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Breadfruit (*Artocarpus altilis* Fosb.) - An Underutilized and Neglected Fruit Plant Species

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Abstract: Breadfruit (*Artocarpus altilis* Fosb) is a rich source of carbohydrates, minerals and vitamins. Though the crop has been distributed widely, it has often scored as underutilized crop and little attention has been given to its large scale commercial cultivation due to limited knowledge on planting material, agronomic practices and production techniques. Recently, breadfruit has been identified as an alternate source of carbohydrate and the starch can be processed into many forms that would offer potential opportunities in agro-processing and agro-export industry. The objectives of this review are to highlight the economic values of the breadfruit crop, to provide information about its cultivation and to promote the breadfruit's cultivation. Though currently breadfruit is an underutilized and neglected fruit plant species in many countries including Malaysia; cultivation of this fruit crop is expected to grow.

Key words: Agroforestry % *Artocarpus* % Biotechnology % Breadfruit % Carbohydrates % Farming % Staple food % Fruit plants

INTRODUCTION

During the process of human civilization, man has identified important plant species and domesticated them for their applications such as source of food, medicine, aroma, timbers, fruits, vegetables, fire wood and cattle feed in addition to other applications. Breadfruit (*Artocarpus altilis* Fosb) provides an alternate source of staple food and has high economic value [1]. It has become a component of home garden in the countries of South Pacific region. Currently, there is a great deal of interest in expanding the use of breadfruit in agroforestry and home gardens of South East Asia. Agroforestry in general is a broad term which combines silviculture, agriculture and other land use technology to maximize the land productivity. In fact, agroforestry integrate trees in farmland and rangeland, diversify and sustain production in order to improve the socioeconomic status of local communities by providing them with valuable timber, woods, medicinal herbs, fruits vegetables and other sources [2].

In Malaysia, commercial agroforestry was initiated in 1950's since then considerable efforts have been taken to establish agroforestry. However, about 90% of the farmers are smallholders; and due to uneconomic size of holdings they often experience problems of low productivity. Major food products such as rice, vegetables, fruits and beef are imported every year which has escalated the food bills. Even today, Malaysia is a net importer of food, importing food from neighboring countries seems cheaper than producing them; and there is growing demand that has necessitates adequate supply of high quality food at affordable prize. Despite the continuous effort, socio economic factors such as acute shortage of labour, increasing cost of production, rapid liberalization of agricultural trade have brought new challenges in agricultural trade [3]. To resolve this challenge, third National Agricultural policy (NAP3, 1998-2010) was formulated with the objective to maximize the productivity through the optimization of resources [4]. Further, NAP3 focuses on the integration of forest trees on a large scale to maximize the land utilization to fullest extent.

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Breadfruit is one of the principal fruit trees that offer potential for marketing and income generation in the sector of agroforestry and agriculture. The utilization of breadfruit plant species in agroforestry and agriculture will be in line with the NAP3 and National Biotech Policy (NBP) of Malaysia. The purpose of this review is to highlight the importance of breadfruit and issues relevant to the breadfruit production; to propose and promote this underutilized and neglected crop plant for agroforestation and home gardens to maximize land usage in the countries where environment is suitable for the cultivation of this plant species in general and Malaysia in particular.

Importance of Breadfruit: Breadfruit has long been an important staple crop of Polynesia and has grown widely in tropical, pacific, Caribbean and African countries [5, 6]. The fruits are an excellent source of carbohydrates, vitamins [7] and low fat. Fruits can be eaten at all stages of growth as it can be baked, boiled, roasted, fried or steamed [8]. In spite of its carbohydrate richness, breadfruit is substituted partially for wheat flour in many bread, pastry and snack products. Further, it is a good source of fiber, calcium, copper, iron, magnesium, potassium, thiamine and niacin. Some varieties are good sources of anti-oxidants and carotenoids.

Breadfruit tree posses multiple utility value, literatures suggests that Pacific Islanders used all parts of the breadfruit especially the latex, leaf tips and inner bark as traditional medicine. The wood is light in weight, flexible and resists termites attack. It is used for buildings, constructing small canoes, making handicrafts, drums and also as firewood [6, 9, 10]. The bark is used to treat headaches while roots are strong astringent and used as a purgative.

In Caribbean, the senescence leaves were used to prepare tea to reduce blood pressure; it is also thought to control diabetes. Further more in Taiwan, the leaves of breadfruit are used to treat liver disease and fevers. Whereas, in some Polynesian Island, the leaves are used as platters for serving food and as cattle feed [10]. Latex is often used to treat broken bones, sprains, sciatica, etc. This multipurpose tree also provides martial for fabric, glue, animal feed, insect repellent compounds and much more.

Common Names: In English, breadfruit is the common name of *Artocarpus altilis* Fosb plant species. The list of common names for the breadfruit in different countries (or languages) is given in the Table 1.

Table 1: Common names of breadfruit (*Artocarpus altilis* Fosb) plant species

Country	Common name/names of *Artocarpus altilis* Fosb
Cambodia	Sakéé, Khnaôr sâmloo
Cook Islands	Kuru
Fiji	Uto, Buco
French	arbre à pain
Hawaii	Ulu uru
Indonesia	Sukun
Malaysia	Sukun
Micronesia	Mei
Papua New Guinea	Kapiak
Philippines	Rimas
Spanish	pana, panapén, mapén, árbol de pan, buen pan, fruta de pan
Thailand	Sa-ke, khanun-sampalor
Vietnam	Sakê

Taxonomy
Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Urticales
Family: Moraceae
Genus: *Artocarpus*
Species: *altilis*

Breadfruit, *Artocarpus altilis* Fosb (*A. communis*. Forst.; *A. incisus* L.f.) is a member of Moraceae plant family. The family Moraceae contains over 50 genera and over 800 plant species, which are mostly tropical and subtropical, also includes a number of economically important species. The name *Artocarpus* is derived from Greek words "artos-bread" and "carpus-fruit" [11]. The genus *'Artocarpus'* contains about 50-60 species distributed throughout the Indo-Malaysian region and in South China [12].

Origin and Distribution: Bread fruit (*Artocarpus altilis*) is originated from *A. camansi* Blanco and *A. mariannensis* Trecul [13, 14]. The breadnut (*A. camansi* Blanco) is native to New Guinea, Moluccas (Indonesia) and the Philippines. Around 3,000 years ago, breadfruit was first domesticated in the western Pacific and spread throughout the tropics by migrating Polynesians where it begun to cultivate widely by Pacific islanders. In the late 1700s, several seedless Polynesian breadfruit varieties and breadnut from New Guinea were introduced to the Caribbean; where, breadfruit is regarded entirely as a food for the poor. Then it was subsequently distributed

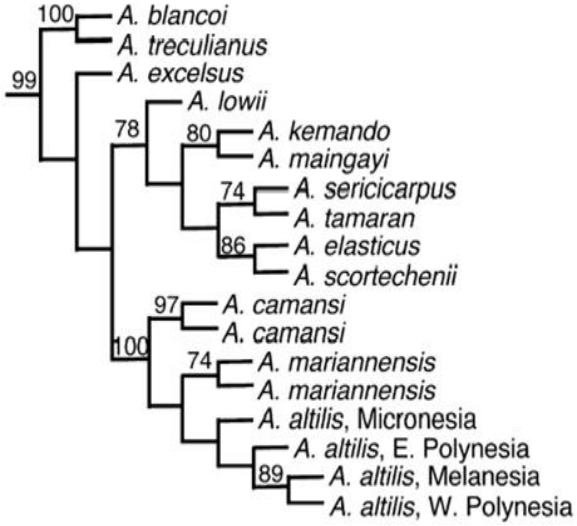

Fig. 1: Phylogenetic relationship between breadfruit (*Artocarpus altilis* Fosb) and its wild relatives; adapted from Zerega *et al*., (2004) [13].

throughout the Caribbean to Central and South America, Africa, India, Southeast Asia, Madagascar, the Maldives, the Seychelles, Indonesia, Sri Lanka, northern Australia and south Florida. In recent years, some breadnut trees have been planted in French Polynesia, New Caledonia, Palau, Pohnpei and Hawai‘i, mainly by Philippine immigrants [9, 15].

In order to understand the relationship between breadfruit and wild relatives, Zerega *et al*., (2004) collected 254 samples of breadfruit and its relatives, among the samples 24 of them were *A.mariannensis*, 30 *A. camansi* and 200 Pacific cultivars [13]. The samples were analyzed using amplified fragment length polymorphism (AFLP) with three different primer pair combinations. The experimental data analysis reported by Zerega *et al*., (2004) [13] revealed the role of *A. camansi* and *A. mariannensis* in determining the breadfruit (Fig. 1).

Botanical Description: Breadfruit is a fast growing tree, usually it grows up to 12-15 m tall and trunk diameter could be 1-3 ft often with buttress roots. All parts of the tree contain latex. The breadfruit trees are usually posses many spreading branches, with pronounced leaves, stipule scars and lenticels. Generally, the leaves are seen as a cluster at the end of the branches. The crown is conical when the trees are young or grown under shaded conditions become rounded and somewhat irregular when older. There is a striking variations in the texture of the leaves. Usually leaves are leathery, smooth and deeply lobed with varying sizes ranging from 22 to 90 cm long

Fig. 2: Breadfruit (*Artocarpus altilis* Fosb) leaves showing different degree of lobbing; photograph adapted from D. Ragone (2006) [53].

and 20-50 cm wide. The leaf margins are broadly obovate to ovate and dissected into 5 to 11 lobes. Pattern of leaf lobes can vary among the cultivars (Fig. 2), most often the leaves are with 5-11 lobes. The leaves are dark green often glossy on the upper side and a lighter green under side, sometimes covered with pale reddish hair on the midrib and veins.

The inflorescence of breadfruit is shown in Figure 3; the tree bears a multitude of tiny flowers. The breadfruit is monoecious, meaning with male and female flowers on the same tree. Female inflorescences consist of 1500-2000 florets arranged in a cluster and attached to a spongy core (Fig. 3A). The female inflorescences are elliptic, green, prickly head, measuring about 2.5 in (6.35 cm) long. Normally, the male inflorescence appears first. The male flowers appear densely on a drooping cylindrical or club-shaped spike of about 5 to 12 inches long (Fig. 3B). The male flowers are 1.5 mm long and consist of a two lobed calyx and a single stamen [16].

The flowers are fused together and develop into the fleshy, edible portion of the fruit. At the time of anthesis, the filament of the stamen elongates pushing the anther out of the calyx tube. Pollen grains are shed within 10 to 15 days after the emergence of the male inflorescence and anthesis continued for a period of about 4 days. Female flowers become receptive 3 days after the emergence of the inflorescence and opening of the flowers starts at the base and progress successively. Flowers are cross-pollinated with small powdery pollen grain spread both by wind and insects [17-19], but pollination is not required for the fruit to form [20].

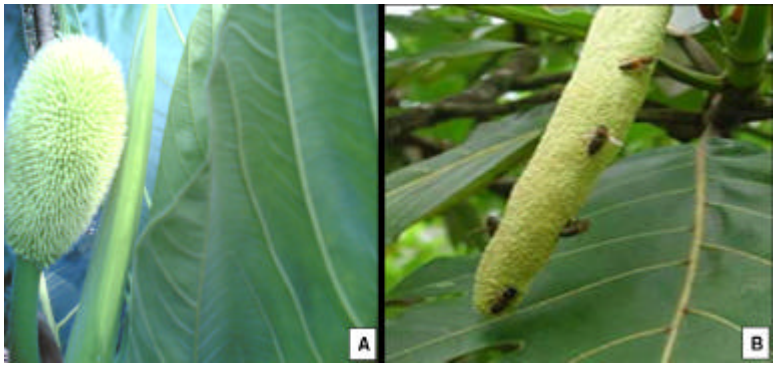

Fig. 3: Breadfruit (*Artocarpus altilis* Fosb) inflorescence; (A) female inflorescence showing a spongy core of 1500-2000 tiny flowers; (B) club shaped spike male inflorescence (ranges from 5 to 12 inches long); photograph adapted from Breadfruit Institute, National tropical botanical garden, Hawaii.

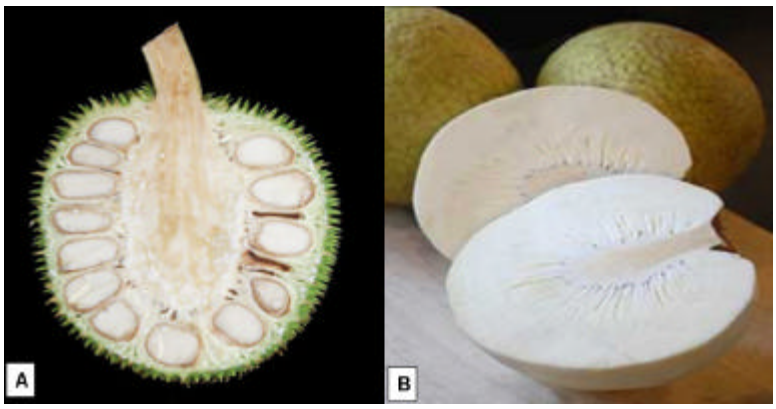

Fig. 4: *Artocarpus altilis* Fosb. fruit (breadfruit); (A) breadfruit with seeds; and (B) seedless breadfruit; photograph adapted from Breadfruit Institute, National tropical botanical garden, Hawaii.

Fruits are variable in shape, size and surface texture, often they are round, oval, or oblong ranging from 9 to 20 cm (3.6-8 in) wide and more than 30 cm (12 in) long, weighing 0.25-6 kg (0.5-13 lb). The rind is greenish-yellow with a pattern of hexagonal markings and the markings may be smooth, spiny, or spiky surface. Flesh is usually soft, creamy white or pale yellow with pleasant fragrant and depending on the varieties it may contain none or many seeds (Fig. 4A and B). However, many cultivars produce seedless fruits; though the ovules are seen, they are usually tiny and in most cases it will be aborted. But in few cultivar types the fruit produce seeds, seeds are brown, typically shiny, round or obovoid, irregularly compressed and can germinate immediately; therefore it cannot be dried or stored. Trees grown from seed begin to produce fruits around 6-10 years or sometime sooner. Asexually propagated trees start fruiting in 3-6 years [7, 9, 21].

The flowering and fruiting in breadfruit is episodal and tends to occur in once or twice a year. In Caribbean region and in Trinidad, fruiting occurs throughout the year, where as in Hawaii, breadfruit production is seasonal, typically occurs between June and August [7, 21].

Growth and Development: Breadfruit has a wide range of adaptability to ecological conditions. It grows best in equatorial lowlands below 600-650 m (2000-2160 ft) but also found at elevations up to 1550 m (5100 ft). It requires a well distributed annual rainfall of about 1500 to 2500 mm for optimal growth of the tree [22, 23]. Breadfruit can tolerate various types of soil; however, the growth is more vigorous in deep, fertile and high humus soil. In general, it prefers light to medium soils with good drainage. Fruit drop may occur when the soil is excessively wet. It can also grow in soils with pH 7.4-6.1.

Propagation: Breadfruit can be propagated either by using seeds or by asexual propagation methods. The seeded breadfruit cultivars can be grown by using

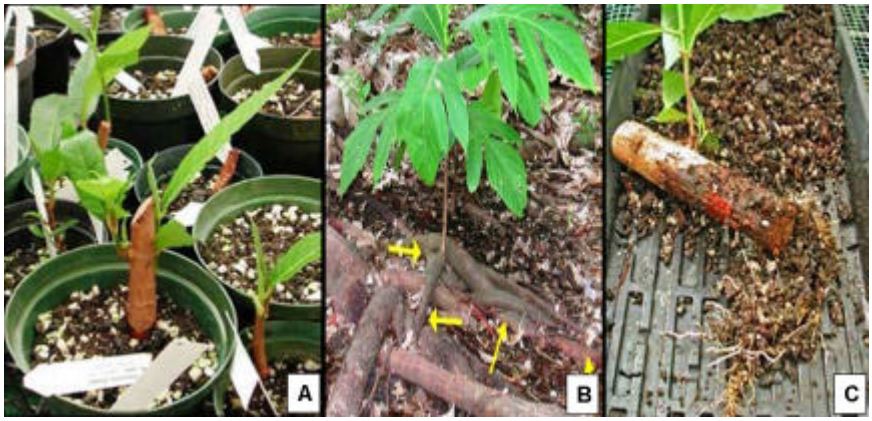

Fig. 5: Vegetative propagation of breadfruit plant (*Artocarpus altilis* Fosb); (A) shoots produced by the root cuttings in potting media; (B) sucker produced by a root in natural habitat; (C) sucker produced from a horizontally placed root cutting in organic material; photograph adapted from D. Ragone (2006) [53].

their seeds. The seed desiccation leads to loss of their viability and hence seeds of breadfruit cannot be stored for long period. Therefore, planting should be taken up when the seeds are fairly fresh. If seed storage is necessary, seeds should be stored at 40% of their original moisture content in airtight polythene containers at 20°C. Storage of the seeds under these conditions can maintain the seed viability for about three months. Under suitable conditions germination begins within 10 days and 100% germination is achieved within 35-40 days after sowing. Seed germination rate declines to 40% if planted after 30 days of storing. Germination of the seed is hypogeous. The seedling reaches to plantable size (around 30cm height) in approximately 7 to 9 weeks after sowing or 3 to 4 weeks after the elongation of hypocotyl [7]. However, seeds are rarely used for propagation due to variation in the growth and performance of seedlings. In addition, seedlings will not be true to type and hence this practice is being discouraged. However seed propagation is necessary to raise rootstocks for vegetative propagation which removes such variation in planted trees. One more drawback of using seeds is that breadfruit trees produced from seeds take a longer time to bear fruits and grow taller than the trees produced by vegetative propagation [9].

Methods of Vegetative Propagation: The seedless breadfruit is often propagated from the rooted shootlets / root cuttings, air layering, budding and grafting onto seedling root stocks and by using *in-vitro* tissue culture techniques [24, 25]. Pruning of the parent tree leads to increase in the number of suckers. Vegetative propagation produces progeny which are genetically identical to the genetically superior mother plant. The success of the different vegetative propagation methods varies and it depends on the local climate and water availability. In the case of grafting, the success depends on suitability of rootstocks.

Rooted Shoots and Root Cuttings: The roots which are present slightly below the soil surface often grow and produce a shoot, especially when it is cut or damaged. The pruning of the parent plant before planting or a field grown tree always helps to increase the number of suckers. When the roots growth attains a certain length (or stage), about 10-20 cm in length roots pieces (cuttings) can be used in propagation of breadfruit plants (Fig. 5). Root cuttings should be carefully removed from the mother plant to minimize the damage to the parent plant.

Care should be taken to avoid damage to the new root system. The newly formed shoots from root cuttings can be removed by cutting it at an angle before planting. The number of rooted cutting can be increased by making cuttings of about 1 to 2.5 in (2.5-6.35 cm) thick and 9 in (22 cm) long. The ends of root cutting may be dipped into a solution of potassium permanganate to coagulate latex and the cuttings are planted horizontally in sand or in plastic bags containing organic material such as compost, seaweed, dried manure or combination of it. Root cuttings should be kept in shade and watered daily [6]. Success of root cutting rooting ranges from 80 to 85 % and the cuttings can be made ready to be transplanted from the propagating bed in 3-5 months time [26]. Root cuttings mediated propagation is widely practice in central Java, Indonesia. Though this traditional method of propagation is effective and easily done, it is relatively slow. To overcome this hurdle, inarching and budding is recommended as an alternative to root cuttings [22, 27].

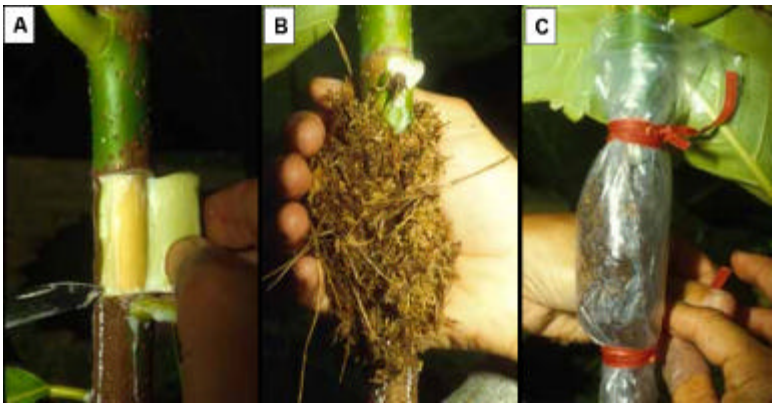

Fig. 6: Air layering in breadfruit plant (*Artocarpus altilis* Fosb) propagation; (A) removal of a ring of bark exposing the inner woody tissue; (B) covered wound portion of the stem with handful of damp moss; and (C) wrapped moss on stem wound portion with polythene sheet and tightly sealed at two ends; photographs adapted from Breadfruit Institute, National tropical botanical garden, Hawaii.

Air Layering: Air layering is also used in propagation of breadfruit but success of air layering depends on the age of the tree. In air layering, adventitious rooting is induced on an aerial stem while it is still attached to the parent plant. Branches of 5-15 cm in diameter are commonly used for air layering. From the selected branch stem a ring of bark is removed and moist rooting medium such as moss or moistened soil or compost or other organic material need to be used to cover the stem (without bark) and held in place with polythene sheet (Fig. 6). After 2-6 months roots develop from the girdled stem, which can then be cut off from the parent plant and used for planting. Coronel (1983) reported that in air layering young tree produces adventitious roots much earlier (i.e., 30-40 days) than mature tree (i.e., up to 6 month) [22]. In addition, not all the cultivars respond to air layering and layered branches can become brittle and susceptible to wind [28, 29].

Stem Cuttings: Stem cuttings is another method which facilitates propagation of breadfruit. Cuttings are parts of a plant separated from the mother plant and treated in various ways to encourage production of a new complete plant. The cuttings may be a piece of stem, branch-let or root. Woody leafless branch cutting is treated with plant growth regulators (Auxin) such as Indole-3-butyric acid (IBA) and Indole-3-acetic acid (IAA) to induce roots under mist condition. After 10 weeks, about 95% of the cuttings do produce sufficient roots and new plant from stem cutting can be made ready for planting in 4 months [27]. The stem cuttings are planted by placing stem slanting position and watered regularly for several months until the plants becomes ready (60 cm tall) for replanting. A refined method of rapid propagation uses stem cuttings taken from root shoots [30].

***In-vitro* Propagation:** Currently, the *in-vitro* propagation techniques are commonly used in large scale propagation of economically important plant species. The *in-vitro* propagation techniques can also be used in multiplying woody plant species. The technique has been successfully applied to produce large scale plantlets of jack fruit [31- 33]. At present very limited reports are available on *in vitro* propagation of breadfruit plant. Information on jackfruit's *in vitro* propagation can be useful in *in-vitro* propagation of breadfruit plant. In general, in *in-vitro* propagation method involves *in vitro* culture initiation, multiplication of shoot-lets, root induction and acclimatization of plantlets. In order to have an efficient breadfruit plant micropropagation protocol, suitable explant needs to be identified and media content should be most appropriate. Breadfruit plant species is considered as a worthy of research attention in Asian countries due to its richness in values and its potential in contributing to the small farmer's income.

***In vitro* Culture Initiation:** For *in vitro* culture initiation different types of plant tissues can be used. Shoot tips, axillary buds (nodal sectors), seeds and zygotic embryos can be used to initiate the *in vitro* cultures [34, 35]. Shoot tip of size 0.5cm-1.0cm long containing meristem and 2-3 leaves primordia can be used as an explant in plant micropropagation. Wilkins (1991) suggested that explants taken from young new branches or from recently pruned branches initiates better shoot proliferation [36]. Growth and multiplication of shoots under *in vitro* conditions depends on number of factors [37] such as genotype,

Table 2: Plant growth regulators (auxins and cytokinins) combinations and their concentrations used for *Artocarpus sps.* shoot proliferation in *in-vitro*

Type of explant	Combination and concentration of plant growth regulators	Reference
Shoot tip	3.0 mg/L BA and 0.1 mg/L NAA	[50]
Shoot tip	4.4 µM BA (shoot initiation) 2.2 µM Zeatin (Shoot initiation and proliferation)	[52]
Shoot bud	2.5 mg/L BA + 0.5 mg/L NAA (shoot initiation) 1.25mg/L BA + 0.25mg/L NAA+15% (v/v) coconut milk (shoot proliferation)	[32]
Apical bud	45 µM BA + 9.0µM kinetin	[45]
Shoot bud	8.88 µM BA + 2.68 µM NAA (shoot initiation)/4.44 µM BA + 0.54 µM NAA+ 10% (v/v) coconut milk	[54]

Table 3: Auxins (plant growth regulator) and their combinations used for *Artocarpus sps.* root induction in *in-vitro* plant propagation

Plant tissue culture media supplement	Rooting %	Reference
IBA and NAA (1.50 mg/L)		[45, 50]
IBA and NAA 0.5 mg/L + 10 days of incubation in total darkness produced roots	42	[51]
None. Shoots rooted on hormone-free medium	60	[52]
1.0 mg/L of each NAA and IBA	N/A	[32]
10 µM of IBA or NAA	60-80	[45]
5.37 µM NAA and 4.92 µM IBA.	80	[54]

age of the stock plant, size of explants, concentration of exogenously supplied carbon sources in the medium, plant growth regulators, etc. [38]. The *in vitro* propagation work reported by other researchers have shown that carbon sources in plant tissue culture media plays an important role in the micropropagation and regulates several developmental processes in the cells of plant explant used [39, 40]. In addition, exogenously added plant growth regulators in the media plays an important role in organogenesis and response of the plant explants on media. Plant growth regulators or their combinations used in the plant tissue culture media for shoot induction (proliferation) purpose are depicted in Table 2.

Once the *in vitro* cultures are initiated, plantlets can be multiplied *in vitro* using explants from *in vitro* cultures. The level of the *in vitro* multiplication and number of multiplication cycles varies from plant species to plant species. This type of information is not available for breadfruit plant propagation, as there are no reports on the large scale micropropagation of the breadfruit plant.

Rooting of Regenerated Shoots: To minimize the cost of production, half strength plant tissue culture media can be used for root induction. Regenerated shoots found to grow well on half strength of MS medium supplemented with auxin [41]. Re-growth of roots is generally known as root-regenerating potential (RRP) which is defined as the capacity of roots to initiate and elongate new lateral roots. In woody ornamentals the RRP is known to vary with the plant species [42]. Plant growth regulators (auxins and cytokinins) and their concentrations used for root induction are given in Table 3.

Hardening and Nursery Establishment: Once the plantlets attain optimum height, they should be taken out from the tissue culture environment to acclimatize them to the natural condition. The transfer of plantlets from culture room to natural environment and acclimatizing them to that condition is referred as hardening [43]. The procedure of hardening and establishment of *in vitro* plantlets to soil varies with plant species. For most of the plant species *in vitro* generated plantlets are sensitive to natural condition and may not survive effectively when they are transferred to natural condition. Roy and Hadiuzzaman (1991) reported that when rooted plantlets were transferred from culture tubes to earthenware pots containing sterile sand, soil and humus in the ratio of 1:2:1 and covered with a transparent plastic bag, about 80% of plantlets survived [44]. Whereas, Amin and Jaiswal (1993) reported around 5% survival of regenerated plantlets under *in vivo* conditions [45]. On the other hand Dhar (1998) failed to establish plantlets due to poor rooting of the plantlets in *in-vitro* [46].

Method of Planting: Breadfruit plants are planted by preparing pits of 1.5m depth and 3 ft wide. Insecticide is mixed with the soil to protect the roots and shoots from the infestation of grubs. A wider spacing of 40 x 40 ft should be followed for commercial plantations [47]. Usually there should be only about 25 trees per acre (84/ha). A closer spacing of 8m x 8m is recommended for breadfruit plants obtained from grafting method of propagation. In this case of spacing, 150 trees can be accommodated per hectare. Those grown from root suckers will bear fruits in 5 years and will be productive for about 50 years. In a well established orchard/

Fig. 7: Signs of the *Artocarpus altilis* Fosb. fruit (breadfruit) maturity; brown color stains on the breadfruit surface from latex exudation indicates harvest maturity of the fruits; photograph adapted from Technical Bulletin No. 24 [48]

plantation, papaya, banana, pineapple or vegetable crops can be inter planted. There has been no record for fertilizer recommendation for breadfruit plant/tress; however Coronel (1983) suggested periodic application of ammonium sulphate at the rate of 0.5-1 kg per tree twice a year [22]. Morton (1987) has recommended an addition of superphosphate at the rate of 2 kg per tree to increase the size and quality of the fruits [9].

Fruit Harvesting and Yield: Breadfruits become ready for harvest in about 3 months after flowering. Fruits are harvested both for vegetable as well for fruit purpose. There are several characteristic features of the fruit that can be used as indicator for harvesting time. It includes pattern and color of the fruit skin, flesh texture and color and sugar composition. However, the change in skin color from green to light green or yellow and flattened or wider spines on the skin indicates the maturity of fruits.

Fruits harvested for vegetable purpose should be light green in color, irregular fruit surface, firm flesh and white pulp which is hard to squeeze. Fruits with the yellow skin color with brown areas, flatten fruit surface, creamy pulp which is noticeably soft can be used for desert purpose. Although there are several indicators for fruit maturity, the most reliable is the presence of latex stains on the surface of the fruit. When fruits are scratched slightly, a small drop of latex appears on the fruit surface and it indicates that the fruits are ready for harvest as a starchy vegetable. On the other hand, intensification of brown staining on fruit rind surface indicates complete ripening of the fruit [48]. Mature breadfruits are shown in Figure 7.

Breadfruits do not reach maturity simultaneously hence fruits have to be picked as and when they reaches maturity. Generally, fruits are picked by manual method by cutting the fruit stalk or by using pruning pole. To minimize the damage to the fruits, it is recommended to hold the fruit by hand or net before reaching the ground. Wide variation was reported for fruit yield per tree ranging from less than 100 to more than 700 fruits per tree, depending on the variety, age, condition of the tree and regions where it is grown. Under orchard conditions, yield estimates range from 16 to 50 mt /hector (7-23 t/ac) of fruit based on 100 trees/ha (40 trees/ac). In general, the trees yield 50 to 150 fruits per year. In southern part of India, normal production is 150 to 200 fruits per plant annually. Whereas in South Pacific region, the fruit yield is about 50 to 150 fruits per year/plant, while in West Indies it is estimated of 25 fruit per tree [9]. Studies in Barbados indicate a reasonable potential of 6.7 to 13.4 mt per acre (16-32 mt per ha).

Crop Management: Young plants should be kept in partial shade and free from weed during first three to four years [7]. Mulching young plants with straw or other mulching material at a depth of 5-10cm around the base is beneficial to keep soil moist, supply nutrients and control weeds around the root system. Pruning and training is not

commonly practiced, however where production of fruit is the main purpose, the first lateral branches from top can be pruned to slowdown the upward growth and to enhance the spreading of the canopy. By pruning, weak, dead and infected branches should be removed at the end of rainy season and after fruit harvest to increase the light penetration to the inner canopy.

Bread fruits are relatively hardy and free from pest and diseases. However, occurrence of pest and diseases were noticed to be regional. In Australia fruit spotting bug (*Amblypelta sp*.) causes serious damage to fruit [6], while in Solomon Islands it has been reported that an unidentified noctuid (dull-colored night-flying moths of the family Noctuidae) causes damage to fruits [7]. Where as, in places like West Indies mealy bugs and glassy winged sharp shooters are considered as serious pest [9]; while in Hawaii, spotted leaf hoppers has been observed. The hemipteran, *Rastrococcus invadens* Williams, are seen in Togo and Benin regions of West Africa [49]. Several causal organisms are responsible for fruit rot of breadfruit. Fruits are known to be affected by Phytophthora, Colletotrichum (anthracnose) and Rhizopus (soft rot), but these can be controlled by the application of 1% of Bordeaux mixture on the entire tree at two weeks interval during ripening stage [6].

Though breadfruit is grown almost in 90 countries, it is still considered as an underutilized crop. Despite the aforementioned multipurpose utility of breadfruit, only a few trees are grown by small farmers at their backyards. Widespread cultivation has not received much attention among large farmers, because it has hardly undergone any scientific improvement. The plantation companies have not considered this plant for large scale plantation because of low income in comparison to other plantation crops like oil plam and rubber (in Malaysia). However, breadfruit is a potential plant species especially for agroforestry. More efforts are needed to convince the farmers to make them realize the importance of breadfruit and to initiate and promote bread fruit production by developing a commercial strategies. Cultivation of breadfruit by more farmers could boost agroforestry significantly and could help farmers to get additional income opportunities. Nonetheless, government policies and initiatives by forest department will be instrumental to promote cultivation of this underutilized and neglected fruit crop plant, breadfruit.

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