Agroforestry on Guam: Breadfruit Cultivation

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December 2020

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COLLEGE OF NATURAL
& APPLIED SCIENCES

Introduction

The seedless breadfruit, known in CHamoru as *lemmai* (Topping *et al.*, 1975), occupies an important role in Guam's history. It also has the potential to shape the island's future as a significant contribution to Guam's food security and agricultural sustainability. Breadfruit, an attractive, long-lived tree that yields an abundance of nutritious fruit, has many desirable characteristics for expanded cultivation:

1. It is easily grown as a backyard crop or in a commercial orchard.
2. There is established consumer demand in the local markets.
3. It provides a versatile fruit that can be baked, boiled, steamed, roasted, or dried.
4. Trees can produce fruit for 50 years or longer.
5. Trees are capable of extremely high yields.
6. No pesticides or chemical fertilizers are required. Crop can be developed as an 'organic' or regenerative product for the market.
7. Advances in growing technology developed in Hawaii can now be applied on Guam.

The goal of this publication is to provide farmers and gardeners with the information necessary for success in breadfruit cultivation. Special emphasis is placed upon the tree's traditional role in island culture, current production, propagation, and tree care.

Much of the information in this publication is drawn from two organizations in Hawaii:
(1) The Breadfruit Institute at the National Tropical Botanical Garden (Ragone, 2006), and (2) The Hawaii Homegrown Food Network (Elevitich *et al.*, 2014).

Origin and Traditional Uses

A primary source of information on the origin and traditional uses of breadfruit and other island plants is the work of William E. Safford (1905). He was both a botanist in the United States Department of Agriculture and a lieutenant in the United States Navy. After the United States acquired Guam from Spain, Safford served for one year, from August 1899 to August 1900, as the first assistant governor of Guam. Not only did he conduct a detailed survey of the island's flora, but he also provided sympathetic insights into the role of plants in CHamoru society at the turn of the 20th century. This resulted in his book, "Useful Plants of Guam." Published in 1905, it is the earliest account of Guam's flora to be published in English. His accounts provide the bulk of the following descriptions on the origin and uses of breadfruit.

The botanical origin of seedless breadfruit (*Artocarpus altilis*) is in the island regions of Southeast Asia. Breadfruit was transported to the Mariana Islands by seafarers who were destined to become the CHamoru people (Figure 1).

Figure 1. CHamoru voyagers transported seedless breadfruit or *lemmai* to Guam 4,300 years ago.

These ancient voyagers arrived on Guam 4,300 years ago (Athens and Ward, 2004). On board their voyaging canoes they carried, in addition to breadfruit, everything they required, including about 24 plants needed to establish a successful settlement in a new land (Peterson and Wescom, 2019). The ancient CHamoru developed a unique culture with breadfruit as a staple (Figure 2) that is found nowhere else in the world. Breadfruit, thus, is deeply entwined in the long history and culture of the CHamoru people.

Figure 2. Breadfruit has provided the CHamoru people with food, fiber, forage, medicine, and lumber. As a food the fruit can be boiled, baked, fried, or dried.

Safford (1905) describes breadfruit as a principal starchy food for the CHamoru people. "The usual way of cooking it is to boil it or bake it in ovens; or cut into slices and fried like potatoes." He further comments "it was formerly cooked after the manner of most Pacific Island aborigines by means of heated stones in a hole in the earth, layers of stones, breadfruit, and green leaves alternating. It is still sometimes cooked in this way on ranches."

Safford (1905) described in detail how the CHamorus cut breadfruit into thin slices and dried them in the sun or an oven. These could be kept for long periods and eaten during the season when the fresh fruit was lacking. The dried slices could be eaten without further preparation or incorporated into other dishes.

Breadfruit trees were an important source of animal fodder. Safford (1905) describes the tree as one of the best forage plants on Guam. Great quantities of the leaves were gathered to feed pigs, water buffalo, and cows. The fruit was also fed to livestock.

Other products of economic value obtained from breadfruit (Safford, 1905) were:

1. Bark cloth was once made from the fibrous inner bark of young trees and branches.
2. Glue or calking material could be made from the sticky, white sap, which could also be used as a base for paint.
3. The wood was often used for shelving and furniture; and sometimes for canoes.
4. Some incidental uses of the tree included firewood, wrapping food with the leaves, and the burning of dried male flowers to repel mosquitos and other flying insects.

Medicinal use of breadfruit is not addressed by Safford (1905), but Ragone (2006) writes that all parts of the breadfruit can be used medicinally, especially the latex or sap, leaf tips, and inner bark, for a wide range of disorders. Bernice Nelson, a CHamoru *suruhana* or herb healer (B. Nelson, Amot Farm, personal communication), provided two contemporary examples of using breadfruit as a traditional medicine: (1) young leaves can be prepared as a treatment for pink eye, and (2) fallen fruit can be used in the preparation of a douche for females.

Current Production

In the agricultural census for Guam of 2018 (NASS, 2020), 89 farmers reported growing breadfruit. They harvested 44,365 pounds of fruit from 898 trees. The fruit was sold by the pound as fresh produce. These figures represent only a small portion of the breadfruit actually consumed on Guam because most fruit is harvested from backyard or wild trees and is not included in the official statistics. This is especially true for wild trees (Figure 3).

Two forest surveys in 2013 recorded between 68,000 and 73,000 seedless breadfruit trees on the island (Lazaro *et al.*, 2020; Micronesia Challenge, 2019). The value of these wild trees can be illustrated by looking at the 500 trees on the ridge at Asan Beach Park, a unit of War in the Pacific National Historical Park. These trees are easily accessible and the public is free to pick fruit for their own use. Though these 500 trees, which cover an area of three acres, are not included in an official census, it is conservatively estimated they contribute over 10,000 pounds of fruit annually to the island diet.

Figure 3. There are 70,000 wild, seedless breadfruit trees on Guam that receive little or no care but yield edible fruit.

Types

There are two basic types or species of breadfruit on Guam: seedless and seeded. Seedless breadfruit is locally known as *lemmai* (Topping *et al.*, 1975). The scientific name is *Artocarpus altilis*. This species is distinguished by large, deeply lobed leaves (Figure 4), and an absence of seeds in the fruit.

Figure 4. Seedless breadfruit is the type preferred by consumers. The trees can be identified by their large and deeply lobed leaves.

This species is found on many Pacific Islands and is the type recommended for expanded cultivation on Guam. Seeded or fertile breadfruit are known as *dokdok* (Topping, *et al.*, 1975). *Artocarpus mariannensis* is the scientific name. Compared to seedless types, the leaves are smaller and with shallow lobes. It is endemic to the Mariana Islands. Tree numbers are in decline (Wiles, 2005), and consumers tend to prefer the seedless types. An exception is that older CHamoru enjoy eating the nuts, called *hutu* (Topping *et al.*, 1975). They are consumed roasted or boiled much like European chestnuts (Safford, 1905). It is possible for natural hybrids to develop between the seedless and seeded types.

Varieties

There is a large and confusing number of breadfruit varieties or cultivars on Guam. Only some of the more prominent ones are introduced here. Frank Cruz, extension horticulturist (F. Cruz, CBAS-CEO, personal communication) identified 'Bastos' as the variety most associated with the ancient CHamoru people. Other locally found varieties are '*Palada*', '*Ruk*', and '*Palau*'. '*Ulu*' is a breadfruit introduced from Hawaii. Some varieties have been introduced from other Micronesian Islands. '*Meinpadahk*' is such an introduction. It is a natural hybrid between seedless and seeded parents.

Figure 5. Island siblings with a one-year-old 'Ma'afala' tree. It is the variety of seedless breadfruit recommended for commercial production on Guam.

A recent and promising introduction is '*Ma'afala*' (Figure 5). Originally from Polynesia, it has been

evaluated and mass-produced by researchers in Hawaii for distribution to the Pacific Islands, including Guam. It can be seen growing in an orchard on Triton Farm in Yigo and in the demonstration gardens at the University of Guam in Mangilao. '*Ma'afala*' is the focus of the recommendations offered in this publication.

Propagation

The most reliable method for propagating seedless breadfruit on Guam is by means of root shoots. Breadfruit trees typically have lateral roots that grow slightly below the soil surface. When these shallow roots are nicked or cut, for example, by a mower blade, they will produce a shoot or sucker. When the shoot is two feet tall (Figure 6a) it can be separated from the mother tree by severing the root four inches on either side of the shoot with a sharp blade or long-handled lopper (Figure 6b). Large leaves should be trimmed off, but the small rootlets at the base of the shoot should be retained (Figure 6c). Shoots should be planted in a pot with good drainage (Figure 6d) using a commercial potting soil or topsoil mixed with sand. After four to six weeks the shoot will develop a root system and leaves (Figure 6e) and be ready for planting in the field.

Planting

The best planting time is at the start of the rainy season usually in May or June. A hole should be dug 18 inches deep. One-half cup of an organic fertilizer high in phosphorus, such as bone meal, and five pounds of a material high in organic matter, such as compost or aged manure is then mixed in the bottom of the hole with the original soil. The young tree is planted at the same soil level as in the pot. The site should be covered in mulch and watered generously. Mulching will be discussed in a following section.

Spacing

An important consideration in planning the layout of an orchard is vehicular access. If trucks or tractors are to be used in harvesting then a wide spacing between rows is recommended. '*Ma'afala*' is a relatively compact variety. A recommended spacing is 25 feet between trees in the rows and 50 feet between rows. The latter figure allows for vehicular access between rows. The figures translate into 1,250 square feet per tree or 35 trees per acre. For larger varieties, a spacing of 50 by 60 feet is recommended. This results in 3,000 square feet per tree or a density of 15 trees per acre.

Pruning

The primary reason for pruning breadfruit trees is to train or shape them to be short or compact so that harvesting is easier. Without pruning, trees will quickly grow very tall and become difficult to harvest. The removal of the central leader or main trunk is a pruning technique that encourages the tree to grow more horizontally and less vertically (Figure 7).

Figure 7. The removal of the central leader or main trunk is a pruning technique that favors a short, spreading tree that is easily harvested. Pruning begins at one to two years of age and continues every two years.

Pruning should begin when the tree is one to two years old and should be repeated every one to two years. Pruning should also include the removal of shoots or suckers from beneath the tree as they are an unnecessary drain on the tree. They can be removed and used for propagating new trees.

Propagation by Root Shoots

Figure 6a. Select a healthy root shoot about two feet tall.

Figure 6b. Separate the root shoot from the mother tree by severing the root four inches on both sides of the shoot.

Figure 6c. Cut off the leafy top but retain the small rootlets at the base of the shoot.

Figure 6d. Plant the trimmed shoot in a pot with good drainage.

Figure 6e. After six weeks the new tree will be ready for planting in the field.

Mulch

Mulch is a layer of material applied to the surface of the soil. Reasons for applying mulch include conserving soil moisture, improving fertility and health of the soil, reducing weed growth, and enhancing the visual appeal of a planting. The better mulches are organic in nature. Some examples of organic mulches are compost, leaf litter (Figure 8), and aged manure.

Figure 8. Breadfruit trees benefit from a mulch of organic material, such as compost, leaf litter, or aged manure.

The very best mulch is compost. Composting is a natural process which breaks down plant waste into a soil-like material, rich in organic matter, that can be used as a mulch or a soil amendment to improve soil qualities. Green waste or yard debris, such as leaves, grass clippings, and chipped branches can be used in making compost. A compost mulch is applied in a layer several inches thick beneath and around the tree twice a year. Soil productivity will improve as soil invertebrates and other organisms incorporate the compost into the soil.

Pest Management

Breadfruit trees are remarkably free of insect pests and disease on Guam. No pesticide applications are recommended.

A pest management strategy that is highly recommended is field sanitation. This is where fallen fruit are removed from the orchard. This step will minimize the threat of insect or disease attacks. Fallen fruit can be fed to pigs or chickens.

Irrigation

During Guam's dry season, December through May, trees will benefit from irrigation. Drip or micro irrigation is the recommended technique for providing water to the root zone. Irrigation may extend harvests into more months of the year. During the wet season, June through November, rainfall is generally sufficient for tree growth and no irrigation is required.

Flowering and Fruiting

Breadfruit trees produce male and female flowers (Figure 9) on the same tree at the end of branches. The male flowers emerge first and are shaped like hot dogs.

Figure 9. On the left is a male flower, in the center is a shoot of new growth, and on the right are two female flowers. The female flowers require 15-20 weeks to develop into a harvestable fruit.

Female flowers appear later and are round in shape. The female inflorescence is composed of 1,500 to 2,000 tiny flowers attached to a spongy core. The flowers fuse together and develop into the fleshy, edible portion of the fruit. This result is called a compound or multiple fruit (Elevitch *et al.*, 2014). No pollination is required for fruit to form. Fruit typically require 15 to 20 weeks to

mature. The skin of a mature fruit can be green, but is more often yellow, yellowish green, or yellowish brown (Elevitch *et al.*, 2014).

Yield

Twenty-four breadfruit varieties from the Pacific Islands were evaluated on the Islands of Kauai and Maui in Hawaii over a seven-year period from 2006 to 2012 (Yin *et al.*, 2014). The results provide a useful picture of the expected productivity of a commercial orchard on Guam.

The overall averages were 269 fruit per tree per year with a mean fruit weight of 2.64 pounds. Based on a planting density of 20 trees per acre, this translates to an average projected yield of 4,670 pounds per acre. '*Ma'afala*', the variety recommended for Guam, started to bear fruit within 22-23 months of planting. The average fruit weight was 1.27 pounds (Yin *et al.*, 2014). 'Ma'afala' could be expected to yield 7,584 pounds per acre eight years after planting.

Seasonality

Peak availability on Guam for breadfruit is from April to October. There is moderate availability in February and March. There is little or no fruit available in November, December, and January (Bamba *et al.*, 2015).

Harvesting and Handling

The goal of harvesting is to remove mature fruit with minimal damage to the fruit or tree. This is best done with a pole 10 to 16 feet long that has a cutting edge and a basket at the end (Figure 10).

Fruit are generally mature when the skin color turns from bright green to yellowish green. Skin surface changes from bumpy to smooth and flat. Elevitch *et al.* (2014) provides a detailed, illustrated guide on indicators of fruit maturity.

Shelf life can be extended by picking in the early morning, bathing the harvested fruit in cold water for 10 to 15 minutes, and keeping the fruit in the shade at all times. Fruit should never be allowed to touch the ground as this invites rot.

Figure 10. Long poles with a cutting edge and a basket are used to harvest mature fruit.

The sticky sap can be drained from the fruit by cutting off the stem and setting the fruit on the stem end on a clean surface for one hour.

Shelf Life

After harvest, breadfruit has a very short shelf life (Figure 11) of three to five days.

Figure 11. Mature breadfruit is perishable with a shelf life of three to five days.

An area of research at the University of Guam is how to extend shelf life of mature fruit while keeping ideal sensory qualities (J. Yang, CNAS-CEO, personal communication). Some early conclusions on extending shelf life are:

1. It is important to precool the fruit in a water bath to remove field heat.
2. Cold storage at 55°F can extend shelf life, but it may also cause browning.
3. Fresh-cut breadfruit in modified atmosphere packaging at 39°F has a shelf life of 10 to 14 days.

Looking to the Future

For over four thousand years, breadfruit has provided the CHamoru people with food, fiber, forage, medicine, and wood. The trees thrive in Guam's tropical climate. It is estimated there are over 70,000 trees on the island.Trees are high yielding and have a long harvest season. The fruit is nutritious and familiar to consumers. There are no barriers or bottle necks to field production of the fruit. Breadfruit is certainly a worthy candidate for sustainable production and holds great promise for its potential contributions to island food security.

There are challenges, however, in the future, especially in the area of post-harvest handling and marketing. Some of the issues that need to be addressed are:

1. The education of growers to deliver a standardized product to the market that is both attractive and free of bruises or blemishes.
2. The continuation of research to extend the shelf life.
3. The development of marketing strategies that avoid the feast or famine production cycles that often prevail on Guam.
4. The identification of techniques for having year-round production.
5. The exploration of value-added opportunities, particularly stable products, such as chips, dried slices, and flour.

Acknowledgements

The authors gratefully acknowledge the pioneering work on breadfruit by faculty and staff at the University of Guam: Dr. Mari Marutani, Dr. Bob Barber, Dr. Jian Yang, Mark Acosta, Jessica Nangauta and Frank Cruz. The authors are also grateful to Olympia Terral, University of Guam, for her guidance in the preparation of the manuscript.

This publication was made possible through grants 19-DG-11052021-231 and 18-DG-11052021-209 from the USDA Forest Service.

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