



Importance of Genetic Diversity of Underutilized Fruits of Arid and Semi-Arid Regions

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Dry-land horticulture has immense potential in providing nutrition, social security and eco-restoration for the inhabitants of desert or rainfed and tribal land-areas of hot arid and semi-arid regions of the country. Realizing the importance and visionary support, Indian Council of Agricultural Research (ICAR) had prioritized research with few fruits in 1976 and then AICRP on arid zone fruits was started from 1978 with crop based centers in hot-spot region and this strengthen resulted to giving rise of Central Institute for Arid Horticulture in 1993 as national concern for conservation and use of arid crop-plant diversity and their promotion for horticultural exploitation. Arid lands the "dry domains" of India occupy nearly 12% of the total area of the country located in the states of Rajasthan (62%), Gujarat (20%), Andhra Pradesh (7%), Punjab (5%), Haryana (4%), Karnatak (3%) and Maharashtra (0.4%). Production system in these region faces several biophysical constraints (high solar radiation, low and erratic rainfall, high wind velocity, poor soil conditions etc.). Availability of irrigation water and irrigation potential in these regions are meager. These fruit trees possess xeric characters, high 'bound water' in the tissues, reduced leaf area, deep tap root system and complete maximal vegetative growth and reproductive phase during the period of maximum water availability. There is ample scope for these drought tolerant and low input requiring crop-plant and for this there is rich reserve of considerable genetic variability which exists in species from *Thar* desert and tribal areas of the north-western India, which can yield fruits for fresh consumption, products of horticultural and nutraceutical values. Thus, their systematic exploitation and commercialization can not only provide food security but also ensure economic stability in rural masses in vast arid and semi-arid and/or tribal dominating sub-humid areas.

Importance of underutilized fruit crops

- Provide variety of products that include food, fodder, fuel wood, gums, resins, fibre, medicine etc.
- Easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions.
- Most of them are very rich sources of vitamins, minerals, and other nutrients such as carbohydrates, proteins, fats and nutraceuticals.
- Cheap and readily available.
- Vital source of genes against biotic and abiotic stresses.
- Low input requiring crops.
- Produce higher biomass than field crops per unit area resulting in efficient utilization of natural resources.

- Can help achieving ecological security through improvement of wastelands by preventing soil erosion, improving fertility of soil and promoting biodiversity.

Aonla (*Emblica officinalis* Gaertn)

Aonla or emblic or Indian gooseberry (*Phyllanthus emblica* L. syn. *Emblica officinalis* Gaertn.) is indigenous to India and therefore its variability is widespread (Pareek and Sharma, 2009). The types that were commonly grown earlier are Banarsi, having vigorous and spreading growth habit, Chakaiya, having more upright growth habit and Hathijhool (Francis) trees having drooping growth habit but suffer from the malady of fruit necrosis. Cultivar Chakaiya is observed to be free from this malady. The recent promising seedling selections made in Uttar Pradesh are Krishna, Kanchan, NA 6, NA 7 (Neelum), NA 8, NA 9, Balwant (Agra Bold), etc. Selections Kanchan and NA 6 are believed to be variants of Banarsi. NA 7 is a precocious and high yielding selection made from the seedling population of Francis but is free from necrosis. Selections made in Gujarat are Anand 1, Anand 2 and Anand 3. The selection Goma Aishwariya is early and drought tolerant. The Indian gooseberry is an indigenous and important minor fruit. It belongs to the family *Euphorbiaceae*, and it is grown in diverse soil and climatic conditions of India. The medicinal and therapeutic properties of aonla are considered as ‘*amritphal*’ or a wonder fruit for health. It is the richest source of Vitamin C (500 - 1800 mg/100 g) among the fruits after Barbedos cherry, and the content in leucoanthocyanins polyphenols, pectin, iron, calcium and phosphorus makes its fruit largely used in Ayurvedic medicines for making *Triphala* and *Chyavanprash*. It is hardy, productive and highly remunerative even when managed without much care under drought and saline areas of arid and semi-arid regions. The aonla fruit is highly perishable, acidic and astringent; consumers do not prefer them for fresh consumption, whereas aonla fruit is generally used to prepare a number of delicious, processed food products, such as preserve, candy, jelly, toffee, pickle, leather, squash, juice, RTS beverage, cider, shreds, dried powder and ayurvedic tonics, such as Chayvanprash, Triphala, Amrit Kalash and Amol Ki Rasayan.

Phalsa (*Grewia subinaequalis* DC.)

Phalsa is a drought tolerant and suitable crop for cultivation in wasteland and salt affected soil. Despite the various traits, the popularity of this fruit is restricted owing to its perishable nature, small size of fruit and non-synchronous maturity, which necessitates repeated harvesting. *Grewia* has 140 species, out of which 40 are reported in India. Among them, *G. subinaequalis* is the only species of commercial importance. Other edible species are *G. Damine* Graerth., a small tree, found in Rajasthan, Bihar and drier parts of South India; *G. elastic* Royle, found in the sub Himalayan tract, Central India and western Ghats; *G. Flavescens* Juss., in upper Gangetic plains, Bihar and central and southern India; *G. hirsuta* Vahl., in warm parts of India ascending to sub Himalayan tract; *G. rothi* DC., in peninsular region; *G. sapida* Roxb., in North western India eastwards to Assam hills and also in Eastern Ghats.. About 187 accessions of phalsa have been assembled through explorations. Some local selections have been named as Local, Sharbati, Tall, Dwarf, etc. Dwarf type is more productive and juicy.

Bael (*Aegle marmelos* L.)

The bael or Bengal quince (*Aegle marmelos* L.) is indigenous to India and considerable variability exists in Uttar Pradesh, Bihar and West Bengal States where as a result of seedling selection, cultivars such as Mirzapuri, Darogaji, Ojha, Rampuri, Gorakhpur, Azamati, Khamaria, Varanasi, KaghjiGonda, KaghjiEtawah and Deoria Large were developed. Genetic resources of bael have been maintained at NDUAT, Faizabad (23 accessions), CAZRI, Jodhpur (5 accessions). Some superior selections such as NB4, NB5, NB7 and NB9, which produce good quality fruits of medium size, having low fibre and mucilage, have been made.

Three promising lines, Basti Collection-1, Basti Collection-2 and Basti Collection-4, superior in physico-chemical characters, have also been identified. Few promising cultivars such as Pant Aparna, Pant Sujata, Pant Shivani and Pant Urvashi have been developed from Pantnagar. Recently new cultivar GomaYashi have been developed by CIAH-CHES, Godhra. Bael has a wide distribution in various ranges of edaphic-climatic conditions due to its ability to withstand heat, drought and low-temperature poor-nutrient soil. It is deciduous, medium-sized, slender, gum bearing with a cauliflorous fruiting habit, deep tap root system, bold thorny branches and trifoliolate leaves. Its trifoliolate leaves resemble a trident, so people offer them to Lord Shiva Lingam to get rid of worry and suffering. Bael can be used as avenue and ornamental trees (golden color ripen fruit); shells of the dried fruit after removing pulp are used as fashioned cups, small containers, ornamental pills, snuff boxes, etc.. The bael fruit is a rich source of riboflavin used to cure beriberi, and unripe fruit is suggested to treat diarrhea and dysentery, whereas the marmelosin in fruit has therapeutic properties being a good remedy for stomach ailments. However, all plant parts of bael contain various compounds with medicinal values, e.g., coumarins, alkaloids, sterols and essential oils, that have analgesic, antipyretic, anti-inflammatory, anti- antifungal, microfilaria, hypoglycemic, anti dyslipidemic, antiproliferative, wound healing, insecticidal and anti-fertility abilities. Bael fruit is consumed only in processed products, such as powder, preserve, nectar, toffee. These products have had high market demand during the COVID-19 pandemic period due to its ayurvedic medicinal values. Their current price in the market is high and for this reason, bael is becoming a remunerative crop for farmers of arid and semi-arid areas.

Ber (*Ziziphus mauritiana* Lam.)

ber or Indian jujube (*Z. mauritiana* Lam.) is indigenous to India and thus a wide variability of its genotypes exists throughout the Indian subcontinent. arid-zone fruits or as poor man' s apple. The ber tree is fast growing and has a spreading canopy and a short bole; branches are slender, downy, brown bold spines in pairs. The ber tree is extremely drought-hardy due to the deep taproot system and xerophytic characteristics, such as (a) dormancy (leaf shedding) during the peak period of hot summer preventing transpiration, (b) waxy and hairy leaves, (c) thick bark. It grows well even in marginal or poor soils where most other commercial fruit trees either fail to grow or have very poor performance. The jujube seeds contain saponins, jujubogenin and obelin lactone. Jujube wood is utilized as fuel or charcoal making and its leaves are used as fodder for sheep and goats. The fruit has a spongy, sweet, tasty pulp and is an excellent source of vitamins C, A, B, carotenoids, protein, Ca, P, K, Rb, Br, La and sugars (fructose, glucose and galactose)

Annonas (*Annona* sp.)

Custard apple is one of the drought-hardy fruit plants belonging to the family *Annonaceae*, which is commercially cultivated in a limited area of the Indian Deccan plateau region. The light, gravel and small pebbles soil is also suitable for its cultivation. Custard apple plants are small, semi-deciduous shrubs with simple leaves, cauliflorous flowering, bisexual and protogynous flowers, superior ovary, fruit etaerio of berries (Nalwadi *et al.*, 1975). Its flower is borne mostly in new flushes after the shedding of old leaves commencing from March to August with a peak in April – May(Sahoo *et al.*,2000). The fruit is climacteric, it may be symmetrically heart-shaped, lopsided or irregular, and the interspaces between the protuberances become yellow at full maturity (Patil and Rothe, 2017). The demand of custard apple fruit is increasing in domestic and international markets thanks to their sensory, therapeutic and nutritional properties, as well as their pleasant flavor. Custard apple fruit contains vitamins A, B, C, E, and K1, essential minerals, antioxidants and polyunsaturated fatty acids. They are antimalarial, antifeedant, immunosuppressive, cytotoxic, diterpenes and are used to treat HIV (Liu *et al.*, 2015) Moreover, a range of cosmetic products using custard

apple is available in the market, such as perfumery, soaps, pimple creams, essential oils, hair lotions, ayur slim capsules, cold balms, anti-stress massage oil, pain massage oils, and foot care creams (Zahid *et al.*, 2018). Various species can be used as rootstocks to which desirable species can be grafted. Seedling rootstocks of annonas are generally derived from heterogeneous open-pollinated plants. *A. glabra* has dwarf characteristics and good adaptation to damp areas. *A. reticulata* can withstand diverse ecological conditions and survive long dry periods. It is very useful as a vigorous rootstock. It is well adapted to unfavourable soil conditions and can grow in soils having pH 5.0 to 8.0. Because of its high tolerance to variable soil types, it is considered to be a good rootstock for cherimoya and soursop. Each species will have a slightly different ideal type due to their inherent biological differences. For cherimoyas, early maturity, better fruit appearance and long post-harvest life for the tropics and greater cold tolerance in the subtropics are the main objectives (Nakasone and Paull, 1998).

Karonda (*Carissa carandus* L.)

On the basis of fruit colour, the cultivars of Karonda or Christ's thorn (*Carissa congesta* Wight. syn. *C. carandas* L.) have been classified as Green fruited, Pink fruited and White fruited. The shape and size of their fruits resemble very much. These also have variability in shape and size. There is, however, tremendous scope to select desirable types from the rich variability. Some promising clones such as K1, K2, K3 (Joshi *et al.*, 1986), No. 3, 12, 13 and 16 (Karale *et al.*, 1989) and 3 clones named as Pant Manohar, Pant Sudarshan and Pant Suvarna have been selected. The other related species is Natal plum or ciruela de Natal (*C. grandiflora* A. DC. *C. macrocarpa* (Eckl.) A. DC.). Germplasm collection consisting 3 *Carissa* species and 24 cultivars have been maintained at different centres in India (Anon., 1998). Thirty six accessions of *C. congesta* have been collected from parts of Rajasthan, Maharashtra and Karnataka. Areas for future explorations of Karonda are Uttar Pradesh (Varanasi, Mirzapur, Faizabad, Gorakhpur, Lucknow and Allahabad), Rajasthan (Jodhpur, Jaipur, Udaipur, Bikaner) and Maharashtra (Wardha, Jalgaon, Nagpur, manmad). Precocity in bearing, big fruit size, pink colour of skin and small seed should be looked for during germplasm collection. Accessions having high yield, large fruit size and high vitamin C content need to be introduced from South Africa. Genetic variability in plant growth, fruit size, shape and colour of Karonda has been reported (Bankar and Prasad, 1992; Bankar *et al.*, 1992).

Ker (*Capparis deciduas*)

Ker is an important fruit plant growing wildly on marginal land in arid region. Its raw fruits are consumed as vegetable and are used for pickling. The raw fruits are brined and sun dried to use it throughout the year. Dried ker fruits are sold at a very high price in domestic market and also have good export value. The fruits are dried either by blanching or by dipping in salt solution. The genus comprises of more than 300 species distributed throughout the warm regions of the world (Ushar, 1974). About 40 species occur in India, of which a few have economic importance and among them *Capparis deciduas* is most important. In India, it is found mainly in Rajasthan, Punjab, Haryana and Gujarat; Thar desert, arid regions of north-west plains and Deccan peninsula. Being an open pollinated plant, large variability occurs in seedlings for plant vigour, morphology, productivity and quality parameters. Thirty-five accessions of *Capparis* germplasm collected from parts of Rajasthan and Gujarat are conserved in cryobank at NBPGR. Recently, 33 accessions of *C. deciduas* were collected from Ahmadabad, Banskantha, Kutch, Gandhinagar, Mehsana, Morbi, Patan, Surendernagar districts of Gujarat and Sirohi and Jalore districts of Rajasthan. Variability in fruit colour and size has been recorded. Two distinct, tall and dwarf types have been identified at CCSHAU,

Hissar. The traits, big fruit size, small seed and long storage life need to be targeted during the collection.

Kumat (*Acacia senegal*)

Kumat much-branched thorny tree with pale smooth bark is known as Kumat or Kumata. It is commonly found on hillsides and stabilized sand dunes. It yields the true gum Arabic, which is an important commercial product and used in pharmaceuticals. Apart from gum production, seeds are used as food; leave & pods as fodder and wood for fuel wood and charcoal. It is hardy species surviving under most adverse conditions and an ideal for agro forestry systems. Its gum remains valuable article of trade and is one of the main cash crops of the desert region Central Arid Zone Research Institute (CAZRI). Jodhpur has developed a technology of inducing gum exudation by injecting ethephon solution into the main stem through a small size hole.

Lasoda

Lasoda (*Cordia myxa dichotoma* F.) is also known as Gonda or Lehsua or Indian cherry. Lasoda leaves have sunken stomata and other characters associated with drought tolerance. Plants are deciduous. Great variation exists in natural population with respect to morphological characters particularly plant height, spread, leaf size, fruit size and quality parameters like fruit colour, pulp content, seed/pulp ratio and pickling quality. Besides *Cordia myxa*, the other important species are *C. Gharaf* Forsk. (goondi), *C. rothii*, *C. macleodii*, *C. vestita* and *C. wallichii*. Goondi trees are of medium size having dense foliage with crooked trunk. It is a small-fruited type of lasoda bearing very small (about 1 cm) and orange to light pink fruits that are reported to have medicinal value. At CIAH, Bikaner 65 genotypes of lasoda have been collected. A collection of 45 genotypes has been reported by Saini *et al.* (2002) at CCS Agricultural University, Hisar. Two species of *Cordia* and 45 cultivars have been maintained in the repositories at different centres in India such as Kovilangulam, Kumarganj, Sardarkrushinagar, Jodhpur and Bichpuri (Anon., 1998). NBPGR Regional Station, Jodhpur and Central Institute for Arid Horticulture, Bikaner have identified some big fruited types of Lasoda having high productivity. A large fruited type Paras is known in Gujarat. Lasoda growing areas in states of Gujarat, Madhya Pradesh, Jharkhand, Chattisgarh and foothills of Uttarakhand can be targeted for further collections.

Pilu (*Salvadora leoides* Decne)

The genus *Salvadora* comprises five species of which *Salvadora leoides* Deene (pilu or toothbrush tree) and *S. persica* L. (Indian mustard tree or saltbush) are important. Considerable variability is found in nature. *Salvadora leoides* is distributed in arid regions of Punjab, Rajasthan and Gujarat and the other species *S. persica* L. is more common in other drier tracts of the country (Chundwat, 1990). *Pilu* is also known as kharijal, meetajal, mustard or salt bush, toothbrush tree, and belongs to the family *Salvadoraaceae*. It is a perennial, evergreen, large, much-branched shrub or tree widely found in Gujarat, Rajasthan, Haryana and Punjab and is suitable for the forestation of ravines, saline and alkaline lands as shelterbelts/windbreaks due to its hardy xerophytic nature. *Pilu* possesses a number of potentially therapeutic compounds, namely salvadoricine, salvadourea, β -sitosterol, trimethyl amine, thioglucoside, di-benzyl thiourea, rutin, potash, chlorine, sulfur, etc. *Pilu*'s fibrous branches are a natural toothbrush (Miswak) and thus are used for oral hygiene. They are also used in a number of important medicines, e.g., antiseptics, abrasives, detergents, astringents, fluorides, enzyme inhibitors, dental diseases, anti-tumors, anti-leprosy, anti-ulcers, anti-gonorrhoea, and antiscorbutic products.

Approaches to Exploit Genetic Resources

1. Interspecific hybridization: Crossing or mating between two different species of the same genus is referred to as interspecific hybridization. Because interspecific hybridization involves two species of the same genus, it is also termed as intrageneric hybridization. Main features of interspecific hybridization are given below: It is used when the desirable character is not found within the species of a crop. It is an effective method of transferring desirable genes into cultivated plants from their related wild species. Interspecific hybridization is more successful in vegetatively propagated species. Interspecific hybridization leads to introgression which refers to transfer of some genes from one species into the genome of another species.

2. Intergeneric hybridization: Intergeneric hybridization refers to Crossing or mating between two different genera of the same family. Such crosses are rarely used in crop improvement because of various problems associated with them. The main features of intergeneric crosses are given below:

Intergeneric hybridization is used when the desirable character is not found in different species of the same genus. This method is rarely used in crop improvement programme and that too transfer of some specific characters into cultivated plants from allied genera. Intergeneric hybridization has been generally used in asexually propagated species is more successful in vegetatively propagated species.

3. Embryo rescue: Embryo can abort after fertilization due to incompatibility with the endosperm and supporting maternal tissues of the ovule and or ovary. This may be overcome by removing young embryos from developing ovules and growing them aseptically in vitro on a culture medium into intact plants. This technique is called embryo rescue.

4. Somatic hybridization: Somatic hybridization refers to crossing of crop plants through fusion of somatic cells. In this method somatic cells are used for hybridization and the sexual process is bypassed. The fusion of somatic cells takes place through protoplasts. Somatic hybridization permits hybridization between any two plant species irrespective of their taxonomic relationship.

Transgenic: Genetically engineered organisms are referred as transgenic. In other words, a genotype developed by the process of genetic engineering is called transgenic. It may be a plant, an animal or microbes such as fungi, bacteria and viruses. Transgenic plants are obtained involving tissue culture and genetic engineering techniques.

Cisgenics: Cisgenics is the genetic modification of a recipient plant with a natural gene from a crossable -sexually compatible plant. Such a gene includes its introns and is flanked by its native promoter and terminator in the normal sense orientation. Cisgenic plants can harbour one or more cisgenes, but they do not contain any transgenes.

Future Outlook

There is need to:

- To understand the gene pool to identify taxa and a series of specific genotypes which can be of value as rootstocks.
- Evaluation of a large number of indigenous species so as to explore their possibility as rootstocks under different agro climatic conditions.
- To develop rootstocks which can control the overall tree morphology and its vigour and to maximise its adaptation to different edaphic conditions.
- Biotechnological tools may be applied to incorporate resistant genes in wanting commercial cultivars from the wild species relatives.

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