

NEW SOURCES OF COLD HARDINESS FOR CITRUS BREEDING

In an assessment of natural hazards on world crop production, an average of more than \$100 million per year is lost in the continental United States due to freeze damage to 22 major crops. The greatest loss is in citrus production and amounts to about one-third of the national average. A severe freeze occurred in 1962 which cost Florida more than one-third of its total production, in excess of 10 million boxes (41 kg.) of fruit and one-fourth of its 52 million trees. Similar losses occurred again in 1977 and, most recently, in 1981 and 1982. These losses impact negatively not only on the present and future economic stability of an industry, but also in meeting the dietary needs (supply and nutrition) of an expanding world population, which is facing ever-increasing uncertainties in adequate nutrition and subsistence levels.

Citrus grown in subtropical climatic zones are subject to exposure to severe freezes. Production losses can be staggering, extending into 3 or more years after initial impact, and making total recovery a slow and laborious process. The capacity of citrus to survive freezing temperatures does not begin to approach the -50°C killing temperatures of northern woody plants. Survival is largely a combination of ice avoidance, tolerance of tissues to ice, and the capacity of freeze-injured trees to recover. Trees in Florida do not have a "true winter dormancy" as such, but more of a quiescent stage of growth which is more cold hardy if winter hardening has occurred. Because major damage can occur to trees of commercial cultivars exposed to temperatures below -6.7° , protection technologies are needed to stabilize existing industries. With the cost of energy ever increasing, making it an almost prohibitive source of protection, the development of cold-hardy citrus through genetic improvement has taken on new significance.

One of the major objectives of the U.S. Department of Agriculture's breeding program at Orlando, Fla., is the development of more cold-hardy citrus cultivars and rootstocks. *Eremocitrus glauca* (Lindl.) Swing. and *Poncirus trifoliata* (L.) Raf. are being used heavily as sources of winter dormancy and cold hardiness in intergeneric crosses.

E. glauca (the Australian desert lime) is the only pronounced xerophyte in the orange subfamily. A native evergreen of Australia, this tree grows wild in semiarid to arid cli-

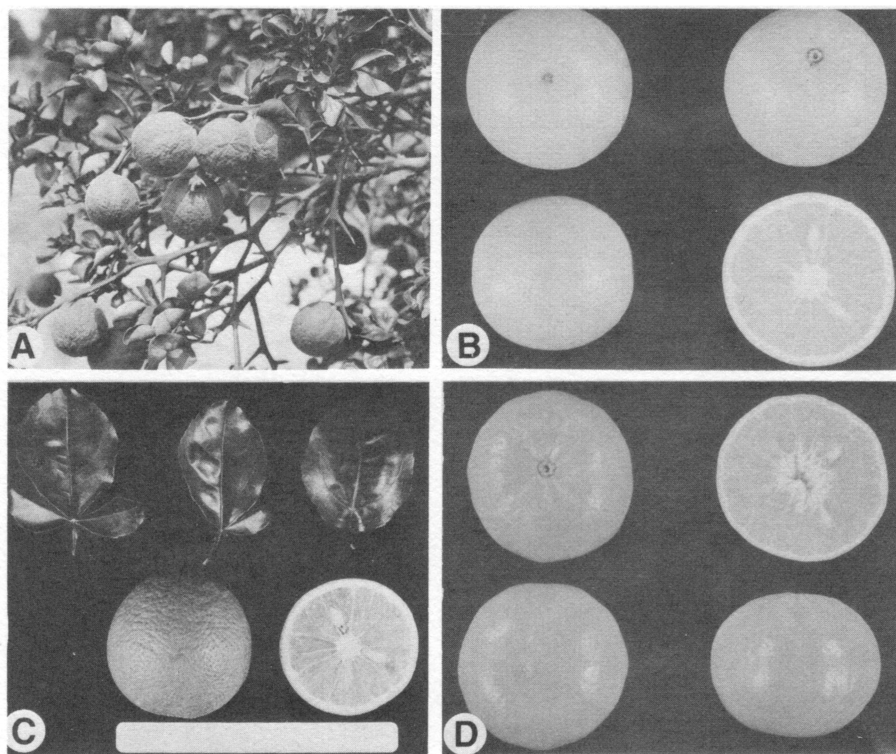


Fig 1. A. *Poncirus trifoliata*. B. *Citrus sinensis* cv. Valencia orange. C. (*C. paradisi* x *P. trifoliata*) x *C. sinensis* hybrid. D. Sunburst mandarin hybrid.

matic zones and has survived temperatures of -14°C . The tree has a deep winter and late spring dormancy, excellent cold hardiness, and has been hybridized with *Citrus*, *Microcitrus*, *Fortunella*, and *Poncirus*. *Eremocitrus* x *Citrus* hybrids (cover photograph) exposed to -10.0 and -7.2° in 1981 and 1982 in Florida had no visible tree damage, while nearby commercial citrus orchards had complete leaf and extensive wood damage.

Although these trees are cold hardy, the fruit are not cold hardy nor are they of commercial quality. Backcrosses with *Citrus* are being made to improve fruit characteristics. These hybrids have not been evaluated as rootstocks at the present time.

P. trifoliata is a native of northeastern Asia, is a deciduous tree, and has pronounced winter dormancy and cold hardiness. It has survived temperatures below -18°C . Hybrids of *P. trifoliata* and *Citrus* are more cold hardy than their *Citrus* parent but their fruit are inedible. Several *Citrus* x *P. trifoliata* hybrids are being used commercially as rootstocks, but none induce cold hardiness to commercial citrus scions in Florida. Recent backcrosses of (*C. paradisi* x *P. trifoliata*) x *C. sinensis* (Fig. 1C) have produced several

hybrid plants which are cold hardy and produce nearly edible fruit. These fruit resemble commercial orange cultivars in size, color, soluble solids, acidity, texture, and flavor.

Interspecific citrus crosses, particularly with *C. reticulata* (a mandarin) as 1 parent, have yielded several moderately cold-hardy clones with excellent fruit characteristics. Several, including 'Sunburst' mandarin hybrid (Fig. 1D), have been released recently for commercial propagation. However, the degree of cold hardiness attainable within the *Citrus* genus is limited. Conversely, intergeneric crosses between *E. glauca*, *P. trifoliata*, and *Citrus* sp. offer citrus breeders opportunities for selection of individual clones that possess new and unique recombinations of character traits derived from widely separated genera. They may provide the cold-hardy citrus clones being sought. In addition, this broader genetic base may also increase the protection against diseases and other climatic stresses.

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