UNIVERSITY OF GUAM
WESTERN PACIFIC TROPICAL RESEARCH CENTER

MANGO VARIETIES AT IJA RESEARCH AND EDUCATION CENTER

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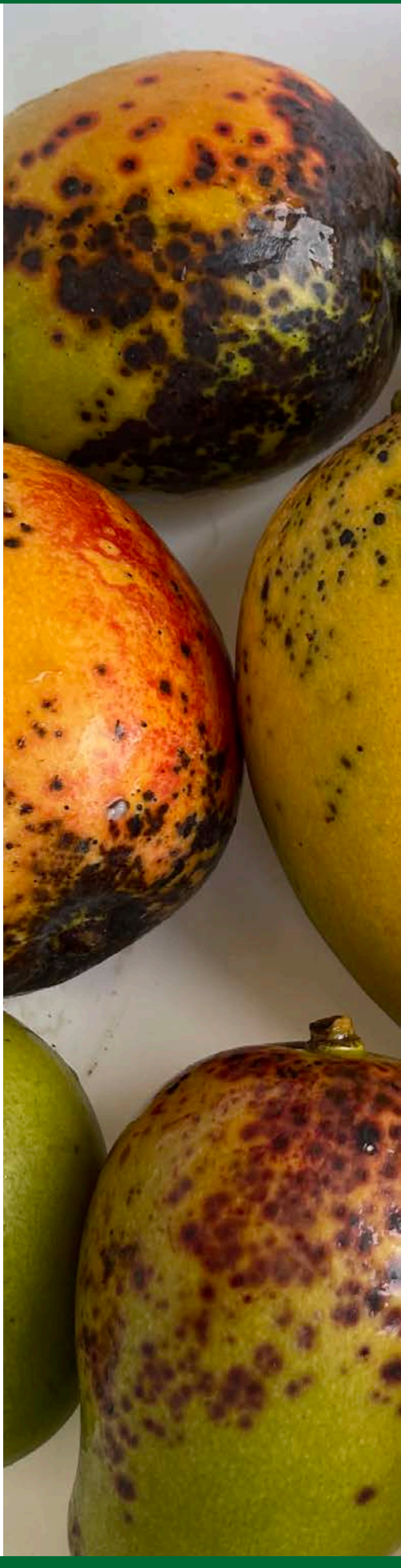
CONTENT



Cover photo caption: A mango orchard with 29 mango varieties at the University of Guam's Ija Research & Education Center.

INTRODUCTION

Mango, *Mangifera indica*, is a desirable fruit that has its origins in Asia and has been under cultivation for 4,000 years. During the Spanish colonial period, mango was spread throughout the tropical and subtropical regions of the world, including to Guam. It now ranks fifth among the top fruits in the world. Several hundred varieties of mango are currently recognized.

Mango is very popular on Guam, but local production is erratic, and often unsuccessful, due to anthracnose, *Colletotrichum gloeosporoides*, an invasive plant disease, and other constraints. There is much interest in improving island mango production, especially through the adoption of 1) new, improved varieties and 2) grafting as a propagation technique.

The key to improving island mango production may lie in a tree collection of 29 varieties maintained by the University of Guam.

The goal of this publication is to describe the background for these 29 mango varieties (Plate 1) — their origins, seed types, fruit and tree characteristics, and principal disease threat — and a technique for inducing flowering.

HISTORY

Dr. Thomas E. Marler, former professor of pomology at UOG, led the establishment of the mango planting at Ija Research & Education Center (IREC) in Southern Guam. He realized the value of a collection of mango varieties in advancing Guam's agricultural development.

From 1993 to 1999, Marler planted 36 mango varieties at IREC. This collection encompassed the major commercial and backyard varieties in world production. The origins of the varieties included Florida, Jamaica, Thailand, India, Philippines, Hawaii, and other regions.

The young trees came from commercial nurseries in Southern Florida and arrived grafted and without soil. They were immediately potted, and after vegetative growth was established, the trees were planted into the field at IREC. The name of the rootstock is not known.

After the trees were established, they received little attention for 20 years. There were no programs for irrigation, fertilization, pruning, or data collection. At present, the trees are crowded and overly tall.

Over the years, seven varieties perished, leaving a present total of 29 varieties. The varieties that did not survive were Baily's Marvel, Springfels, Spirit of 76, Kent, Valencia Pride, Cushman, and Julie.

At present, the primary planting consists of 25 varieties (Plate 1). It is located in what was formerly called Zone 3, which covers an area of 0.20 ha (0.50 ac).

There are three small additional plantings. The largest is called the secondary planting, formerly known as Zone 1 (Plate 2). It contains six varieties. There are two outliers, Manalagi and Okrong, to the northwest of the primary planting. In a separate area of IREC are seven Carrie trees.

In addition to mango, Marler established plantings of a wide range of tropical and subtropical fruit trees at the Ija and Yigo Research & Education Centers.

Plate 1. Map of the primary mango planting at Ija Research & Education Center. The orchard contains 25 of the major commercial and backyard varieties in the world.

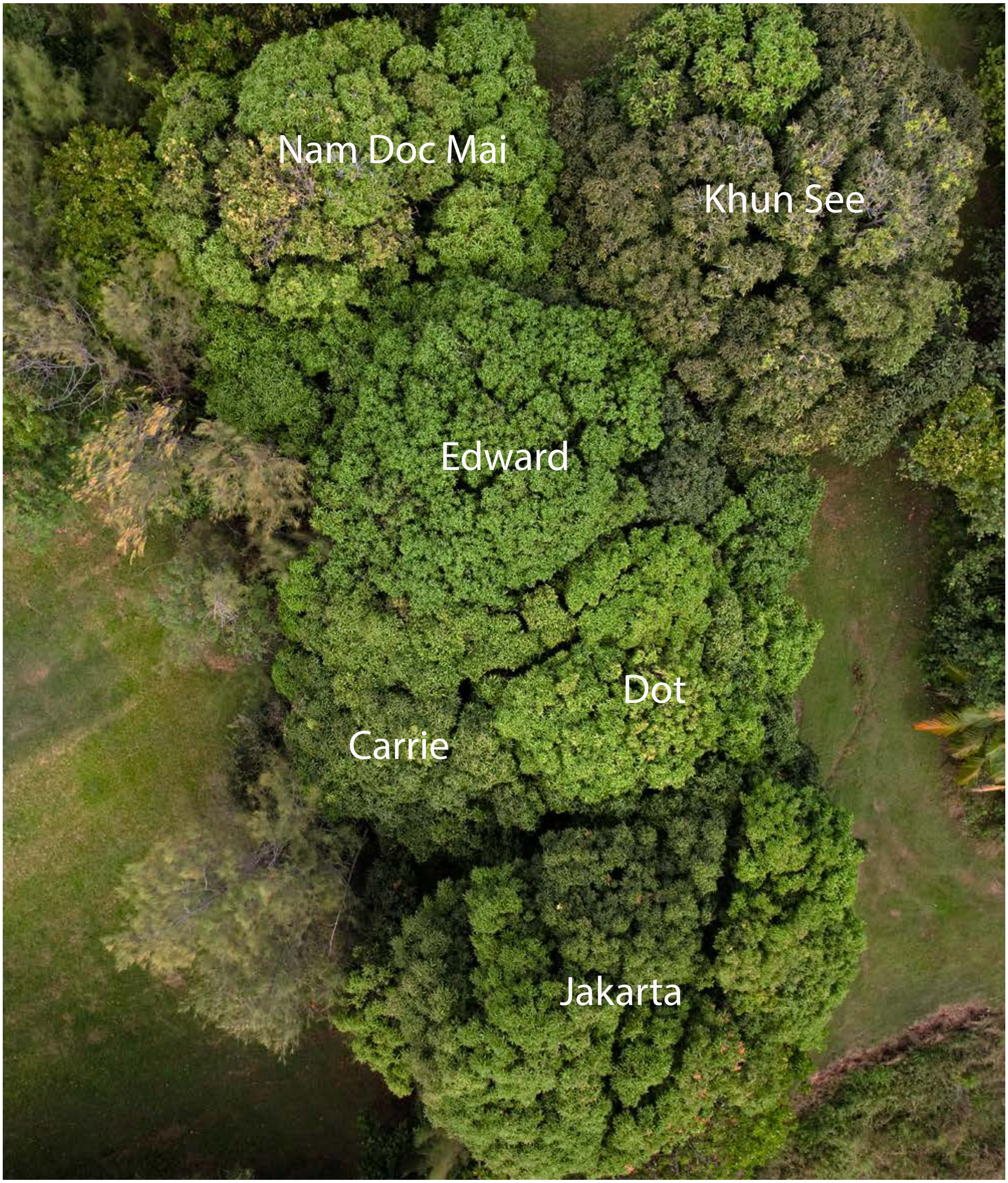


Plate 2. Map of the secondary planting at IREC. Of the six varieties in the planting, Edward, Carrie, and Dot are duplicates of varieties in the primary planting.

SOIL ENVIRONMENT

The soils at IREC are unlike the soils on which the island's mangos are grown. Soils at IREC are typical of the "badlands" found in the interior of Southern Guam. These soils are acidic, low in fertility, and prone to erosion. They are further degraded each year by wildland fires that destroy large acreages of natural vegetation.

The Ija soils have been characterized (Golabi et al, 2014) as very fine, kaolinitic, isohyperthermic Oxie Haplustalfs. These soils were formed from weathered rocks where depth to bedrock is 50-100 cm. These soils contain considerable amounts of aluminum and iron oxides. The soils are very acidic with pH measurements as low as 4.2.

IMPORTANCE

The collection of mango trees at IREC is an informal germplasm repository that maintains genetic resources for future use. Germplasm repositories typically provide the raw materials for plant breeding and crop improvement programs. The Ija mango trees, more specifically, can be used to promote varieties that:

- Are adapted to Guam's tropical climate and pattern of wet and dry seasons.
- Are resistant to or tolerant of the principal mango disease on Guam – anthracnose, caused by Colletotrichum gloeosporoides.
- Can be classified, based on their time of fruiting, as early, middle, or late at their time of harvest.
- Can be developed as a source of budwood for the grafting of the improved varieties.
- Can be used to breed new varieties that are adapted to the local environmental and economic conditions.

The importance of the IREC mango trees is amplified by the current plant quarantine regulations on Guam. These regulations prevent "any mango propagative material" from being brought to the island (personal communication, Christopher A. Rosario). No additional varieties, thus, can be introduced to Guam.

TYPES

Eighteen of the 29 varieties at IREC are monoembryonic (Table 1) and have a subtropical origin in the Indian subcontinent. Seedlings are not identical to the mother but can vary considerably (Mukherjee and Litz, 2009). For this reason, monoembryonic types are always propagated by grafting. Ten of the varieties are of a second type called polyembryonic (Table 1). Carabao and Brahn Kai Meu are examples of this type. They have a tropical origin in Southeast Asia and produce seedlings that are true to type (Mukherjee and Litz, 2009). These can be started by seed or grafted.

FLOWER INDUCTION

Flowering in mango can be induced by the spraying of potassium nitrate (KNO_3) (Plate 3) on mature branch tips (Nagao and Nishina, 1994; Bamba and Wall, 2016). 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 formulation of potassium nitrate (13:0:45) is used. This material is locally available on Guam. It is mixed as a 2% solution. This is the equivalent of 57g (2 oz, 4 Tbsp., or ¼ cup) in 3.8 liters (1.0 gallon) of water. One to three weeks later, depending on variety, flower buds will emerge (Plate 4).

Plate 3. To induce flowering, potassium nitrate (KNO_3) was sprayed on the mango trees.

Plate 4. This Carabao variety, as with all the varieties treated with potassium nitrate, produced flowers within one to three weeks of being sprayed.

POLLINATION

The principal pollinators of mango at IREC are flies (Plate 5) that belong to the family Calliphoridae in the order of Diptera (personal communication, Ross H. Miller). They are commonly known as blow flies, or bluebottles. The adults are attracted to the flowers, where they collect nectar as a source of food.

THREATS

Mango flowers are fragile (Plate 6) and easily damaged by plant diseases and insect pests. The two major threats at IREC are anthracnose disease (Plate 7), caused by *Colletotrichum gloeosporoides* (Nelson, 2008), and the mango shoot looper (Plate 8), *Perixera illepidaria*, (personal communication, Aubrey Moore).

Plate 5. The principal pollinators of mangoes at IREC are flies that are commonly known as bluebottles, or blow flies.

Plate 6. Mango flowers are fragile and susceptible to plant diseases and insect pests.

Plate 7. The principal disease of mango is anthracnose produced by *Colletotrichum gloeosporides*. It can attack flowers during warm, wet weather.

Plate 8. A tiny, but serious, pest at IREC, is the mango shoot looper, *Perixera illepidaria*, which can attack flowers and prevent fruit development.

Both required chemical control methods. See Appendix A for a log of the sprays. Anthracnose is an island-wide threat, whereas mango shoot looper is a localized threat.

SURVEY RESULTS

The mango plantings at IREC were surveyed weekly from Jan. 26 to June 20, 2022, with the goal of monitoring flowering, fruit development, and pest and disease threats.

On March 3, 2022, an inventory of trees was conducted with a focus on estimating tree height, vigor, bole number, and presence or absence of flowers and fruit. The results are presented in Tables 2 and 3.

On June 13, 2022, a sample of fruit was collected from each tree for the purpose of determining skin color, weight, level of ripeness, sweetness, and weevil damage (Plate 9) (Tables 1 and 4).

The survey results can be summarized by the following observations:

Varieties that flower early are subject to severe attack by anthracnose (Plate 7). On Jan. 31, the panicles were barren stalks (Plate 10) for Keitt, Khun See, Carabao, Edward, Haden, Manalagi, Okrong, Palmer, and Tommy Atkins.

- Potassium nitrate was an effective tool in triggering flowers. The 27 varieties that were sprayed with KNO_3 all produced flowers.
- Pollination is by blow flies, or bluebottles, at IREC.
- Mango flowers are vulnerable to disease and insect pests (Plate 6). Early flowering varieties are susceptible to anthracnose (Plate 7), while late flowering varieties at IREC can be attacked by mango shoot looper (Plate 8).
- The threats posed by anthracnose and loopers diminishes once fruit are set and fruit development is underway (Plates 11 and 12).

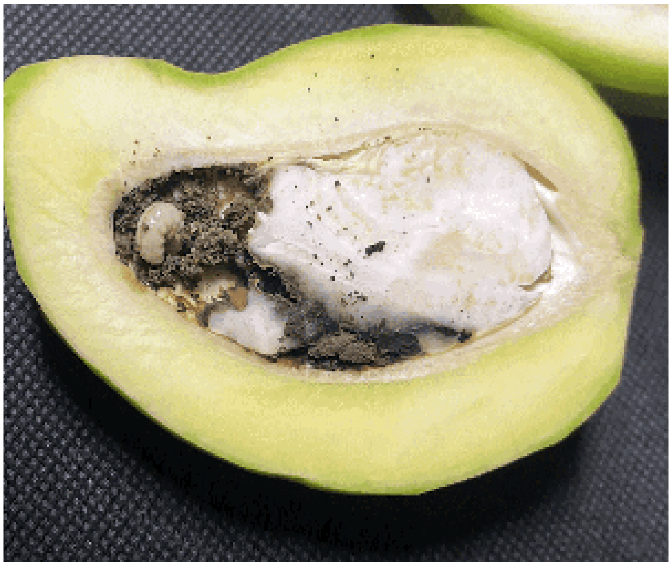


Plate 9. Twenty percent of the fruit sampled in 2022 was infested with mango seed weevil. The fruit is still edible and can be used for home consumption.

Plate 10. Barren flower stalks or panicles can be the result of an anthracnose or looper outbreak.

Table 1. Characteristics of mango varieties at IREC.

Variety Name	Origin	Seed Type*	Fruit Size**	Fruit Fiber***
Beverly	Florida	mono	medium	medium
Bombay	Jamaica	mono	small	low
Brahm Kai Meu	Thailand	poly	medium	high
Carabao	Philippines	poly	small	medium
Carrie	Florida	mono	medium	low
Cogshall	Florida	mono	medium	medium
Dot	Florida	mono/poly	large	high
Duncan	Florida	mono	large	medium
East Indian	Jamaica	mono	large	n/a
Edward	Florida	mono	large	low
Fairchild	Panama	mono	medium	low
Glenn	Italy	n/a	n/a	n/a
Green Kasturi	Borneo	poly	small	low
Haden	Florida	mono	medium	medium
Hatcher	Florida	mono	small	medium
Jakarta	Florida	mono	medium	low
Keitt	Florida	mono	medium	high
Khun See	Thailand	poly	medium	medium
Madame Francis	Haiti	n/a	n/a	n/a
Manalagi	Indonesia	poly	large	low
Nam Doc Mai	Thailand	poly	medium	low
Okrong	Thailand	n/a	n/a	n/a
Okrong Tong	Thailand	poly	small	low
Palmer	Australia	mono	large	low
Rapoza	Hawaii	n/a	n/a	n/a
Simmons	Florida	mono	large	low
Tommy Atkins	Florida	mono	medium	low
Van Dyke	Italy	mono	medium	high
Zill	South Africa	mono	small	high

***Monoembryonic or polyembryonic based on dissection of seed on June 14, 2022.**

****Based on weight of samples collected on June 13, 2022: Small = 0-200g, Medium = 200-400g, Large = 400-600g.**

*****Estimated during taste testing on June 14, 2022.**

Table 2. Tree inventory for primary mango planting at IREC on March 3, 2022.*

Variety Name	Ht. (m)	Vigor	Bole # Breast Ht.	Flowers	Fruit	Damaged Flowers**
Beverly	6	high	7	no	no	yes
Bombay	10	high	4	no	no	yes
Brahm Kai Meu	12	high	4	yes	yes	no
Carabao	9	high	9	yes	no	yes
Carrie	11	high	6	no	no	no
Cogshall	8	medium	3	no	no	no
Dot	10	medium	3	no	no	no
Duncan	9	medium	5	no	no	no
East Indian	9	medium	3	no	no	no
Edwards	6	high	7	yes	no	yes
Fairchild	7	low	6	no	no	no
Glenn	8	medium	6	no	no	no
Green Kasturi	8	high	3	no	no	no
Haden	9	medium	5	no	no	yes
Hatcher	11	medium	5	no	no	yes
Keitt	8	low	5	no	no	no
Madame Francis	6	high	4	no	no	yes
Manalagi	8	high	3	yes	no	no
Okrong	12	medium	3	no	no	no
Okrong Tong	8	medium	3	no	no	yes
Palmer	8	medium	3	no	no	yes
Rapoza	7	low	2	no	no	yes
Simmons	7	high	4	yes	no	no
Tommy Atkins	7	medium	4	no	no	yes
Van Dyke	14	high	5	no	no	yes
Zill	8	medium	2	no	no	no

*All trees were planted in 1998.

**Early flowers ruined by anthracnose (barren panicles).

Table 3. Tree inventory for secondary mango planting at IREC on March 3, 2022.*

Variety Name	Ht. (m)	Vigor	Bole # Breast Ht.	Flower	Fruit	Damaged Flowers**
Carrie	11	high	5	no	no	yes
Dot	15	high	5	no	no	yes
Edward	16	high	4	no	no	yes
Jakarta	15	high	3	yes	no	yes
Khun See	10	high	2	no	no	yes
Nam Doc Mai	9	high	3	no	no	yes

*All trees were planted in 1993.

**Early flowers ruined by anthracnose as evidenced by barren panicles.

Plate 11. As fruit develops the threat posed by anthracnose and looper diminishes.

FUTURE WORK

Some recommendations for future work are:

- Prune trees to a uniform height of two meters (6 ft) for easier orchard management.
- Explore the use of gibberellic acid to inhibit flower induction. This would delay flowering that naturally occurs in the rainy season, when anthracnose attacks the flowers. The delay would move flowering into the dry season, when the disease threat is less and successful fruit production is likely.
- Identify rootstocks to be used in mango grafting on Guam.

SUMMARY

The collection of mango trees at IREC provides a valuable opportunity for improving mango fruit production on Guam.

Planted from 1993 to 1999, the 29 varieties were drawn from all the major mango producing regions in the world and include many of the most successful varieties in international commerce (Plate 13). This stand of trees, furthermore, can be used to identify varieties that:

- are adapted to Guam's climatic conditions.
- are resistant or tolerant of anthracnose disease.
- can be classified as early, middle, late in their fruit development.
- can be used as sources of propagation materials for grafting.
- can be used in breeding new varieties.

Potassium nitrate was shown to be an effective tool in inducing flowering in the mango trees at IREC.

Plate 12. Ripening mangos can be attacked by anthracnose, which results in black spots or blotches. Though unsightly in appearance, the fruit is still edible.

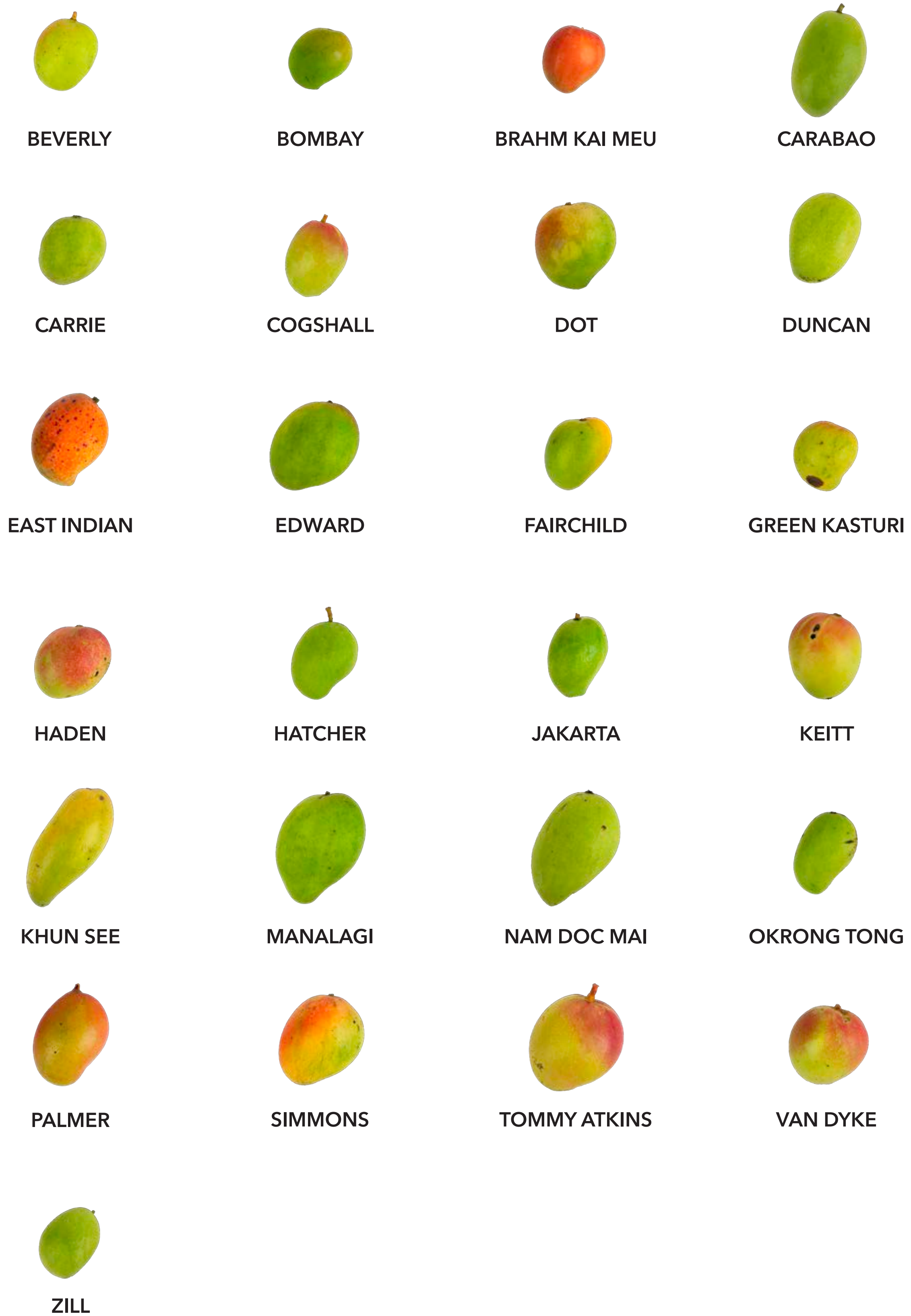


Plate 13. Photographs of mango fruit grown at IREC. The key to improving island mango production may lie in this collection of varieties.

Table 4. Fruit characteristics of mango varieties at IREC as recorded on June 13, 2022.

Variety Name	Skin Color	Weight (g)	Ripeness	Sugars* (%)	Weevil**
Beverly	green/red	250	½	8	no
Bombay	green	123	¼	9	no
Brahm Kai Meu	yellow/red	207	full	18	yes
Carabao	yellow/green	194	½	8	no
Carrie	light green	262	½	9	no
Cogshall	yellow/red	297	¾	7	no
Dot	green/yellow/red	437	¾	8	no
Duncan	light green	567	¾	8	no
East Indian	green/orange	539	full	n/a	n/a
Edward	green/yellow	482	full	7	no
Fairchild	green/yellow	250	full	18	yes
Glenn	n/a	n/a	n/a	n/a	n/a
Green Kasturi	green/yellow/red	195	½	11	no
Haden	green/red	208	½	7	no
Hatcher	green	129	¼	10	no
Jakarta	green	270	¼	8	no
Keitt	yellow/red	277	½	7	no
Khun See	green/yellow	315	½	11	yes
Madame Francis	n/a	n/a	n/a	n/a	n/a
Manalagi	green	449	¼	7	no
Nam Doc Mai	green/yellow	350	½	10	no
Okrong	n/a	n/a	n/a	n/a	n/a
Okrong Tong	green	142	¼	7	no
Palmer	red	499	¾	7	yes
Rapoza	n/a	n/a	n/a	n/a	n/a
Simmons	yellow/red	554	full	16	no
Tommy Atkins	green/red	337	½	8	no
Van Dyke	green/red	304	½	8	no
Zill	green	144	¼	7	yes

***Soluble solids or Brix measured with a hand-held refractometer and expressed as a percentage.**

**** Presence of mango seed weevil (larva) inside seed.**

ACKNOWLEDGEMENTS

Our deepest gratitude goes to Thomas Marler, who pioneered mango research on Guam. Our gratitude also goes to the three technicians who planted the first trees in 1993 at IREC and have cared for them ever since: Frankie Mantanane, Kenneth Paulino, and Glenn Meno.

There are many UOG employees who contributed to this study. Francis Taijeron was instrumental in all field operations. Jesse Bamba identified anthracnose as the principal disease threat. Aubrey Moore identified the mango shoot looper and provided guidance and equipment for its control. Ross H. Miller identified blow flies, or bluebottles, as the principal mango pollinators. UOG students in Introduction to Agriculture (AL-101) during Spring 2022 were instrumental in gathering the field data presented in this paper. Jonae Sayama formatted the report and integrated the illustrations. Luke Fernandez created the poster depicting the mango fruit.

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APPENDIX

Appendix A. Spray log for mango trees at IREC for 2022.

Appendix A. Spray log for mango trees at IREC, 2022*.

Application Date	Primary Target	Secondary Target	Materials Applied	Active Ingredient	Rate per Gallon	Comments
8-Feb	flower induction		potassium nitrate	13:0:45	4 tbs	small trial
15-Feb	flower induction		potassium nitrate	13:0:45	4 tbs	small trial
21-Feb	anthracnose disease	plant nutrition	Daconil fungicide foliar fertilizer	chlorothalonil 30:10:10	2 ¼ tsp 1 tbs	
1-Mar	anthracnose disease	plant nutrition	copper fungicide foliar fertilizer	copper hydroxide 30:10:10	4 tbs 1 tbs	
3-Mar	flower induction	anthracnose disease	potassium nitrate Neem Oil foliar fertilizer	13:0:45 hydrophobic extract 30:10:10	4 tbs 2 tbs 1 tbs	all trees
11-Mar	anthracnose disease	plant nutrition	Daconil fungicide Foliar fertilizer	chlorothalonil 30:10:10	2 ¼ tsp 1 tbs	
14-Mar	flower induction	anthracnose disease	potassium nitrate copper fungicide foliar fertilizer	13:0:45 copper hydroxide 30:10:10	4 tbs 4 tbs 1 tbs	vegetative trees
21-Mar	mango shoot looper	flower induction/ anthracnose disease	DiPel insecticide Manzate fungicide potassium nitrate	*Bacillus thuriensis* mancozeb 13:0:45	1 ½ tbs 2 ½ tbs	all trees
23-Mar	mango shoot looper	anthracnose disease	DiPel insecticide Daconil fungicide	*Bacillus thuriensis* chlorothalonil	1 ½ tbs 1 ¼ tsp	all trees mist blower
28-Mar	mango shoot looper	anthracnose disease	DiPel insecticide copper fungicide	*Bacillus thuriensis* copper hydroxide	1 ½ tbs 4 tbs	all flowers
30-Mar	mango shoot looper	anthracnose disease	DiPel insecticide Manzate fungicide	*Bacillus thuriensis* mancozeb	1 ½ tbs 2 ½ tbs	all trees mist blower
7-Apr	mango shoot looper		DiPel insecticide	*Bacillus thuriensis*	1 ½ tbs	all flowers

***All spray applications were to the lower branches that could be reached with a backpack sprayer.**

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