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A Survey of the Potential for Breeding In the Annonaceae Family

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Although fruits and ornamental trees of the Annonaceae (custard-apple) family are spread throughout the tropics, with many genera native to Africa and the East Indies, the important members of this family which bear edible fruits originated in North America. The largest edible fruit native to North America, the papaw, *Asimina triloba* (L.) Denal., belongs to the Annonaceae family. Its tropical relatives, the sour sop, *Annona muricata* L.; the sugar apple, *Annona squamosa* L.; the custard apple, *Annona reticulata* L.; and the cherimoya, *Annona cherimola* Mill., are native to Central and South America.

Annona squamosa, the sugar apple or sweetsop (the custard apple of India and Egypt), became naturalized in India so long ago that today there are an estimated 45,000 hectares mostly harvested from the wild. It is said that the leaves and bark contain a bitter annonaine or hydrocyanic acid and cattle and goats do not bother the trees. Since this annona can be seen in sculptural designs at Ajanta and Ellora and is mentioned in Hindu Sanskrit writings, it is often assumed to be native to India. However, according to Chandler (2), the West Indies is probably its original home.

Popenoe (9) considers *Annona cherimoya* to have originated in the highlands of Peru where W. E. Safford found clay artifacts which looked like cherimoyas in pre-Columbian graves. The cherimoya is likely the oldest cultivated fruit crop in the Americas.

The papaw is a member of this otherwise tropical family that can tolerate −20°F. and ranges all the way from the Gulf Coast to Michigan and southern Ontario. The subfamily, Anonoideae, tribe Unoneae includes both the *Asimina* and the *Annona.* The subtribe of *Asimina* is Xylopineae and it belongs to series Hexapetalae, while the subtribe of *Annona* is Anonineae. Bowden's chromosome count (1) corresponds well with this classification. In seven species of Asimina, he found $2n = 18$. In five species and one species hybrid of *Annona* the chromosome count was $2n = 16$.

While the soursop or guanabana, *Annona muricata* L. and certain selections of cherimoya have such a delicate flavor and aroma that they are ranked among the very best of the world's fruits, their production is limited by a rather narrow climatic adaptability and problems of pollination. The *A. muricata* is adapted to tropical lowlands and may lose its otherwise evergreen leaves when temperatures fall to 40°F (3). The cherimoya grows well in the cool, even temperatures of the tropical highlands, yet is rather sensitive to frosts and slowly dies in the above freezing, low winter temperatures of the San Francisco Bay area. In the coastal areas of Los Angeles and San Diego a few small commercial plantings of cherimoya can be found, but in coastal Florida it is poorly adapted.

An interspecific cross between the lowland tropical *Annona squamosa* and *A. cherimola* resulted in a hybrid called atemoya which shows a wider range of climatic adaptability, and in the case of 'Keller' atemoya has the good fruit quality of the cherimoya (14). Other crosses with *A. cherimola,*

A. squamosa, A. reticulata, and *A. glabra* L. have been made, but the combining of desirable genes in the Annonaceae has hardly begun. The range in genetic material is broad and seems adequate to meet the demands of climate, soil, and pests.

Annona squamosa grows on rocky, dry soils, but in India it sometimes has a problem of roots dying out after flooding (5). In the Florida Everglades, the pond apple, *Annona glabra,* grows with its roots in water. Although the chromosome count for A. glabra is 2n = 28 and for *A. squamosa* 2n = 16, it has been demonstrated that the two are cross compatible (14). Grafting is also a possibility. Some growers report annonas among the easiest trees to graft or bud (9). There have been some reports of overgrowth, or incompatibility, or dwarfing, but *Annona squamosa* is more vigorous on *A. muricata* than it is on its own roots, and when *A. reticulata* is used as a rootstock it is said to greatly increase early growth and fruiting (2).

Annona purpurea Moc & Sesse ex Dunal. is also hydrophilous, but it, like *A. glabra* tolerates dry sandy soils as well. *A. purpurea* produces large fruit with bright orange flesh and pleasant aroma. Its thick skin would be a valuable character in breeding for resistance to fruit flies or chalcid flies. It might also add some resistance to fruit cracking and shipping damage (8). Genes for thick, hard shell can also be found in *A. scleroderma* Saff. and *A. testudine*a Saff.

A. spinescens Mart from Brazil is a low, hardy tree, producing a small, round fruit, practically flavorless, but the dark orange external fruit color and salmon pink flesh make it attractive to include in a breeding program. The ilama, *A. diversifolia* Saff and *A. squamosa* also sometimes have pink or purplish pigment to contrast with the usual pure white of annona flesh. In India, this color is said to come true from seed, but R. J. Knight failed to get such color from seeds he planted in Miami, Fla.

Seedless *A. squamosa* have been found and tetraploids have been induced, but neither were found to be of superior merit (7).

Some annonas have very attractive flowers or compact growth habits that make them valuable as ornamentals. The ylang-ylang, *Cananga odorata* (Lamb) Hook. f. & Thoms., of southern Java, India, and the Philippines has flowers so aromatic that they are valuable in the perfume industry (2).

In 1940 Rehder estimated there are more than 70 genera and more than 600 species of Annonaceae (10). Verdcourt in *Flora of Tropical East Africa: Annonaceae* (1971) describes 27 genera of Annonaceae including *Annona* (13).

Perhaps *Asimina triloba* Dun., the papaw, will prove to be for the annonas what *Poncirus trifoliata* (L) Raf. is to citrus. With the ultimate goal of producing hybrids between *Asimina* and *Annona,* G. A. Zimmerman of Harrisburg, Pennsylvania successfully crossed the papaw with Asimina species from Florida and Georgia having more showy and fragrant flowers. His crosses, using pollen from *A. longifolia* Kral* and *A. obovata* (Willd.) Nash. on *A. triloba,* resulted in quite cold hardy hybrids with fruits having pleasing qualities. Shortly before his death, Zimmerman reported fruit set on his *Asimina* hybrid using *Annona* pollen (14). Unfortunately most of Zimmerman's work and collection have been lost.

At the University of Illinois, J. C. McDaniel is again making interspecific hybrids of *Asimina,* but points out that Annona has a different chromo-

*Zimmerman called his hybrids *Asimina trigustifolia* (*A. triloba* X *A. angustifolia* Raf.) and *Asimina trilobovata* (*A. triloba* X *A. obovata* (Willd) Nash). A revision of *Asimina* by Kral in 1960 makes *A. longifolia* Kral the present equivalent of *A. angustifolia* (4).

some number (6). Perhaps the climbing ylang-ylang, *Artabotrys odoratissimus* R. Br., variously reported n = 9 or n = 8 will bridge the gap between Asimina (n = 9) and Annona (n = 8) (1).

With papaws, like the annonas, good crops can be enhanced by hand pollination, and generally this is the limiting factor in production Hormone treatments for the setting of parthenocarpic fruit have been tried with cherimoya, but its practical application remains to be developed (12).

The six or twelve petals of the Annonaceae flowers drape in a tentlike fashion over the anthers and stigmas as if to protect the pollen from heavy rains. In this pendulous position, the pollen is above the stigmas and it would seem natural that pollination would be by gravity. Few insects have been seen visiting these flowers and wind pollination also seems remote. Yet in the early part of this century Wester discovered dichogamy which prevails throughout the Annonaceae (14). The stigmas are receptive 24 hours or more before the pollen of the same flower is shed, and by the time the pollen dehisces, the stigmas have usually turned brown. There are few places where heavy crops of fruit are set without hand pollination. It was in 1958 when Popenoe was looking over a naturally heavy fruit set of cherimoya near Almunecar, Spain, with Luis Sarasola, that they began to doubt that protogyny was the major problem with fruit set. Sarasola has written, "Good crops are not a matter of hand pollination nor of cultural treatment. Almost certainly they are the result of favorable climatic conditions, most probably temperatures which rarely go above 85° F., and relative humidities which throughout the flowering season in spring are commonly 60 to 75 percent during the driest hours of the day." These conditions would allow the stigmas to remain receptive until the pollen is released in the same flower (8).

Perhaps this idea will lead to misting during the flowering season or planting under the canopy of taller trees for cooler temperatures and higher humidities, for even with hand pollination fruit fails to set in very hot, dry weather.

When the problems of fruit set are solved and the diverse genetic material available in Annonaceae has been prudently manipulated, sour sop sherbet and concentrated cherimoya nectar will be familiar to a much larger proportion of the world's population.

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