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Exploring the Unexplored in the Caribbean: Traditional and Emerging Fruit Crops in Puerto Rico, the Dominican Republic, and Haiti

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Abstract

The Caribbean archipelago is a mosaic of languages, cultures, and cuisines, resulting in differential preferences regarding foods, including fruits. The relative importance of fruit crops in the Caribbean depends on their value as export crops and on their value in domestic markets. Several fruit crops were commercially important (with ups and downs) in many Caribbean islands throughout most of the 20th century and even before, remaining important to date and possibly for decades to come. Other crops have been important in one or several islands, but not in the other islands of the Caribbean. This paper is a review of fruit crops, situations and tendencies in Puerto Rico, the Dominican Republic, and Haiti.

Exploration in the Caribbean often evokes thoughts of conquest, treasures, pirates, and tropical beaches. This paper explores the treasures of fruit crops in two Caribbean islands, Hispaniola (comprising the Dominican Republic and Haiti) and Puerto Rico. With alternating good and bad market periods, in both islands sugarcane (*Saccharum* spp.), coffee (*Coffea* spp.), tobacco (*Nicotiana tabacum* L.), cacao (*Theobroma cacao* L.) and cattle (*Bos* spp.) have been leading agricultural commodities since the era of European colonization starting in 1492. All of these commodities are easy to process into long-lasting products (sugar, roasted coffee, cocoa and chocolate, cigars, leather and salted beef) that could be shipped to international markets with the transportation available in the 15th to19th centuries without important deterioration. The slow overseas transportation systems, lack of refrigeration and controlled atmosphere technology for fresh fruit, and relatively crude processing technology at the time were major factors in the slow development of large commercial fruit orchards in the Caribbean region. Thus, until the 20th century, fruit crops were minor components in the agricultural economy of the Caribbean, with consumption directed to nearby markets.

Production of fruit crops in the Caribbean islands was not organized on a larger scale or commercially oriented until banana (*Musa*) and pineapple (*Ananas comosus* [L.] Merr.) plantations were established for export as fresh fruit and/or processed products to the U.S. and Europe in the early 20th century, with the advent of better transportation and conservation technology for fresh fruits and improved processing technology. The expansion of the urban population in the islands and in major export markets for Caribbean products (mainly the U.S. and Europe), changes in local diets, and the development of better post-harvest practices made it possible for other tropical and subtropical fruit crops to flourish in the Caribbean. In the last half of the 20th century, the area under organized production of citrus [mainly sweet orange (*Citrus ×sinensis* [L.] Osbeck), tangerine (*Citrus reticulata* Blanco), and lime (*Citrus aurantifolia* [Christm.] Swingle)], avocado (*Persea americana* Mill.), and mango (*Mangifera indica* L.) grew steadily until these crops came to be recognized as economically important and no longer "backyard" fruit species.

Indeed, some of the aforementioned crops developed beyond initial expectations. For example, mango became a major export item

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in Puerto Rico and is the second largest export crop in Haiti, with sales of approximately USD $8 million each in the year 2006 (3, 5). Avocado has become so important in the Dominican Republic, that this country is one of the main avocado exporters in the world ($18.5 million in 2008)(2). Papaya (*Carica papaya* L.) and passion fruit (*Passiflora* spp.) have also become commercially viable fruit crops in the Caribbean islands, although passion fruit has been what growers call a "roller coaster crop" because of its sharp alternation of high and low prices.

The "new" fruit crops are largely considered by the general public in some of the Caribbean islands as "exotic" (even though the species may have been introduced to a particular island a century ago, but was not widely known or grown there) or are actually of recent introduction to the Caribbean islands. Some of the "new" crops are also emerging as economically important crops because of their acreage and production volume. Other crops, already known in the islands for decades or even centuries but that remained in a "backyard" status, are now growing in importance and larger acreages of organized orchards are coming into being.

There are similarities and also striking differences in the emerging fruit crops grown commercially as traditional in the Dominican Republic, Puerto Rico and Haiti. A brief discussion of the newcomer and emerging crops in those three nations follows.

Puerto Rico

The island's agriculture is strongly geared towards local markets, which may be attributed, at least partially, to the fact and awareness that of all the food its population consumes, Puerto Rico has been producing between 5 and 15% (depending on the source of information) (9). This situation has a reflection on fruit crop production, most of which is not produced for export. Among large fruit crops, the main exception to the local-market orientation is mango, of which the bulk of the organized and high-tech production is exported.

The fruit crops industry had an estimated farm gate worth of approximately $33 million in the fiscal year 2007-2008 (3), although that figure is most likely underestimated, with a real value closer to $40 million. The large fruit crops [with official farm gate values (USD) in 2007-2008 in parentheses] are bananas ($16.5 million), mango ($8 million), tropical ("West Indian") avocado ($4 million), citrus ($11 million, mostly orange and tangerines, with the relative importance of limes increasing and that of grapefruits decreasing), and pineapple ($855,000)(3).

Growers continue to plant new orchards of the traditional food crops, or to replace old orchards of one crop with new orchards of other fruit crops, depending on market interests. For example, growers in Puerto Rico have been switching from pineapple for processing to pineapple for fresh fruit and for decoration. Many new avocado orchards were planted between 2004 and 2009, but at the same time old avocado orchards were dismantled due to urbanization of former agricultural areas or abandoned because of excessive *Phytophthora* root disease pressure. Hence, the acreage for several food crops remains the same, although the actual orchards have changed. Orange and tangerine production has generally been linked to coffee production in the mountains, where citrus is intercropped with coffee. Passion fruit acreage has dwindled due to production limitations (high virus and fungus disease pressure, high production costs) and from external competition (cheaper pulp and juice in the international markets).

Some fruit crops are commonly recognized and sought after by the general consumer population, but until recently were considered of scarce importance as fruit crops in organized, large scale marketing systems, and hence unworthy of organized production for local consumption or exportation (i.e., nice, appreciated, but nonetheless "backyard" species). In Puerto Rico, quenepa **(***Melicoccus bijugatus* Jacq.) and panapen or breadfruit (*Artocarpus altilis* [Parkinson] Fosberg) are the true representatives in this "emerging

fruits" group. Both species have been known and used in Puerto Rico for centuries, but had never achieved "crop" status. The increasing demand for both quenepa and pana in recent decades has fueled interest in intensive utilization of existing trees and establishment of new and organized orchards. It has also brought about efforts to select superior trees to develop commercial cultivars, and research on horticultural production practices (1). Because of their short post-harvest life (10), quenepas are consumed mostly as a fresh fruit, although part of fruit production is used in small local industry as a fermented beverage (15). Panapen is used as a starchy staple, either boiled or fried (11).

Other fruit crops of promise, but not truly increasing in importance at this time, are carambola *(Averrhoa carambola* L.), Caribbean cherry *(Malpighia glabra* L.), sapodilla *(Manilkara zapota* [L.] P. Royen*)*, and zapote *(Pouteria sapota* [Jacq.] H.E. Moore and Stearn). Local demand for carambola, sapodilla and zapote does not seem to be large enough to support large acreages under organized production in Puerto Rico. Potential growers of those crops in Puerto Rico may need to explore the possibility of exporting the fruits and/or processing as alternative outlets for their production. The largest fruit grower company in Puerto Rico, MARTEX, has commercial orchards of mango, banana, citrus, and avocado, as well as orchards of less developed fruits such as Spanish lime, sapodilla, zapote, carambola, and sugar apple, among others. Part of the MARTEX production is exported, mainly to the USA, Europe, and several islands in the Caribbean.

Sapotaceae fruits such as caimito (*Chrysophyllum cainito* L.), sapodilla and zapote grow very well in Puerto Rico, but so far there are few commercial orchards and these fruits have stayed largely in "backyard fruit" status, as the demand for the fresh fruit and their derivative beverages is relatively small in the island. However, the pulp of Sapotaceae fruits for beverages is in high demand in areas of the US with large Central American, Mexican, Dominican, and Cuban populations, and there is potential for commercial production in Puerto Rico to export the pulp towards such markets. MARTEX exports to the U.S., Europe and the Caribbean.

Caribbean cherry enjoyed a period of high interest in the middle of the 20th century, fueled by the demand for fruits with a high concentration of vitamin C. The interest in Caribbean cherry production decreased when synthetic sources of vitamin C became more economical than using this fruit as a source; however, recent interest in making vitamin C supplements with natural sources (i.e., from fruits) for the health product industry has increased the potential of Caribbean cherry as a fruit crop in Puerto Rico and other tropical regions.

The main "new" crops in Puerto Rico are mostly in the Sapindaceae family: rambutan (*Nephelium lappaceum* L.), lychee (*Litchi chinensis* Sonn.), and longan (*Dimocarpus longan* Lour.). Rambutan is already on its way to becoming a very important fruit crop in Puerto Rico. Rambutan can be grown successfully in several areas of the island, and there are several commercial orchards. Expansion of the lychee in Puerto Rico may be limited by the perception that the crop is more delicate and the weather requirements are more stringent than for other fruit crops of choice; it also has to compete in the local market with the related and more popular quenepa. Lychee can be found producing fruits in several regions of Puerto Rico. Although longan can be grown successfully in Puerto Rico, the fruit is commonly referred to as "too sweet" for the local taste, and thus longan may have a market disadvantage as compared to its relatives quenepa, rambutan, and lychee, unless varieties with lower sugar/acid ratio can be grown and/or the crop is managed to reduce its fruit sugar content.

Even though many Puerto Ricans are not excited about giant granadilla (*Passiflora quadrangularis* L.), this fruit has potential as a crop for local consumption, due to high demand among immigrants from the Dominican Republic, Colombia, and other South Ameri-

can countries. There is also great potential for *Hylocereus* spp. production in Puerto Rico.

Fruit flies are abundant and aggressively colonize fruit crops in Puerto Rico, which is seen by many existing and potential growers as an important limitation for the development of orchards of new crops geared to fresh fruit exports. Nevertheless, several fruit crops have been identified by Bryan Brunner (University of Puerto Rico-Mayaguez Campus, personal communication), as having potential to develop into important commercial fruit crops for consumption in Puerto Rico, including mangosteen (*Garcinia mangostana* L.), gandaria *(Bouea gandaria* Blume=*Bouea macrophylla*), marang (*Artocarpus odoratissimus* Blanco), abiu (*Pouteria caimito* Radlk.), jaboticaba (*Myrciaria cauliflora* [Mart.] O. Berg), grumichama (*Eugenia dombeyi* Skeels), langsat (*Lansium domesticum* Correia), pitahaya, ketembilla (*Dovyalis hebecarpa* [Gard.] Warb.), and canistel (*Pouteria campechiana* Baehni). Of this group, the mangosteen has already become a newspaper sensation in Puerto Rico, when trees on a farm in Mayaguez started producing fruits (7). However, so far few people are willing to invest in a crop that takes 8 to 10 years to reach production. No doubt we will see more growers trying mangosteen production in Puerto Rico and elsewhere, to take a share in a market of mangosteen beverages of more than $200 million per year.

Additionally, Jose Zamora, Extension Fruit Specialist of the University of Puerto Rico, indicated that there is interest and potential for commercial production of mandu (*Garcinia dulcis* [Roxb.] Kurz), madruno (*Garcinia madruno* [Kunth] Hammel), rheedia (*Rheedia edulis* [Seem.] Plant. & Triana) *Reedhia edulis*), pomegranate (*Punica granatum* L.), Surinam cherry (*Eugenia uniflora* L.), Japanese plum (*Eriobotrya japonica* [Thunb.] Lindl.), jackfruit (*Artocarpus heterophyllus* Lam.), strawberry guava (*Psidium littorale* Raddi), custard apple (*Annona reticulata* L.) and several species of *Spondias* in Puerto Rico

The Dominican Republic

The traditional fruit crops with the largest acreage and economic importance in the Dominican Republic are banana, citrus (led by oranges), avocado, mango, coconut, pineapple, and papaya (2, 14). This country has invested heavily in fruit crops, both conventional and organic. In 2007, the Dominican Republic was the world leader in export of organic banana (65% of the world market, with sales of $45 million, and 15,000 ha under certified organic production) and organic Tahiti lime (Citrus latifolia [Yu. Tanaka] Tanaka). In 2008, the country supplied 85% of organic bananas imported by the European Union. Production and exportation of organic mango, avocado, and coconuts continues to grow since 2000, with over 6,000 ha (6, 8).

About 40% of all the bananas produced in the country are certified organic. The area of banana orchards harvested decreased from the year 2000 (28,000 ha) through the year 2007 (17,700 ha), and most of the reduction was in conventional banana. Nevertheless, during the same period the average banana productivity in the country increased, as the production in 2000 was approximately 343,000 MT and the production of 2007 was approximately 552,000 MT.

Orange orchards increased from 5,000 ha in the year 2000 to 7,000 in the year 2007; the fruit is destined to either the fresh fruit market or is processed by the local juice and candy industries. Some of the fruit is exported, mainly to Puerto Rico. Production declined by about 30% between 2000 and 2007, which is attributed in large part to disease pressure and reduced application of costly fertilizers. In 2008 and 2009, few new orchards have been planted out of fear of citrus greening disease. Tangerines are appreciated, but a large percentage of the production comes from wild trees.

The area planted to lime orchards increased 66% between the years 2000 and 2007, from 1260 to 2100 ha, respectively. Commercial lime production in 2007 was estimated at

3,000 MT (4). Certified organic Tahiti lime for export is commonly favored for new orchards, although the selling price of "Creole" (Mexican type) lime is generally very attractive for the local market. Grapefruits (*Citrus paradisi* Macfad.) have fallen out of favor and production remained the same at about 3,300 MT per year during 2000-2007 (4).

In 2008 there were nearly 8,000 growers registered in the avocado cluster of the Dominican Republic. Commercial avocado orchards covered 6,100 ha in the year 2000 and expanded to 8,800 ha by 2007 (4). Avocado production in the year 2000 was 86,000 MT, increased to 115,000 MT in 2007 and to 168,000 MT in 2008. About 11% of the production is exported. Certified organic production is still small, with 286 ha and 532 MT of fruits accounted in 2004.

Mango has become a very dynamic component of the fruit industry in the Dominican Republic. There is an avid local market and exports have been increasing in the last 20 years; in 2003 nearly 1,000 MT of mangos were exported, and in 2008 the amount exported increased to 4,000 MT with an approximate worth of $4.5 million. About 20% of the mango exported in 2008 was certified organic. There is a very active mango cluster (with approximately 500 members), which has helped in modernizing the crop management and marketing in the country. The mango cluster and other institutions organize the "Dominican Mango Expo", which is held in June every year in the municipality of Baní, home to a number of commercial orchards of mango, where there are many local cultivars of mango. Baní is known as the "mango capital" of the country. The number of commercial mango growers in the country in 2008 was estimated at approximately 800. 'Keitt' is the leading export cultivar, and the USA and England are the main foreign markets. There are plans to establish orchards with mango cultivars from India in 2010, to export for the green mango market in North America.

Pineapple had its highest production in 1994, with 145,000 MT, and decreased when Dole closed its operations in the country in favor of the lower labor costs in Asia. Pineapple production increased and decreased between 2000 and 2007 (65,000 MT per year), with the highest production occurring in 2001 with 137,000 MT (4).

Coconut acreage (about 36,000 ha) remained practically static between the years 2000 and 2007, but in the same period the productivity decreased by about 25% between, mainly due to pests such as mites (4).

Papaya production continues to be battered by virus diseases, which shorten the productive life of orchards and reduce fruit quality. In spite of virus diseases, the area under papaya production remained stable at around 2,300 ha between 2000 and 2007, with 23,000 MT per year (14). The country is self-sufficient and exports papayas to the USA, Canada, Europe and several Caribbean countries.

Guava is an ancestral species in the island, documented by the Spanish conquerors in the late 15th century as being used by the Taino Amerindians. Production and harvesting of guava fruits from wild plants to be used for the candy industry and for juice has been going on in the Dominican Republic for centuries. Production for fresh fruit dates from the latter part of the 20th century and has found a faithful domestic market that demands green skinned and white-fleshed large fruits of high quality. Due to concerns over citrus greening disease, since approximately 2005, potential fruit growers have been favoring crops such as guava and mango, which are perceived as a more secure investment than citrus.

Passion fruit is a crop plagued by diseases caused by viruses and fungi, which makes orchards short-lived and with yields below their potential. Reasonable production costs and improving local and export markets have kept old growers producing and have made the business attractive to new ones (personal communication from Julio Morla, from the Passion Fruit Cluster of the Dominican Republic), but the net area under passion fruit production in the Dominican Republic remained about 500 ha between the years 2000 and 2008 (13). The

Dominican Republic exported passion fruit juice, pulp and fresh fruit for nearly $250,000 in 2008, and the main markets were the USA and Puerto Rico (2). The related crop giant granadilla suffers from the same afflictions as passion fruit, but local demand is always larger than supply, keeping prices very attractive for growers. As a result, very little of the production is exported, and giant granadilla exports in the years 2002-2007 totaled nearly $40,000 (2).

Soursop (*Annona reticulata* L.), a traditional fruit in the country, continues to be a very small crop in the Dominican Republic. Most of the production comes from wild trees and there are few organized orchards. A large percentage of the production is consumed locally, with a small export value of approximately $40,000 in 2008 for fresh fruit, pulp, and various juice and candied derivatives of soursop (2). The importance of other Annonaceae fruits is even less than that of soursop. Organized production of custard apple (*Annona cherimola* Mill.) is being tried in the cool-weather mountains of the municipality of Jarabacoa (personal communication of Raul Cordero, Instituto Salesiano de Agricultura).

Caribbean cherry is still in the "backyard species" category, in spite of several attempts to develop it into an economically important crop. Only a minute percentage of the crop is exported. The amount of juice, candy and fresh fruit exported during the period 2002-2007 totaled approximately $125,000 in those six years (2). Most of the harvest comes from wild trees and a few organized orchards, and the majority of the fruits are processed into juice for the domestic market or eaten as fresh fruits shortly after harvest.

The strawberry industry in the Dominican Republic moved about $1.5 million in 2007. Production is concentrated in the highlands of the Central Mountain Range (with cool temperatures adequate for strawberry production). For the timing being, local production of prime strawberry fruit depends on importation of transplants from the USA that are then brought to the fruit production stage in Dominican fields. Other growers produce their own transplants locally. Some operations grow the plants in annual systems, while others grow the plants as short-term perennials. The local demand is large enough to sustain a much larger local production of strawberry.

Grapes (*Vitis vinifera* L.) are produced mainly in the dry southwestern region. In 2008 there were 325 small growers with 200 ha. In 2008 about 85% of the grapes were consumed as fresh fruit, but local wines (53,000 bottles) were produced with the remaining 15%.

The same crops mentioned as having potential in Puerto Rico are also of interest in the Dominican Republic, which has the advantages of more available land and more area with low temperatures that may serve for production of crops or cultivars with higher chill requirements.

The emerging crops include dwarf golden apple (*Spondias cytherea* Sonnesat), quenepa, rambutan, and macadamia. There is interest in mangosteen, lychee, and other fruits with potential for exportation to the USA, Canada and Europe.

Organized orchards of dwarf golden apple were planted in the first few years of the 21st century, mainly in the wet region of Monte Plata and surrounding provinces north of the city of Santo Domingo. The main target of those orchards is to produce fruit pulp for export. Export of the fresh fruit, pulp, juice, jam, and other derivatives is still small (worth $35,000 in 2008, mostly to Canada), but unsatisfied demand in multiple markets (Canada, several Caribbean islands, Suriname, the UK, Switzerland, the Netherlands, France, Germany, Brunei and the USA) suggests that there is ample room for growth for golden apple production (2). There is some production of good quality pomegranate (*Punica granatum* L.), fruits of which can be bought while waiting for traffic lights in Santo Domingo.

Macadamia was imported to the island with the purposes of providing a profitable alternative crop for traditionally low-income mountain dwellers, and also to serve as a permanent crop for protection against soil

erosion. As of 2008, there were 3,000 ha of macadamia planted in the country, mainly in the municipalities of Jarabacoa, Manabao, Constanza, Barahona, Los Montones and San Cristobal. The oldest macadamia orchards are already in production, and new orchards of macadamia (about 20,000 plants in 2009) are being established in the Barahona and Santiago mountains, with markets already secured with the local ice cream and candy industries (personal communication from Henry Ricardo, researcher of the IDIAF). Meanwhile, production of cashew nuts increased slightly from the year 2000 (950 MT) to the year 2007 (1025 MT) (4), with few organized orchards being maintained. At the same time, a robust industry of candied cashew apple has existed in the country for centuries, which is sustained with fruits from trees growing in the wild or from trees used as living posts in countryside fences.

Spanish lime or quenepa, traditionally a backyard tree, is now reaching the stage that warrants organized orchards to supply the local and export demand. Spanish lime exports to the USA alone were approximately $716,000 in 2007, and increased to approximately $1 million in 2008. Canada is another increasing market for Spanish limes from the Dominican Republic ($38,000 in 2007, $66,000 in 2008), and smaller amounts were exported to several European and Caribbean countries between 2005 and 2008 (2).

Traditionally backyard species consumed locally for generations, breadfruit (*Artocarpus altilis* [Parkinson] Fosberg) and jackfruit (*A. heterophyllus* Lam.) of the Moraceae have been gaining importance for export. Breadfruit exports were worth $66,000 in 2002, and increased to $350,000 in 2008. Jackfruit exports, both fresh and canned, were worth $200,000 in 2002, and increased to $817,000 by 2008. The main jackfruit markets in 2002-2008 were Europe, USA, Canada, Surinam, and the Lesser Antilles (2). Most Dominican production of breadfruit and jackfruit still comes from wild trees or multispecies orchards with little maintenance. However, it is likely that new and organized orchards will be established in the near future to keep up with the increasing demand.

Zapote is highly regarded by Dominicans and much of the production is readily consumed in the country. Frozen pulp of zapote is exported regularly to the USA, but in small amounts (approximately $10,000 in 2008), and there is opportunity for a larger supply of Dominican-grown zapote in the U.S., Canada, and European markets. Organized production of sapodilla, caimito, and true mamey (*Mammea americana* L.) is still small, with some exports, and is very much below its potential.

There is interest in local production of crops needing lower temperatures than traditionally thought of for the Caribbean, such as peach, apple, kaki, lychee, and plums. Those crops can be grown successfully at high elevations in the island. Some of those crops have been grown in small amounts in the mountains of the Dominican Republic for decades, mainly from seeds or vegetative material introduced from Spain, Israel, Japan, and the USA. More research is needed to evaluate and select genotypes appropriate for the local conditions and market preferences and needs. Interestingly, as these crops are considered "exotic" in the Caribbean, vacation resorts in the Dominican mountains mention gardens and collections of peach, apple, plum, and other temperate climate fruits as part of the attractions to be enjoyed in their grounds or surroundings.

Overall, the fruit industry (both conventional and organic) seems to be growing and developing in the Dominican Republic, and is strongly geared towards export. Well-known fruit crops (avocado, mango, citrus, and banana) are in the lead, but emerging crops (such as quenepa, breadfruit, jackfruit, and dwarf golden apple) are making progress and their contribution to the industry and the country's economy is growing.

Haiti

The fruit industry of Haiti is vastly different from that in neighboring Dominican Republic and Puerto Rico. The growth of the population

and increased economic pressures are exacerbating the widespread process of deforestation in Haiti, and as a result low quality fruit trees are being cut down for fuel or wood. A large percentage of the fruit produced in Haiti comes from wild trees, and for poor rural residents without steady income, the philosophy about trees in general is very straightforward: a tree will be cut down if it is worth more as wood or fuel than as a food supply. For their high revenue potential, trees of mango, tangelo, and tangerine (such as the local variety 'Mandarine de Jacmel') are highly appreciated and protected by people in the countryside, and as a result, wild mangos and tangerines account for a large percentage of the tree population of Haiti. Other fruit tree species or trees bearing low-quality fruit generally are not protected by the Haitians and are regarded largely as potential wood and coal.

Fortunately, that trend is slowly changing, due in large part to non-governmental agencies that are promoting the grafting of thousands of wild fruit trees with selected cultivars pf avocado, mango, and citrus (12). Those selected cultivars are more productive or have acceptance in international markets, hence giving growers an opportunity to sell for exportation and further increase their income. Another advantage of the grafted fruit crops is harvesting out of the traditional season for Haiti, which may also generate better income for the growers. For example, avocado trees grafted with 'Choquette' and 'Lula' cultivars are harvested out of the traditional season in Haiti, expanding the season of availability to consumers and the likelihood of better income for growers. The Organization for Rehabilitation of the Environment, and the United Caribbean Trust, among others, have been active in spreading grafted trees of golden apple, citrus, avocado, and mango for small growers. A single tree of grafted mango, avocado or tangerine is said to generate up to $50, $60, and $90 per year, respectively (12).

Without a doubt, mango is the king of fruits in Haiti. Mangos represent the largest percentage of the tree population throughout Haiti, and are one of Haiti's major export crops, second only to coffee. The accounted production of mango in Haiti surpasses by far the accounted production of mango on any other island of the Caribbean, with exports of about 9.1 million kg worth $6.7 million in 2004 (4) and estimated values of around $10 million in 2008. It is estimated that Haiti is exporting about 20% of its potential mango output. Because of the many microclimates and cultivars in Haiti, mangos can be produced almost year-round in different regions of the country. There are about 10 million mango trees in Haiti, of which approximately 1 million are of the 'Madame Francis' cultivar (with importance for export). The other 9 million trees are comprised mostly of about 140 local cultivars of little value in international markets.

Organized production of mango, avocado, banana, citrus, and coconut is considerably larger than that of most other fruit crops in Haiti. However, according to FAO estimates for 1998-2007, of the aforementioned crops, Haitian production of tangerine increased to 7650 MT, but production of avocado, banana, and orange remained static at around 43, 293 and 25 thousand MT per year, respectively. From 1998 to 2007, production of papaya and pineapple did not change much from around 100 and 3,000 MT per year respectively, and coconut production declined from 30,000 MT in 1998 to 25,000 MT in 2007 (5). Ludger Jean-Simon, crop specialist and Livelihoods Program Coordinator with Catholic Relief Services (CRS) and the American University of the Caribbean in Haiti, informed the author that there is interest in increasing the acreage and productivity of guava, banana, and citrus in the country, but commercial production of most other fruit crops remained static between 2000 and 2008.

Aside from the crops mentioned so far, the fruit sector remains mostly underdeveloped in Haiti. Crops such as papaya, pineapple, cashew, passion fruit, and giant granadilla are grown commercially to some extent in Haiti, but their importance is much lower

than that of mango, avocado and citrus, and production is mainly for local markets (personal communication, Ludger Jean-Simon).

Haiti has the potential to significantly increase its fruit industry. Species and cultivars able to grow and produce well in hot dry weather, with limited irrigation, are more likely to be grown more extensively in Haiti. Other crops mentioned here as with potential in Puerto Rico and the Dominican Republic may be grown in areas of Haiti where rain and/or irrigation are less limiting, and/or where the temperatures are more moderate.

Summary

In the three countries discussed in this paper, the traditional and organized fruit crops are the same (mango, citrus, avocado, banana, pineapple, papaya) although the relative economic importance of each crop may be different from one country to another. Puerto Rico has the advantages of ample diversity in ecological regions and fewer limitations to export to the U.S. mainland. However, Puerto Rico has limitations in the area that may be dedicated to new large orchards in flat lands, because of the strong competition from non-agricultural land development; the island also has a shortage of labor and high labor costs. Development of orchards in the Puerto Rican mountains is possible, but those orchards are more difficult to establish and operate than orchards in flatlands in the coastal plains. Traditional fruit crops will continue to be produced in Puerto Rico, but the extent of production will be dictated by market prices, and by land and labor availability and costs. Emerging fruit crops such as quenepa, panapen or breadfruit, rambutan and mangosteen should have a bright future in Puerto Rico.

The Dominican Republic still has an abundance of good quality land available for the fruit industry, and more abundant and cheaper labor than Puerto Rico. The spectrum of ecological regions available for fruit crops, from irrigated semiarid locations for grapes and mangos, to wet tropical forests for coconuts, to alpine-like mountains for peaches and apples, to wet tropical valleys for citrus and pineapples, makes for a diversity of locations that can accommodate almost any tropical and subtropical fruit crop, and even some temperate fruit crops. Dominican growers of fruit crops for export are well-organized in clusters and associations, which facilitates their interactions with foreign markets and local suppliers. The export sector is still well below its potential, but it has been increasing in importance. Traditional fruit crops for local and international markets are likely to continue as important crops, with their relative importance being dictated by market prices and cost of production inputs. The expansion of emerging crops will be driven by foreign markets rather than by local demand. In that regard, crops such as rambutan, lychee, mangosteen, pitahaya, golden apple, breadfruit, jackfruit and quenepa, among others, are likely to increase in acreage and economic importance in the near future.

Haiti has ample room for development, providing the industry is further organized and has easier access to irrigation and post-harvest handling and storage facilities. The country has the advantages of a large pool of labor, several international non-governmental organizations working on the development and improvement of the fruit industry, and growers that are not as tied to using synthetic agrichemicals as in other countries, which may help the growth of the profitable organic sector. While the production of fruits will need to grow to keep up with the demand of the increasing local population, new opportunities to grow fruits for export will probably be major forces in the development of the fruit crops industry in Haiti.

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What Animals Are Effective Natural Seed Dispersers for Pear?

Seed dispersal by animals affects the population ecology and evolution of many plant lineages. Scientists in Spain assessed quantity and quality of seed dispersal from fruit removal to seed germination in the Iberian pear (*Pyrus bourgaeana*). Whereas the abundant rodents, rabbits, and deer damaged all seeds eaten, the uncommon carnivores badger and fox and the abundant boars dispersed a large fraction of ingested seeds as viable propagules, acting as legitimate seed dispersers. Despite low rates of visitation by badgers, they transported more viable seeds than the abundant boars, because of better seed treatment and a higher feeding rate on pears. Pyrus bourgaeana was frequently visited by a myriad of frugivores, yet it relied on the dispersal service provided by an infrequent carnivore, the badger, rather than on those provided by the abundant mammalian herbivores. Therefore, under some circumstances, uncommon animal counterparts play major roles in their interactions with flowering plants. Paraphrased from Fedriani, J. M and M. Delibes. 2009. Ecoscience 16(3):311-321.