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Caribbean Forbidden Fruit: Grapefruit's Missing Link with the Past and Bridge to the Future?[1]

KIM D. BOWMAN AND FREDERICK G. GMITTER, JR.[2]

Abstract

A single introduction of grapefruit (*Citrus* x *paradisi* Macfadyen) into Florida from the West Indies in 1823 is identified as the original source of all known grapefruit germplasm. Essentially all grapefruit cultivars in the United States are bud sports or nucellar seedlings derived from this single introduction. A heterogeneous population of grapefruit-like *Citrus* known as "forbidden fruit," recently rediscovered in the eastern Caribbean region, may provide a valuable source of genetic diversity for grapefruit cultivar development.

Introduction

The grapefruit, *Citrus* x *paradisi* Macfadyen, is a commercial crop of great importance in many parts of the world. In Florida, the area of the world with the greatest grapefruit acreage, it has been estimated that 10,081,200 grapefruit trees were under cultivation during 1987 (6), producing an annual yield of nearly two million metric tons (5). Most plantings of grapefruit in Florida are the commercially seedless cultivar, 'Marsh,' or one of the red-fleshed limb sports derived from 'Marsh,' principally 'Ruby' and 'Thompson' (7). Small amounts of 'Star Ruby' have also been planted. The remainder of the Florida grapefruit trees in production are primarily 'Duncan,' a seedy cultivar. The Texas industry is focused on the red cultivars; in the past 5 years, 80% of the new plantings have been 'Star Ruby,' 'Ray,' 'Henderson,' or 'Rio Red' (5). Although the origins of 'Marsh' and 'Walters' are not certain, all of the commercially grown cultivars ('Marsh' Family, 'Star Ruby,' and 'Duncan') are thought to be derived from a single germplasm sample that was introduced into Florida about 1823, as shown in Fig. 1 (4, 8, 18). In fact, the ancestry of essentially all grapefruit selections in this country could probably be traced to this single introduction. Grapefruit cultivar development may benefit tremendously from the availability of a more diverse germplasm pool within *Citrus* x *paradisi*. A heterogeneous population of grapefruit-like *Citrus*, known as "forbidden fruit" or "shaddette," has been discovered in the Caribbean (1) and may supply a source of valuable genetic diversity. In this paper, we will summarize what is known about the origin of grapefruit, the limitations to genetic improvement imposed by some aspects of this early history, and the potential of the Caribbean forbidden fruit for grapefruit cultivar development.

History

Despite careful searching, the grapefruit has never been found native in Asia, where all of the other *Citrus* species are known to have originated (10, 15, 16). The Barbados "forbidden fruit" describe by Hughes in 1750 has been considered by most *Citrus* taxonomists to be the first report of grapefruit in the literature (1, 10) although the name, grapefruit, was not recorded until 1814 from Jamaica (11). The specific epithet *Citrus paradisi* was applied by Macfadyen in 1830 (12), along with the first relatively complete botanical description. Macfadyen clearly indicated that the common name of the species and one variety of

[1]Florida Agricultural Experiment Station Journal Series No. R-00022.
[2]Graduate Student and Assistant Professor, respectively, Department of Fruit Crops, University of Florida, IFAS, Citrus Research and Education Center, Lake Alfred, FL 33850.

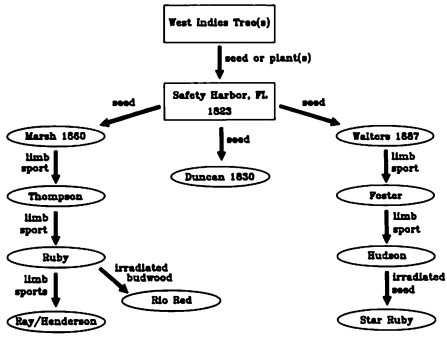

Figure 1. Probable pedigree of all commercially important grapefruit cultivars grown in USA.

C. paradisi was forbidden fruit and that a second variety with pyriform fruit was called "Barbadoes Grape Fruit." Numerous other reports of the forbidden fruit and/or grapefruit can be found in the early Caribbean literature, generally indicating that these two kinds of *Citrus* were closely related, but not identical. These descriptions are frequently contradictory (for reviews, see 1 and 10). The last report of the existence of the forbidden fruit as a distinct entity was from Bermuda in 1918 (2). Subsequently, reports of the forbidden fruit have not appeared in the literature, and most contemporary authors have considered forbidden fruit to be an early synonym for grapefruit, or an extinct related form (10).

Although there has been considerable controversy concerning the origin and taxonomic status of the grapefruit (1, 3, 10), most contemporary authorities believe that it originated in the West Indies from one or a series of chance hybridizations between sweet orange (*Citrus sinensis* [L.] Osbeck) and pummelo (*Citrus grandis* [L.] Osbeck) during the 17th or 18th century (15). One or more *Citrus* selections known in Europe as "Apple of Adam" probably were brought to the West Indies in the 17th century (13) and may have been progenitors of the Caribbean "forbidden fruit."

The first recorded importation of grapefruit germplasm into North America was by Count Odette Phillippi in 1823 (14). These seeds and/or plants were apparently obtained from some place in the West Indies and planted in a grove at Safety Harbor, Florida. Subsequently, seeds and budwood from this grove were distributed throughout Florida and eventually the world. All of the commercially important grapefruit cultivars, including 'Duncan' and the cultivar families based on 'Marsh' and 'Walters,' are believed to be derived from this one original germplasm sample (Fig. 1) (4, 8, 18).

Rediscovery of Forbidden Fruit

Recently, we have described populations of *Citrus* growing in Saint Lucia (West Indies) that are locally known as "shaddette" (1). Some residents note that elderly Saint Lucians once referred to these selections as "forbidden fruit," or the French Creole equivalent. These trees appear identical or very similar to the forbidden fruit described in the early Caribbean literature and are probably apomictic clones or zygotic progeny of those selections. A great amount of variation can be observed among shaddette trees growing in Saint Lucia. If early descriptions of forbidden fruit were based on examination of one or a few specimens from similar populations, it is easy to understand the conflicting descriptions of morphology produced by different authors.

Many shaddette selections bear a striking similarity to grapefruit in both vegetative and fruiting characteristics (Fig. 2). Imported grapefruit cultivars (such as 'Marsh') also are grown in Saint Lucia, and the shaddette is locally considered to be a related wild form. After examination of Saint Lucian shaddette, we believe it is probable that grapefruit would be most properly regarded as a cultivar group within the hybrid species *Citrus* x

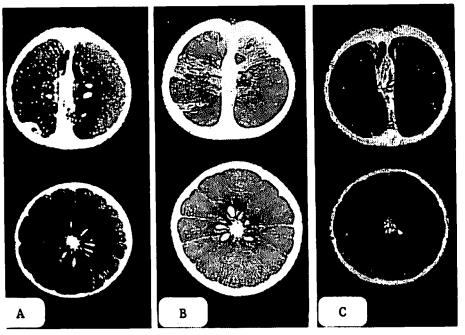

Figure 2. Fruit of (A) shaddette, (B) Duncan grapefruit and, (C) Star Ruby grapefruit.

paradisi and that other representatives of this species are now known in Saint Lucia as shaddette. Cooper (4) reported a similar wild fruit, known as "chadique," growing in Haiti.

Some existing selections of shaddette may be of value as fresh fruit or juice cultivars. Eating quality of the fruit from many individual shaddette trees is excellent. We have imported budwood (under quarantine) of three shaddette selections from Saint Lucia for further examination in Florida.

Characteristics

The shaddette is a medium-large tree bearing leaves composed of a glabrous elliptic-ovate blade attached to a slightly to broadly winged petiole. Short axillary spines are present on very young growth, but mature branches and limbs on seedling trees may be either spineless or very stoutly spined.

The characteristics of shaddette fruit vary considerably from one selection to the next. Fruit may be oblate, globose, or pyriform and sometimes hang in distinct clusters. Fruit diameter is generally 9 to 12 cm, and the rind may be thick or thin. The flesh is composed of medium-large juice vesicles that may range from pale yellow to pale pink. Most fruit are seedy, and some selections produce monoembryonic seed. A more complete description has been reported elsewhere (1).

Cultivar Development

Grapefruit has been a tremendously successful crop in the United States, representing about 22% of the total *Citrus* crop annually (17). Obviously, the cultivars available at the present time are adequate for successful commercial production. However, one may easily identify several desirable genetic changes that would simplify cultivation, increase grower income, or diversify markets. Fruit size, time of maturity, fruit color and flavor, cold tolerance, and disease susceptibility are all characters less than optimum in currently available grapefruit cultivars.

In the past 100 years, genetic improvement of grapefruit has relied almost completely on natural or induced bud mutations in existing cultivars. Three of the principle reasons for the lack of progress in grapefruit cultivar development by intraspecific sexual hybridization are: 1) the limited amount of variation available within the known selections of *Citrus* x *paradisi*, 2) the low ratio of zygotic/apomictic seedlings produced by these grapefruit cultivars, and 3) the long juvenile period of the species. The first of these barriers to successful cultivar production by intraspecific hybridization may be greatly alleviated by identification of a diverse wild population of the same species. Initial indications are that the Caribbean shaddette may be such a population. In addition, selections producing some monoembryonic seed can be found among shaddette, and these may supply needed sexual seed parents for crosses with grapefruit regardless of the nature of the phylogenetic relationships. It is possible that some shaddette selections will also exhibit greater precocity than grapefruit.

The cultivar group identified as grapefruit was channeled through a very narrow genetic bottleneck during its introduction into North Amer-

ica in the early 19th century. The extremely rapid growth of the grapefruit industry in Florida, based on these few selections, overshadowed the relatively small but diverse populations of similar fruit growing in the undeveloped and isolated islands of the West Indies. In fact, introductions of 'Marsh' and 'Ruby' grapefruit in Saint Lucia have mostly displaced the use of shaddette there. By the time the value of germplasm diversity was recognized, the identity of the forbidden fruit was lost to the developed world because of the early confusion in the literature. As a result, there has been only a very narrow range of genetic variability available within the species to supply desirable genetic traits. Interspecific hybridization of grapefruit provides no solution to the problem of cultivar improvement because such progeny generally lack the fruit characteristics needed to win market acceptance as grapefruit.

A species' greatest genetic diversity is usually found in its region of origin; this is where plant breeders generally seek genetic resources for enhancement of crop germplasm. In the case of grapefruit, we have identified a diverse population of "wild grapefruit" (shaddette or forbidden fruit) growing less than 150 km from Barbados, the suspected site of grapefruit's origin. The challenge ahead is to characterize genetically the phenotypic variation observed within this population and to utilize it for the development of improved grapefruit cultivars.

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Judges for Hedrick Awards

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