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MANGO PRODUCTION GUIDE FOR GUAM

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December 2022

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RESEARCH CENTER

CONTENT

INTRODUCTION

There is much interest in improving mango production on Guam (Plate 1). It is a highly desirable fruit, but production is erratic, and often unsuccessful, because of a plant disease and other constraints.

This production guide for mango focuses on the island of Guam and emphasizes a sustainable or environmentally friendly approach to fruit production. The goals for this sustainable approach are to 1) improve access to locally produced food, 2) reduce reliance on imports, 3) recycle green waste as compost, and 4) protect the environment. The strategy for achieving these goals is to promote the use of organic mulches, drip irrigation, natural enemies for insect pest control, and orchard practices that reduce disease threats and to decrease the use of synthetic pesticides and fertilizers. A special effort is made to recommend the use of composted materials as organic mulches, in place of chemical fertilizers, to improve soil fertility.

Plate 1. Island farmers examine and compare mangoes and have shown a strong interest in improving their mango production.

BOTANY

The mango tree is scientifically known as *Mangifera indica L.* and is a member of the Anacardiaceae, or cashew, family. It originated in Asia and had since spread to all subtropical and tropical regions of the world (Bally, 2006). In the CHamoru language, mango is known as *mangga* (Topping et al, 1975).

HISTORY

The earliest introduction of mango trees to Guam probably occurred during the early Spanish Colonial Period (Yadav and Singh, 2017). Beginning in 1600, Spanish ships brought varieties, for example "Carabao" and "Pico," from Manila to the island, where they became established.

A primary source of historical information on mango and other island plants is the work of William E. Safford (1905). He was both a botanist in the U.S. Department of Agriculture and a lieutenant in the U.S. Navy. After the United States acquired Guam from Spain, Safford served as the first assistant governor of Guam from August 1899 to August 1900. 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, "The Useful Plants of the Island of Guam." Published in 1905, it is the earliest account of Guam's flora to be published in English. His accounts provide valuable observations on mango production on Guam in 1899-1900.

According to Safford's observations 122 years ago, Guam was producing mangoes of the finest quality on disease-free trees that were started by seeds that produced true-to-type plants. The most critical observation was that in 1899-1900, Guam was free of mango diseases. Safford appreciated this point and in the last observation addressed the need to prevent disease introductions. His advice was ignored. Mango plantings now suffer crippling attacks from the introduced disease anthracnose caused by *Colletotrichum gloeosporiodes*.

EARLY OBSERVATIONS OF GUAM MANGOES

- *"The natives value the fruit more highly than any other food product on the island."*
- *"Guam mangoes are large, sweet, fleshy, juicy, and almost entirely free of fiber…"*
- *"There are few trees on the island, but these produce fruit of the finest quality."*
- *"The trees grow to great size…, but nearly all have been blown down by storms and continue to grow, as it were resting on their elbows… they continue to bear fine fruit."*
- *"The trees are propagated by seed, and the fruit of the seedlings appears to be identical with that of the parent tree… grafting… is not practiced."*
- *"The tree is… entirely free from disease or injurious parasites."*
- *"In view of the excellent quality of its fruit and the danger of bringing in disease… from abroad, importation of living mango plants should be forbidden."*

Excerpts from "The Useful Plants of the Island Guam" by William E. Safford, 1905

CURRENT PRODUCTION

Two vegetation surveys in 2013 recorded between 208,000 and 220,179 mango trees on the island (Lazaro et al, 2020; Micronesia Challenge 2019). This made mango the 25th most abundant tree species on Guam. Most of these trees receive little or no care.

In the agricultural census of Guam in 2018 (NASS, 2020), 131 farmers – or 50% – reported growing mangoes. They harvested 74,343 pounds of fruit from 695 trees. The fruit was sold by the pound as fresh produce. These figures do not include fruit harvested from backyard trees for home consumption. There is a staggering gap on Guam between the high number of trees existing and the low amount of fruit marketed.

TYPES: MONOEMBRYONIC VERSUS POLYEBRYONIC

Mango varieties can be classified by the type of seed the tree produces (Hamilton et al, 1992). The seeds of monoembryonic varieties produce only one shoot or sprout when they germinate. The resulting seedling can vary from the mother tree in fruit quality and appearance. Many mango trees on Guam are monoembryonic. The seeds are not desirable in propagating new trees.

The seeds of polyembryonic varieties produce multiple shoots. The resulting seedlings are "true to type" or are genetically identical to the mother tree. Polyembryonic types are highly desirable in propagation by seed.

RECOMMENDED VARIETIES

Five mango varieties are currently recommended for production on Guam (Tuquero et al, 2016).

1. **Carabao** (polyembryonic) is a popular backyard crop on Guam. It came to Guam during the Spanish galleon trade, in the 1600-1800 period.
2. **Haden** (monoembryonic) is one of the most widely grown mangoes in the world. It was originally grown from a "Mulgoba" seed planted in Florida in 1902 and is now the parent of many new varieties.
3. **Pico** (polyembryonic), or **Padero**, is an early Spanish introduction from the Philippines, where it is now a common, commercial variety.
4. **Saipan** (usually polyembryonic) is a relative (*Mangifera odorata*) of mango that produces a fibrous fruit and grows well in hot, humid regions.
5. **Edward** (monoembryonic) is from Florida and is a cross between Haden and Carabao.

Additional varieties of mango are likely to be recommended when the evaluation of the 29 varieties at Ija Research & Education Center is completed (Plate 2).

CONSTRAINTS TO PRODUCTION

There are four inter-related constraints to producing mango on Guam: 1) latitude, 2) climate, 3) disease, and 4) genetics.

Guam's geographic closeness to the equator means there are minimal fluctuations in seasonal day length and temperature. This uniformity favors vigorous vegetative growth at the expense of flowering and fruiting. Mango flowering is thought to be triggered by cool night temperatures (Bally, 2006), which rarely occurs on Guam.

Guam's tropical climate is characterized by high humidity and high rainfall. These factors can prevent flower induction and fruit development. Fruit production is best when a dry period begins before flowering and extends to harvest time (Bally, 2006).

The high rainfall, high humidity, and uniformly warm temperatures predispose the fragile flowers and setting fruit to the development of anthracnose. This fungal disease develops black lesions that cause the flowers and fruit to drop.

Haden is a popular backyard mango in Honolulu, Hawaii. Guamanians who visit Honolulu are often impressed with the fruit qualities. They save the seed and upon returning to Guam they start a new tree with it. The results are disappointing or frustrating for the grower. The new tree will likely produce inferior fruit to what the Guamanian observed in Honolulu. Worse, the new tree may yield few or no fruits at all. This is because Haden has a monoembryonic type of seed, as do many of the introduced seeds on Guam. Monoembryonic, technically speaking, means that a single seed will contain only one fertilized egg. On a practical level, it means the resulting seedling will not be "true to type" or "true to seed." This means the seeds from a Haden tree will not grow up to be the same Haden variety as the mother tree.

The seeds will produce a wide variety of different and unknown traits. This is because in monoembryonic types the seed is the product of female and male genes. This is further complicated by the fact that only the mother, the source of the eggs, is known. The identity of the father is unknown but is the source of pollen that fertilizes the egg. The result is a genetic mixture that does not resemble either parent.

The current situation on Guam is that mango is propagated by seed, often of monoembryonic types, like Haden, that are not "true to type." This means that growers will not know how productive the tree will be, what shape or size the tree will grow to, when the tree will fruit, how big the fruit will be, or how the fruit will look or taste. To further worsen the situation, each generation of trees will produce seedlings that increasingly deviate from the original desirable "Haden" traits. Combining these constraints explains why mango trees on Guam display vigorous vegetative growth and can attain great heights but produce few, if any, harvestable fruit.

IDEAL VARIETY CHARACTERISTICS

The ideal mango tree for Guam would have the following characteristics:

- Resistance or tolerance to anthracnose disease.
- Tap root for deep anchorage against typhoon winds.
- Compact form for ease of spraying and harvesting.
- Desirable fruit traits: large, sweet, and fiber-free.
- High yields: regular and heavy fruit production.

PROPAGATION

Mango can be propagated by seed, air layering, or grafting (Bamba and Wall, 2016).

By seed: When starting by seed, only polyembryonic types such as Carabao, Pico, and other varieties from Southeast Asia should be used. This type produces seedlings that are "true to type" or are identical to the mother tree.

Air layering: Air layering is not recommended for mango propagation for two reasons. First, there is a low rate of success. Second, air layering produces a very weak root system, in general, in mangos and, in particular, the offspring lack a tap root, which is a desirable feature on typhoon-prone Guam.

Grafting: Grafting can produce trees with highly desirable characteristics, but it is not recommended that farmers or gardeners do it themselves. Instead, young trees should be purchased from an established nursery. The nursery will choose the correct scion and rootstock for propagation.

SITE SELECTION

Mango trees grow and produce well on a wide variety of soil types. They are noted for their ability to produce acceptable yields on soils of low fertility (Mavuso and Bevacqua, 1985). The site should have good drainage or a slight slope so excess water can run off.

Seedling and grafted trees are deep-rooted, which favors resistance to drought and storms. For this reason, the deeper soils of southern and central Guam are preferred.

Plate 2. Twenty-nine varieties of mango are being evaluated at the University of Guam's Ija Research and Education Center in Southern Guam.

SPACING

Trees should be planted in widely spaced orchards. The wide spacing allows for 1) air circulation between trees, which lessens the threat of anthracnose disease and 2) enough sun radiation to favor flowering. For these two reasons, a spacing of 10-12 m (30-36 ft) is recommended. A general rule to remember when planting mango trees is that grafted trees require less space than seedling trees (Mavuso and Bevacqua, 1985). The former can be spaced at 10 by 10 m, while the latter is spaced at 12 by 12 m or greater distance.

PLANTING

The planting hole should be excavated to a depth of 45 cm (18 in). Then, the hole should be refilled halfway with topsoil mixed with a fertilizer high in phosphorus, such as bone meal, and a generous amount of compost or other material rich in organic matter. After the young tree is transplanted into the hole and the hole filled with soil, an irrigation basin, 1.0 m (3 ft) by 1.0 m (3 ft), should be made and filled with water. The water will settle the soil and cause good contact with the roots. The best time of year for planting in Guam is in the months of May and June, which can coincide with the start of the rainy season.

IRRIGATION

Young trees require frequent watering during the dry season. After three years, irrigation becomes optional. Irrigation can be a tool for improving yields if applied during the fruit development stage. A sustainable technique is drip or mini sprinkler irrigation.

MULCH / FERTILIZERS

Mulch is a layer of materials applied to the surface of the soil under and around the tree. Reasons for applying mulch include conserving soil moisture, improving fertility and health of the soil, suppressing weed growth, and enhancing the visual appeal of a tree planting. The better mulches are organic in nature. Some examples of organic mulches are compost, leaf litter, and aged manure. The best mulch is compost. Composting is a natural recycling process that breaks down plant waste into a soil-like material, rich in organic matter, which can be used as a mulch or soil amendment to improve soil quality. 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 7.5 cm (3.0 in) thick beneath and around the tree twice a year. Soil productivity will improve as earth worms and other organisms incorporate the compost into the soil. The breakdown of compost releases nutrients and minimizes the need for commercial or synthetic fertilizers.

FLOWERING

Growth in mango occurs in stages called flushes. A new flush of leaves emerges and then hardens during a dormant phase. Natural flowering is triggered by low night temperatures (Nagao and Nishina, 1994) during the months of December and January. This causes flower clusters, or panicles (Plate 3), to develop on the terminals or ends of these hardened flushes.

Plate 3. Mango flower clusters, or panicles, contain a large number of male flowers and few bisexual flowers. The latter develop into fruit.

The clusters contain large numbers of male flowers and few bisexual or hermaphrodite flowers. The bisexual flowers require pollination and then develop into fruit.

FLOWER INDUCTION

Flowering in mango can be artificially induced by the spraying of potassium nitrate (KNO_3) on hardened branch tips (Nagao and Nishina, 1994; Bamba and Wall, 2016) (Plate 4). Credit for this discovery goes to Filipino horticulturist Ramon Barba, who perfected the technique in the 1970s (Barba, 1974). The technique is now widely used in commercial orchards in the Philippines. A crystalline or laboratory grade of potassium nitrate (13:0:46) is used. This material is locally available on Guam. It is mixed as a 2% solution. This is the equivalent of 57 g (2 oz, 4 Tbsp, or 1⁄4 cup) in 3.8 liters (1.0 gallon) of water. One to three weeks later, depending on variety, flower buds will emerge.

Plate 4. A UOG student sprays mango flowers to induce flowering.

POLLINATION

Flies are the primary pollinator (Plate 5) of mango on Guam (Bevacqua, Taitano, and Ares, 2022). Other factors that may contribute to pollination are wind and other insects, such as honey bees, wasps, and ants (Bally, 2006).

SEASONALITY

Peak availability on Guam for ripe mango is from April to August. Green, or young, mango is available from January to May (Bamba et al, 2015).

HARVESTING

Fruits are usually harvested by hand or with the help of long-handled picking devices. The fruit are handled gently as they are easily damaged. Care should be taken to avoid sap contacting the fruit during harvesting and handling, as it is caustic and causes dark blemishes on the fruit. Sap can also burn human skin (Bally, 2006).

Plate 5. Flies are the principal pollinators of mango flowers on Guam.

HANDLING

To maximize the storage life of mangos, fruit can be generally dipped in hot water and fungicide to slow the development of postharvest fungal rots (Bally, 2006). Controlled cool temperatures are essential if fruit quality is to be maintained during storage. Temperatures will vary depending on the stage of fruit ripeness and variety (Bally, 2006).

YIELDS

Mango trees can be biennial or alternate-year bearers. This means a good year for fruit can be followed by a poor one. This contributes to erratic fruit production. Thus, crop yields can be variable. A single tree can produce between 200 and 300 kg (440 and 660 lb) of fruit in a heavy cropping year and as low as 5 kg (11 lb) in a bad year (Bally, 2006). Yields can also be influenced by rainfall during flowering, anthracnose disease, variety, and age of tree.

PRUNING

Pruning is the selective removal of branches to achieve a desired tree size and form that facilitates fruit production. If left unpruned, mango trees, especially seedling trees, can become very large. Fruit high in the tree cannot be reached during harvest. Pruning to limit tree height is a desirable practice that should be done every year. Pruning may also be necessary to thin the canopy and remove dead limbs. Mango trees are very tolerant of pruning (Bally, 2006). Limbs of any size can be removed.

DISEASE

Anthracnose is a devastating fungal disease that can attack mango flowers (Plate 6), fruit (Plate 7), and foliage. Control in the orchard requires the integration of four management practices (Nelson, 2008):

- Site selection
- Resistant varieties
- Cultural practices
- Fungicide sprays

Plate 6. During warm and wet weather, mango flowers are susceptible to damage by anthracnose disease.

Plate 7. Mango fruit can be attacked by anthracnose disease, which results in black spots and blotches. Though unsightly in appearance, the fruit is still edible.

Disease pressure is lessened by planting trees in full sun in widely spaced orchards that allow for air circulation. This is a sustainable method for discouraging anthracnose. Similarly, if flowering and fruiting occur during dry periods, there will be less disease threat (Bally, 2006).

No mango variety has been documented that is completely resistant to anthracnose (Tarnowski and Ploetz, 2008; Pandey et al, 2011). Even where relative resistance has been observed, it may not be true for all geographic areas. Take the example of Zill, a commercial variety widely grown in South Africa. Zill is classed as resistant in Florida (Ploetz, 1999), but in the Philippines it is considered very susceptible (Nishijima, 1994). At present on Guam no varieties can be reliably identified as anthracnose-resistant. Cultural practices that minimize disease threat focus on field sanitation (Nelson, 2008) and include disposal of fallen fruit and removal of plant debris from the orchard. Fungicides can be effective tools in the control of anthracnose. Sprays should begin when flowers first appear and continue at intervals until fruits are 1½ to 2 inches long (Nelson, 2008). A possible drawback to the use of fungicides is a growing public perception that fungicides, like other pesticides, have a harmful effect on human health and the environment (Onyeani, 2017). For this reason, consumers increasingly prefer to purchase "organic fruit" that is pesticide-free.

INSECT PESTS

On occasion, mango trees can be attacked by insects. Flowers and fruits are especially susceptible to insect damage. The principal insect threats are mango shoot looper, *Perixera illepidaria*, mango seed weevil, *Sternochetus mangiferae* (Plate 8), fruit piercing moth, *Eudocima spp*, mango blotch miner, *Acrocercops singramma*, mango bud mite, *Aceria mangiferae*, mealy bug, Rastrococcus spp, red banded thrips, *Selenothrips rubrocinctus*, and several types of scale insects (Bamba and Walls, 2016). A sustainable approach to insect pest management is to tolerate minor crop damage by occasional pests and rely on natural enemies, like some species of wasps, to control the pests. Only for serious outbreaks, and as a last resort, should chemical insecticides be applied.

SUMMARY

This production guide for mango focuses on the island of Guam and emphasizes the fruit's history, types, constraints to production, ideal variety characteristics, flower induction, and the principal threat – anthracnose disease. There is also an emphasis on the use of compost applied as a mulch instead of the use of commercial fertilizers. This publication offers long-term guidance for the sustainable production of mango, while ensuring a livable island environment for generations to come.

Plate 8. Mango seed weevil is an occasional insect pest. Consumers of local fruit on Guam would be surprised to learn that weevil larva can be found in the seed.

ACKNOWLEDGEMENTS

This production guide was prepared as an instructional tool for a field workshop on mango propagation on May 7, 2022, at the Ija Research and Education Center. The workshop was part of a series offered by UOG for beginning farmers. The workshops were supported by a grant from the USDA National Institute of Food and Agriculture. The grant was administered by Adrian Ares, Ph.D.

Luke Fernandez and Jackie Hanson, communications specialists with UOG College of Natural and Applied Sciences, were responsible for layout, editing, and printing of the final publication.

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