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Conserving Honey Bees with Forage Plant Mexican Creeper - *Antigonon leptopus*

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JOURNAL OF HORTICULTURAL SCIENCES

Volume 15 **Number 2** **December 2020**

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Short Communications

In this issue…

Hearty New Year Greetings from our Editorial Team to all the readers of JHS!

As the world is slowly coming out of glitches of pandemic, there is no other better way than celebrating 2021 as Year of Fruits and Vegetables as announced by United Nations Assembly to welcome the new year and recognize the importance of nutrition for better health. Fruits and Vegetables ensure the Nutritional Security to humankind. They play key role in addressing the malnutrition that is a major concern. We are proud that JHS creatins awareness of importance of fruits and vegetables by publishing the recent developments in research with respect to these crops.

Diversity of fruit crops and genetic resources available with respect to fruit crops are important for developing better fruit crop varieties. ***Sankaran and Dinesh*** *have reviewed the "Biodiveristy of Fruit Crops in India" in a very comprehensive way. There is diversity in Jasmine species.* ***Ganga et al.*** *carried out the palynological investigations and recorded the variability in pollen morphology in different species of Jasmine by documentating images using scanning electron microscope. Biodiversity can be linked to livelihood also. One such success story with tamarind selection 'Lakhamna' is being reported by* ***Kanupriya et al.*** *This tamarind selection has been identified from participatory breeding programme. It has a better pod characters and more preferred by consumers.*

Protected cultivation has seen greater momentum in last two decades. ***Adeniji et al.*** *identified the best varieties of tomato for polyhouse cultivation in Nigeria.* ***Rao et al.*** *selected two gladiolus hybrid selections IIHRG-7 and IIHRG-11 with red purple and red coloured flowers respectively. These hybrids have resistance to Fusarium wilt and suitable for cut flower and flower arrangement purposes.* ***Sankaran et al.*** *analysed the variance for 6 quantitative and 30 qualitative traits in mango in 400 genotypes and identified 18 clusters. Selected genotypes from specific clusters can be used in hybridization programme.*

The production aspects are important in perennial crops. It is crop management that needs to be prioritized for enhanced yield. ***Adiga et al.*** *have reviewed the research work carried in "Canopy Management in Cashew", providing the wholistic view of cultural operations to have a better crop. Use of soilless medium in nursery industry is gaining importance. Best suited potting mixture for mango stone graft of cv. Alphonso has been identified by* ***Lad et al.*** *They found that cocopeat + leaf manure + compost (1:1:2) as pot mixture provided better plant growth.*

Growing Chrysanthemum in pots is practiced in home and terrace gardens. The cultivar Kikiobiory is well suited for this purpose. ***Thakur*** *has studied the nitrogen requirement for this cultivar and has come out with the recommendation of 300 mg of N per pot applied*

twice in September and October in Punjab for best results. In another study, ***Singh and Bala*** *confirmed that use of benzyl adenine at 200 ppm helped in extended vase life of Chrysanthemum morifolium flowers.* ***Nair et al.*** *recorded that foliar spray of 30:20:20 NPK at weekly interval recorded more number of flowers of Dendrobium cv. Singapore White with significantly longer spikes.*

Crop production is directly influenced by pollinators. Decline in honey bee population is a serious concern and to conserve the pollinators community approach through ecosystem services is required. ***Rami Reddy*** *reports the benefits of having ornamental plant Mexican Creeper (Antigonon leptopus) as forage plant. This creeper attracted all the four species of honey bees studied. This creeper can be used as bioindicator of honey bee population.*

Aravindaraj et al. *have reported the honey dew secretion by Thrips palmi and analysed the composition of it. They had identified different sugars present in the honey dew secretion of Thrips. Thrips not only cause direct damage but act as vectors of many plant viruses. Management of diseases in perennial crops is a challenge. Phytophthora incited root infection in citrus needs concerted efforts.* ***Ingle et al.*** *have demonstrated that use of potassium salt of phosphonic acid could help in management of Phytophthora root rot in Nagpur Mandarin.*

Mushrooms can fill the gaps in nutritional security as they are rich in nutritive value. Iron deficiency is important issue to be addressed. Iron fortified oyster mushroom products have been developed by ***Pandey et al.*** *The bioavailability of iron from Arka Mushroom Fe-Fortified Rasam Powder has been confirmed. In another study, the amino acid profile of 18 isolates of oyster mushroom species belonging to 4 species have been documented by* ***Azeez et al.*** *Quantification of essential and non-essential amino acids has been reported. Nutritionally superior isolates can be selected from these isolates.*

The editorial team of JHS expresses the sincere efforts of reviewers who really complement the publication processes. All scientists and scholars can utilize the open access of JHS. Recently FAO has made JHS available through AGRIS. It is indexed by Redalyc, CABI_Hort and Scopus. All subscribers, scientists and scholars are requested to continue their support in publishing quality information in ***Journal of Horticultural Sciences****.*

S. Sriram
Editor in Chief

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Review

Biodiversity of Tropical Fruits and their Conservation in India

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ABSTRACT

India is one of the 12 mega biodiversity centres with 2 biodiversity hotspots which are the reservoirs of plant genetic resources. India stands at 7thplace in the global agricultural biodiversity status. Among fruit and nut crops, there are about 117 cultivated species with 175 wild relatives of which only 25 species have been domesticated. Genetic resources conservation of fruit trees is intricate and complex as they are belonging to various genera and species which require specific climate. Hence, *in situ* and *ex situ* conservation can go simultaneously. The western ghat and North eastern India are centers of diversity for several important native fruits including Mango, Jackfruit and Citrus. Apart from the major fruit crops, India is home to several underutilized fruit crops. However, due to increased pressure on land use several of the wild types, which are a great source of genes governing useful traits, are disappearing. Thus, there is an urgent need to conserve them in both *in situ* and *ex situ* conditions. The genetic diversity and modes of conservation of tropical fruits are discussed in this paper.

Key words: Conservation, *Ex situ*, Fruits, GIS, Germplasm, *In situ*, Tropical, Varieties and Wild species

INTRODUCTION

India is one of the reservoirs of plant genetic resources which stand at 7th place in the globe in terms of richness of agricultural biodiversity. There are about 117 cultivated species of fruits and nuts with 175 wild relatives of which only 25 species have been domesticated for the use. Genetic resources conservation of fruit trees is intricate and complex in view of vast diversity of tropical, subtropical and temperate fruits germplasm belonging to various genera and species available in the country and consequent requirement of specific and complimentary conservation approaches encompassing both *in situ* and *ex situ* conservation. Plant genetic resources are of great importance as they form the basic raw materials to meet the current and future needs of crop improvement programmes. A wider genetic base, thus, assumes priority in plant breeding research aimed at developing new varieties for increased crop production (Paroda, 1991). This diversity comprises of native landraces, local selections, elite cultivars and wild relatives of crop plants. The collection and conservation of this diversity in a systematic manner is the primary responsibility of all plant genetic resources institutes/ centres. The mention of use and cultivation of fruits can be seen in epics like 'Ramayana'. Plant genetic resources are thus our heritage, which need conservation for posterity.

During the long period of domestication, utilization and cultivation, a wide array of fruit crop variability got generated by natural means and through both conscious and unconscious selection. Huge wealth of variability also got generated/adapted and diversified by crop introductions in the exotic environment or through migration of human population.

Although, humankind has used only about 5,000 plant species worldwide to meet food and other needs, this number is just a fraction of the total world flora. With population growth, we are increasingly dependent on most productive plants. Today, only about 150 plant species are important in meeting the food (calories) needs of humans worldwide. Hence, there is a greater dependence on fewer plant species; 20 to 30 species? in global context (Harlan, 1975). This gradually, has resulted in the loss of native genetic

resources, which are otherwise essential as building blocks of genetic diversity. It is estimated that there are about 500 species of tropical fruit trees in Asia Pacific Oceania region, which include 30 families and 59 genera (Arora, 1998). In Southeast Asia alone, there are 120 major fruit species and 275 minor fruit species (Verheij and Coronel 1992). In Asia, 50-60 species belong to the most important indigenous fruits (Arora and Rao 1996). Citrus, mango, banana, rambutan, jackfruit, litchi and durian occupy 80% of total fruit production in the region.

WILD SPECIES AND DIVERSITY

The role of wild species in the fruit improvement programme is increasingly becoming important as the donor source for many of the disease and pest resistance. However, in most of the perennial trees, wild species or the indigenous germplasm has not been evaluated extensively either by morphological or by molecular means. Some geographical? areas may be richer in biodiversity than other areas, and some species may also have more variation than others in a particular area.

Conservation of germplasm is very important, because many species are becoming extinct and many others are threatened and endangered. The diversity of some fruits is well documented, while for others relatively little work has been done (Arora, 1994). Gaps in collections are found both between species and between regions. This is especially true for both underutilized species and wild crop relatives, where big gaps are noted. Kostermans and Bompard (1993) indicate that *Mangifera blommesteinii, M. leschenaultii*, *M. superba* and *M. paludosa* are in real danger of extinction. High genetic erosion has been noticed for jackfruit, *Citrus* spp. and *Litchi chinensis* in a survey carried out by the International Centre for Underutilized Crops (ICUC) and IPGRI (Haq, 1994). It is to be mentioned here that collection and utilization of wild species is not an easy task, as they require specific climate and do not so easily get acclimatized to the *ex situ* conditions on introduction.

BIODIVERSITY OF FRUITS

The concept of origin of cultivated plants was first put forth by A de Candolle and the geographic centres of variability were described by Vavilov. He identified Asia as a major centre with "Indian centre" of North East region as primary or secondary centre of origin for many crop plants. This region is centre of diversity for several important native fruits including mango, jackfruit and citrus. The plant genetic resources represent a sum of the diversity that come from wild species and primitive forms, accumulated through evolution and natural selection, plant introduction, migration and domestication and the material developed by artificial selection and breeding. The North Eastern region had remained isolated for a long time even today the accessibility is poor to many parts of this region. The wet tropics with rain forests, undisturbed environmental conditions and variable altitudes are some of the major reasons for genetic diversity.

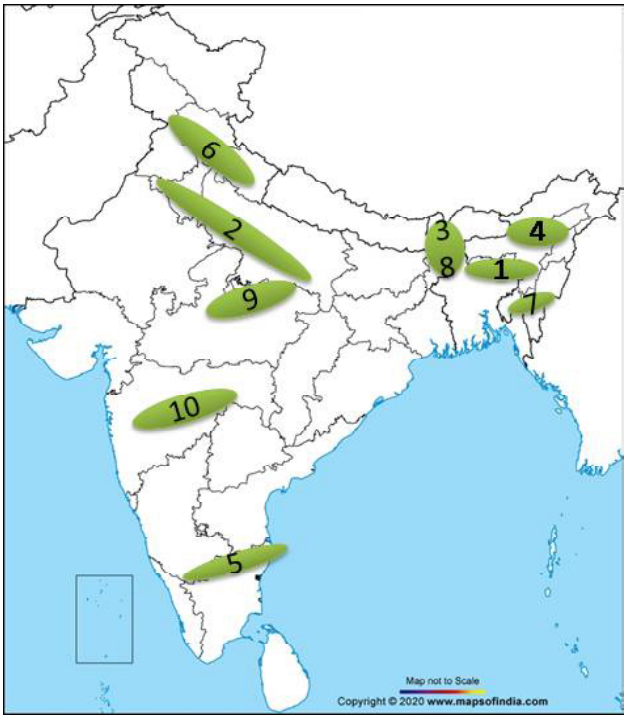

Fig.1. Distribution of fruit genetic resources in India

1. **North-eastern Himalayas-wild, semi-wild cultivated species**
2. **North-west- Semi-wild and cultivated types**
3. **South-centre - mostly cultivated types**

"Vast diversity in tropical and temperate fruits cultivated and wild - 109 species several wild, endangered and endemic species"

Biodiversity can be located both in the wild or in the backyard. Regarding many of the tropical fruit species, the variability can be traced in wild, wherein many species grow naturally even today viz., the occurrence of *Mangifera sylvatica* in the North-eastern parts of India or *M. andamanica* and *M. nicobariaca* in Andaman group of islands. In the wild

diversity was generated over a period mainly because of spontaneous mutants and the dispersal of seeds and seedling population. Seedling populations have been the source of diversity in the backyard as noticed in the case of fruits like mango and jackfruit. Diversity due to natural means has come about due to the seed dispersal as in pickling types of mango viz., Appemidi types in Uttara Kannada district of Karnataka or varietal wealth found in the Western Ghat regions.

CHARACTERISTIC FEATURES OF TROPICAL FRUIT TREE DIVERSITY

The main causes for the tropical fruit diversity in India be it mango or an underutilized fruit like jamun, whether in the wild or in the cultivated types have been;

1. the presence of high heterozygosity
2. cross pollination
3. seed propagation
4. absence of vegetative propagation in the earlier days
5. indiscriminate multiplication.

Unlike other crops, where there is a need to create variability, in tropical fruit species, it is the management of diversity, which is the more challenging task. In fact, in crops like mango, the varietal diversity itself is considered as a hindrance to the improvement (Naik *et al*., 1958).

Table 1. Main centres of diversity for fruits in India

Region	Species
Western Himalayas	*Elaeagnus hortensis*, *Ficus palmata*, *Fragaria indica*, *Moms spp.*, *Prunus acuminata*, *P. cerasiodes*, *P. cornuta*, *P. napaulensis*, *P. prostrata*, *P. tomentosa*, *Pyrus baccata*, *P. communis*, *P. kumaoni*, *P. pashia*, *Ribes graciale*, *R. nigrum*, *Rubus ellipticus*, *R. moluccanus*, *R. fruticosus*, *R. lasiocarpus*, *R. lanatus*, *R. niveus*, *R. reticulatus*, *Zizyphus vulgaris.*
Eastern Himalayas	*Fragaria indica*, *Morus* spp., *Myrica esculenta*, *Prunus acuminata*, *P. cerasiodes*, *P. cornuta*, *P. jenkinsii*, *P. napaulensis*, *Pyrus pashia*, *Ribes graciale*, *Rubus lineatus*, *R. ellipticus*, *R. lasiocarpus*, *R. moluccanus*, *R. reticulatus.*
North-eastern region	*Citrus assamensis*, *C. ichangensis*, *C. indica*, *C. jambiri*, *C. latipes*, *C. macroptera*, *C. media*, *C. aurantium*, *Docynia indica*, *D. hookeriana*, *Eriobotrya angustifolia*, *Mangifera sylvatica*, *Musa accuminata/M. balbisiana* complex, *M. manii*, *M. nagensium*, *M. sikkimensis*, *M. superba*, *M. velutina*, *Pyrus pyrifolia*, *P. pashia*, *Prunus cerasiodes*, *P. cornuta*, *P. jenkinsii*, *Ribes graciale*, *Rubus ellipticus*, *R. moluccanus*, *R. reticulatus*, *R. lasiocarpus*, *Myrica esculenta.*
Gangetic plains	*Aegle marmelos*, *Cordia myxa*, *C. rothii*, *Emblica officinalis*, *Grewia asiatica*, *Morus* spp.; *Phoenix* spp.; *Syzygium* spp.; *Zizyphus nummularia* and other species and *Manilkara hexandra* (more in north-western plains).
Indus plains	Meagre occurrence of *Syzygium*, rich variation in *Carissa congesta.*
Western peninsular tract	*Artocarpus heterophyllus*, *A. lakoocha*, *Garcinia indica*, *Diospyros* spp., *Ensete superba*, *Mangifera indica*, *Mimosops elengii*, *Spondias pinnata*, *Vitis* spp., *Zizyphus oenoplia*, *Z. rugosa*, *Rubus ellipticus*, *R. lasiocarpus*, *R. moluccanus.*

(Arora and Nayar, 1984)

Table 2. Wild relatives of some of the fruit crops

S. No.	Family	Species	Remarks
1	Anacardiaceae	*1. Mangifera andamanica* *2. Mangifera camptosperma* *3. Mangifera griffithi* *4. Mangifera nicobarica* *5. Mangifera sylvatica* *6. Semicarpus kurzii* *7. Spondias pinnata* *8. S. cytherea* *9. Bouea oppositifolia* *10. Dracontomelon dao* *11. Buchnania splendons*	Possess tolerance to biotic and abiotic stress
2	Annonaceae	*1. Annona muricata* L. (soursop) *2. Annona reticulata* L. (bullock's heart) and *3. Annona glabra* L	*A. glabra* is tolerant to salinity and could be suitably employed as a rootstock for other species of this group
3	Arecaceae	*1. Areca triandra* *2. Phoenix andamanensis* *3. P. sylvestris* (L.) Roxb. *4. P. rupicola5.*	*P. paludosa* Roxb. All these five species are habitat of seashores
4 to	Clusiaceae	*1. Garcinia cowa* Roxb *2. Garcinia xanthochymus Hook.f* *3. Garcinia microstigma* *4. Garcinia speciosa* *5. Garcinia dhanikhariensis* S.K.Srivast. *6. Garcinia hombroniana* Pierre. *7. Garcinia lancaefolia* Roxb. *8. Garcinia andamanica*King. *9. Garcinia brevirostris* Scheff. *10. Garcinia cadelliana* King. *11. Garcinia calycina* Kurz *12. Garcinia cornea* Linn. *13. Garcinia dulcis* (Roxb.) Kurz. *14. Garcinia jelinekii* Kurz. *15. Garcinia Kingii* Pierre ex Vesque *16. Garcinia Kurzii* Pierre *17. Garcinia lanessanii* Pierre. *18. Garcinia mangostana* Linn.	About 36 species of *Garcinia* are reported be available in India of which 18 *Garcinia* species are found to exist in Andaman & Nicobar Islands. 6 species which are endemic to Andaman & Nicobar Islands ?? viz. *Garcinia andamanica* King. var. *andamanica*, *G. cadeliana, G. dhanikhariensis, G. kingii* Pierre ex. Vesque, *G. kurzii* Pierre. and *G. microstigma* Kurz.
5	Dilleniaceae	*1. Dillenia andamanica* C. E. Parkinson *2. D. indica* L *3. D. pentagyna* Roxb	Edible fruits are produced in all the three species.
6.	Ebenaceae	*1. Diospyrous blancoi* (velvet apple) *2. D. andamanica*	Fruit of *Diospyrus blancoi* has velvety surface and fragrant, cream-white flesh.
7	Euphorbiaceae	*1. Baccaurea sapida* (sapida) and *2. B. ramiflora* (*khatta phal*)	*Fruits of B. ramiflora are rich in vitamin C.*

8	Moraceae	*1. Ficus carica* L. *2. Ficus racemosa* L. *3. Ficus hispida* *4. Artocarpus heterophyllus* (jackfruit) *5. A. altilis* (breadfruit) *6. A. lakoocha* Buch.-Ham. (monkey jack) *7. A. chaplasha* Roxb. (cham pedak)	*Artocarpus heterophyllus has 10 diversity centres in India. This is found in all states and it has multiple uses*
9	Musaceae	*1. Musa balbisiana* var. *andamanica* *2. Musa paradisiaca* *3. Musa indandamanensis* L. J. Singh *4. Musa textilis* *5. Musa sabuana*	Wild species of banana are rich in carotenoid content however the presence of seeds prevents the wider acceptability of the fruits.
10	Myrsinaceae	*1. Ardisia solanacea* Roxb. (Khaariphal) *2. A. andamanica* Kurz.	These species are tolerant to salinity
11	Pandanaceae	*1. Pandanus andamanensium* Kurz *2. Pandanus tectorius* Soland. Ex Parkinson *3. Pandanus lerum* Jones ex Fontane var. *lerum* *4. Pandanus lerum* var. *andamanensium* (Kurz.) D.C. Stone	Nicobari tribes extract the flour from the fruits and cake is prepared out of the flour. *Pandanus lerum* Jones ex Fontane var. *lerum*, and *Pandanus lerum* var. *andamanensium* (Kurz.) D.C. Stone are distributed in the swampy areas and *Pandanus tectorius* distributed in seashore.
12	Rhamnaceae	*1. Ziziphus glabrata* Heyne *2. Ziziphus oenoplia* (L.) Mill var Oenoplia *3. Ziziphus oenoplia* var *pallens* Bhandari & Bhansali	-
13	Myrtaceae	*1. Syzygium andamanicum* *2. Syzygium hookeri* *3. Syzygium kurzii* *4. Syzygium sanjappaina* *5. Syzygium manii* *6. Syzygium claviflorum (wild jamun)* *7. Syzygium aqueum (watery rose apple)* *8. Syzygium samarnagense* *9. Syzygium jambos* *10. Syzygium malaccensis*	-
14	Myristicaceae	*1. Myristica andamanica* Hook.f. *2. Myristica glabra* Blume *3. Myristica glaucescens* Hook.f. *4. Myristica irya* Gaertn. *5. Myristica prainii* King *6. M. elliptica* Wall ex. Hook. f. et Thoms. *7. Knema andamanica* (Warb.) de Wilde ssp. *Andamanica*	*Knema andamanica* (Warb.) de Wilde ssp. *Andamanica, K. andamanica* (Warb.) de Wilde ssp. *nicobarica* (Warb.) and *Myristica andamanica* Hook.f are endemic to the

		8. K. andamanica (Warb.) de Wilde ssp. *nicobarica* (Warb.) *9. K. andamanica* (Warb.) W. J. de Wilde subsp. *peninsularis*	Andaman Islands.
15	Sapotaceae	1. *Manilkara littoralis* - Hindi - Sea Mohwa	Potential rootstock for Sapota
16	Menispermiaceae	*1. Haematocarpus validus*	Recorded from North Andaman. This crop has already been domesticated by a farmer in Diglipur area, North Andaman. The farmer has been identified as the custodian farmer
17	Vitaceae	*1. Vitis parviflora* *2. Ampelocissus barbata* (Wall.) Planchon *3. A. helferi* (Lows) Planchon *4. A. polystachya* (Wall) Planchon	*Vitis parviflora is being used in* grapes may be used in grape breeding programme as it has got reflexed stamen. Whereas the *Ampelocissus barbata* is used as a medicinal plant by the tribes of the Island.

(Sankaran *et al.,* 2014)

BIODIVERSITY OF TROPICAL FRUITS

1. MANGO

Mango is native to India. Mukherjee (1949,1985) opined that this genus might have originated in the region covering Burma, Siam, Indo-China and Malayan peninsula. The genetic diversity of mango available in India is very rich and at present more than one thousand vegetatively propagated varieties exists in the country. Clonal selection, selections from chance seedlings and breeding efforts have resulted in identification of many elite improved varieties of mango for commercial cultivation in the country.

All varieties in mango belong to one species *Mangifera indica*. Apart from *M. indica*, India is also reported to be the home of four other species viz., *M. andamanica*, *M. khasiana, M. sylvatica* and *M. camptosperma* (Mukherjee *et al.*, 1985). The species of *Mangifera* occur mainly as complex biotic community in tropical humid forests, sub-tropical rain forests and tropical dry forests/woodlands of Indo-Malayan biogeographic realm (Mukherjee, 1985).

The *Mangifera* germplasm can be classified under two categories;

1. Seedling races: This group includes both wild and cultivated types. Under this category the cultivated ones come under the monoembryonic types. The polyembryonic types are seen generally in the Western Ghats of Peninsular India.

2. Horticultural races: They include varieties, which when grown under different agro-climatic conditions and propagated vegetatively from the parent material have given rise to clonal variation Varieties like Alphonso, Dashehari and Langra are noticed to have clones resembling them in some of the morphological characters. Yadav and Singh (1985) opined that mango varieties of Northern and Southern regions belong to two different eco-geographic regions.

Centres of mango diversity and distribution in India

In India, seven centres of mango diversity have been recognized (Yadav and Rajan, 1993). These are the places where maximum diversity has been noticed for species as well as varietal diversity. They are:

1. Humid Tropical region-Manipur, Tripura, Mizoram and S. Assam
2. Chota Nagpur Plateau-Trijunction of Orissa, Bihar and Madhya Pradesh
3. Santal Paraganas in Bihar
4. South Madhya Pradesh adjoining Orissa and Andhra Pradesh
5. Dhar Plateau of Madhya Pradesh adjoining Gujarat and Maharashtra
6. Humid Tropical South Peninsular India
7. Andaman and Nicobar Islands

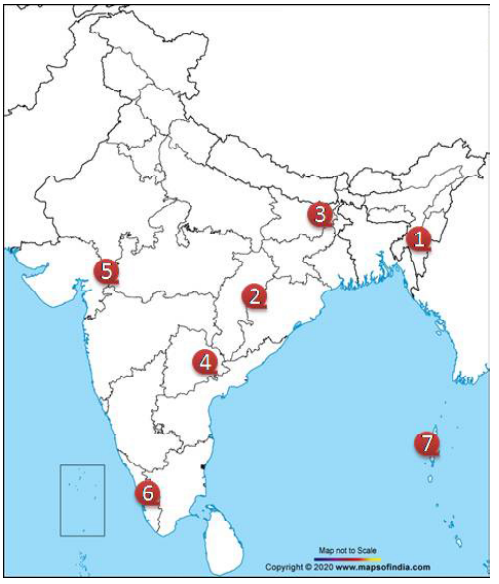

Fig. 2. Mango diversity centres in India

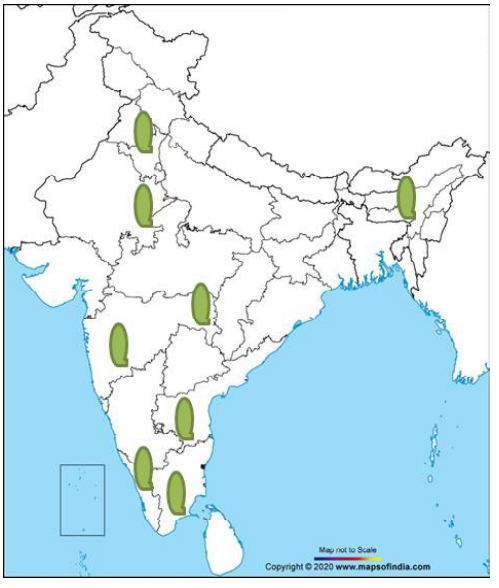

Fig. 3. Distribution pattern of citrus cultivars in India

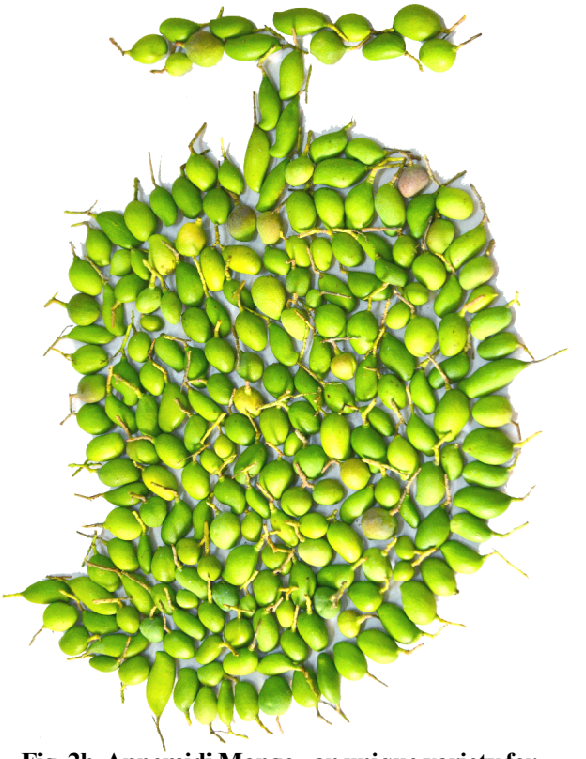

Fig. 2b. Appemidi Mango - an unique variety for pickle purpose

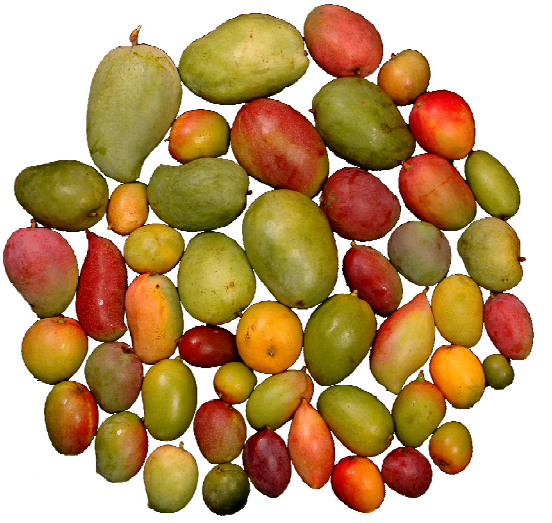

Fig. 2c. Diversity of mango germplam

Varietal diversity

In India about thousand varieties of mango are grown. Most of these varieties have arisen as chance seedlings. Each mango-growing region in India grows a different variety. Although, there are more than thousand varieties have been documented in India of which only twenty-five varieties are cultivated on a commercial scale in different states. Most of the commercial varieties have arisen as a result of

selection from seedling types for different fruit characteristics like colour, taste, flavour, size and bearing habit. Although, growth in mango is genetically controlled, the environmental interaction has brought about the change in growth pattern under different agro climatic conditions, which also has contributed for its biodiversity. In India, three main centres contributed to of the diversity of mango i.e., Lucknow - Saharanpur belt of Uttar Pradesh, Murshidabad area of West Bengal and Hyderabad area of Andhra Pradesh. Most of the varieties in these areas have specific fruit ?characteristics, require specific climate for optimum performance and have strong regional consumer preference.

2. CITRUS

The North East hilly region is rich in fruits, vegetables and flowers, especially orchids. It is considered as a centre of origin of Mandarins and few other citrus fruits. Sixteen species of Citrus, 52 varieties, and seven natural hybrids of Assam were described by Bhattacharya and Dutta as early as 1956. They also reported two species of sub genus *Eucitrus* viz., *C. indica* and *C. assamensis* and three species of sub genus of Papeda viz., *C. ichangensis, C. latipes* and *C. microptera* which grow at high altitudes. *C. indica* is considered to be the most primitive species of citrus and probable progenitor of cultivated species. Diverse forms of Pummelo, Sour Orange, Rough Lemon, Sour Pummelo, Adajamir Sweet Lime etc. are found in this region.

Varietal diversity

Mandarin orange is concentrated in Maharasthra (Nagpur, Amaravathi, Wardha and Yavatmal), North East region of India (Assam, Arunachal Pradesh and Meghalaya), limited area of Karnataka (Kodagu), Tamil Nadu (Nilgris, Palani and Shevroy hills) and Kerala (Wynad). Sathpura hills of Madhya Pradesh adjoining Vidharbha region of Maharasthra also grow good quality mandarins. Kinnow Orange, a hybrid of King X Willow Leaf Mandarin has recently spread in North West India, especially in Punjab, parts of Himachal Pradesh, Uttar Pradesh and Rajasthan. Cultivation of introduced varieties / hybrids also add to the varietal diversity by throwing spontaneous mutants over a period.

Sweet oranges are adapted well to arid tropics and sub tropics. They are commercially grown in Andhra Pradesh, Maharasthra, Punjab and parts of Tamil Nadu, Rajasthan and Utter Pradesh. in Andhra Pradesh Sweet orange cultivar Sathgudi is grown, whereas in Western and Central India sweet orange cultivar Mosambi is popular. In North Western India the cultivars Malta, Jaffa and Valencia are popular.

Acid lime is grown on a commercial scale in Tamil Nadu, Andhra Pradesh, Maharasthra and Karnataka states. Lemons are grown commercially only on a limited scale. Eureka lemon in some regions and Assam lemon in North Eastern India are popular varieties under cultivation.

3. BANANA

Bananas are one of the ancient fruits cultivated by man. It could be assumed that the fruit has evolved with the civilization (Krishnamurthi and Seshadri 1958) and found in Indus valley as early as in 327 B.C. Apart from its mention in Valmiki's Ramayana, it also finds a mention in Kautilya's Arthshastra and ancient Tamil classic Silappadikaram. These evidences suggested the early existence of banana in India. The wild *Musa acuminata* occurs in Assam, Burma, Siam, Indo-China, the Malayan peninsula and Archipelago and the Philippines.

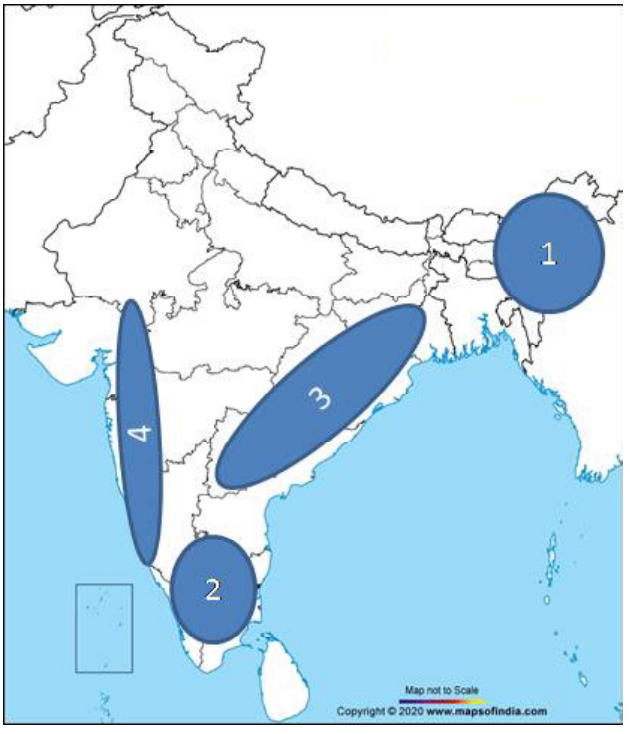

Fig 4. Distribution of banana cultivars in India

Table 3. Distribution of banana cultivars in India

Region/ State	Cultivars
Andhra Pradesh	Amrit Pani (Rasthali, AAB),Thella Chekkarakeli (AAA), Karpura Chekkarakeli (Poovan, ABB), Monthan (ABB), Robusta (AAA)
Assam	Bhimkol, Manohar (ABB), Chini Champa (AB), Malbhog (AAB), Jahaji (AAA), Bor Jahaji (AAA), Kanch Kol (ABB),
Bihar	Alpan (AAB), Chini Champa (AB), Basrai (AAA), Kothia/ Muthia (ABB), Bateesa (ABB), Malbhog (Rasthali, ABB).
Gujarat	Dwarf Cavendish (AAA), Lacatan (AAA), Harichal (AAA)
Karnataka	Dwarf Cavendish (AAA), Robusta (AAA), Poovan (AAB), Rasbale (AAB, Rasthali), Marabale (Pome, AAB), Monthan (ABB), Elekki Bale (AB, Ney Poovan)
Kerala	Nendran (ABB, plantain), Palayankondan (AAB, Poovan), Kunnan (AB), Rasthali (AAB), Monthan (ABB) and Red Banana (AAA)
Maharashtra	Basrai (Dwarf Cavendish, AAA), Robusta (AAA), Safed Velchi (AB), Monthan (ABB), Rajeli (Plantain, AAB)
Tamil Nadu	Virupakshi (Pome, AAB), Poovan (AAB), Rasthali (AAB), Nendran (AAB), Monthan (ABB), Dwarf Cavendish (AAA), Robusta (AAA), Peyan (ABB)
Bengal and Orissa	Champa (AAB), Morthaban (AAB, Rasthali), Amrit Sagar (AAA), Giant Grover (AAA), Lacatan (AAA), Monthan (ABB)

Singh, 1996

The northeastern region of India - including the states of Assam, Arunchal Pradesh, Tripura and Mizoram, lie at a point where *Musa balbisiana* from the Indian subcontinent meets *Musa acuminata* from Southeast Asia. These two species, as well as other wild relatives have mingled to form a distinctive concentration of genetic diversity, occurring in the semi-evergreen, sub-tropical forests of the hill slopes. Further sources of diversity occur in the valleys and plains where bananas are common as a backyard crop. The habitat of wild bananas is shared with tribal groups who practice a form of shifting cultivation. Unfortunately, a growing number of sites where wild bananas once grew are now denuded. Wild species found in North eastern part of India include *Musa acuminata, Musa balbisiana,* several species from the section *Rhodochlamys* as well as *Ensete glaucum*.

The diploid and triploid *acuminata* cultivars were taken by man to the native areas of *balbisiana*, which resulted in natural hybridization and formation of hybrid progeny with the genomes: AA, AAB, and ABB. It is thought that subsequent dispersal of edible bananas out of Asia was brought about by man. Secondary diversification with-in the groups of cultivated bananas are the result of somatic mutations.

Eumusa and *Rhodochlamys* are found in Assam region of India and Thailand whereas *Callimusa* and *Rhodochlamys* in Borneo, its surrounding

Table 4. Distribution of *Vitis* species in India

Species	Region	Salient Characters
V. riparia	North Westeran Himalayan region	Small berries, purple black in colour, cold hardy, early flowering
V .lanata	Himalayan region	Purple black berries known for crack resistance, and plant resistant to diseases
V. barbata	Parts of Assam, Khasi hills and Bengal	–
V. parviflora	North West Himalayas from Kashmir to Nepal	Small berries, delicately flavoured
V. tomentosa	Greater part of Deccan peninsula	–

The species *V. vinifera*, has not originated in India. However, it is very interesting to note that variety Thompson Seedless, which belongs to the species *V. vinifera,* and which is grown in several parts of the world as well as in India has contributed for the diversity in varieties; several mutants have come from the Thompson Seedless, Anab-e-Sahi and Kishmish Cherni grapes due to their extensive cultivation over the years.

5. GUAVA

Guava is an important fruit crop of India. It is said to have originated from tropical America. It is widely distributed all over the equatorial regions of tropical and sub-tropical climate. Guava is reported to have been introduced during Seventeenth century into India.

It has gained considerable prominence on account of its high nutritive value, availability at moderate prices, pleasant aroma and good flavour. It is one of the commonest fruits liked by the rich and the poor alike and is popularly known as the 'apple of tropics'. At present, it is grown throughout the length and breadth of the country from sea level to 1300 m altitude and is so much acclimatized that it appears to be native to India. The most important guava growing states are Uttar Pradesh, Bihar, Madhya Pradesh and Maharashtra.

The genus *Psidium* of Myrtacease family comprises of about 150 species of small trees and shrubs. About 20 species have edible fruits, of which the most cultivated is the common guava i.e., *Psidium guajava* L. It has been reported that the value of the wild *Psidium* species mainly lies in their utility as rootstocks for regulation of vigour, fruit quality and resistance to pests and diseases.

Varietal diversity

Guava is mainly a self-pollinated crop but cross-pollination is also common. This has resulted in large variability in the seedling population from which promising genotypes have been selected in different agro-climatic regions of the country. In India different workers in different regions have described guava varieties. The main centre of variability in guava has been the Allahabad area in Uttar Pradesh. The promising cultivars of different states are given as follows;

Table 5. Distribution of guava varieties in India

State	Cultivars
Andhra Pradesh	Allahabad Safeda, Anakapalli Banarasi, Chittidar, Hafsi (Red Fleshed), Lucknow-46, Sardar, Seedless, Smooth Green, Smooth White.
Assam	Amsophri, Madhuriam, Safrior payele.
Bihar	Allahabad Safeda, Chittidar, Hafsi (Red Fleshed), Harijha, Seedless.
Maharashtra	Dharwar, Dholka, Kothrud, Lucknow-24, Sardar,
Gujarat	Nasik, Seedless, Sindh.
Tamil Nadu	Anakapalli, Banarasi, Bangalore, Chittidar, Hafsi, Nagpur Seedless, Smooth Green.
Uttar Pradesh	Allahabad Safeda, Apple Colour, Chittidar, Red Fleshed, Banarasi Surkha, Sardar, Mirzapuri Seedless.
West Bengal	Behrampur and cvs. of Uttar Pradesh.

In India, due to seed propagation, varietal diversity is seen for guava, but species diversity is not observed.

6. PAPAYA

The papaya (*Carica papaya* L.) is one of the most important fruit crops valued for its rich nutrient content. It is a rich source of Vitamin A (2020 I.U), Vitamin B1 (40 mg), Vitamin C (46mg), protein (0.5%) and mineral matters (0.4%). Papaya is native to tropical America, its place of origin is said to be in southern Mexico and Costa Rica. It was taken to Manila by Spanish in the mid-16th century, reached Malacca shortly afterwards. It was introduced into India during 16th century. It is grown both in tropical and sub-tropical parts of the world. Wild diversity is not reported in India for papaya.

2.6.1.Varietal diversity

In India, varietal diversity is seen for papaya. The variability seen is more because of the open pollination and wide spread multiplication using these seeds. In papaya there are two basic types of varieties. Those varieties, which are dioecious, produce only female and male plants, and 'gynodioecious' that produce both female and hermaphrodite plants. Some of the varieties that are grown in different states are as follows;

Table 6. Distribution of papaya varieties in India

State	Cultivars
Andhra Pradesh	CO 2, CO 5, Sunrise Solo, Taiwanese lines
Bihar	Pusa Dwarf, Pusa Majesty, Pusa Nanha, Pusa Giant, Pusa Delicious and Ranchi
Karnataka	Coorg Honey Dew, Washington, Sunrise Solo, CO2, Surya and Taiwanese lines
Maharashtra	Washington, CO2, Pusa Delicious, Pusa Majesty, Ranchi and Taiwanese lines
Orissa	CO2, Coorg Honey Dew, Washington, Ranchi, Pusa Dwarf and Pusa Delicious
Tamil Nadu	C02, C03, CO4, CO5, CO6, CO7 and Coorg Honey Dew
Uttar Pradesh	Coorg Honey Dew, Pusa Dwarf, Pusa Delicious, CO3 and Barwani Red

islands, and Indonesia. *Australimusa* is largely found in Malayan islands, and Indonesia. It is also found in Assam, Indo-China, Malayan and Papua New Guinea, which is a primary centre of cultivated AA types. *M. balbisiana* occurred in Ceylon, India, Burma, Siam and Malaya where the A X B hybrids have evolved.

4. GRAPE (*Vitis* spp.)

European grape *V. vinifera* is considered to have originated primarily between Caspian and Black sea, and considered a hybrid between two American spp. *V. vulpine* and *V. labrusca*. It also resembles *V. parviflora* and *V. lanata* which are found in Himalayan region. This region may be considered as a secondary centre of origin. Native spp. resembling *Vitis lanata* and *V. palmata* grow wild in the northwestern Himalayan foothills. Indigenous varieties known as 'Rangspay', 'Shonltu White' and 'Shonltu Red' are grown in Himachal Pradesh even today.

Famous Indian medicine scholars, Sushruta and Charaka in their medical treatises entitled 'Sushruta Samhita' and 'Charaka Samhita', respectively, written during 1356-1220 BC, mentioned the medicinal properties of grapes. Kautilya in his 'Arthashastra' written in the fourth century BC, mentioned the type of land suitable for grape cultivation.

Cultivated grapes are believed to have been introduced into the north of India by the Persian invaders in 1300 AD, from where they were introduced into the southern parts of India (Daulatabad in Aurangabad district of Maharashtra) during the historic event of changing the capital from Delhi to Daulatabad by King Mohammed-bin-Tughlak. Ibn Batuta, a Moorish traveller who visited Daulatabad in 1430 AD, reported to have seen flourishing vineyards in south India.

7. SAPOTA

Sapota (*Achras zapota* L.) is a popular dessert fruit belonging to the family Sapotaceae. It is believed to have originated in tropical America, taken to Philippines by the Spanish and from there has spread to other countries (Purseglove, 1968).In India it is grown in the states of Andhra Pradesh, Gujarat, Karnataka and Orissa. About 30 varieties are reported in India at various places. Several locally grown genotypes identified include Bhuri patti, Morabba, Kali patti, Turi patti, Gole patti, Singapuri, Khabari and Chhumukia type. Among these, a genotype identified in Navsari, in Gujarat locally known as 'Morabba' bears fruits of bigger size and superior quality in comparison to Kalipatti, a local genotype grown in about 80% area of Gujarat. It is a selection from grafted plants collected from nursery located in Golwal. It may have originated as bud mutant and is now being propagated vegetatively. Another somatic mutation having desirable characteristics of the fruit was identified in Paria (Rai, 1995). Wild diversity is not observed for sapota, as it has been grown over the years by using grafts.

Biodiversity of underutilized fruits

In India various native fruits, such as aonla (*Emblica officinalis)*, bael fruit (*Aegle marmelos*), jackfruit (*Artocarpus heterophyllus*), jamun (*Syzygium cuminii*), karonda (*Carissa congesta*), Kokum (*Garcinia indica*) and phalsa (*Grewia subinaequalis*) with lot of diversity in a wide range of agro-ecological situations throughout the tropics, subtropics and temperate regions, which could be grouped as underutilized. Some of these fruits yield juice with excellent flavour, which can be converted into blended beverages and these could play an important role in meeting the demand for nutritious,

pleasantly flavoured and attractive natural food of high therapeutic value. Encouraging local people to produce these fruits can help in uncontrolled harvesting from the wild under check and conservation of various species in their native habitats where they perform best.

8. JACKFRUIT

Artocarpus is a genus of small to large evergreen trees, distributed from Sri Lanka and India to South China and through Malaysia to Solomon Islands. Nine species are recorded in India. The spp, *A. heterophyllus* Lam. is grown for their edible fruits, and *A. chaplasha* Roxb., *A. hirsutus* Lam. and *A. lakoocha* Roxb., are important timber trees.

A. chaplasha Roxb is distributed in the moist deciduous and evergreen forests of the sub-Himalayan tracts from Nepal eastwards to West Bengal, Assam and Tripura. In West Bengal and Assam, it occurs in moist types of mixed deciduous and evergreen forests. In Andaman and Nicobar Islands it is an important constituent of evergreen and deciduous forests.

A. cummunis J.R. & G. Frost, commonly known as bread fruit is found mainly in Westcoast and Western Ghats, Wynad, in the Nilgris, Lower Plains, the Courtallam hills and the Annaimalais. There are two distinct varieties in this species. One is a seeded type and the other entirely seedless. The seeded types are found in a wild state in its native and are of little economic value. It is not useful in culinary preparations but the seeds, which resemble chestnut, are relished when roasted or boiled.

A. heterophyllus Lam. commonly called as jackfruit is one of the most popular fruitsof South India. The tree is indigenous to the evergreen forests of the Western Ghatsat altitudes of 450 - 1200m, but seen growing throughout other hotter parts of India too. Because of seed propagation, the existing population of jack comprises innumerable trees differing from each other in fruit characters of shape, size and quality.

A. hirsutum Lam is commonly found in the evergreen forests of Western Ghats from Konkan southwards, is common in North Kanara and Kodagu in Karnataka to Kerala where it is an important tree. It requires heavy rain fall, not less than 174 cm annually and thrives well on lateritic soils at the foot of the Ghats. The tree can stand shade, but thrives best with a fair amount of light. It does equally well in the open and withstands exposure to sun after the first few years.

A. lakoocha Roxb, is commonly known as monkey jack. In its wild state it is chiefly found in the moist or deciduous forests along the banks of streams and along the site of moist ravines. It thrives best in deep laterite soils and generally comes to bear after about eight years. It is commonly cultivated throughout the greater part of India as a shade or ornamental tree. It is perhaps one of the foremost among neglected but useful trees. It is distributed in evergreen, semi-evergreen and moist deciduous forests upto an altitude of 1800 m in eastern and northern India. On the west coast it is found from Konkan southwards to Kerala, and in Tamil Nadu. It is also found growing in many localities in Andaman Islands.

9. AONLA

Aonla or Indian gooseberry (*Emblica officinalis* Gaertn.) is considered as a wonder fruit for health-conscious population. It is being grown in India for more than 3500 years. Sushruta, the father of ancient medicine (during 1500 BC-1300 BC), has mentioned about its usefulness in 'Ayurveda' in detail. It belongs to family Euphorbiaceae and is one of the important indigenous fruits of Indian subcontinent. In different parts of India, it is known by different vernacular names such as Amla or Aonla in Hindi (Pathak, 2003). The plant and fruit of aonla are regarded as sacred by 'Hindus' and have great mythological significance.

The aonla tree is native to tropical Southeast Asia, particularly central or southern India, Pakistan, Bangladesh, Sri Lanka, Malaya, Southern China and to Mascarene Islands. Seedling trees are of common occurrence in the mixed deciduous dry forests of India, ascending from sea level (western and Eastern Ghats, Aravali and Vindhya hills) to 1300 m above sea level, from northwest Himalayas (Jammu & Kashmir, Himachal Pradesh, Uttranchal) to eastern Himalayas in Assam, Meghalaya, Mizoram, Manipur and Tripura (Pathak, 2003). The natural distribution of wild aonla is found on the Himalayas, Chota nagpur, Bihar, Orissa, West Bengal, North Circars, Deccan, Karnataka and in WesternGhats (Rawat and Uniyal 2003).

In India, the homeland of aonla, domestication first began in Varanasi (earlier known as Benaras) district of Uttar Pradesh with the initiative of Maharaja of Kashi. Banarasi, a superior genotype was selected from the wild aonla trees available in large number in the nearby Vindhyan hills. Authentic information

regarding its cultivation dates to 1881-82 in the Pratapgarh district of Uttar Pradesh.

The wild aonla germplasm is mostly confined in the mixed forests with sloppy topography and sometimes even difficult to approach. A rich genetic diversity of aonla exists in northeastern region of India, particularly in lower Assam, Maghalaya, Mizoram and Tripura (Yadav *et al.,* 2001). Aonla grows abundantly in the forest of Khasi and Garo hills of Meghalaya and locally known as "Sohmylleng" (Pandey *et al.,* 1993). The natural population of aonla in west Khasi hills (Nongkhyllum, Rajaju, Khonjoy area) of Meghalaya warrants *in situ* conservation, which may even be declared as gene sanctuary for this species (Hore, 1998). Mizoram is homeland of wild aonla and star gooseberry (*Phyllanthus acidus*), which has potential as dwarfing rootstock for aonla. Wild Star gooseberry trees are found in forests of Kolasib, Thingdawl and Champhai in Mizoram. Madhya Pradesh forests have rich diversity of aonla. Jharkhand and adjoining areas of Chhatisgarh have rich diversity of aonla in the native forest. The important sites in Jharkhand are Lali forest near Ranchi, Dalma range of Jamshedpur, Theo Ghat forest of West Singhbhoom, Tiamara valley area between Ranchi and Jamshedpur, Ramgarh area of Hazaribagh, Parasnath hills of Girideeh, Kodemera and Jaomi areas of Bihar border, Simdega and Netarhat forest areas of Gumla, Belta forest of Daltonganj, Palamu and Garhwa of Jharkhand and adjoining areas of Sarguja and Ambikapur districts of Chha tisgarh and Sahdol district of Madhya Pradesh. The Belta forest (Daltonganj), Netarhat range in Gumla and Dalma range of Jamshedpur has comparatively high plant population of aonla in the natural habitat. In western and eastern ghats, three species of *Phyllanthus emblica, Phyllanthus indofisheri* and *Phyllanthus acidus* are of common occurrence. A wild strain of aonla grows in the Himalayas up to an altitude of 1600 m asl. The fruits of wild aonla are relatively smaller. In the mid Himalayas wild aonla is distributed right from western to eastern Himalayas including Nepal (Pathak, 2003).

10. BAEL

Bael (*Aegle marmelos*) is native to India and cultivated throughout the South East Asia and East Indian Archipelago. The genus consists of 2 to 3 species. It is found in UP, Bihar and West Bengal. Some important types selected in different regions are UP: NB 1, NB5, NB6: Bihar: Etawah Kagzi, Sewan Large, Mirzapuri and Deoria.

11. BER

Out of the 50 reported species nearly 18 to 20 are native to India. A resume of species availability in different locations in India are given below :

Species	Location
Ziziphus apatala, Z. *funiculosa*, Z. *incurva*	North-Eastern hills
Z. *mauritiana*, Z. *nummularia*	All over the drier tracts, particularly in North-West India and UP
Z. *oenoplia*, Z. *rugosa*	Throughout India except in drier tracts, particularly in Central and Eastern India
Z. *vulgaris*	North-Western Himalayas
Z. *rupicola*	Central and Eastern India
Z. *xylocarpus*	MP and peninsular region

There are more than 100 named varieties in ber and areas rich in variability have been identified in several places in UP, Rajasthan, Haryana, Gujarat, MP, Maharashtra, AP, Karnataka and Tamil Nadu. However, some popular cultivars are Umran, Gola Reshmi and Illaichi.

12. CUSTARD APPLE

The genus *Annona* contains some 120 species originating from warm countries but few important species became integral part of the Indian culture bearing the names of great heroes of the epic Ramayana. Some important species and their natural distribution are given below:

Species	Common name	Varieties	Location
A. squamosa	Sweet sop, Sharifa, Sitaphal	a) Green types: Balanagar, Mammoth, British Guinea, Washington-95,Barbadose seedling, Arka Sahan, (An F1 hybrid) (b) Red types: Red Sitaphal	Low and medium elevations throughout tropics
A. cherimola	Lakshmanphal	Cherimoyar	Cooler places in India
A. atemoya		Pinks mammoth, Bradley, Keller, Page, African Pride, Island Gem	Adopted to colder climate and alkali soils
A. reticulata	Ramphal or Bullock's Heart	Used mostly as a root stock	
A. glabra	Pond apple	Root stock	Flooded areas
A. muricata	Sour soup, Hanuman Phal	Root stock	Mountain regions of India
A. mantna	Mountain soursop	Used in breeding programme for quality	
A. purpurea	soncoya	Used as resistant source for fruit cracking	
A. scleroderma	Eoshto	Used in breeding programmes for thick hard shell	

13. FIG

The original home of origin of fig (*Ficus carica)* is South Arabia. There are four horticultural types in this crop viz., Smyrna, Capri, Sanpedro and Adriatic. This crop has very narrow range of diversity in India and there is a scope for introducing exotic germplasm. However, there are wild relatives found in India and some of them are given as under:

Species	Common name	Distribution
F. auriculata	Timla	Bihar,Orissa, Khashi hills, Manipur
F. benghalensis	Banyan	All over Inedia
F. benjamina		
F. carica	Fig	Uttar Pradesh, Rajasthan, Andhra Pradesh, Maharashtra, Karnataka
F. elastica	Indian Rubber tree	Assam and Khasi hills
F. glomerata	Cluster fig	
F. hispida		Throughout India
F. krishnae	Krishna's fig	
F. lucescens		North India, MP and W peninsula
F. palmata		N.W India and Rajasthan
F. religiosa	Peepal tree	All over India
F. rumphii		Punjab, MP, Assam
F. samicordata		Punjab, Assam, Bengal, Khasi hills and Manipur

14. SYZYGIUM

This genus *Syzygium* comprises about 1000 species of evergreen trees and shrubs; most of them are tropical in origin. Jamun is found in Western Ghats and very extensively in the tropical region. The diversity found is due to the high heterozygosity and seed multiplication. Some of the species are described below:

Species	Common name	Distribution
S. aqueum	Watery Rose-apple, Fruits edible	A small tree distributed in Assam and Meghalaya
S. arnottianum	Produces edible fruits	Western Ghats, The Nilgris, Palni and Anamalai hills
S. aromaticum	Clove, dried flower buds are of commercial importance	Evergreen trees cultivated in Tamil Nadu and Kerala
S. claviflorum	Fruits are acidic and edible	Andamans
S. cumini	Java plum, Jamun, Jambu	Throughout India
S. fruticosum	Wild Jamun	Avenue tree
S. jambos	Rose-apple	Many parts of India
S. mappaceum	Grown as ornamental plant	Assam, Meghalaya, Arunachal Pradesh and Tamil Nadu
S. samarangense	Wax Jumbu, fruits edible	Andamans and many parts in India
S. zeylanicum	Aromatic fruits are edible	Maharashtra, Karnataka, Orissa, Kerala and Andamans

15. POMEGRANATE

Pomegranate (*Punica granatum*)is an ancient fruit, which originated in Persia, Afghanistan and Baluchistan naturalized in Western India very early. Its wild forms are found in lower hills of Himachal Pradesh. Most of the pomegranate types cultivated in India are of seedling origin and thus providing a wide range of variability with respect to fruit shape, size, and mellowness of seed, aril colour, rind colour, sweetness and acidity of juice. Some popular varieties in different regions are furnished below:

Region	Variety/type
Maharashtra	Ganesh, Super Bhagwa, Solapur Lal, Mridula, Aaraktha,G-137,P-23, P26, Muskat
Karnataka	Ganesh, Ruby, Bassein Seedless
Gujarat	Dholka
Rajasthan	Jodhpur Red, Jodhpuri White
Tamil Nadu	Yercaud, Vellodu, Kabul Red, CO-1

Apart from the above-mentioned fruit species, there are several other species of fruits for which considerable diversity exists in the wild and conservation of such fruits needs to be carried out both *in situ* as well as in *ex situ.* There is also a need to work out the diversity using molecular means, so that the concept of 'core collection' can be practiced effectively.

CONSERVATION OF TROPICAL FRUIT TREES

Conservation of plant genetic resources is undertaken at genotype, gene pool, species and ecosystem level using diverse approaches. Plant genetic resources conservation is possible using in situ and ex situ approaches wherein each approach extends further options depending on the biological status, propagation method and population size of the species. Vast genetic diversity of underutilized fruits represents varied germplasm of wild, semi-wild species, genetic stocks, cultivars, farmers selections etc. requiring application of more than one method of conservation. It is, therefore, emphasized that a complementary conservation strategy (Rao, 1998; Rao and Sthapit, 2013), involving the use of more than one relevant

approach (in situ and ex situ) would be the best option for achieving safe conservation of these underutilized fruit species facing severe threat of extinction. There is big challenge to protect and conserve wild and semi-wild species of several major and minor fruits. Most of the wild species of these fruits occur in the protected areas and buffer zones of forest reserves and National parks. More over regeneration capacity and population size of some of the species is highly inadequate which is a matter of further concern and there is a probability of these being pushed to rare and endangered category (Malik *et al.,* 2006). Due to various developmental projects and changing climate these areas have become highly vulnerable and there is an urgent need to protect and collect the existing important plant diversity for safe ex-situ conservation. Coordination with forest department and joint programmes with Ministry of Environment, Forest and Climate Change is imminent to collect the germplasm and to ensure suitable in situ conservation measures.

In situ conservation of tropical fruit tree species is one of the most important aspects in the overall conservation of fruit diversity (Dinesh, 2001). It is well known that many of the species of mango, when introduced to other areas do not perform well or die. It is observed that the Mangifera andamanica, M. camptosperma and M. griffithi when introduced to mild tropics could not survive (Prakash, 2001). It is to be mentioned here that inspite of innumerable problems that are faced in the ex situ conservation, it is still advantageous to maintain them in the field gene bank, as it keeps the biodiversity of a particular species safe when plants are destroyed in the wild. Hence, to rationalize the concept of core collection was introduced, which in a limited set represents the genetic spectrum in the whole collections (Brown, 1989). It is proposed that landraces should be preserved for future generations as they harbour a diversity of interesting traits for future breeding work, for developing new farming systems and moreover, reflect the cultural identity of certain groups of people (Altieri and Merrick, 1987).

Until recently, germplasm conservation of crop landraces, as well as of their wild relatives, relied on ex situ methods (i.e., the conservation of biological material outside its natural habitat, UNCED 1992), mostly in germplasm banks. More recently in situ (on-farm) conservation (i.e. the conservation of biological diversity in its natural habitat) has been proposed as a conservation strategy which allows evolutionary processes to continue rather than being halted as occurs in ex situ conservation (Frankel *et al.,* 1995; Maxted *et al.,* 1997).

POLLEN STORAGE AS A MEANS TO CONSERVE DIVERSITY IN TROPICAL FRUIT TREES

Genetic conservation through pollen storage is desirable for a variety of horticultural plant species, since pollen is known to transmit important genetically heritable characters. Pollen is a product of genetic recombination and can provide a reliable source of nuclear genetic diversity at the haploid stage. Fruit tree pollen is generally required to be stored for controlled crossings, either to achieve a desired breeding objective, or to overcome a constraint involved in commercial fruit production.

Gene pool conservation at the haploid stage can, therefore, be effectively accomplished through pollen, which can provide a rich source of nuclear genetic diversity. A major emphasis on research needs include pollen storage (Arora and Rao, 1995) for citrus, mango, rambutan, jackfruit, durian and litchi. Pollen cryopreservation research has been recently recognized by IPGRI (IPGRI, 1995). As one of the gene pool components in an integrated PGR conservation programme, pollen can serve as an alternative or additional ex situ conservation method. Alexander and Ganeshan (1993) have extensively reviewed pollen storage research in fruit crops. Grout and Roberts (1995) have elaborately described the methodology involved in pollen cryopreservation. Hoekstra (1995) has assessed the merits and demerits of pollen storage for genetic resources conservation.

One of the main lacunae so far in the survey and collection of tropical fruit tree species has been the non-adoption of 'Geographic Information System' (GIS) tools, with the result that many of the regions with rich diversity were excluded. However, the use of Geographic Information System tools of late has helped in avoiding duplication of surveys and carrying out surveys with fair degree of accuracy.

These tools can also help in isolating genotypes with exceptionally good characteristics.

GIS TOOLS AND PREPARATION OF DISTRIBUTION MAPS

Geographic Information System (GIS) is widely used in management of natural resources. Presently GIS is being widely used in mapping biodiversity by different organizations. GIS is a database management system with specific functions to handle spatial data, i.e., latitude and longitude. Many applications of GIS have been developed for commercial purposes or for specific management purposes, for example, Atlas, MapInfo for Windows, Arc/Info, etc. for commercial use, and GRID, FloraMap, DIVA, etc. for specific purpose of mapping biodiversity. For mapping biodiversity and its assessment for tropical fruit tree species, software such as FloraMap and DIVA which were developed by the International Potato Centre (CIP) and International Centre for Tropical Agriculture (CIAT) for research purposes. GIS has two kinds of software, viz. rector-based system and raster-based system. The rector-based system stores geographic data as points, while the raster-based system stores data as grid cell. For mapping genetic diversity, rector-based system is popularly used. Using DIVA and FloraMap maps have been generated for fruit species like *Mangifera* and *Citrus*.

BIODIVERSITY ASSESSMENT USING MOLECULAR TECHNIQUES

With the advent of molecular biology techniques, DNA-based markers have replaced enzyme markers in germplasm identification and characterization. Because of its plasticity, ubiquity and stability, DNA is the ideal molecule for such analysis in fruit crops (Lalitha Anand, 2001). Although, molecular markers have been used to create extensive linkage maps for many annual plants (Helentjaris 1987; Bernatzky and Tanksley 1986; McCouch et al., 1988), few attempts have been made for their use in fruit crops. Genetic analysis and breeding of woody perennial fruit species can be complicated by many factors including long periods of juvenility, high ploidy levels, lack of described Mendelian markers and so on (Rowland and Levi, 1994). Hence, the task of developing molecular marker-based genetic maps is both challenging and important.

The basic premise is that variation in the nucleotide sequence of DNA can be exploited to produce characteristic fingerprints. The systems available are:

1. Restriction fragment length polymorphism (RFLP)
2. DNA amplification fingerprinting (DAF which comprises AFLP- amplified fragment length polymorphism / RAPD- random amplified polymorphic DNA)
3. Microsatellites / Simple Sequence Repeats (SSRs)
4. Cleaved amplified polymorphic sequences (CAPS).

SUMMARY

Collection, characterization and conservation of genetic resources of important tropical fruit ?? species such as *Mangifera* species, Citrus species, *Annona squmosa* (Custard apple), *Aegle marmelos* (Bel), *Artocarpus heterophyllus*, *Buchanania lanzan* (Chironjee), *Capparis decidua* (Ker), Carissa carandus (Karonda), wild and semi-wild *Citrus* species, *Cordia myxa* (Lasoora), *Embolica officinalis* (Aonla), *Garcinia* spp., *Grewia asiatica* (Phalsa), pau *Manilkara hexandra* (Khirni), *Phoenix sylvestris* (Date sugar palm), *Salvadora oleoides* (Pilu), *Syzygium cumini* (Jamun), *Tamarindus indica* (Tamarind) and *Ziziphus* spp. (Ber) has been undertaken. Several underutilized fruit species are propagated through seeds as vegetative propagation methods are hardly available. Presently many ex-situ conservation approaches have been suggested for long-term conservation depending on propagation method and seed storage behavior of these under utilized species. Successful cryopreservation protocols have been developed for seeds, embryos and embryonic axes in several non-orthodox difficult-to-store seed species and more than 2000 accessions have been successfully cryo-stored at National Cryo gene bank. However, there is still need to establish and strengthen field gene banks and clonal repositories for conservation and utilization of germplasm and to facilitate farmers with elite planting material of these important indigenous fruits.

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