

Advances in production technologies of major underutilised fruit crops

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Underutilized fruit crops refer to those fruits which may be high in value but that are not widely grown. An exact definition of minor fruit crops is perhaps difficult. In a general sense, these fruits are consumable by in relatively less quantity may be due to less palatable or less availability than other fruits. These fruit s may have lesser demand in the market or grown in a limited extent. Other terms for these fruits are less-known, less appealing, less-exploited fruits, underutilized, stray fruits, wild fruits etc. However, any sharp line of distinction between the major and minor fruits is difficult. A fruits which is major fruit in one region or country may be minor in other region or country. For example Rambutan in major fruits crops in Indonesia, Malaysia but in minor crops in India. Similarly mango is the most important fruit in India while it is regarded as a minor fruit crop only in some western countries. Avocado is another example, it is a major commercial fruits in South and central American countries but minor fruit in India (Tripathi *et al.*, 2014) .If area and production are considered to be the criteria to call a fruit crop as major or minor, difference may be observed even in the same country as well. The climatic conditions are important for cultivation which influences the area and spread of crop. This makes some fruits to grow extensively over large area in a region unlike other parts in a country. The temperate fruits like apple, pear, peach, plum etc. are known to comprise as the major crops under the conditions of Kashmir, Himachal Pradesh and Uttarakhand while these are minor crops in the Hills of South India where some less chilling varieties are grown to a small extent. Similarly, tropical fruit crops are grown as the major fruit crops in South India but these are considered as minor crops in parts of north India. Litchi is a commercial crops in Bihar, West Bengal, Uttarakhand and North east but it is minor crops in other regions (Tripathi *et al.*, 2015,2019). Thus it is difficult to decide which crops are minor crops. But the production and the consumption may be considered as criteria for categorising crops as minor crop. The minor crops may categorised in several groups such as tropical and subtropical; native and introduced.

As far as the native fruits are concerned, India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. India contributes significantly to the biodiversity of the world by accounting 7.31 % of the global plant diversity from 2.4% of the world's area. It is one of main centre of crop diversity and the homeland of 167 cultivated species and 320 wild relatives of crop plants. Out of 18 biodiversity hot spots identified in the world, four hotspots, i.e. Western Ghats, Eastern Himalaya, Western Himalaya, and

Nicobar islands are in India. Apart from this, India has 26 recognized endemic centres which are home to one - third of all the flowering plants from identified and described so far. Several fruit plant species have originated in Indian subcontinent. India is centre of origin of, jack fruit, bael, aonla, ber, khejri, jamun, tamarind, mahua, phalsa, Lasoda, karonda, wood apple, pilu, bilimbi, Garcinia, and several other wild fruits (Arora,1985; Arora, 1998; Singh *et al.* 2009; Table 1). Several minor fruits such as Rambutan, mangosteen, longan, avocado, water apple, hog plum, macadamia nut, kiwifruit, longsat, durian, passion fruit, dragon fruit, pulasan, carmbola, etc. were introduced during last few centuries and several are naturalized in Indian conditions (Arora, 1985; Arora, 1998. Pareek *et al.*, 1998; Table 2). Apart from these there more than 100 wild edible fruits native to India which are yet to be domesticated but these are gathered from forest by the rural and tribal people and sold in the rural market (Tripathi *et al.*, 2014 &2015).

The area under minor fruits is around 10 percent of the total area under fruits and production is less than 7 percent of total fruits production. Most the the minor fruits are cultivation in dry and less fertile lands thus the productivity is low except in jackfruit. Among them highest area is under jack fruit followed by kiwi fruit and Aonla. The cultivation of kiwifruit is confined to hill states of North India. In fact jack fruit and aonla were minor fruits till 25-30 year back but now it has occupied several thousand acre area almost all regions of the country except higher hills. The ber and custard apple also occupied sizeable area under cultivation particularly in the arid and semi arid regions (Anonymous, 2015; Table 3).The production technologies are some of the fruits is described as follows.

Table 1 : Indigenous underutilized Fruits in India

Common Name	Scientific Name	Family	Common Name	Scientific Name	Family
Jack fruit	<i>Artocarpus heterophyllus</i>	Moraceae	Tamarind	<i>Tamarindus indica</i>	
Aonla	<i>Emblica officinalis</i>	<i>Euphorbiaceae</i>	Phalsa	<i>Grewia tiliifolia</i>	Malvaceae
Star Gooseberry	<i>Phyllanthus acidus</i>	<i>Euphorbiaceae</i>	Bael	<i>Aegle marmelos</i>	Rutaceae
Bilimbi	<i>Averrhoa bilimbi</i>	<i>Oxalidaceae</i>	Wood apple	<i>Ferronia limmonia</i>	Rutaceae
Jamun	<i>Syzygium cumini</i>	Myrtaceae	kokum	<i>Garcinia indica</i>	Clusiaceae
Ber	<i>Ziziphus jujuba</i>	Rhamnaceae	Yellow mangosteer	<i>Garcinia xanthochymu</i>	Clusiaceae
Jherberi	<i>Ziziphus nummularia</i>	Myrtaceae	Malabar tamarind	<i>Garcinia gumigatta</i>	Clusiaceae
Rose Apple	<i>Syzygium jambos</i>	Myrtaceae	Governor's plum	<i>Flacortia indica</i>	Flacourtiaceae
Pommelo	<i>Citrus grandis</i>	Rutaceae	Mahua	<i>Madhuca indica</i>	Sapotaeceae
Citron	<i>Citrus medica</i>	Rutaceae	Pilu	<i>Salvadora oleoides</i>	Salvadoraceae
Phog	<i>Calligonum polygonoides</i>	Polygonaceae	Ker	<i>Capparis decidua</i>	Capparaceae
Sea buckthorn	<i>Hippophae rhamnoides</i>	Elaeagnaceae	Indian almond	<i>Terminalia catappa</i>	Combretaceae

Table 2 : Exotic underutilized Fruits in India

Common Name	Scientific Name	Family	Common Name	Scientific Name	Family
West Indian Cherry	<i>Malpighia glabra</i>	Malpighiaceae	Malay Apple	<i>Syzygium malaccense</i>	Myrtaceae
Durian	<i>Durio zibethinus</i>	Malvaceae	Mangosteen	<i>Garcinia mangostana</i>	Clusiaceae
Soursop	<i>Annona muricata</i>	Annonaceae	Rambutan	<i>Nephelium lappaceum</i>	Sapindaceae
Passion Fruit	<i>Passiflora edulis</i>	Passifloraceae	Custard Apple	<i>Annona squamosa</i>	Annonaceae
Atemoya	<i>Annona atemoya</i>	Annonaceae	Manila Tamarind	<i>Pithecellobium dulce</i>	Fabaceae
Dragon fruit	<i>Hylocereus.spp</i>	Cactaceae	Avocado	<i>Persia americana</i>	Lauraceae
Longan	<i>Dimocarpus longan</i>	Sapindaceae	Macadamia nut	<i>Macadamia integrifolia</i>	Proteaceae
Longsat	<i>Lansium domesticum</i>	Meliaceae	Manila Tamarind	<i>Pithecellobium dulce</i>	Fabaceae
Kiwifruit	<i>Actinidia chinensis</i>	Actinidiaceae	Java Apple	<i>Syzygium samarangense</i>	Myrtaceae
Surinam cherry	<i>Eugenia uniflora</i>	Myrtaceae	Tamarind	<i>Tamarindus indica</i>	Fabaceae
Persimmon	<i>Diospyros kaki</i>	Ebenaceae	Hickory	<i>Carya tomentosa</i>	Juglandaceae
Egg fruit	<i>Pouteria campechiana</i>	Sapotaceae	Carambola	<i>Averrhoa Carambola</i>	Oxalidaceae

Table 3: Area, production and productivity of underutilized fruits in India (2013-14)

Fruit	Area (000)	Production (000)	Major production areas
Jack fruit	151	1722	Kerala Karnataka, Tamilnadu, west Bengal, North East India
Aonla	88	972	U P, Maharashtra, Tamil Nadu
Custard apple	37	298	Maharashtra, Telangana, Gujarat, Rajasthan
Ber	44	425	Rajasthan, Haryana, Gujarat
Passion Fruit	13	78	Kerala, Karnataka, Nagaland ,Mizoram, Tamilnadu
Kiwifruit	90	559	Himachal Pradesh, Uttarakhand
Pecannut	1	1	Himachal Pradesh, Uttarakhand
Jamun	Trace	NA	All over India except higher hills
West Indian Cherry	Trace	NA	Hot humid regions of South India
Star Gooseberry	Trace	NA	Maharashtra, Karnataka
Durian	Trace	NA	Tamil Nadu, coastal Karnataka
Soursop	Trace	NA	coastal Karnataka
Bilimbi	0.02	NA	Hot humid regions of South India
Mangosteen	0.02	NA	Kerala, Karnataka, Tamil Nadu
Rambutan	1.0	NA	Kerala, Karnataka, Tamil Nadu
Atemoya	0.001	NA	Maharashtra, Karnataka
Java Apple	Trace	NA	Hot humid regions of South India

(Anonymous, 2015, Tripathi *et al* ,2014a,b))**Aonla (Indian goose berry)**

Aonla or Indian gooseberry (*Embllica officinalis*) is an indigenous fruit of India. Aonla is a subtropical plant and prefers dry subtropical climate. Heavy frost during winter is not conducive to its cultivation. A mature aonla tree can tolerate freezing as well as high temperature of 46°C. Warm temperature seems conducive for the initiation of floral buds. Higher humidity is essential for initiation of fruit growth of

dormant fruits during July–August. Dry spells result in heavy dropping and delay in initiation of fruit growth. Since aonla is a hardy plant, it can be successfully grown in variable soil conditions. The deep root system, reduced foliage, dormancy of fertilized fruit lets (April–June) makes aonla an ideal plant for arid and semi-arid conditions. Aonla can be cultivated in marginal soils—slightly acidic to saline/sodic (pH 6.5–9.5) conditions. Heavy soils or high water table areas are not suited for its cultivation. The important varieties are Banarasi, Francis, Chakaiya, Kanchan, Krishna, NA 6, NA 7, N-10, BSR-1. Aonla has long been raised through seeds (sexual method) and vegetative methods (budding grafting). The seeds are used for the production of rootstocks. The seed does not show any dormancy and germinates early. Six months to one-year-old seedlings are being used as rootstock. The vegetative propagation of aonla is done by different methods. It can be successfully propagated through patch/modified ring budding in north India during rainy season with 60–100% success. Besides, Veneer grafting also has successfully been attempted. Aonla scion shoots can be safely stored for 5–7 days with ample success. The plants are planted 6–10 m apart during July–August in pits of 1x 1x1 m size. Since self-incompatibility appears to be a problem with aonla varieties, 2 varieties in alternate rows need to be planted. A dose of 10kg farmyard manure, 100g N, 50g P and 100g K should be given to one-year-old plants of aonla. This dose should be increased yearly up to 10 years and thereafter a constant dose should be given. In sodic soils, 100–500g of B and zinc sulphate should also be incorporated along with fertilizers as per tree age and vigour. Established aonla orchards in general do not require irrigation particularly in normal soils. Aonla is not much affected by diseases and insects. But the attack of diseases and pests reduce the yield and quality of fruits. Some of the diseases affecting aonla are ring spot, leaf spot. These can be controlled by application of Diathane M-45. The fruit rot is an important disease of aonla which affects the stored fruits of aonla. This can be controlled by treatment of fruit with Borax and salt solution before storage. Among the pests, Shoot gall, Bark eating caterpillar, aphids are major ones. A budded/grafted aonla tree starts bearing third year onwards after planting, whereas a seedling tree may take 6–8 years. An aonla tree may bear 100–300 kg/tree, giving 15–20 tonnes/ha. Aonla is rarely used as fresh fruit. Aonla fruits can be stored for 6–9 days at ambient temperature.

Bael (wood apple)

It is native to India. Bael fruits consist of moisture (61.5%), protein (1.8%), fat (0.3%), minerals (1.7%), fibre (2.9%) and carbohydrates (31.8%) per 100 g of edible portion. Though bael is a fruit crop of subtropical origin, it has got a wider adaptability and can perform equally well in tropical, arid and semi-arid regions. Several improved varieties have been developed by various organizations. The important ones are Pant Aparna, Pant Shivani, Pant Sujata, Pant Urvashi, Narendra Bael-5, Narendra Bael-7, Narendra Bael-9, CISH B-1, CISH B-2, Goma Yashi. Seedlings raised from seeds are not considered suitable planting material because of late bearing and not being true to the types which show great variation in form, size, edible quality and number of seeds. For commercial orcharding, plants produced by vegetative propagation

methods viz., patch budding and soft- wood grafting should be used. Seedlings can be used as rootstock for producing true to the type planting material. Rainy season is the best time for planting. Dig the planting pits of 1m x 1m x 1m size at 6-8 m distance. Plant produces a number of fruits hence application of manures and fertilizers is beneficial. Apply 10kg farm yard manure, 50g N, 25g P and 50g K per plant to one year old plants. This dose should be increased every year in the same proportion up to the age of 10 years, after which the fixed dose should be applied each year. Half dose of N, full dose of P and half dose of K should be given after harvesting the fruits. Remaining half dose of N and K should be given in the last week of August. Young plants need to be watered regularly in summer and one month interval in winter for their rapid vegetative growth and establishment. Bael being a hardy crop, there is no serious insect pest and diseases as of now. But sooty mould has been noticed in commercial bael orchards which can be managed by spraying wettable sulphur+chlorpyrifos/methyl parathion+ gum acacia (0.2+0.1+0.3%). During new leaf emergence, leaf eating caterpillar is causing serious problem and it can be managed by application of Thiodan @ 0.1%. Fruit cracking and fruit drop are two important physiological disorders found in bael. These can be managed by providing good irrigation facility, making wind breaks around the orchard and by spraying borax @ 0.1% twice at full bloom and after fruit set. Budded and grafted plants start fruiting after 4-5 years of planting whereas, seedlings after 8-10 years of planting. Bael Fruit takes 10-12 months for ripening after fruit set. Bael is climacteric fruit that can be ripened, off the tree, if harvested at proper maturity stage. Maturity can be judged by the change in skull colour from dark green to yellowish green. Mature fruit should be harvested individually with 5 cm fruit stalk. A full grown (10-12 years old) bael tree produces on an average 150-200 fruits under good management practices. The fruits can be stored at room temperature for two weeks. At 10° C, it can be kept up to three months.

Rambutan

Rambutan (*Nephelium lappaceum* var. *lappaceum*) is a popular fruit of Indonesia, Malaysia and Thailand. It has been widely cultivated throughout Southeast Asia. In India, rambutan cultivation is limited to some parts of South India. The fruits of rambutan are red to yellow in colour. These are similar to litchi except long hair like structures on fruits. Rambutan fruits are mostly used as fresh fruit. In India, Rambutan is cultivated in home gardens of Thrissur, Pathanamthitta, Kottayam and Ernakulam districts of Kerala, Nagercoil, Courtralam, The Nilgiris districts of Tamil Nadu, Dakshina Kannada and Kodagu districts of Karnataka. The actual area and production of rambutan in India are not available but it is estimated that the area under the crop is less than 500 acres. There is good potential of expression of this crop in Kerala, Tamil Nadu and Karnataka. Rambutan tree is an evergreen tree which may grow up to a height of 12–20 m. Rambutan is adapted to warm tropical climate. It requires around 22–30°C temperature for optimum growth. The plant requires good rainfall of 200-500 cm well distributed through out the year. Rambutan is grown successfully in wide range of soils. Well drained sandy loam to clay loam soils with organic matter

are most suitable for optimum growth and yield. It can be grown successfully in red laterite soil if adequate organic and inorganic fertilizers are applied. The optimum soil pH is 4.5 to 6.5. Rambutan is sensitive to water logging. The orchard in slight sloppy land has been found performing better. Rambutan is propagated by seed or by vegetative methods such as budding, grafting and layering. Seed propagation is easy but is not recommended for commercial multiplication as more than 50 per cent produced only male flowers. The seedlings are used for rootstocks purpose only. The seeds lose their viability very soon. Thus it should be sown immediately after removing the aril. The seedlings become ready for grafting in 9-10 months. Vegetative propagation is essential as rambutan seedlings take long time for fruiting and female to male trees is 4 or 5 to 7. Approach grafting is found successful but it is more labour intensive and cumbersome. Air-layering may at first appear successful, but many air-layers die after being transplanted into field nursery or poly bags or later in the field, long after separation from the mother tree. Among various budding methods, Patch-budding is preferred as having a higher rate of success. The budding is done in the on well-grown rootstocks of 8 to 12 month old in month of May or July. The success rate is reported to be as high as 83.6% in other countries. There are several commercial varieties of rambutan grown in south eastern Asian countries. CHES (IIHR) Chettalli have released two varieties on rambutan namely Arka Coorg Arun and Arka Coorg Peetabh. The seedling trees of rambutan are vigorous and spreading type and require more space for growth and generally are planted at 10x10 to 12x12 meter distance. The vegetatively propagated trees are smaller in size and they should be planted at a spacing of 8x8 or 8x6 m. The most appropriate spacing is 200-250 plants/ha. The planting is done in pits of 1x1x1m size which are done 2 to 3 weeks ahead of planting and filled with a mixture containing three parts of top soil and one part of compost. Planting is done preferably during June-July after the onset of monsoon so that the plants are well established at the end of the monsoon. Rambutan trees exhibit strong apical dominance and have a tendency to produce long, upright growth. Early pruning and training to form an open center tree is recommended. After harvesting, fruited twigs are pruned back to stimulate new growth. A fertilizer dose of 200g nitrogen, 25g of phosphate and 100g potassium per tree per year of age is recommended for rambutan. For the first four years, the fertilizers should be applied in four equal dressings, every three months. For fruiting trees, 200g N, 25g P and 130g K per tree per year of age are recommended. Maximum fertilizer rate is reached at 12 years and should remain constant thereafter. Irrigation is given as needed in dry seasons. In order to induce flowering of full-grown plants, there is a need to allow the rambutan plant to pass through a period of drought for about 21-30 days. Rambutan is a cross-pollinated crop. Rambutan grafted trees start bearing fruits from fourth year onwards. It may take up to five months for the fruits to develop into ripe fruits after fruit set. In South eastern Asian Countries, rambutan produces fruits twice a year, but in India it gives only one crop per year. The fruits are usually ripe in month of July to October. Harvesting is done by shears or sharp knives by cutting the inflorescence stalk. The fresh fruit are easily bruised and have a limited shelf life. An

average tree may produce 5,000-6,000 fruits (60–70 kg) per tree. The studies revealed that physiological Loss in Weight (PLW) of fruit increased gradually with the days of shelf life. The fruits may be used for making squash, jam, canning etc.

Avocado

Avocado (*Persia americana*) is a native of tropical America. It originated in Mexico and Central America. In India, avocado is not a commercial fruit crop. It was introduced from Sri Lanka in the early part of the twentieth century. In a very limited scale and in a scattered way it is grown in Tamil Nadu, Kerala, Maharashtra, Karnataka in the south-central India and in the eastern Himalayan state of Sikkim. Avocado is the most nutritive among fruits and is regarded as the most important contribution of the New World to human diet. The pulp is rich in proteins (up to 4%) and fat (up to 30%), but low in carbohydrates. Avocado is mainly used fresh, in sandwich filling or in salads. It can also be used in ice creams and milk shakes and the pulp may be preserved by freezing. Avocados can be grown on a wide range of soils, but they are extremely sensitive to poor drainage and cannot withstand water-logging. They are intolerant to saline conditions. Optimum range of pH is from 5 to 7. Depending on the race and varieties, avocados can thrive and perform well in climatic conditions ranging from true tropical to warmer parts of the temperate zone. It can not tolerate the hot dry winds and frosts but it may be grown in tropical or semitropical areas with some rainfall in summer. In India, avocado is not a commercial fruit crop. It was introduced from Sri Lanka in the early part of the twentieth century. In a very limited scale and in a scattered way it is grown in Tamil Nadu, Kerala, Maharashtra, Karnataka in the south-central India and in the eastern Himalayan state of Sikkim. In Kodagu, a avocado is grown as one of the mixed crops in coffee-based cropping system.

All three horticultural races i.e. West Indian, Guatemalan and Mexican of avocado have been tried in India. Mexican and Guatemalan races are grown successfully in humid mid hill of Himalaya. The cultivars of West Indian race are grown in localized pockets in Maharashtra, Tamil Nadu and Karnataka. Several varieties such as Purple, Green, Fuerte, Pollock, Peradeniya Purple Hybrid, Trapp, Round and Long are grown in India. In India, avocado is commonly propagated through seeds. The seeds should be sown immediately after extraction from fruits. Seedlings are also used as rootstocks. Budding or cleft grafting has found successful for vegetative propagation of varieties and selected varietal clones. Cleft grafting was found most successful during March and September under Chettalli conditions. Avocado plants multiplied from seeds start bearing five to six years after planting while grafted plants start bearing in 4-5 years. Avocado is planted at a distance of 6 to 12 metres depending on the vigour of variety and its growth habit. The Pits of 1x1x1 m are dug before onset of monsoon and filled with farmyard manure and top soil (1:1 ratio) before planting. Planting is done in month of June -July. Training is done to give proper shape to the plants. Little pruning is done to thin out and removal of dried branches in grown up plants. Heavy pruning has been found to promote excessive vegetative growth and reduces yield. Irrigation at intervals of three to

four weeks during the dry months is beneficial for growth and yield of avocado. To avoid moisture stress mulching with dry grass/dry leaves is desirable. An avocado is heavy feeder. In general, About 1.2 kg Nitrogen, 0.8kg Phosphorus and 1.0 kg potassium per tree should applied 6 year and onwards. Micro nutrient deficiency particularly Iron is common. Basal or foliar application of micro nutrient is essential. Avocado flowers twice in year in Coorg region. The fruits ripe in July - August and December-January. At Maturity, fruits of purple varieties change their colour from purple to maroon, whereas fruits of green varieties become greenish-yellow. The yield ranges from about 100 to 500 fruits per tree. Avocados do not ripen on the tree, and fruits soften only after 5-10 days storage. Fruits need to be picked carefully. They should be harvested at the correct stage of maturity. Among insect pests, scales, mealy bugs and mites are the important ones, and may be controlled by suitable insecticides. Root rot, fruit spot, anthracnose and stem-end rot and scab are main diseases of avocado. Root rot which is caused by *Phytophthora cinnamoni* most serious disease of avocado. This may be control by application of suitable fungicides such as metalaxyl (2g/l).

Dragon fruit

Dragon fruit (*Hylocereus undatus*) belong to family cactaceae. The plants of dragon fruit resembles with others cactus with angular fleshy, thorny stem. The plants are perennials and may survive for more than 20 years. The stem is green in colour, weak and require support for growth. The Dragon fruit is originated in Tropical and Subtropical Mexico in South America. The fruits are medium but large oblong shape fruits has distinguished red colour with large scales. Fruits set 30-40 days after pollination. Dragon fruit is non climatic fruits and some of the fruits remain pinkish red at maturity. Dragon fruit adapts well to tropical climates. The optimum temperature range for dragon fruit cultivation is about 20 - 30 °C with well distributed annual rainfall of 100-150 cm. It need good sunlight, but not suitable for long period. Dragon fruit plant prefer light acidic soil with pH ranging from 5.5 to 6.5. Three types of Dragon fruit species. The first species has Red colour fruit coat with white colour flesh, the second species has Red colour fruit coat with red colour flesh and third species has yellow colour fruit coat with white colour flesh. The species with red colour fruit coat with white colour flesh are most popular. Dragon fruit can easily multiply through stem cutting. Generally 20-25cm long stem cuttings are used for planting. The cutting roots profusely and become ready for planting with 5-6 months. The planting distance depends on the size, slope of field and type of trellis used. Generally in single post system planting is done at 3x3 m distance. the pair row system plating may done at 6x2-2x6x 1 m distance. For planting, Pit of 60 x 60 x 60 cm are dug. Generally planting should be done in rainy season. Dragon fruit is a climbing cactus with weak and segmented stem. It requires a vertical pole support to grow for optimum growth and fruiting. The support may be made in two ways i.e. single pole type and continuous standing type. Generally 1 to 2 old plants should be given 10 to 15 kg of farm yard manure, 200 g nitrogen, 50 g phosphorus and 50 g of potash. This should be divided in

three equal doses and applied in 3 times in a year. The plant of 3 and more year is should be given 20 kg farm yard manure, 500 g Nitrogen , 750 phosphorus and 300 g of potassium. These should be applied in four equal splits doses after harvesting and during growth, before flowering and after fruit set every year. Once are plants are grown up . These need to be pruned by removal of dried branch and diseases branches. This helps in maintaining growth and vigour of plants. There should be 50 main branches with 1 or 2 single branches after harvesting. The root system of dragon fruit is shallow and distributed in 15 to 30 cm depth. Hence irrigation should be insured to provide sufficient water during dry season. Drip irrigation found beneficial for better yield and growth. Weed management is important for the growth in initial stages. The creeping and climbing type weed should be removed at the frequent period of interval as these entangle with the vines and affect the growth and yield. The flower production generally take place during April – August. It is cross pollinated and flowers open in the night. Fruits will be matured 30 -50 days after flowering. Fruiting period will continue up to 3-4 months. Harvesting may be done three-four times with in this period. The fruits turn red in colour at ripening. One plant normally yields 15 to 25 kg of fruits. The pests like mealy bugs and termite have been found damaging the dragon fruit. As for as the disease is concerned the watery stem rot caused by *Xanthomonas* is caused damaged to vines in heavy rainy areas. Proper drainage, wider spacing, adequate air circulation and proper sunlight light to help in minimizing the disease.

Passion fruit

Passion Fruit (*Passiflora edulis* Sims) is a native of Brazil belonging to the family *Passifloraceae*. It is grown mostly in tropical and sub-tropical part of the world from South America to Australia, Asia and Africa. Fruits are rich in Vitamin A (1300-2500 IU/100 g pulp), Vitamin C (30 –50 mg/100 g pulp). It is found growing at an altitude of 800-1500m above sea level. It generally requires an average annual rainfall of 100 cm. In India, it is found to be grown in areas of receiving rain from between 100 cm and 250 cm. Passion fruit is grown on many soil types but light to heavy sandy loams, of medium texture are most suitable. Soil with a pH of 6.5 to 7.5 is the most suitable. There are two distinct forms of passion fruit , the standard yellow (*Passiflora edulis* f. *flavicarpa* Deg.) and the purple (*Passiflora edulis* f. *edulis*). The hybrids of these two have also been developed for cultivation. In India a hybrid of purple and yellow form Kaveri was developed at Central horticultural Experimental Station, which is very popular among the farmers. Passion fruit is propagated through seed, stem cutting , cleft grafting and serpentine-layering . A spacing of three metre from row to row and two metre plant to plant from is suitable. Pits of 45 x 45 x 45 cm size are dug and filled with a mixture containing three parts of top soil and one part of compost. Planting is done during June-July . Passion fruit is a woody vine it needs support for good growth and fruiting. The vines are trained on a frame of wires and poles 1.5 to 2 meter above the soil surface. Passion fruit vines bear fruits only on current season's growth and systematic pruning of vine encourages new growth resulting in regular and higher yield of fruits. A fertilizer dose of 110g N, 60g P₂O₅ and 110g K₂O per vine per annum

is recommended for the 4 year old orchards in South India. Nitrogen should be applied in 3 split doses in the months of February-March, July-August and October -November . On an average, passion fruit requires irrigation of 12-15 litre /vine/day in summer and 6-8 litre /vine/day in winter. Drip irrigation is very useful. Brown spot and Root rot are main disease of passion fruit while fruitfly ,thrips ,mites) are main insect-pests. Passion fruit flowers and fruits throughout the year under favourable conditions. The first fruits are obtained from the ninth month and full bearing is reached in 16-18 months. About 60-70 days are required from fruit set to the harvest of fruit. On an average, yield of 10-12 tonnes per hectare per year can be obtained. Fruits harvested should be disposed off quickly to prevent the loss in weight and appearance.

Mangosteen

Mangosteen(*Garcinia mangostana*) is a broad-leaved, medium-size, ever-green tree. It is considered by many to be the most delicious fruit of the tropics with a universal appeal. It is considered 'the finest fruit of the world' or 'queen of fruits'. Mangosteen cultivation is popular in Indonesia, Philippines, Burma, Sri Lanka and Malaysia. The fruit was introduced more than a century ago in India, but currently it is successfully grown only in selected places on slopes of Nilgiris (Tamil Nadu), Malabar and Kanyakumari, Waynad,(Kerala) and Kodagu (Karnataka). The mature tree reaches a height of 10 to 15m with a dense pyramidal crown and glossy bright leaves. Mangosteen fruit resembles small-sized orange with a smooth reddish purple cortex (rind) .The pulp is white , soft and juicy that it almost melts in mouth with an indescribably sweet and pleasant flavour. Mangosteen requires humid tropics with 180–250 cm rainfall.It is found growing in an altitude of 400–900 m in south India. Generally, frost-free regions with equatorial climate that lie at the foothills are suitable for cultivation.The occurrence of natural variability is also limited by the fact that 'seeds' are of asexual origin, they are formed from the nucellar tissue in the parthenocarpic fruit. Mangosteen may be grouped in two types ,one with large leaves and fruits of variable size and the other with small leaves and small fruits. In Philippines, a variety called Jolo produces fruits that are larger, with big seeds but more delicious pulp than the common cultivated type. Mangosteen is commonly propagated through seeds. Planting distances vary from 8 to 10m between trees, depending on soil fertility.The Pits of 1x1x1 m are dug before onset of monsoon and filled with farmyard manure and top soil (1:1 ratio) before planting. Planting is done in month of June -July. Mangosteen is a slow growing tree.Training is done to give proper shape to the plants. Pruning is done to thin out and removal of dried branches in grown up plants. Mangosteen requires good soil moisture and higher humidity for better growth and yield. Regular irrigation is required in dry season to sustain the growth of the plants. Irrigation at intervals of three to four weeks during the dry months is beneficial for growth and yield of avocado. Mulching is recommended to avoid moisture stress. Much work has not been done of the nutrient demand of mangosteen. But adequate amount of farmyard manures should be applied. The fruits ripen in July - August under cool conditions.The fruits are sold in market immediately after harvesting.

Kokum

Kokum (*Garcinia indica*) is originated in the western Ghats. It found growing naturally in Konkan (Maharashtra), Goa, Western Ghats region of Karnataka and Waynad area of Kerala. A product, Kokum is prepared from this species by drying the outer rind and used to garnish curries and for preparing cooling syrup (Amrit kokum). Besides kokum, nector, juice, squash are also prepared from rind. Edible fat “kokum butter” is obtained from the seed, used in soap and candle manufacture and suitable for ointment (used for local application to ulceration, fissure of lips, chopped hands and feet etc.), cosmetics and other pharmaceutical preparation. This species also has antithelmentic, antiscorbutic, antiseptic and cardio tonic properties. It is useful in curing piles dysentery and tumors pain. Widely used as fish preservatives and a good source of acid for coagulating rubber. Juice used in indigestion, preparation of chutneys, as antiseptic for washing wounds of cattle, rinsing of mouths etc. Due to high content of disaturated and monosaturated glycerides, it is in demand as a substitute for cocoa and extender in chocolate and confectionary products. Kokum required high rainfall and moderate climate for optimum growth and fruiting. It is hardy tree can be grown in on a wide range of soils, with pH is of 5 to 7. In India, kokum is gaining popularly is part of Maharashtra and Karnataka. Some high yielding varieties have developed from Konkan Krishi Vidya Peeth, Dapoli (Maharashtra). Some high yielding lines have been identified at CHES, Chettalli. Kokum is generally propagated by seeds. Recently cleft grafting has been found successful in kokum. Kokum is a slow growing tree, planting may be done at 6 to 10 m distance. Most of the orchards in Karnataka, it is planted at the border of plantation. The Pits of 1x1x1 m are dug before onset of monsoon and filled with farmyard manure and top soil (1:1 ratio) before planting. Planting is done in month of June - July. The fruit ripe during May to June. A high yielding mature tree may yield 500 to 700 fruit. Fruits are harvested manually when the outer skin turned red. Fruit are used for preparing juices.

Karonda

Karonda (*Carissa carandas*) is a medium-sized, wild, thorny shrub of family Apocynaceae. It is a very hardy, drought-tolerant plant that thrives well in a wide range of soils. It grows naturally at elevation of 300 to 1800 meters in the Western Ghats and several parts of our country. It flourishes well in hot and dry climate. Karonda fruit is a rich source of iron and contains a fair amount of Vitamin C. It is antiscorbutic and very useful for cure of anaemia. Mature fruit are used for making pickle, jam, squash, syrup and chutney. It is grown on a limited scale in Rajasthan, Gujarat, Bihar and Uttar Pradesh. It is hardy and can be grown in any type of soil. There are few varieties of karonda and generally used for pickle purchase. Recently CHES Chettalli has identified two promising lines namely CHES K-II-7 and CHE K-35 which can be used as table purpose. The fruits of these lines are comparatively bigger in size (12-15 g), dark red in colour and with high TSS. The plant is propagated through seed. Cuttings can be practised for vegetative propagation of selected promising clone. Planting can be done as hedge on the border of orchard at 60cm

to 1m distance. Commercial planting of selected big fruit size clones may be done at 3x 3 m distance. Pits of 60 X 60 cm should be dug in May-June. These pits filled with soil and farmyard manure. Planting should be done in the month of July. The plants start bearing in two-three years after planting. Regular pruning is required to control the size of plants in high rainfall conditions of Kodagu. Pruning is generally done in the month of October. The fruits of karonda mature in the month of April –May in Kodagu. Fruit are harvested manually. All fruits do not mature at one time. Thus harvesting is done three - four times at regular intervals. A mature tree may yield 1000 -3000 fruit.

Jamun

Jamun (*Syzygium cumini*) is indigenous to India. Its tree is tall and evergreen. Jamun fruits are a good source of iron and are said to be useful in the troubles of heart and liver. The seeds of jamun are an effective medicine against diabetes and their powder is widely used in India to control diabetes. Since jamun is a hardy fruit, it can be grown under adverse soil and climate conditions. It thrives well under both tropical and subtropical climate. It requires dry weather at the time of flowering and fruit setting. Early rains are beneficial for better growth, development and ripening of fruit. Young plants are susceptible to frost. Jamun trees can be grown on a wide range of soils-calcareous, saline sodic soils and marshy areas. Deep loam and well-drained soils are the most ideal. Several promising lines of jamun have been identified on the basis of colour, size and seedlessness. Jamun is propagated both by seeds as well as vegetative. Patch budding and forkert budding were found most successful for vegetative propagation. Patch and forkert budding in month of March give more than 70% success. In low rainfall area, July –August is ideal time for budding. Planting should be done in pits of 1m x 1m x 1m size are dug 10 m apart for seedling trees and 8m apart for budded plants. Seedling trees start bearing at the age of 9-10 years, whereas budded ones take 5-6 years. Fruits ripen during June- July or with the onset of rains. It takes about 3-5 months to ripen after full bloom. Fruits change their colour from green to deep red or bluish black at maturity. Fully ripe fruits are harvested daily by hand picking or by shaking the branches. Jamun trees need a number of pickings, since all fruits do not ripen at a time. The average yield of fully grown budded tree may yield 60 –every year. Jamun fruits are highly perishable. They can be stored only up to 2 days at ambient temperature. Precooled fruits packed in perforated polythene bags can be stored for 3 weeks at 8-10 C and 85-95% humidity.

Pummelo

Pummelo (*Citrus grandis*) is the largest fruit among Citrus fruits. It belongs to the family Rutaceae. Locally it is known as Chakotha, Chakotara etc. In India this is grown on a limited scale, in few parts of the countries especially in parts of Karnataka, near Kanya Kumari region of Tamil Nadu and lower hills of Uttarakhand and Himachal and parts of Bihar. There is no commercial variety of fruit in our country. Several local lines are grown in different regions. These are Red Flesh, white flesh, Devanahalli, Kanapara, Triumph, Royal etc. Several promising lines of pummelo have been identified on the basis of size, colour and less number of

seed by several institutes. Pummelo perform well in subtropical climate. The trees grow in almost any soil that is well drained, sufficiently aerated. Traditionally pummelo is propagated by seed. It is also propagated by budding , patch budding was found successful for pummelo under Coorg conditions. Rangpur lime and Cleopatra Mandarin may used for rootstock for pummelo. Pummelo is planted at 6 x 6 meter distance. The pit of 1x1x1 m size should be dug 2 to 4 week ahead of planting in May-June. Pits should be filled with a mixture farmyard manure and soil. Planting is done in the month of June –July. Regular fertilizer is required for better growth and yield of pummelo. Recommended doses for Coorg mandarin (25 kg farm yard manure along ,5kg neem cake and 600g N, 200g P₂O₅ and 400g K₂O per plant per year) may used for pummelo under Coorg condition.The fruits mature in month of December –January. A tree may yield 100-300 kg per year.

Sour Sop

Sour sop(*Annona muricata* L) is a native of South America belonging to the family Annonaceae. It is found both wild and cultivated throughout the West Indies and from southern Mexico to Peru and Argentina up to an altitude of 1100 m msl. It is grown mostly in tropical region of the world from South America to Australia, Asia and Africa. In India, the exact detail of the introduction of this plant is not known. Presently it is found growing the tropical humid part of Karnataka, Tamil Nadu and Kerala. The sour sop is an evergreen, slender, low branching and bushy tree. The fruit ovoid or ellipsoid and usually irregularly shaped weighing 500g to 1.5 kg The skin is dark green , pulp has an agreeable sub-acid taste with a distinct flavour. Fruits are harvested when fully mature and turned yellowish green. The ripe fruit are usually consumed fresh as a dessert or snack item. The fruit pulp is an excellent source of vitamins B and C, potassium, riboflavin and niacin. The sour sop has some medicinal uses. Soar sop is a popular crop of grown in South America countries. Mexico Venezuela, Brazil are major producer of soar sop. In India, though soar sop was introduced long back but it is grown very limited scale in the plantations. Sour sopIt is grown primarily at altitudes lower than 900 m above sea level. Sour sop grows and produces well at 21 to 30°C. Sour sop can be is grown on many soil types but sandy to sandy loam soils of medium texture are most suitable. In India, not much have been done on identification of elite material . Sour sop is usually propagated by seed. Seeds should be planted as soon as possible after removal from the fruit for better germination. A spacing of 4 to 6 meters distance is recommended depending on the climate and soil type.. In Coorg condition it flowers through out the year with two main flowering peaks in April- May and October-November. The fruit is picked when full grown and still firm but slightly yellow-green. The sour sop is a shy-bearer, the usual crop being 12 to 24 fruits per tree.

Longan

Longan (*Dimocarpus longan* Lour.) is a highly esteemed fruit species in Asia .It is commercially grown in Thailand, China and Vietnam. Longan is evergreen tree which can grow up to 20 m. Fruits are fleshy, very

sweet, translucent, white aril which surrounds a red brown to black seed from which it separates easily. Fruit can be eaten fresh, frozen, canned or dried. There are many cultivars of Longan cultivated in China, Thailand and are south Asian countries. In India longan is found in some of the backyards in south India. There is no recognized variety of Longan in India. Longan is a subtropical tree that grows well in the tropics but requires a short winter season for satisfactory flowering. However, longan is sensitive to frost and is likely to be killed or badly injured by prolonged low temperature. The best temperatures for flowering and fruit set are 20 - 25°C. Sufficient soil moisture is needed from fruit set until maturity. Suitable annual precipitation is about 1,500 mm. Drought and excessive rainfall adversely affects the growth and yield because of result in poor pollination and flower, fruit drop. Heavy, fine textured red loamy soils with high fertility and good water holding capacity are preferred soils for longan cultivation. Longan can be propagated from seed, air-layering, budding, grafting, cutting and inarching. Among the vegetative propagation methods, air layering is the most popular method and has been widely used for a long time. This is usually carried out during rainy season. Beside air layering, it can also be propagated by whip-and-tongue grafting. Trees should be planted at the beginning of the rainy season. Planting distance ranges from 6 x 6 m to 12 x 12 m depending upon the varieties and the soil conditions. Longan takes about 5 months from blooming to harvest. The fruits are non-climacteric and have to be harvested when ripe. Maturity is determined by fruit shape, skin colour and taste. Longan fruit has a short shelf-life. Under ambient temperature (25°-31°C) harvested longan fruit rind turns brown within 3-4 days. Longan fruits can be processed into canned longan, dried longan nuts, longan nectar and frozen longan.

Tamarind

Tamarind (*Tamarindus indica*) is native to Tropical Africa and belongs to the family Fabaceae. It is normally growing as a wild species. But hybrid qualities are reported to be cultivated in the southern part of India. Tamarind tree takes about 13-14 years for full growth, but it has got very high demand in foreign countries (particularly middle east) so Tamarind tree grows well in deep, well-drained soils, which are slightly acid. Trees will not tolerate heavy cold, wet soils but are tolerant of salt spray and can be planted fairly near the seashore. The tamarind is well-adapted humid tropical area with seasonally high rainfall. Young trees are very susceptible to frost, but mature trees will withstand brief periods of 48o C without serious injury. Dry weather is important during the period of fruit development. Spacing of trees is normally 20 to 25 ft. in commercial orchards. Tamarind fruits mature in early summer. They may be left on the tree for as long as 6 months after maturity so that the moisture content will be reduced to 20% or lower. Fruits for immediate processing are often harvested by pulling the pod away from the stalk. The tree begins to bear fruit at the age of 13-14 years and continues to yield abundant crops for more than 60 years. The flowers appear from June and July and the pods ripen in the cold season. The pods should be allowed to ripen on the

tree until the outer shell is dry. Mostly the harvesting of tamarind takes place between 1st March to 15th April. Fruits harvested by the pulling pod away from the stalk. The fruits harvested are stored in neat and clean place. The harvested pod should sun dried for getting best pulp. Fruit harvested after 15th April must be stored in refrigeration. A full-grown tree yields 180-225 kg of fruit per season.

Carambola

Carambola, *Averrhoa carambola* L. is originated in Ceylon and the Moluccas. Carambola tree is slow-growing, short-trunked with a much-branched, bushy, broad, rounded crown and reaches 20 to 30 ft. Carambola should be classed as tropical and sub-tropical because mature trees can tolerate freezing temperatures for short periods. It thrives up to an elevation of 1,200 m. The carambola needs moisture for best performance and ideally rainfall should be fairly evenly distributed all year. It grows well on sand, heavy clay or limestone, but will grow faster and bear more heavily in rich loam. It needs good drainage and cannot stand flooding. There are 2 distinct classes of carambola—the smaller, very sour type, richly flavored, with more oxalic acid; the larger, "sweet" type, mild-flavored, rather bland, with less oxalic acid. Air-layering has been practiced and advocated. A spacing of 6 x 6 m has been advocated. In India, carambolas are available in September and October and again in December and January. Trees maintain under good management practices may yield 40 to 75 kg fruit/tree/year. Carambola fruits can be transported successfully without to longer distances. The matured fruits can be stored for 4 weeks at 10° C. The carambola is relatively pest-free except for fruit flies. Fruit flies some time attacks fruits. Anthracnose caused by *Colletotrichum gloeosporioides* may be a problem in some areas. Leaf spot and sooty mould is reported from some parts

Noni

Noni (*Morinda Citrifolia*) is a small tree that grows an average height around 10-20 feet. The leaves are thick, shiny, dark green and deeply veined. The fruits have an unusual shape and about 3 - 5 inches long, ovoid & yellowish- white & become quite soft at maturity. This small evergreen tree has large bright green elliptical leaves. The fruit is borne on stalks that arise opposite to an unpaired leaf. The fruit starts out as a small lump that swells, produces flower, then forms into the fruit. It can be grown in adverse climatic conditions, even it comes very well in any type of degraded and unfertile land with any type of soil, performs better in sandy loam soil. It can be grown in Tropical and subtropical region. It can tolerate saline, alkaline and water logging. The tree starts bearing early and gives harvestable yield from 2nd year onwards. The tree flowers and fruits throughout the year. The Planting is done at 4 x 4 m distance. Pits of 2'x2' size are made before planting. These pits are filled with mixture of farm yard manure and top soil. The planting is done during monsoon season (June - October). Noni thrives with moderate irrigation and can survive even in drought conditions, once the plant is established. Irrigate during early stages of the crop as

required depending upon the moisture condition. Normally Noni crop is resistant to pest and diseases. However if require it can be controlled easily by organic pesticides. A tree may yield 20-30 kg fruit /year

Malabar tamarind

Malabar tamarind (*Garcinia gunmigatta*) is also known as panampuli, kodumpuli or Cambogia. It is small or medium tree found in Western Ghats. The fruit rind is used as spice in curries and its juice is used for reducing fat and also prevents blood clotting by reducing triglycerides. It is used as fish preservatives in Kerala, South Tamilnadu and in some part of Karnataka (Kodagu and Dikshinkannada). The rind of ripe fruits are processed and used as a condiment in fish and prawn preparation to impart flavour and taste and to improve keeping quality. It has immense value in drugs production for reducing the obesity and rinsing mouth. Seed contain edible fat and used asgarcinia butter.Panampuli required high rainfall and moderate climate for optimum growth and fruiting. It is hardy tree can be grown in on a wide range of soils. One high yielding line has been identified at CHES, Chettalli. Panampuli is generally propagated by seeds. It is a slow growing tree, planting may be done at 6 to 10 m distance. There no commercial plantation of panampuliin Karnataka , it is planted at the border of plantation. The Pits of 1x1x1 m are dug before onset of monsoon and filled with farmyard manure and top soil (1:1 ratio) before planting. Planting is done in month of June - July.The fruit ripe during July-August. A high yielding mature tree may yield 500 to 700 fruit. Fruits are harvested manually when the outer skin tuned yellow. Fruit are used for preparing veneer and rind is dried.

The future (underutilized) fruits are getting popularity due to their health benefits. There is tremendous potential of these crops in the crop diversification in the coffee growing regions of Western Ghats . Some of them have lot of potential for pharmaceutical and processing industries. Some woks have been done on identification of superior lines of these crops but very limited research works has been done on the production technologies of these crops. There is need to pay more attention to these crops.

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