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Redefining an Ancient Crop: The Future of the Mango

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Abstract

Commercial mango (*Mangifera indica* L.) growers in the Western Hemisphere are facing ever-increasing challenges for profitability with the export cultivars 'Tommy Atkins', 'Haden', 'Kent', 'Keitt' and 'Ataulfo'. The entry of the yellow-skinned cultivars 'Ataulfo' and 'Madame Francis' into the export market opened new doors and focused attention on the search for new cultivars that will return the industry to a profitable status. Over 400 named cultivars and selections of *Mangifera indica* and 12 *Mangifera* spp. have been collected around the world and successfully cultivated within the genetic collection of Fairchild Tropical Botanic Garden in South Florida. This collection, the result of over 20 years of collecting and breeding, could be integral to the redefinition of the commercial mango industry in the decades to come. Annual orchard pruning, nitrogen management and the use of bloom-inducing chemicals are increasingly impacting the grower's ability to achieve quality. New cultivars suitable for the industry must also be weighed against these management issues to allow the grower to remain profitable. The trend in the industry is a vertical integration from the field to the market. New cultivars, either patented or trademark protected, are integrated into relationships between specific producers and importing companies. These relationships allow for accountability within the market and greater involvement of the grower in the direction of the industry. Significant challenges remain for the identification and testing of new cultivars in different regions and climatic conditions and for the creation of international standards for import and export.

In the last several decades, the mango has continued its growth as a fresh sales commodity within the United States, with the domination of a handful of cultivars selected in Florida before the 1950s. These cultivars have served the industry well, but at present mango producers across exporting nations are reporting losses and investing little in their respective industries. Concern is growing about the short and long term profitability of the export mango industry in the Western Hemisphere. Policy makers for the mango industry want to increase consumption within the United States to allow for an increase in the volume of exports and liquidations paid back to growers, but current fruit quality within the marketplace is inconsistent and generally mediocre. The result is lower prices and poor consumer demand. Inconsistent and mediocre quality is due to a range of factors, but the cultivars currently produced and production practices in exporting countries contribute substantially to the problem. At the present time there are few norms established for mango production and extension programs are nonexistent or ineffective.

The entry and acceptance of the Mexican cultivar 'Ataulfo' over the last decade created an opportunity for the sale of yellow mangos within markets that were previously limited to red-skinned cultivars. Unlike the yellow-skinned 'Madame Francis', imported from Haiti for the last several decades, 'Ataulfo' has crossed over from ethnic markets to mainstream marketing channels in the United States. Prices paid to growers for 'Ataulfo' have been superior to those for red-skinned cultivars until quite recently; yet, due to yield potential, size and other quality traits of 'Ataulfo', growers continue to produce at an unprofitable level.

There are many cultivars of mango with yellow or green skin. 'Ataulfo' and 'Madame Francis' present an opportunity for the introduction of existing and new cultivars that were previously excluded due to their skin color. The acceptance of yellow- and green-skinned mangos in the market opens up considerable economic possibilities for local production and marketing of high-quality mangos in South Florida and other regions, as well as large-scale export ventures.

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The objective of the present paper is to provide an overview of the work at Fairchild Tropical Botanic Garden (FTBG) in the development of new mango cultivars and production protocols for the mango industry.

Overview of the Collection, Conservation, Breeding and Selection

The collection, conservation, selection and breeding of mango began over 20 years ago at FTBG with the goal of promoting mangos with superior flavor, production, horticulture, appearance and disease resistance for the estate and home garden market, as well as niche local and export markets. A living collection of over 400 clones of mango (*Mangifera indica* L.) and 12 *Mangifera* species has been collected and is conserved at the Williams Grove Genetic Facility of FTBG located in Homestead, Florida. Single trees of each clone are grown on the 0.8 ha site. Duplicate collections are maintained at two additional sites in South Florida to protect against loss. Further duplication is achieved through the distribution of genetic material throughout the world and by maintaining close collaboration with institutions, governments and growers in other production regions.

The promotion of mangos began with the creation of the Fairchild International Mango Festival and the Curator's Choice distribution program. This program promoted mango cultivars with innovative horticultural traits to the more than 30,000 members of Fairchild Tropical Botanic Garden, as well as, the International Mango Festival visitor. Priority was given to selections with a superior flavor and horticulture, including small tree size, disease resistance and overall ease of management. This program resulted in increased visibility for new mango cultivars and has distributed nearly 1500 Curator's Choice mango trees each summer for the last 17 years.

These efforts have led to a suite of mango cultivars with superior characteristics and there has been limited adoption of them within the South Florida and export industry for niche markets. The selections and directed breeding

effort began in the last decade in cooperation with Zill High Performance Plants, a commercial nursery in Boynton Beach, Florida. Priority was given to selection for superior flavor, dwarf trees and favorable horticultural traits. Initial releases of cultivars began in 2009.

Selection and Pre-screening

Seed of selected mother trees was collected out of the genetic collections at FTBG and Zill High Performance Plants and other orchards with a wide diversity of scion cultivars. Where possible maternal trees were selected growing in close proximity to desirable male trees. The intent was to harvest fruit that were the product of out-crossing between desirable maternal and paternal trees. Seed were removed from the fruit and husk, planted in the nursery and grown with standard commercial care. Seedlings were manually screened by leaf aroma while at the 3 to 5 leaf stage. Leaf aroma is closely linked to flavor in mango and by this method pre-selection for distinct flavor types was possible.

Pre-screened seedlings were grown in the nursery under standard commercial production conditions and additional seedling screenings were conducted for slow, compact growth habit, precocity, and disease tolerance. By



Fig. 1. Yellow-skinned mango selection for release from Fairchild Tropical Botanic Garden.



Fig. 2. Red-skinned mango selection for release from Fairchild Tropical Botanic Garden.

this method a field population of thousands of candidate seedlings was assembled at Zill High Performance Plants in Boynton Beach, FL over more than a decade.

Evaluation of fruit flavor and quality has been ongoing for more than a decade. Flavor has remained the most important criterion for selection. Flavor characterization is a complex issue for mango, with few, if any standards available for reference. We recognize six broad flavor types in mango, the 'Alphonso' type, the 'Pairi' type, the 'East Indian' type, the 'Dusehri' type, the Southeast Asian type and the wild mango type. Each flavor type is distinctive and preferred by the people native to that specific region of the world. Preference has been given to flavors that fall within the 'Alphonso', 'Dusehri' and Southeast Asian types. Our experience has shown these flavor types to have the broadest appeal within the United States marketplace.

Evaluations were also conducted as part of the public taste evaluations at the FTBG International Mango Festival. In addition, mango flavor is highly dependent on soil type, nutritional status of the tree and other climatic factors. Flavor evaluations were therefore conducted where possible across multiple years and from different locations. Public response has been positive to the flavors of the new selections; however, consistency of flavor throughout years and growing condi-

tions has been a challenge. Our experience has shown that the more complex the flavor profile, the more that can go wrong at the point of the consumer. Consistency of flavor must be considered in the selection of new cultivars.

Field evaluations were conducted on managed tree size, production, disease tolerance (tree and fruit), season, ease of blooming, and overall horticultural ease. Evaluations of nearly 40 elite selections have been conducted at 4 locations in Florida and two locations in Costa Rica. Field evaluations are ongoing, as they require a number of years and conditions to provide credible results. Field horticultural evaluations are necessary for the long term suitability of these selections for the industry. Prices paid to growers are not likely to increase over the years to come; therefore, field efficiency and increased yields will be integral to grower success.

Mango Production Protocols

Florida and other subtropical production regions have elaborated management protocols for commercial mango that rely on intensive inputs of water, fertilizer, mechanical pruning, and chemical pest and disease control. These protocols have allowed for exceptionally high yields that are 3 to 4 times the world average. Florida and other subtropical regions are considered marginal climates for proper mango growth and production. The success of these systems rests with the appropriate application of technology and sustainable, heavy yields. Fertilization programs were tailored to replace the nutrients removed by the harvest in soils low in native fertility. Proper blooming in the subtropics is not a critical issue due to the cool winter temperatures and thus the cultivars selected in these regions were not screened for this criterion.

The subtropical growing model was carried into the hot tropics and implemented on extensive production areas destined for export using cultivars developed in Florida. In most of these production regions, the mango was grown on a subsistence system with low inputs of modern technology. In the hot tropics, these

production models were applied and adapted to local conditions, but they have not been able to achieve, nor sustain the exceptional yields per unit area that were possible in subtropical regions. In most producing countries, extension programs are inadequate to assist growers, and much of the information available on modern production techniques has been received from consultants and commercial companies.

Management protocols were modified in order to address these shortfalls and to increase yields. Modifications to the management protocols have often been based on incorrect assumptions or applied incorrectly to the different cultivars. The result has been an increase in production costs for the grower and a reduction in overall quality for the mangos produced. Management misconceptions can be broken into the following areas:

1. Soils. High fertility soils have been chosen for mango production across extensive areas of the hot tropics. These soils result in excessive nutrient retention and vigor of the trees. Size control, flowering and fruit quality are problematic under such soil conditions. Low fertility soils allow for greater horticultural control and ultimately superior flowering and fruit quality.

2. Fertilization. There has been a general misconception in the fertilizer programs, with an excessive use of nitrogen. Nitrogen rates and formulations are excessive and are applied in anticipation of a large crop load and not in reaction to nutrient depletion from fruiting. The excess nitrogen applications are exacerbated by bloom induction treatments with potassium nitrate or paclobutrazol, both of which result in an excess of nitrogen and poor fruit quality. The reduction and close control of nitrogen is integral to mango fruit quality and must be factored into any successful production protocol.

3. Irrigation. While conducive to consistency of production in most areas, in the hot

tropics irrigation has often been excessively used for the mango to increase fruit size and to promote overall tree health. The result has been excessive vigor, poor flowering, difficulty in tree size control and excessive incidence of fungal disease.

4. Pruning. Mechanical pruning, an essential annual management tool in the subtropics, has been all too often mismanaged in the hot tropics, resulting in poor flowering and an overall lack of confidence in the practice. The result is excessive tree size, poor color and fruit quality and increased grower costs for harvest and handling. Pruning, in combination with vigor control, is a necessary component of the successful management protocol. The selection of dwarf scion cultivars can improve grower expenses in this area.

5. New cultivars. The export mango industry must address all of the management protocols listed above in order to provide a quality experience for the consumer. Dwarf trees with excellent flowering and production potential, disease resistance and exceptional eating quality are needed to address the challenges for the industry. Many of the cultivars promoted by the Tropical Fruit Program of FTBG ('Cogshall', 'Fairchild', 'Mallika', 'Rosigold', 'Manilita') have attained limited commercial success due to these traits. The need has been clearly demonstrated.

'Angie' and 'Jean Ellen' were released from FTBG Tropical Fruit Program in 2009 for use in patio and estate agriculture in South Florida and Tropical America. These two cultivars are small trees, flower easily in the tropics, ripen their fruit before the arrival of the summer rains in South Florida and have exceptional quality. Values of 18°Brix or higher are attained with these two selections each year and their eating quality is consistent across a variety of soil and climatic conditions. Additional releases will follow in the next few years to address the continuing needs of the mango industry as it struggles to remain profitable.