THE POTENTIAL FOR FLORIDA OF HYBRIDS BETWEEN THE PURPLE AND YELLOW PASSIONFRUIT

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Abstract. Both the purple passionfruit (Passiflora edulis Sims) and the yellow passionfruit (P. edulis f. flavicarpa Deg.) have desirable qualities. The purple form has high fruit quality, which includes a particularly pleasing aroma, and is self-fertile, but under Florida conditions it sets only one crop per year, in spring. Also, the purple form is less resistant than the yellow to soil-borne fungus diseases, and plants on their own roots do not persist for long in South Florida’s soils. The yellow passionfruit grows vigorously in Florida soils and produces throughout the growing season when properly cross-pollinated, but most plants of this form are self-incompatible and dependent on insect cross-pollination. The hybrid between the forms described here, Selection M-21471A, shows a blending of characters from each parent: fruit color and aroma of the purple form are genetically dominant to a degree, as are the self-incompatibility and resistance to soil-borne disease shown by the yellow form.

Introduction and Review of Literature

The purple passionfruit (Passiflora edulis Sims, referred to in this paper as “the purple form”) was first processed commercially some 40 years ago in Australia, one of the few countries where this fruit is regarded as “an everyday commodity.” The main producing countries, after Australia (including the Territory of Papua and New Guinea), are South Africa and some East African countries. The yellow passionfruit (P. edulis f. flavicarpa Deg., referred to here as “the yellow form”) entered commercial cultivation more recently and is grown principally in Hawaii and Fiji. Other countries now undertaking to grow this form are Brazil (where it is native), Indonesia, Malaysia, the Philippines, and Taiwan, among others. (9)

Before Degener segregated his forma flavicarpa from Passiflora edulis Sims, Killip (1) noted that because of variation in fruit and floral and other characters within this species, “several species and varieties have been described.” He observed two well-marked forms himself, but remarked that “For the present I prefer not to assign formal names to these variants.” Killip considered the species to have an extensive distribution: “Throughout Brazil, where apparently native, entering Paraguay and northern Argentina.” In addition he cited other Central and South American countries from which the species was known (1).

The purple-fruited form of Passiflora edulis has been cultivated off and on in Florida for at least 85 years (7), but no passionfruit has ever established itself here as a commercial crop. Over a period of years, seven different introductions of the purple passionfruit failed to survive in the field at the U.S. Plant Introduction Station, near Miami (3). In 1958, Fusarium was isolated from a sick vine of one of these introductions (10), but this fungus may have been a secondary invader, judging from information subsequently obtained. A disorder with two concurrent manifestations, “duck-foot” (swollen crown and roots at the soil line) and sunburn of the stem, accompanies infection by Phytophthora parasitica Dastur in South Africa. The vines in field plantings decline and eventually die (8). (This fungus is a primary cause of foot rot in Florida citrus plantings.) A species of Phytophthora was isolated from declining vines of the purple form of P. edulis in Dade County, Florida, last year (4). Vines of the same taxon, growing in the field in Hawaii, have succumbed to a crown rot and wilt of undetermined cause (5). In Queensland, the “purple passion vine is usually propagated on a wilt resistant stock such as the golden passion fruit (P. edulis forma flavicarpa).” (6) Thus it is evident that the purple-fruited form of P. edulis has a marked sensitivity to soil-borne fungus diseases, which preclude its cultivation in much of the world.

The yellow passionfruit shows no obvious sensitivity to soil fungi. It has persisted in the field at the Miami station for nearly 15 years. This parallels the response of the same form of passionvine to field conditions in Queensland and Hawaii (6, 5). The idea of combining the desirable fruit quality of the purple passionfruit with the ruggedness of the yellow passionfruit, through cross-breeding, had already occurred to people in Australia (6), Hawaii (5), and Israel, and early in 1969 we undertook to try it, too. We were particularly encouraged by results obtained in Hawaii by Nakasone, Hirano and Ito, who found their
Materials and Methods

All crossing between the two forms has used the purple form as the seed parent, because all plants of the yellow form tested to date are incompatible with the pollen of the purple form. Flowers of the (purple) seed parent must be emasculated shortly before anthesis to prevent self-pollination, which otherwise is extremely likely to contaminate any cross-pollination. For the seed parent we employed M-19053, a vigorous plant of the 'Norfolk Island' strain of Passiflora edulis. The chief obstacle to crossing the two forms results from the too-brief overlap in flowering seasons. Under South Florida conditions, the purple passionfruit has normally set most of its crop and is beginning to taper off in flowering by the time the yellow passionfruit begins to bloom (Table 1). Thus we were limited in our choice of pollen parents to the earliest-flowering yellow passionfruit vines (e.g. Clone 1-1 of P.I. 243804, from Trinidad) instead of those with the largest or juiciest fruit, such as some vines of a lot introduced from Hawaii (M-18913).

A limited number of F1 seedlings reached fruiting size under ordinary cultural methods, and we observed this population during the 1971 and 1972 seasons. We also propagated the most vigorous seedling, M-21471A, and distributed a few plants, to test for growth and fruiting, to cooperators in Florida and Costa Rica.

Results and Discussion

Information collected on the most outstanding F1 hybrid is compared with characters of both parents in Table 1. Because of its recent origin, the hybrid plant has been evaluated only for the last two years, but the yellow-fruited parent was first observed ten, and the purple-fruited parent eight years ago. In spite of these differences in length of time observed, we believe that M-21471A has characteristics that justify this report. Fruit color is intermediate between those of the two parents, as was reported for other purple-yellow hybrids (5), and is quite attractive. M-21471A well fits the description of the best of a group of hybrids of similar origin in North Queensland that "have large oval fruits with a claret-coloured skin and a pulp which is intermediate in flavour and aroma to that of the two parents." (6)

Weight of the fruit averages a little more than that of the pollen parent (1.4 grams difference), although dimensions of the hybrid are slightly less (6 mm shorter and 7 mm less diameter) than those of the pollen parent. This suggests that the hybrid's fruit is denser than that of the pollen parent, but additional work is needed to confirm that possibility. The hybrid approaches the pollen parent instead of the seed parent in number of seeds per fruit, and this enhances its horticultural value, because the amount of juice is directly related to the number of seeds within a fruit (2).

Character of the juice is the quality most subject to nonobjective evaluation. At this writing, it has not received a thorough laboratory analysis. The juice has been well received, and people who have tasted both prefer that of the hybrid to that of the yellow-fruited parent. Lacking a sophisticated analysis of it, we nonetheless can say that the juice blends characteristics from both parents and has a rich, pleasant aroma and a subacid taste (Table 1). Its relatively mild flavor makes the hybrid's fruit acceptable for fresh consumption, as is, or in salads or desserts, and the delicate aroma (superior to that of juice of the yellow form) can better be preserved through quick-freezing, the method now used on the bulk of the purple crop, than by heat processing (to 190° F.), which lowers the quality of the product (9).

The vigor of M-21471A is outstanding: one could say "typical of an F1 hybrid," except that unusual vigor is not typical of all the vines in this particular progeny. Cuttings of M-21471A strike readily and grow rapidly, so cuttage is a practical means of propagating the cultivar. About a year ago (29 October 1971), a local cooperator took two young vines of the selection to replace plants of the purple form that he had lost from the crown rot and wilt associated with Phytophthora infection. He placed each young vine in a position vacant through the death of one of his purple-fruited vines. The newly-set plants grew with vigor and have shown no sign of disease since then. Two surviving vines of the purple form, growing alongside the hybrid vines, now show advancing crown rot, and their decline appears imminent. Thus M-21471A promises to resist the soil plagues that have kept the purple passionfruit from establishing itself in southern Florida for all these years. The behavior of this selection in this respect coincides with that of the purple-yellow hybrids observed in Hawaii by Nakasone, Hirano, and Ito (5). Photographs of the declining plants taken in Hawaii closely resemble those of Phytophthora-
Table 1. Distinguishing Characters of Two Parental Forms and a selected F₁ Hybrid Passionfruit

<table>
<thead>
<tr>
<th>Entities:</th>
<th>Seed Parent, M-19053 Passiflora edulis Sims</th>
<th>F₁ Hybrid, M-21471A</th>
<th>Pollen Parent, Clone 1-1, P.I. 243804 P.edulis f. flavidarpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>color</td>
<td>Dark purple to black</td>
<td>Dark red to brownish-purple</td>
<td>Light yellow</td>
</tr>
<tr>
<td>weight</td>
<td>1 1/3 oz. [36.7 g]</td>
<td>3.0 oz. [85.9 g]</td>
<td>2.98 oz. [84.5 g]</td>
</tr>
<tr>
<td>length</td>
<td>1 7/8 in. [4.9 cm]</td>
<td>2 5/8 in. [6.6 cm]</td>
<td>2 7/8 in. [7.2 cm]</td>
</tr>
<tr>
<td>diameter</td>
<td>1 5/8 in. [4.2 cm]</td>
<td>2 1/8 in. [5.4 cm]</td>
<td>2 3/8 in. [6.1 cm]</td>
</tr>
<tr>
<td>Approx. number of seeds</td>
<td>125</td>
<td>215</td>
<td>230</td>
</tr>
<tr>
<td>Juice:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>character</td>
<td>Deep orange color, very pleasantly aromatic, sweetly subacid</td>
<td>Deep orange color, pleasantly aromatic and sweet, with much of Seed Parent's character</td>
<td>Deep orange color, pleasantly aromatic, but less so than the purple form, very acid</td>
</tr>
<tr>
<td>uses</td>
<td>Eaten fresh or mixed in ades and confections; may be quick-frozen</td>
<td>Same as purple parent</td>
<td>Usually diluted, sweetened and drunk as an ade or added to other juices or to confections; often processed</td>
</tr>
<tr>
<td>Vine:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>growth</td>
<td>Subject to Crown Rot and Decline</td>
<td>Extremely vigorous, not susceptible to soil-borne disease</td>
<td>Vigorous, persists for 10 years or more in the field</td>
</tr>
<tr>
<td>flowering season</td>
<td>15 Mar. -- 1 May</td>
<td>1 Apr. -- 1 Nov.</td>
<td>15 Apr. -- 15 Nov.</td>
</tr>
<tr>
<td>time of anthesis</td>
<td>0730 hrs</td>
<td>1030 hrs</td>
<td>1330 hrs</td>
</tr>
<tr>
<td>self-compatible</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>fruiting season</td>
<td>25 May -- 7 July</td>
<td>1 Jun. -- 1 Jan.</td>
<td>1 July -- 1 Feb.</td>
</tr>
</tbody>
</table>

NOTE: All data refer to field performance in southeastern Florida.
infected plants in Dade County, suggesting that the Hawaiian plants were affected by the same problem as ours. Nakasone and his co-workers found their hybrid's resistance due to a single dominant gene, present in *Passiflora edulis* f. *flavicarpa*, the recessive allele (for susceptibility) of which is carried by the purple-fruit edulis. The *flavicarpa* germplasm obviously confers the same kind of resistance on the Florida hybrid material.

Because of its hybrid origin, one obviously cannot expect to propagate M-21471A from seed and maintain its desirable traits. Cuttings (as already mentioned) afford an easy means of propagation, but if used, the plants grown as sources of cutting wood should be protected by screening or some other effective means of isolation against possible infection with virus diseases, which affect *Passiflora* seriously in other countries and greatly hamper any further development of Florida's papaya industry. The purple-yellow cross can be re-synthesized periodically, as plants are needed, but the lack of uniformity in seedlings observed to date makes direct seedage without clonal selection a questionable procedure until more genetically uniform parent plants can be produced.

Flowering seasons, as compared in Table 1, indicate the time of year during which vines of a given group may be expected to flower, but this does not imply that a given vine will flower every day throughout the designated season. As a rule these passionvines have a flush of flower-bearing growth that results, if pollination is adequate, in fruit set; the fruit then develops and ripens during the succeeding 70 to 90 days, after which, in the yellow passionfruit and the hybrid, one may expect subsequent similar flushes on through the growing season. Normally a heavy crop of flowers appears late in winter or early in spring and is followed by considerable vegetative growth through June and early July. Individual vines within each group vary in the timing of onset and termination of flowering. After the midseason vegetative flush, heavy blooming begins again and continues through late summer and fall. In Florida the purple passionfruit, unlike the other two entities, flowers heavily only once, from late winter through early spring. The fruit then ripens in late spring and early summer. No flowering normally follows the exuberant vegetative growth of summer, although the vines may produce a few flower buds that abort before anthesis. (High summer temperatures may trigger this behavior, whose cause we have not determined.) Knowledge not available three years ago suggests that, in further hybridization work, one could induce earlier flowering in the preferred *flavicarpa* pollen parents by exposing them to supplemental lighting for six weeks before the time when flowers are needed. We have found this procedure effective with *Passiflora incarnata* L. and its hybrids.

Time of anthesis in the hybrid population is intermediate between that of the two parents (Table 1). Flowers of the hybrid plants open in mid-morning, halfway between the early-morning opening of the purple parent and the early-afternoon opening of the yellow parent. Flowers of both forms and their hybrids stay open for the rest of the day, following anthesis, and can be pollinated successfully as late as sunset, although the purple form ordinarily self-pollinates long before that time.

Unfortunately the hybrid plants in the M-21471 population resemble the pollen parent, P.I. 243804 (Clone 1-1) in being self-incompatible, and thus dependent on compatible cross-pollination to ensure fruit set. They cannot be back-crossed to the pollen parent, although they do cross with any plant with which this parent is compatible. Like the pollen parent, they will not accept pollen from the seed parent or other self-compatible clones of the purple form (*P. edulis* Sims). Thus a compatible cultivar must be interplanted with M-21471A and pollen vectors such as the carpenter bee supplied, unless one resorts to hand-pollination, as is done in some labor-rich parts of the world (9). We repeated the cross of purple-by-yellow forms in the spring of 1972, this time using a self-compatible pollen parent (M-17236) in the hope of obtaining horticulturally acceptable plants that are also self-compatible. Judging from previous interaction of M-17236 and M-21471A, we expect such hybrids to be compatible with M-21471A, but final results are yet to be obtained from this particular cross.

**Conclusion**

Such a wide natural distribution as that reported by Killip (1), covering such a variety of ecological niches, would be expected to encourage survival of different types in different areas. In summation, then, it is apparent that in P. I. 243804 and M 19053 we have two distinct ecotypes within the same species: one (yellow-fruited) adapted to lowland tropical conditions, having resistance to fungus diseases, and adapted to a long cropping season; the other (purple-fruited) adapted to higher altitudes and subtropical conditions, where
a scarcity of pollen carriers makes self-compatibility an advantage, and where soil-borne fungi present no problems. South Florida presents a mixed sort of environment, a lowland subtropical region where winters are more severe than within the Tropics and where pollen vectors may be absent. Therefore neither ecotype, as we received it, succeeded here. A combination of the right characters from each form can change this situation and make passionfruit dependably productive under our conditions. M-21471 represents the initial step toward this goal.

Interpretive Summary

One seedling plant of a cross between two passionfruits shows promise as a new fruit cultivar for southern and central Florida and other warm regions. Fruit weight (3 ounces) approximates that of the yellow-fruited pollen parent, and juice quality approaches that of the purple-fruited seed parent. The vine resists soil-borne disease. Fruit color is an attractive maroon. The new selection is self-incompatible, like the pollen parent, so must be cross-pollinated for satisfactory fruit production.

Literature Cited


RETARDATION OF TUNG BLOOM AS INFLUENCED BY TIME AND METHOD OF SPRAY-OIL APPLICATION

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Abstract. Repeated applications of high-volume spray oil to tung trees in January, February, and March induced greater blossom delay than single applications. However, injury from the high concentration of cumulative oil sprays reduced fruit set in 1969. A 3-year study indicated that best freeze protection occurred when spray oil with succinic acid 2,2-dimethylhydrazide (SADH) was applied to dormant tung trees about 2 or more weeks before freezes that occurred in February and March. By contrast, simulated fall applications of spray oil induced early growth of trees in the greenhouse. Placement of oil on dormant terminal buds caused more bud retardation and injury than on other plant parts. Extent of blossom delay and oil injury depends on amount of oil coverage. Oil-treated buds had only slightly greater bud retardation and flowering under lower temperature regimes than under high-temperature exposure. Spray oils of lighter molecular weight were less injurious to terminal-bud development but induced less bud retardation than the heavier oils.

Tung (Aleurites fordii, Hemsl.) crops in southeastern United States were substantially reduced during the past three decades by untimely freezes. Freeze damage is perhaps the most serious obstacle to producing a high yield of tung nuts annually. During 1971, flower buds in many orchards in northern Florida were destroyed by freezes. After the destruction by Hurricane Camille in 1969,