Genetic Resources of Aonla (*Emblica officinalis* Gaertn.)

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Aonla tree has gained great socio-economic impact in large part of the country. It has significant contribution to improvement of economic status of farming communities through commercial orcharding, nursery production and processing of herbal respect of fruit size, maturity period and yield per plant. Due to predominance of seedling propagation India holds rich genetic diversity in cultivated and their wild relatives of aonla. Genetic erosion status of these resources is constantly high due to severe deforestation, natural calamities and adoption of a few popular cultivars in the selected pockets. However, enormous variability in aonla still remains unexploited and awaits proper attention on exploration, collection and maintenance to conserve genetic diversity available in the nature. Besides cultivated species of *Emblica (Phyllanthus)*, some other available species can be utilized in aonla breeding programme to infuse hardiness into the offspring for adverse habitat. This paper discusses the diversity region, extent of variability with respect to quality, fruit character, germplasm holdings, evaluation and selection of genotypes, etc.

Key words: Aonla, Diversity, Genetic resources, Germplasm

Exploitation of the potential of under utilized fruit crops will not only benefit the countries in which they are produced, but also cater to the increasing demand for exotic products in the developed world. Thus resolving the problems associated with these crops is a global challenge that needs to be addressed collectively. Aonla has been regarded as a sacred tree in India. The tree is worshipped as mother earth and is believed to nurture humankind because the fruits are very nourishing. It is also known as amritphal and mainly recognized due to its high nutritive, medicinal and therapeutic properties. It contains high amount of vitamin-C (500-1500mg/100g), it is also rich in pectin, iron, calcium and phosphorus. Dried fruits of aonla can be is used in curing hemorrhage, diarrhea, chronic dysentery, diabetes, jaundice, dyspepsia, cough etc. Recently, aonla has gained more popularity in arid and semi-arid region of the country because of its hardy nature, prolific bearing capacity and ability to grow under various adversities as a remunerative crop (Shukla *et al.*, 2002). It may be an important fruit in future due to its high productivity, suitability in wasteland particularly salt affected soil and sandy soil of arid ecosystem. Aonla is the main ingredient of *Chyavanprash* and *Triphala* powder, which is used for curing different abnormalities. The fruit contains a chemical substance galic acid and leucoanthocyanin, which have antioxidant property.

However, production of aonla is besieged with certain problem viz. Variable sex ratio, fruit dropping, prolonged fruit bud dormancy, shy and alternate bearing, fruit necrosis, ring rust and fruit rot diseases, post harvest losses, poor quality of value added products and lack of marketing facilities. Keeping in view its vast potential and significance to export trade there is need to make efforts for efficient management of aonla post harvest technology for improving the productivity and utilization of quality produce of aonla.

Composition

S.No.	Components	Quantity
1	Vitamin-C (mg/100g)	600-1100
2	Vitamin-A(I.U.)	10-100
3	TSS (%)	10-25
4	Acidity (%)	1.5-2.5
5	Total sugar (%)	3.5-5.5
6	Reducing sugar (%)	2.0-4.0
7	Pectin (%)	2.5-3.5
8	Phosphorus (Fresh weight, mg)	1.5-2.5
9	Phosphorus (Dry weight, mg)	7.5-15.0
10	Sulphur (Fresh weight, mg)	7.0-20.0
11	Sulphur (Dry weight, mg)	20.0-80.0
12	Iron (Fresh weight, mg)	10.0-20.0
13	Iron (Dry weight, mg)	50.0-100
14	Total minerals (Fresh weight, %)	0.35-0.70
15	Phenols (Dry weight, %)	2.0-4.0
16	Pulp (%)	80-95
17	Fibre (%)	0.8-2.5
18	Seed (%)	3.5-8.0
19	Dry matter (%)	12.0-20.0
20	Juice (%)	45.0-78.0

Taxonomy

Aonla (*Emblica officinalis* Gaertn.), which is also known as Indian gooseberry, myrobalan and emblic, belongs to the family Euphorbiaceae which comprises about 350 (Hooker, 1973) to 500 species (Bailey, 1917) mostly shrub, few herb or tree. It bears two types of shoot. On the basis of growth characteristics, these have been categorized as long or indeterminate (Bajpai, 1965). The indeterminate

shoots are longer and continue to put forth new growth in the season. The determinate shoot appears on the nodes of indeterminate shoots and their numbers at each node may vary from 3-5 in different cultivars. These determinate shoots bear small sized leaves (9-14 x 2-4 mm), which are of simple type. Flowering in aonla takes place during March-April under hot arid conditions and in the month of February in Uttar Pradesh on newly emerged determinate shoots. However, there are two prominent cropping season in South India i.e. July-August and April-May (Naik, 1963. The fertilized ovary of aonla is unlike those of other fruit plants, which remains dormant for 3.5 month and resume growth following division in endosperm and zygote nuclei in the month of August. The fruits mature some times in December under hot arid ecosystem of Rajasthan. Other related species *Phyllanthus acidus* commonly known as star gooseberry is grown for ornamental purposes. In arid and semi arid conditions aonla is observed to be deciduous in nature due to abscission of determinate shoots during January -February. Generally, it bears two types of shoot i.e. determinate and indeterminate shoot. The indeterminate shoots are longer and continue to put new growth in the season while flowers are borne in the axil of the leaves on determinate shoot as axillary cymules. In North India, senescence /leaf shedding of aonla plants begin in the month of February and complete shedding of determinate shoots takes place in the end of February to mid of March. The new shoots emerged out during first week of April (Bajpai, 1965, Ram, 1971 and Shukla *et al.,* 2004a). The flowering occurs twice in a year, February- March and June-July (Naik, 1963). In aonla male flower appears first in the axil of leaves at the distal end of same shoot. The percentage of female flower varies from 1.12 to 8.33 depending upon varieties. Aonla is higly cross pollinated crop due to its monoecious nature and pollination takes place through wind, honey bees and gravity (Reddy and Janki Bai, 1979). The common visiting hours of honeybees is late evening and morning (Bajpai, 1957). Fruit setting can be increased up to 18-28 per cent by hand pollination. However, Pathak and Pathak (1993) did not notice any fruit set for a number of years in some isolated Banarasi aonla plant even after profuse flowering. It indicates the presence of self-incompatibility in this cultivar. A gene controlled natural incompatibility system is held responsible for unfruitfulbess in some aonla cultivars. Infromation related to narrow and broad based heritability of desirable traits is still lacking. Preliminary observations indicated that yeild attributing traits are poligenically inherited as crosses between large and small-fruited types failed to produce any set segregation pattern in the progenies with respect to fruit size and related attributes.

Genetic resources

Aonla is a hardy friut plant, which can be successfully grown under various agro-edaphic situations. It is said to be indigenous to tropical south-eastern Asia particularly in central and southern India (Firminger, 1947). It is also reported to be the native of India, Sri Lanka, Malaysia and China. Aonla thrives well throughout Tropical India and is met with wild or cultivated species in the region extending from the base of Himalaya to Sri Lanka and from Malacca to south China. In India, aonla is widely grown in Uttar Pradesh, Gujarat, Rajasthan, Madhya Pradesh Tamil Nadu etc. The seedling aonla plants are commonly observed in Vindhyan hills, Northern hills region (Garo, Khasi and Jaintia hills) and also in North-western Himalayan region up to the elevation of 1350 m above msl. Besides, the potential areas for aonla diversity is Andhra Pradesh (Vizag), Gujarat (Anand, Nadiad), Madhya Pradesh (Panna), Maharashtra (Ajanta, Akola, Bhandara, Buldana, Chandrapur, Jalgaon, Kolhapur, Ramtek, Satara and Yoetmal), Tamil Nadu (Annamalai, Azhakiapandiapuram, Khrayamttels, Krishnagiri, Nilgiri hills, Panpozhil, Salem and Siruwani hills), Uttaranchal (Kumaon hills), Uttar Pradesh (Azamgarh, Bareilly, Pratapgarh, Raebareli, Sultanpur and Varanasi). In aonla variability exists in seedling population in respect of fruit size, maturity period and yield per plant. In fact seed germination is not a problem therefore, great genetic variability is being found for desirable economic traits in aonla growing areas of the country. Besides cultivated species of *Emblica* (*Phyllanthus*), some other available species can be utilized in aonla breeding programme to infuse hardiness into the offspring for adverse habitat. Recently, an exploration was conducted in parts of hill ecosystem of Himachal Pradesh, where it was found that there is ample scope for selection of frost tolerant/resistant types, although the fruit size was smaller but plants are more hardy than exiting commercial varieties (Shukla and Dhandar, 2003). Further, Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Jharkhand and NEH region are hunting ground for aonla variability.

Genetic variability regions

Aonla is found in dry deciduous forest of India except in extreme North-west ascending to 1450m in Himalayas.

Centres	No. of collections
Abohar	–
Anantpur	15
Arrupukottai	15
Bawal	06
Bikaner	–
Bangalore	–
Faizabad	22
Jodhpur	03
Jobner	06
Mundra	–
Rahuri	08
SK Nagar	12

* Source: Status of genetic resources of aonla at AICRP centers (Saroj and Awasthi, 2004)

State/Region	Diversity Areas
Andhra Pradesh	Vizag, Anantapur
Gujarat	Anand, Nadiad, Surendranagar
Rajasthan	Ajmer, Jaipur, Kota, Churu, Hanumangarh, Alwar, Jaisalmer
Maharashtra	Akola, Bhandara, Buldana, Chandrapur, Jalgaon, Kolhapur
Tamil Nadu	Salem, Dindigul, Tuticorin
Uttar Pradesh	Vindhyan hills, Bundelkhand, Allahabad, Mirzapur, Sonbhadra, Mathura, Agra, Etawah, Mainpuri
Madhya Pradesh	Bhopal, Gwalior, Shivpuri, Indore, Sheopur, Betul, Hoshangabad, Balaghat, Satna, Sidhi, Panna
North-western Himalaya	Jammu & Kashmir, Himachal Pradesh, Uttaranchal up to 1500m above sea level
North-eastern Himalaya	Assam, Meghalaya, Manipur, Tripura, Khasi hills, Mizoram

Conservation and evaluation of elite genotypes at different centres

Organizations	Accession No.	References
Dryland Agril. Research Station, Anantapur, A.P.	12	Pareek, 1998
Agril. Research Station, Arrupukottai	05	Pareek, 1998
Dryland Agril. Research Station, S.K. Nagar, Gujarat	12	Pareek, 1998
NDUAT, Faizabad	21	Pareek, 1998
GBPUAT, Pantnagar	10	Ram, 1993
CIAH, Bikaner	43	Shukla *et al.*, 2004
NBPGR, New Delhi	05	Anonymous, 1999
CISH, Lucknow	12	Pathak *et al.*, 2003
MPKV, Rahuri	06	Karle, 2000

It is also found in Sri Lanka, USA, Cuba, Iran, Pakistan, Iraq, China, Malaysia, Thailand, Philippines, Vietnam, Trinidad, Japan, etc. This crop has extensive adaptability to grow under diverse climatic conditions ranging from non-tropical plains to humid sub tropical mid elevation hills. The forests have been traditional source of aonla for medicinal uses estimated to be 41000 tonnes. Out of this about 35000 tonnes of aonla is collected from the forests of Madhya Pradesh. Increasing demand from industry, especially for Ayurvedic formulation and appreciation of nutraceutical and medicinal properties for its house hold consumption has resulted in growing of this tree as cultivated crop. Initially, it was grown as seedling tree having large variability coupled with long gestation period. Higher economic return from the crop, coupled with increasing demand had led to commercialization of aonla across the country. Aonla has great potential for its export to meet the growing demand of health conscious population. Further, Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Jharkhand, and NEH region are hunting ground for aonla variability. Besides, hill and mountain ecosystem viz., Vindhyan hills, Himachal Pradesh are areas where tremendous variability was found.

Range of variability in plant characters

Aonla being highly cross pollinated crop seedling plants depict heterozygosity in morphological and physiological traits of tree.

A. Plant phenology

Plant height	5-10 m
Canopy spread	4-6 x 3-5 m
Girth	40-100 cm
Lengths of determinate shoot	10-25 cm
Size of leaf	2-4 cm
No. of fruit/shoot	5-15
No. of viable shoots/branch	20-40
No. of female flower/shoot	5-15
Fruit yield (kg/tree)	50-150
Period of fruit availability	October-January
Flowering period	February-April

B. Fruit characters

Fruit colour	Apricot yellow-Reddish yellow
Fruit weight	26-40 g
Fruit size	2.27-4.10 cm
Pulp weight	24-38 g
Pulp content	89-95%
Pulp thickness	1.5-2.10 cm
Stone weight	1.12-2.27 g
Stone length	1.1-2.1 cm
Stone width	1-1.7 cm
Stone content	5-13%
Seed number	4-8
Seed content	0.015-0.056%
Number of segments	5-8
Seed weight	0.2-0.5 g

C. Variability for quality

Vitamin-C	568-950 mg/100g
Dry matter	12-25%
TSS	10-24%
Acidity	1.1-2.23%

Ideotypes of aonla

Plant traits	Dwarf, regular in bearing, precocity in bearing, wider adaptability, early and late maturity
Fruit yield	High
Fruit quality	Surface colour, high vitamin-C
Seedlessness	Small-sized
Resistance to physiological disorders	Disorders like necrosis and misshapen fruits
Fruit weight	>38 g
Fruit length	>4 cm
Fruit width	>4 cm
Fruit shape	Oval to oblong
Acidity	3.5<
Vitamin-C	>550 mg

Utilization of Genetic Resources

Most of the plantations have been raised from seed. Therefore, these exist a great variability. Some named cultivars like Banarasi, Francis (Hanthijhool), Chakaiya and Bansi Red are known to be the natural selections, which got acclimate in specific agro climate zones and they possessed some merits and demerits. For instance, Banarasi is early maturing but shy bearer (less number of female flower/branch let) and prone to heavy dropping of friuts with poor shelf life. Francis suffers from severe incidence of fruit necrosis and Chakaiya fruits are fibrous, small in size with tendency to bear heavy crop in alternate years. Besides these natural selections new selections have been identified at NDUAT, Faizabad and are released for commercial cultivation. These are Kanchan-NA4 and Amrit-NA6 (selection from Chakaiya), Krishna and Neelam-NA7 (selection from Banarasi) and Balwant or Agra Bold-NA10 (selection from Banarasi). Similarly in Gujarat, Anand1, Anand 2, Anand 3 from seedling population availble in the area are new promising types. In the early the years there was no improved cultvars of aonla. Some popular types were named after locality of their occurrence, plant type and fruit colour, Banarasi, Chakaiya, Hathijhool, Green tinged, Red tinged, White streeked, and Bansi red, being grown among them.

Germplasm survey, collection and evaluation work on aonla was initiated at the Narendra Dev University of Agricultural and Technology, Faizabad during 1982-83. Nenteen germplasm including 10 in fruiting stage are being maintained at this university. Considerable variability in fruit shape (round, flattened, round and triangular); length (3.91-2.90cm); width (4.50-3.50cm); fruitweight (50.55-26.91g); number of segments (6); fruit colour (whitish-green to apricot-yellow, yellowish green, light green with pink tinge, pink); seed size small to large; flesh colour whitish green to pink; fibre more to less; TSS (8-14%); acidity (1.9-2.5) and ascorbic acid 422-600mg/100g pulp have been observed with available genotypes. Diversity in vegatative growth (upright, spreading, drooping; flowering (February end to first week of April); sex ratio (1: 28- 1:355); fruit maturity and productivity have also been observed with these genotypes.

Some Promising Selections

Banarasi : It is developed through seedling selection from Varanasi district of U.P. It is shy bearing in nature due to less number of female flowers and presence of self incompatibility. It is rich in vitamin-c. It is an early maturing variety and mild susceptible to necrosis.

Francis : It is seedling selection popularly known as Hathijhool. The branches are dropping habit, moderate bearer, and greenish yellow fruit, nearly fibreless and highly susceptible to necrosis.

Chakaiya : It is also seedling selection having spreading growth habit. It contains fibrous fruits with six segments. It is late maturing variety and free from necrosis.

Krishna : This is chance seedling of Banarasi from Pratapgarh. It is early maturing var.shy bearing habit, pinkish green flesh and less fibrous.

Important merits and demerits of aonla genotypes

Variety	Breeding method	Merits	Demerita
Banarasi	Seedling selection	Bold size, upright growth, high vitamin-C	Less number of female flower, self-incompatability, shy bearer
Francis	Seedling selection	Large fruit size	Susceptible to necrosis, drooping growth habit
Chakaiya	Seedling selection	Profuse fruiting	More fibre content
Krishna (NA-4)	From Banarasi	large fruit	Shy bearer
Kanchan (NA-5)	From Chakaiya	Regular bearer, preferred by industries	Small size fruits
NA-6	From Chakaiya	Less fibre content	Fruit cracking/misshapen fruit
NA-7	From Francis	Free from necrosis, prolific bearer	Limb breakage
NA-10	Banarasi	Bold fruit	Moderately susceptible to necrosis

Kanchan: It is believed to be a chance seedling of chakaiya. It is spreading growth habit and bears profusely; fruit is yellowish in colour and suitable for pickle preparation.

NA-6 : It is chance seedling of Chakaiya. It is semi-spreading growth habit, light green colour of fruit, good keeping quality, late maturing, moderate bearer and free from necrosis.

NA-7: It is seedling selection from open pollinated strain of Francis. It is precocious and prolific bearer, mid season, free from necrosis and suitable for preserve making.

NA-8 : It is chance seedling of Chakaiya. It is upright growth habit, late maturing, moderate bearrer, susceptible to necrosis and good keeping quality.

NA-9 : It is seedling selection from open pollination strain of Banarasi. It is semi spreading growth habit, moderate keeper, early, shy bearer and susceptible to necrosis.

NA-10 : It is chance seedling developed from Banarasi locally known as Agra Bold. It is semi spreading growth habit, yellowish green with pink tinge, highly astringent, good keeping quality, early, moderate bearer and moderately susceptible to necrosis.

Balwant: It is developed through selection from Banarasi at RBS College, Agra, UP. It is prolific bearer, semi spreading growth habit, moderate bearer and good keeping quality.

Anand- 1 : It is developed at GAU, Anand. It is moderate bearer.

Anand- 2 : It is also developed from GAU, Anand. It is prolific bearer, fair keeping quality.

Laxmi-52 : It is developed from CISH, Lucknow.

Genetic improvement

Selection

Most of the Indian varieties are developed through selection. Major research work in this direction is being done at NDUAT Faizabad, GAU, SK Nagar, RBS College, Agra etc. Recently, some cluster bearing and coloured genotypes has been identified through exploration in Rajasthan, which will be further evaluated at national repository of aonla at CIAH, Bikaner. While selecting new ideotypes some important plant characteristics are kept in mind i.e., plant height, vigour, growth habit, precocity, fruiting intensity and fruit size, etc.

Hybridization

In order to get combination of highly desirable traits in one cultivar a systematic crossing programme is essential. There is an apperent need to create some genetic combination by fusion of segregating gametes of the seedling population. While sexual progenies may have comparatively low mean performance related to the parental clone, the range in the performance of the progeny can greater with some individual exceeding the performance of the best parent. Such transgressive sergeants having both good genes and better combination of genes can be selected and propogated asexually. These superior individual can become variety or may be used as superior parental clones in future breeding programme. Occurance of xenia effect between Chakaiya x Krishna, Banarasi x NA-9, Francis x NA-7, Kanchan x NA-6 and NA-6 x NA-9 for fruit size and weight were reported from the crosses. (Srivastava and Pathak 1993).

Mutation

In India, research work related to application of mutation in aonla is almost negligible but there is greater prospect to develop coloured varieties through induced mutation and selection from bud sport.

Polyploidy

Exact ploidy level is not known in aonla but it is realised that aonla is characterized by polyploidy behaviour in composition of chromosome. The structural and numerical changes in chromosome can be made through application of colchicine, which is found to be useful for getting small seeded fruit or seedlessness. Keeping in view the usefulness of polyploidy breeding, these principles may applied in aonla to obtain desirable economic attributes.

Major problems in aonla

- Since, aonla is highly heterozygous plant, therefore, large size of population is required for selection
- It has long generation cycle i.e., 2-8 years, depending upon species and varieties
- Lack of recombination
- Long juvenile phase prohibiting early assessment of strain
- Presence of self-incompatibility
- Frost susceptibility
- Lack of knowledge on inheritance pattern

Strategies

- Varietal development for wider geographic adaptability.
- Varieties suitable for export and based on market demand.

- Resistant to frost. Rust disease and drought.
- Development of varieties with less fiber content and good pollinating variety.
- Varieties with high sex ratio with more number of female flowers.

Future line of work

- Development of varieties with high percentage of female flowers.
- It is desirable to breed colored variety as its demand in the trade market would be more in comparison to traditional varieties.
- Exploitation of heterosis (hybrid vigour).
- To evolve variety with very small stone size.
- Development of variety suitable for export purpose.
- Development of transgenic aonla through biotechnological tools.
- Breeding for resistant to frost, biotic and abiotic stresses.

Acknowledgements

Authors express their sincere thanks to Director, NBPGR, New Delhi and CCPI, NATP Plant Biodiversity at CIAH, Bikaner for providing necessary help in conducting explorations.

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