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Problems and Opportunities in Passion Fruit Culture and Development

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Abstract

About 3500 metric tons (MT) of purple and yellow passion fruit (*Passiflora edulis* Sims and *P. edulis* f. *flavicarpa* Degener) and hybrids between these two forms are produced in the world annually. Growers of this crop are confronted by fungal disease that attacks the fruit, leaves, stem and roots. Also, expensive trellising must be erected to support the vines, and the fruit must be harvested at frequent intervals by picking it up from the ground where it falls when it ripens. Purple-fruited cultivars tend to fruit in spring and early summer, but do not flower well during hot weather, unlike the yellow passion fruit which thrives under lowland tropical conditions. Current breeding efforts are aimed at crossing inbred purple- and yellow-fruited lines to obtain F-1 hybrids with maroon fruit, that bear well all summer. One collection from the wild, P.I. 424814, was found to have genes for dwarfness and the ability to hold mature fruit on the vine a month or more after color break. Another accession, M-32025, had genes for extra locules (up to 5 versus the usual 3), making a dense, firmly-packed fruit. Combining all these traits can produce dwarf cultivars with disease-resistant, dense fruit that may be collected from the vines as needed rather than picked off the ground after it drops.

Purple and yellow passion fruit (*Passiflora edulis* Sims and *P. edulis* f. *flavicarpa* Degener) and hybrids between these two forms are grown in many countries, including Australia, Brazil and other South American countries, Central America, South and East Africa, several Caribbean countries and the United States (Florida and Hawaii). Exact world production figures are not readily available, but several years ago the estimate was put at 3500 MT annually (3). Demand for this fruit in processed and fresh form may be expected to grow if stable world supplies can be developed and maintained.

Disease resistance or tolerance, both to virus and to fungal pathogens, is vital to development of stable passion fruit production. Breeding for disease resistance is discussed elsewhere (9), so this topic will not be covered extensively here. *Passiflora edulis* in one of its forms or ecotypes has an enormous natural distribution in South America (6), and this natural store of germplasm has not been investigated adequately. This fact was emphasized by observations made some years ago on P.I. 424814, a wild purple passion fruit collected from a roadside in Santa Catarina state, Brazil. In a population of seedling plants from this accession, we found genes for resistance to fruit disease (anthracnose, *Colletotrichum gloeosporioides* Penz.), dwarfness, a tendency to re-bloom in autumn shown by no other purple passion fruit accession at Miami, and for retention of fruit on the vine for a month or more after maturity (as shown by color break). This one introduction opened up a number of avenues of investigation that may in time simplify the culture of this crop. Its existence also suggests that other valuable genotypes may remain to be discovered in Brazil, Uruguay and Argentina.

Dwarfness and Compact Growth

One problem in passion fruit culture to date has been the need to supply expensive trellising of one sort or another to support the vigorous vines. A gene for dwarfness appeared in one line derived from P.I. 424814 that was grown by USDA horticulturists at Isabela, Puerto Rico. The dwarf plant

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was approximately one meter tall, and bore a full crop of maroon-colored fruit. The implications of this trait are obvious: if the right characters can be combined with dwarfness, including fruit quality, disease resistance and high productivity, tomorrow's grower will be able to produce passion fruit more or less as stake tomatoes are grown, without making a heavy investment in trellising. This type of culture also will make crop rotation easier since the stakes for support are much more easily moved or replaced than are trellises.

Seedlings from a test cross to determine the mode of inheritance of dwarfness are still young, but this trait appears to be a simple Mendelian recessive that may be affected to some degree by accompanying modifier genes.

Retention of Ripe Fruit on the Vine

Passion fruit normally drop from the vine when they mature, and the usual mode of harvest is to collect them from the ground. The trait of delayed dropping will be of value in many areas where soil-borne disease is common. Pickers will be able to select mature fruit while it is still on the vine and relatively clean. In plants of P.I. 424814, ripe fruit continued to hang on the vine for a month or more after color break. If the delayed drop character is incorporated in commercial lines, this will make it possible to collect fruit less frequently than at present, and to expect considerably less fruit spoilage, with a reduced rate of cullage in the packing house. Delayed dropping appears to be inherited as a simple Mendelian dominant, appearing in numerous seedlings derived from P.I. 424814.

Intraspecific Ecological Adaptations and Season of Maturity

The South American range of *Passiflora edulis* includes much of Brazil and parts of Argentina and Uruguay, and as might be expected with such a distribution, the species shows a wide range of genetic variation (6). The purple-fruited form is best adapted to subtropical climates and to higher elevations within the tropics proper. It shows little resistance to soil-borne disease at sea level in warm climates and does not flower well during hot weather. The yellow passion fruit is well adapted to lowland tropical conditions, shows more resistance to soil-borne disease than does the purple, and flowers and sets fruit well through the summer.

Purple and yellow-fruited forms of *P. edulis* have no sterility barriers, producing vigorous intervarietal hybrids that are fully fertile and more or less intermediate between the parents for climatic adaptation and other attributes (7). 'Possum Purple,' which appeared as a chance seedling in a mixed planting of *P. edulis*, is a maroon-fruited vine that has shown itself to be an intervarietal hybrid inasmuch as its seedlings segregate for fruit color.

One problem undoubtedly related to genes from the the purple-fruited form in its background is the fact that 'Possum Purple' bears a heavy crop in late spring and early summer, then ceases flowering and bears no fruit in midsummer, and subsequently yields a light crop in autumn. A lengthened fruiting season is essential for the economic health of the passion fruit industry in Florida and similar subtropical areas. Yellow passion fruit vines as a rule crop well through summer and into the autumn here, but their fruit is not the preferred type for the fresh market in North America and Europe.

Currently we are crossing inbred yellow- and purple-fruited lines with the objective of obtaining F-1 hybrid combinations that will make it feasible to grow a high-quality commercial product from seed, thereby circumventing the problem of maintaining virus-free mother plants for vegetative propagation. Virus problems are not

serious in passion fruit at present in Florida, but they definitely are so in the nearby Caribbean (4). Part of the overall evaluation of F-1 seedling populations will be an investigation of how the trait of cropping through the summer season is inherited. A hybrid between purple and yellow forms of passion fruit that bears a large maroon-colored fruit of excellent quality has been developed in Hawaii, and promises to become important there in the near future (Zee, pers. comm.). Because this hybrid is self-incompatible, it is likely to be a shy bearer in Florida and other places where pollinating insects are in short supply.

Supernumerary Locules

One trait that appeared in a line of yellow passion fruit that came to Florida from South America but probably was brought to Colombia from Hawaii, is fruit with supernumerary locules. *Passiflora edulis* fruit normally has three locules, but many fruit on the vines in this group have four or five locules. The value of this trait, other than its novelty, is yet to be determined although it makes for a large, fully-packed fruit. The fact that 'Possum Purple' often tends to make a light fruit with low pulp content, however, suggests that the character for extra locules can be of value to growers if incorporated into commercial lines. It appears to be under genetic control since it is common in one line of yellow passion fruit (M-32025 inbred), but the mode of inheritance is yet to be determined.

Interspecific Hybridization, Disease and Cultural Expansion

Interspecific hybridization may offer hope of escaping some of the disease problems that currently plague growers of passion fruit. Although *Passiflora edulis* in all its genotypes appears subject to leaf and soil-borne diseases in south Florida, a few other species appear less affected. Both *P. laurifolia* L. and *P. alata* Dryand. show few leaf or root problems, and fruit of *P. laurifolia* also appears free of fungal infections. The quality of *P. laurifolia* fruit is not outstanding. However, fruit of the hybrid of *P. alata* x *P. laurifolia* is pleasant-flavored and of good quality, and may have commercial potential. All hybrids of this parentage observed to date are pollen-sterile diploids, but they set fruit when backcrossed to either parent. Treatment of the F-1 plant with colchicine to double the chromosome number may restore fertility. However, this may not end the problem of getting good fruit production in Florida, inasmuch as both parents are strongly self-incompatible and insects may not be inclined to work the pendent flowers of the hybrid plants, which resemble those of no species in the local flora. This problem may not appear in the Caribbean area and tropical America, however, where insect pollen vectors for the parental species are common.

Self-incompatibility appears to be the rule in *Passiflora edulis* and in most *Passiflora* species, with out-crossing being the normal breeding system. Carpenter bees (*Xylocarpa* spp.) of the subfamily Anthophoridae (family Apidae) are the natural pollinators of this group of plants (1, 2, 5). In extreme southern Florida these bees are uncommon, and the task of pollination is left to honeybees which, with relatively small bodies and a frequent preference for flowers of other plant genera are not efficient pollinators of *Passiflora* (9).

An earlier interspecific hybridization that was undertaken to extend the range of culture of edible passion fruit is beginning to show some progress. In 1980, I crossed *Passiflora edulis* with *P. incarnata* L., the maypop, with the objective of combining the maypop's ability to survive freezing temperate zone winters with the superior fruit quality of the purple and yellow passion fruit (8). Because the first in-

dividuals of this cross were pollen-sterile, I treated them with colchicine (0.2% aqueous solution) to restore fertility, and obtained several lines from intercrossing the colchiploid material.

In 1989, the first cooperative test planting of tetraploid hybrid seedlings was set at the Southeastern Fruit and Tree Nut Research Laboratory at Byron, GA. The seedlings have survived four winters there to date, freezing to the ground in late autumn and resuming growth from belowground in spring. In 1991, nine of the plants most outstanding for productivity and fruit quality, plus one efficient pollenizer, were selected and propagated asexually. These were set in a replicated test planting at Byron in the spring of 1992. After a couple of seasons' evaluation in the field it should be possible to ascertain what potential this group of plants has as a new fruit crop for the temperate zone. Another potential use for this hybrid in warm-climate regions was discovered by a cooperator in Israel. There, the extreme vigor of these alloploid vines enables them to cope successfully with nematodes that severely weaken vines of other *Passiflora* species, and their use as rootstocks for selected cultivars of *P. edulis* has been suggested. They have also survived severe cold that killed *P. edulis* vines growing near them (Gazit, pers. comm.).

From the information presented here it seems evident that the *Passiflora* germplasm assembled to date offers breeders a number of presently unexploited approaches that can help alleviate numerous problems that presently confront passion fruit producers. Furthermore, the number of useful characters found as a result of relatively limited plant exploration suggests the desirability of a well-planned, coordinated effort to find new sources of disease resistance and enhanced environmental adaptation for this crop among plant populations growing within the natural range of distribution.

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Isoenzyme Analysis of Red Raspberry

Red raspberry genotypes were separable using enzymes malate dehydrogenase, phosphoglucoisomerase, phospho-glucomutase, and triose phosphate isomerase. In addition, staining for isocitrate dehydrogenase and shikimate dehydrogenase revealed polymorphisms in some cultivars. By combining these results with those of 78 previously tested cultivars 75 of the 104 (72%) genotypes were uniquely characterized.

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