free base (cavity at stem end) was observed as absent (CHES 1), shallow (Chakaiya, NA 6, NA 20, G 1), deep (Krishna), flat (NA 7, NA 10, BSR 1) and fruit apex was observed as flat (CHES 1, Chakaiya, Krishna, NA 7, NA 10, NA 20), papillate (NA 6, BSR 1), depressed (G 1). Maximum fruit weight (55.43 g) was recorded in NA 20 and minimum (5.89 g) in BSR 1. Maximum fruit length (3.33 cm) was recorded in NA 20 and fruit breadth (3.70 cm) in Chakaiya, whereas minimum fruit length (1.87 cm) and breadth (2.28 cm) were recorded in BSR 1. The results are in line with Singh et al. (2017) in their study on evaluation of aonla cultivars. The variability among the qualitative characters may be due to their different genetic makeup and it was also observed by Nagar et al. (2017) in bael. The variation among the growth parameters might be due to particular germplasm/ cultivar character. Increased fruit weight might be attributed to the character of genotype. The

weight and size of the fruits might be also related to the bearing habit and yield of that variety (Malshe et al. 2016). Similar kind of results in aonla was reported in past by Ghosh et al. (2013) in laterite soil of West Bengal.

The maximum TSS (18.32ºB) was recorded in BSR 1 being at par with G 1 (17.48ºB), whereas minimum TSS (9.17ºB) was recorded in NA 7. Maximum acidity (2.63%) was recorded in NA 10; which was at par with G 1 (2.48%) and minimum (1.92%) in NA 6. TSS: acid ratio was observed maximum (7.71) in BSR 1, followed by CHES 1 (7.34), however it was recorded minimum (4.09) in NA 7. Ascorbic acid was recorded maximum (567 mg/100g) in Chakaiya; followed by NA 7 (514 mg/100g) and minimum ascorbic acid (323 mg/100g) was recorded in BSR 1. The variation in the chemical constituent might be associated with the varietal characters and prevailing soil and climatic conditions in that locality (Malshe et al. 2016). Similar results were also observed by Singh et al. (2017) in aonla and Nagar et al. (2017) in bael.

Maximum yield per plant (102 kg) was recorded in NA 20; followed by NA 7 (90 kg) and minimum (36 kg) in BSR 1. Yield per unit plant volume was observed maximum (1.04 kg/m^3) in NA 7, however it was minimum (0.24 kg/m^3) in G1. Plant yield per unit canopy area was observes maximum (5.77 kg/ m^2) in NA 10 and minimum (1.56 kg/m^2) in BSR 1. The yield per unit volume was calculated to know the fruiting intensity on the plant and yield per unit canopy area was calculated to find out the variety suitable for increasing the yield with the increase the population pressure as well as adopting the variety suitable for more yields per unit area. The yield per plant and hectare was observed maximum (102 kg and 28.34 MT/ha) in NA 20, however, yield per unit canopy area (5.77 kg/m^2) as well as per unit plant volume (1.04 kg/m^3) was observed maximum in NA 7 because the planting was done at equal spacing but the plant spread EW and NS was observed less in NA 7. It means the plants of NA 7 can be recommended in high density planting.

Conclusions

The variety NA 7 can be recommended on the basis of yield per unit canopy area as well as yield per unit plant volume as it is the era of high density planting and land holding is also decreasing so this cultivar is having the capacity to produce more in reduced land holding. There is a more pressure of yields per unit area to meet out the demand of increasing population. However, fruit size and yield per ha was reported more in NA 20. Qualitative parameters such as TSS, acidity and ascorbic acids were found highest in BSR 1, NA 10 and Chakaiya, respectively. All the varieties were evaluated for different parameters so the breeder or grower can select as per their need.

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Table 1. Physiochemical properties of the soil of aonla orchard.

Soil Type:	Loamy Sand
Salt 1: 2 (dSm-1)	0.19
Organic carbon (%)	0.25
Available phosphorus (kg/ha)	13.6
Available potas (kg/ha)	192

Table 2. Plant growth parameters of aonla cultivars (average data 2017-18, 2018-19, 2019-20).

Cultivars	Plant Shape	Plant Height (m)	Plant Spread-EW (m)	Plant Spread-NS (m)	Stem Girth (cm)	Plant Volume (m^3)	Plant Canopy Area (m^2)
CHES 1	Spreading	5.69	4.58	4.44	46.45	90.9	15.98
Chakaiya	Spreading	4.90	5.57	5.88	59.76	126.1	25.74
Krishna	Spreading	5.72	6.58	6.46	62.91	191.1	33.40
NA 6	Spreading	6.32	5.56	5.85	67.06	161.5	25.56
NA 7	Spreading	5.56	4.47	4.44	54.56	86.8	15.59
NA 10	Spreading	5.95	5.40	5.53	59.23	139.8	23.48
NA 20	Drooping	6.30	5.81	6.07	78.62	174.6	27.72
G 1	Upright	6.70	7.15	7.53	95.37	283.9	42.35
BSR 1	Spreading	5.30	5.28	5.56	46.96	122.4	23.08
CD (P=0.05)	--	0.39	0.97	1.02	4.32	14.6	1.50
Range	--	4.90-6.70	4.47-7.15	4.44-7.53	46.45-95.37	86.8-283.9	15.59-42.35

EW=East-West, NS=North-South

Table 3. Morphological and physical characteristics of aonla germplasm under semi–arid conditions of Haryana (average data 2017-18, 2018-19, 2019-20).

Germplasm	Fruit Shape	Fruit Base (Cavity at stem end)	Fruit Apex	Fruit Weight (g)	Fruit Length (cm)	Fruit Breadth (cm)
CHES 1	Flattened round	Absent	Flat	15.36	2.43	2.94
Chakaiya	Flattened round	Shallow	Flat	35.47	3.28	3.70
Krishna	Triangular	Deep	Flat	27.82	3.18	3.47
NA 6	Flattened round	Shallow	Papillate	29.89	3.12	3.40
NA 7	Oval	Flat	Flat	28.06	3.31	3.43
NA 10	Flattened round	Flat	Flat	21.99	2.95	3.24
NA 20	Round	Shallow	Flat	55.43	3.33	3.51
G 1	Flattened round	Shallow	Depressed	13.80	2.46	2.84
BSR 1	Flattened round	Flat	Papillate	5.89	1.87	2.28
CD (P=0.05)	--	--	--	4.35	0.33	0.32
Range	--	--	--	5.89-55.43	1.87-3.33	2.28-3.70

Table 4. Physico-chemical parameters of aonla cultivars (average data 2017-18, 2018-19, 2019-20).

Cultivars	TSS (°B)	Acidity (%)	TSS: Acid Ratio	Ascorbic Acid (mg/100g)	Yield/Plant (kg/plant)	Yield (MT*/ha)	Yield (kg /m^3)	Yield (Kg/m^2)
CHES 1	15.05	2.05	7.34	443	48.67	13.52	0.54	3.05
Chakaiya	10.56	2.34	4.51	567	70.00	19.45	0.56	2.72
Krishna	10.62	2.19	4.85	494	65.33	18.15	0.34	1.96
NA 6	11.17	1.92	5.82	377	87.33	24.26	0.54	3.42
NA 7	9.17	2.24	4.09	514	90.00	25.00	1.04	5.77
NA 10	14.19	2.63	5.40	473	83.33	23.15	0.60	3.55
NA 20	13.04	2.24	5.82	453	102.00	28.34	0.58	3.68
G 1	17.48	2.48	7.04	427	68.67	19.08	0.24	1.62
BSR 1	18.32	2.38	7.71	323	36.00	10.00	0.29	1.56
CD (P=0.05)	0.92	0.28	0.55	14.2	9.0	2.0	0.85	0.52
Range	9.17-18.32	1.92-2.63	4.09-7.71	323-567	36-102	10.00-28.34	0.24-1.04	1.56-5.77

TSS=Total Soluble Solids, MT=Metric Tons

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