Controlled Pollination to Assess Intraspecific Compatibility Among *Passiflora incarnata* Genotypes from Different Provenances

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Abstract. *Passiflora incarnata* L., commonly known as maypop, is a wild passion fruit native to many areas of the eastern and southern United States where the climate ranges from subtropical to temperate. Although *P. incarnata* has had little attention paid to it for breeding purposes, it could be used in breeding for fruit production and possibly contribute cold hardiness genes in combination with other *Passiflora* species. The study was performed in 2018, 2019, and 2021 at the Mississippi State University South Mississippi Branch Experiment Station in Poplarville, MS, United States. *Passiflora* propagules were collected from various locations: Florida (FL), Illinois (IL), Mississippi (MS), Missouri (MO), and Oklahoma (OK). Of the 122 flowers across the five *P. incarnata* genotypes from differing locations, none of them produced a fruit or had any indication of successful or partially successful fertilization when selfed, indicating strong self-incompatibility. If self-compatibility does exist in nature, it is likely to be rare. However, certain combinations of *P. incarnata* from different locations produced successful fruiting, including IL × MO (52% success), FL × MO (85%), FL × OK (80%), MS × OK (40%), MO × IL (50%), MO × OK (40%), and OK × MO (80%). The differences across provenances show that incompatibility exists within *P. incarnata* but can depend on location. Overall, fruit weight, fruit size, and soluble solids content measured in this study were similar to and, in some cases, greater than those previously reported. These differences help to illustrate the diversity within *P. incarnata* and the still-untapped potential for breeding improvements. The problem of self-incompatibility is complex and there is much to learn about how *Passiflora* species, especially *P. incarnata*, function. Much of the U.S. domestic market is not familiar with passion fruit, especially as a table fresh product. This could be a barrier to adoption, but it could also prove to be an opportunity to create a niche within the present market and expand it. Although maypop fruit quality is not equal to that of *Passiflora edulis* Sims, selecting superior wild genotypes with desirable attributes to be used in future intra- and interspecific breeding is possible based on the results of this study.

*Passiflora* is a large genus that comprises numerous species. It is primarily a tropical crop, grown in regions with mild winter temperatures; however, there are temperate and subtropical *Passiflora* species, most of which are exclusively known for their unique flowers. One prominent exception is *Passiflora incarnata*, commonly known as maypop, a wild passion fruit native to many areas of the eastern and southern United States (Killip, 1938). Historical documentation of *Passiflora* species in North America is limited (Hernsen, 2021); however, archaeological evidence has placed *P. incarnata* as a prominent food crop for Native American populations since the Late Archaic period (Gremillion, 1989; Hoch, 1934), thus identifying it as an important dietary supplement for indigenous peoples. These groups may have attempted to domesticate it as a stable food crop as well (Asch and Hart, 2004; Gremillion, 1989). Although not broadly grown as a fruit crop, European settlers also consumed maypops. Present day consumption of maypop is limited to local foragers and hobbyists who prize the fruit for its unique flavor. Yet, with the current increase in the Hispanic population throughout the United States, there is a base of people who are familiar with the flavors that passion fruit can offer because many *Passiflora* species are native to Latin America (Jorgensen et al., 1984). This segment of the U.S. population could provide a built-in market for new and improved passion fruit cultivars.

In addition to its potential nutritive properties, *P. incarnata* has been used extensively for medicinal purposes. In many areas of the world, it is used as a sedative and anxiolytic (Dhawan et al., 2001) along with other uses (Dhawan et al., 2004). Although broadly used for herbal medicine, toxicity to extracts of *P. incarnata* has been noted (Fisher et al., 2000). Thus, the ramifications of consuming maypop as a food product merit further study.

Although the vine produces exquisite flowers and an edible fruit, it is primarily considered a weed that can interfere with production of crops such as peanuts (*Arachis hypogaea* L.) (Wehtje et al., 1985). The vine has a perennial root system and is often found in disturbed sites because it resprouts readily from cut root pieces (Tague and Foré, 2005; Wehtje et al., 1985). The aboveground portion of the vine dies back to the soil line in autumn because of various elements, such as exposure to cold temperatures, reduction in daylength, and disease or insect pests, although all potential causes have not been fully explored. Flowers of this species are mostly hermaphroditic, hermaphroditic, and functionally andromonoecious (Dai and Galloway, 2011, 2012; Krosnick et al., 2017; Spears and May, 1988). These conditions contribute to self-incompatibility, thus requiring pollination from insects, primarily large-bodied bee species (Krosnick et al., 2017; McGuire, 1999).

Fruit-bearing *Passiflora* cultivars have been developed mainly from *Passiflora edulis f. edulis* and *P. edulis f. flavicarpa*; however, very little crop production is done in more temperate climate zones because of the lack of cold hardiness in these species (Knight, 1971). Few places within the United States have the tropical or subtropical climate that can sustain fruit production of commercial-level passion fruit. Studies suggested that ethylene and ethylene could be used to accelerate ripening in passion fruit and improve postharvest quality, thus allowing the plant to be grown as an aboveground annual in the southern United States (Arjona and Matta, 1991; Dozier et al., 1991).

Alternately, species native to temperate climates such as *P. incarnata* could be used in breeding for fruit production and possibly contribute cold hardiness genes in combination with other *Passiflora* species (Winters and Knight, 1975). *Passiflora incarnata* has had little attention paid to it for breeding purposes (McGuire, 1999) aside from work done over many years by Knight in Florida that eventually led to ornamental cultivar releases, but none for fruit production. Most genotypes of *P. incarnata* used in breeding were selected from the wild without much consideration for valuable characteristics. Because of its wide adaptation to climates and soil conditions, *P. incarnata*...
certainly contains the necessary genetic variation for breeding work (Knight, 1994; McGuire, 1999). Objectives for a breeding program to introduce commercial quality fruit from *P. incarnata* should include rind color, pulp flavor and color, seed size, and postharvest quality just to name a few. Vine characteristics such as disease and insect resistance, moderate of rampant growth, increased flower production and timing, and shortening of flower to harvest times are also key considerations. To establish a breeding program targeted at genetic improvement, wild, native accessions should be collected and evaluated. Private breeding companies and public individuals (King, 2000) have been commercially successful as fruit companies and public individuals (King, 2000) have yielded interesting genotypes, but none have been considered commercially successful as fruit crops (Knight, 1971, 1994). Ornamental hybrids containing *P. incarnata* have been more notable (Knight et al., 1995). One problem with interspecific crosses between *P. incarnata* and *P. edulis* is that the F1 hybrids are often pollen sterile (Knight, 1991). Increasing ploidy level is one method to improve genetic compatibility. Colchicine has been used to increase the ploidy level of interspecific crosses involving *P. incarnata* to recover fertility (Bruner, 1988; Knight, 1991). The elevation of ploidy level has not always been completely successful though, as the F1 hybrids are sometimes pollen sterile and self-incompatible (Knight, 1991, 1992). Naturally occurring tetraploid plants of *P. incarnata* have been reported (Lloyd, 1963), but are not common. *P. incarnata* is also andromonoecious, which further complicates fertility issues (May and Spears, 1988; Spears and May, 1988). Hand pollination can increase fruit size and quality (Arjona et al., 1991; Knight, 1991), but the associated cost and labor involved is problematic. Natural self-compatible individuals of *P. edulis* exist (McGuire, 1999) and this may be the case for *P. incarnata* as well, although no confirmed cases have been documented (Knight, 1991). The increase to tetraploid levels may have promise for use in breeding to develop a temperate zone passion fruit (Knight, 1991), but using diverse germplasm may uncover improved fertility that could circumvent the need for chromosome doubling.

The objective of this research was to use *P. incarnata* genotypes from different provenances to assess viability of controlled self-pollinations and cross-pollinations within this *Passiflora* species.

**Materials and Methods**

The study was performed in 2018, 2019, and 2021 at the Mississippi State University South Mississippi Branch Experiment Station in Poplarville, MS. *Passiflora* propagules were collected from various locations: Florida (FL), Illinois (IL), Mississippi (MS), Missouri (MO), and Oklahoma (OK) (Table 1). *P. incarnata* were obtained from wild plants, either via seed or root cutting. Thus, there was expected variability within location and among plants. Some vines were also of different ages and sizes. Therefore, the floriferousness of the vines was different, leading to only a few flowers on some vines. The number of potted vines also varied between three (MS) and eight (IL).

Collected seeds were submerged in hot water and allowed to sit for 24 h before sowing under intermittent mist in a greenhouse. None of the seeds had any stratification or other scarification. Root cuttings were immediately put into pots with a potting mix and slow-release fertilizer under intermittent mist. On emergence, all vines remained in the greenhouse (2018) and/or fully enclosed screened high tunnel (2018, 2019, 2021), but were removed from intermittent mist once vining habit and tendril growth started. At that stage they were then re-potted into 11.4-L pots (3-gal) pots and hand watered as needed.

Controlled hand pollinations were done once a flower had opened (Fig. 1), generally between 1 pm and 3 pm. Flowers of *P. incarnata* are viable for pollination just a few hours on the day that it opens. Crosses started 9 May 2018 and continued through 26 June 2018, 7 July 2019 to 8 Aug. 2019, and 1 June 2021 to 28 July 2021. An anther was removed with tweezers and pollen was placed by gently rubbing the anther against the stigma. All other anthers were removed from the flower. The greenhouse and screenhouse had no other potential pollinators inside, so covering of the flower was not necessary. Evidence of positive fertilization was observed usually within 48 h, but final determination of success was not made until fruit fully developed, approximately 40 to 50 d after pollinations were made. An effort was made to perform at least 20 crosses of each combination.

Flower measurements were done in 2021 after flowers had opened (Fig. 2). All flower and fruit size measurements were made with a Mitutoyo Absolute Digimatic (Mitutoyo Corp., Kawasaki, Japan) and soluble solids content was measured on a digital hand-held refractometer (3810 PAL-1; Atago, Osaka, Japan). Fruit density was determined by the formula: $F_d = W/(H \times D)$, where $W =$ fruit weight (g), $H =$ fruit height (mm), and $D =$ fruit width (mm). Fruit shape was calculated as H/D as described in Md Nor et al. (2019). Fruits were collected after natural abscission from the vine.

Data of flower and fruit measurements were analyzed by JMP (version 12; SAS Institute, Cary, NC) using a one-way analysis of variance, and means were compared with standard error of the mean or Tukey's significant differences. A level of $P < 0.05$ was used to determine significance.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Origin</th>
<th>Propagule</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td>Lake Alfred, FL</td>
<td>Root</td>
</tr>
<tr>
<td>IL</td>
<td>Villa Park, IL</td>
<td>Root</td>
</tr>
<tr>
<td>MS</td>
<td>Richton, MS</td>
<td>Root</td>
</tr>
<tr>
<td>MO</td>
<td>Goodman, MO</td>
<td>Seed</td>
</tr>
<tr>
<td>OK</td>
<td>Guthrie, OK</td>
<td>Seed</td>
</tr>
</tbody>
</table>

FL = Florida, IL = Illinois, MS = Mississippi, MO = Missouri, OK = Oklahoma.

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Table 1. *Passiflora incarnata* vine origination, and propagule type used in breeding hybridization.

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**Fig. 1. Examples of flower variability among *Passiflora incarnata* genotypes. Row 1 from left to right: Illinois, Mississippi, and Florida. Row 2 from left to right: Oklahoma, Missouri.**
honestly significant difference at the 0.05 level where appropriate.

**Results and Discussion**

*Passiflora incarnata* has previously been reported as a self-incompatible species (Krosnick et al., 2017; May and Spears, 1988). Attempts to hand self-pollinate flowers in this study validated those previous reports. Of the 122 flowers across the five *P. incarnata* genotypes from differing locations, none of them produced a fruit or had any indication of successful or partially successful fertilization when selfed (Table 2). If self-compatibility does exist in nature, it is likely to be rare. However, certain combinations of *P. incarnata* from different locations displayed combinations that produced successful fruiting, including IL × MO (52% success), FL × MO (80%), MS × OK (40%), MO × IL (50%), MO × OK (40%), and OK × MO (80%). Interestingly, IL failed to produce a single fruit with MS and FL (Table 2). MO was moderately successful as the receiver of pollen overall, with 48% success. That is 23% greater than the overall average. This could be an indicator of more compatible pollen across combinations.
Table 5. Fruit characteristics of intraspecific Passiflora incarnata crosses performed in 2021 among five provenances.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Fruit collected (no.)</th>
<th>Fruit wt (g) ± SE</th>
<th>Fruit ht (mm) ± SE</th>
<th>Fruit width (mm) ± SE</th>
<th>Brix (°) ± SE</th>
<th>Days from pollination to harvest ± SE</th>
<th>Fruit shape (mm/mm) ± SE</th>
<th>Fruit density (g/cm³) ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL × IL</td>
<td>7</td>
<td>39.0 ± 10.0</td>
<td>52.2 ± 4.2</td>
<td>43.7 ± 3.9</td>
<td>18.9 ± 1.0</td>
<td>46.4 ± 2.4</td>
<td>1.21 ± 0.06</td>
<td>1.51 ± 0.15</td>
</tr>
<tr>
<td>FL × MO</td>
<td>14</td>
<td>37.0 ± 4.6</td>
<td>52.5 ± 1.7</td>
<td>43.2 ± 2.3</td>
<td>19.4 ± 0.5</td>
<td>50.2 ± 1.4</td>
<td>1.24 ± 0.04</td>
<td>1.53 ± 0.07</td>
</tr>
<tr>
<td>FL × MS</td>
<td>5</td>
<td>32.6 ± 9.9</td>
<td>51.4 ± 4.7</td>
<td>41.8 ± 5.1</td>
<td>18.6 ± 0.6</td>
<td>46.4 ± 1.5</td>
<td>1.26 ± 0.09</td>
<td>1.37 ± 0.12</td>
</tr>
<tr>
<td>FL × OK</td>
<td>15</td>
<td>57.8 ± 4.7</td>
<td>59.2 ± 1.3</td>
<td>51.6 ± 1.9</td>
<td>18.8 ± 0.2</td>
<td>45.9 ± 0.8</td>
<td>1.16 ± 0.03</td>
<td>1.84 ± 0.07</td>
</tr>
<tr>
<td>IL × OK</td>
<td>3</td>
<td>42.0 ± 2.8</td>
<td>59.7 ± 1.2</td>
<td>55.3 ± 0.7</td>
<td>13.6 ± 0.3</td>
<td>47.0 ± 0.0</td>
<td>1.08 ± 0.02</td>
<td>1.27 ± 0.09</td>
</tr>
<tr>
<td>MO × OK</td>
<td>11</td>
<td>31.5 ± 1.6</td>
<td>51.9 ± 1.7</td>
<td>40.0 ± 0.7</td>
<td>18.5 ± 0.3</td>
<td>51.0 ± 1.0</td>
<td>1.31 ± 0.03</td>
<td>1.53 ± 0.05</td>
</tr>
<tr>
<td>MO × IL</td>
<td>9</td>
<td>32.0 ± 1.7</td>
<td>52.4 ± 1.1</td>
<td>41.0 ± 0.8</td>
<td>17.4 ± 0.7</td>
<td>48.8 ± 1.8</td>
<td>1.28 ± 0.02</td>
<td>1.48 ± 0.04</td>
</tr>
<tr>
<td>MO × FL</td>
<td>4</td>
<td>22.9 ± 5.3</td>
<td>50.7 ± 6.8</td>
<td>35.2 ± 3.2</td>
<td>9.0 ± 3.3</td>
<td>35.5 ± 4.5</td>
<td>1.44 ± 0.06</td>
<td>1.27 ± 0.01</td>
</tr>
<tr>
<td>MO × OK</td>
<td>6</td>
<td>29.2 ± 2.9</td>
<td>50.0 ± 1.4</td>
<td>37.2 ± 1.2</td>
<td>16.6 ± 0.9</td>
<td>48.5 ± 1.9</td>
<td>1.34 ± 0.03</td>
<td>1.55 ± 0.07</td>
</tr>
<tr>
<td>MS × FL</td>
<td>1</td>
<td>9.4</td>
<td>32.4</td>
<td>26.2</td>
<td>16.5</td>
<td>47.0</td>
<td>1.24</td>
<td>1.11</td>
</tr>
<tr>
<td>MS × MO</td>
<td>4</td>
<td>46.3 ± 4.8</td>
<td>53.4 ± 0.9</td>
<td>50.2 ± 0.8</td>
<td>14.7 ± 0.8</td>
<td>44.5 ± 5.0</td>
<td>1.07 ± 0.03</td>
<td>1.73 ± 0.18</td>
</tr>
<tr>
<td>MS × OK</td>
<td>7</td>
<td>48.6 ± 1.6</td>
<td>54.1 ± 0.8</td>
<td>50.4 ± 0.6</td>
<td>15.0 ± 0.7</td>
<td>40.1 ± 2.3</td>
<td>1.07 ± 0.01</td>
<td>1.79 ± 0.07</td>
</tr>
<tr>
<td>OK × FL</td>
<td>4</td>
<td>39.4 ± 13.4</td>
<td>52.2 ± 9.1</td>
<td>43.6 ± 9.5</td>
<td>16.0 ± 1.1</td>
<td>39.4 ± 1.1</td>
<td>1.27 ± 0.11</td>
<td>1.29 ± 0.31</td>
</tr>
<tr>
<td>OK × MO</td>
<td>2</td>
<td>46.1 ± 2.2</td>
<td>60.0 ± 2.7</td>
<td>52.0 ± 2.0</td>
<td>15.8 ± 1.0</td>
<td>46.5 ± 1.5</td>
<td>1.15 ± 0.10</td>
<td>1.49 ± 0.08</td>
</tr>
<tr>
<td>OK × IL</td>
<td>3</td>
<td>41.7 ± 5.0</td>
<td>61.4 ± 2.5</td>
<td>54.6 ± 2.7</td>
<td>18.0 ± 0.9</td>
<td>39.8 ± 3.8</td>
<td>1.29 ± 0.31</td>
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<td>1.21 ± 0.06</td>
<td>1.51 ± 0.15</td>
</tr>
</tbody>
</table>

a FL = Florida, IL = Illinois, MS = Mississippi, MO = Missouri, OK = Oklahoma.

b SE = standard error of the mean.

c FL × IL was significantly different from all other provenances (P ≤ 0.05) as determined by Tukey’s honestly significant difference.

days from pollination to harvest, desirable shapes. Fruit density was calculated as fruit weight divided by fruit height times fruit width. Often, maypop (and other passion fruit species) can look to be ripening normally and of appropriate size, but on further destructive examination are completely hollow or only possess a few seeded arils. Thus, fruit density gives a measure of fullness of the fruit. The higher the value, the more packed the fruit will be with aril filled seeds. McGuire (1998) used a 1 to 5 rating system, whereas Senter et al. (1993) assessed it on a basis of seed number. A single, nondestructive measure incorporating fruit size and weight would give researchers a metric on which to compare within a species or cross. Once enough data are collected, then acceptability parameters could be implemented for use in breeding or other activity. In this limited sample, the values of fruit density ranged from 1.11 to 1.84 (Tables 3–5). The greater the value, the more densely packed the fruit will be. MS had the best filled fruit, followed by FL. Crossing of these two may be advantageous to increase fruit density. There is no established threshold for fruit density, but based on this study, 1.5 may be a cutoff point where below that fruit is not densely packed enough with arils to be adequate for fruit production.

Consumers desire a consistent size and shape (Md Nor et al., 2019), which is necessary for the highest classification (Codex Alimentarius, 2014). All fruit in this study could be classified as oblong spheroid, as they were above 1.05 (Md Nor et al., 2019). When examining the male (pollen) parent within the crosses, the number of fruits collected were different (Table 4). FL pollen produced the fewest number of fruits, with OK and MO being the most. Fruits produced from OK pollen were the heaviest, the tallest, and the widest. Although as a female parent OK fruit was not impressive, using pollen from FL anthers onto flower stigmas from other locations produced the best-looking fruit. Fruit height, brix, days from pollination to harvest, etc., should be considered for successful pollination. This deserves more investigation as to why this occurs.

Table 6. Floral components of Passiflora incarnata from five provenances.

<table>
<thead>
<tr>
<th>Provenance</th>
<th>Sepal length (mm)</th>
<th>Sepal width (mm)</th>
<th>Petal length (mm)</th>
<th>Petal width (mm)</th>
<th>Corona filament length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FL</td>
<td>26.2 c</td>
<td>7.0 c</td>
<td>26.5 c</td>
<td>7.4 d</td>
<td>26.5 c</td>
</tr>
<tr>
<td>IL</td>
<td>32.0 a</td>
<td>10.3 a</td>
<td>29.9 ab</td>
<td>10.7 a</td>
<td>33.1 a</td>
</tr>
<tr>
<td>MS</td>
<td>27.5 bc</td>
<td>8.6 b</td>
<td>28.1 bc</td>
<td>7.9 cd</td>
<td>29.4 b</td>
</tr>
<tr>
<td>MO</td>
<td>29.0 b</td>
<td>8.8 b</td>
<td>29.0 b</td>
<td>8.6 bc</td>
<td>28.7 b</td>
</tr>
<tr>
<td>OK</td>
<td>32.5 a</td>
<td>9.2 ab</td>
<td>31.7 a</td>
<td>9.7 ab</td>
<td>32.5 a</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

a FL = Florida, IL = Illinois, MS = Mississippi, MO = Missouri, OK = Oklahoma.
b Means followed by the same letter are similar and not significantly different (P ≤ 0.05) as determined by Tukey’s honestly significant difference.
and fruit shape were not significantly different among the locations (Table 4).

Overall, fruit weight, fruit size, and soluble solids content measured in this study were similar to and, in some cases, greater than those previously reported (Arjona et al., 1991; McGuire, 1998; Senter et al., 1993). Hand pollinations were done by McGuire (1998), whereas Senter et al. (1993) collected insect-pollinated fruit in the wild and Arjona et al. (1991) did both. Arjona et al. (1991) reported greenhouse-grown fruits at 15.1 g and wild fruit at 38.5 g. The latter value is in line with what was observed in this study; however, the former is much lower. Maypop fruits collected by Senter et al. (1993) averaged 34.3 g and 36.7 g, both similar to what was found in the present study. Fruit weight was not reported by McGuire (1998), but fruit length (height) and fruit width were somewhat smaller, with few exceptions, than observed in Tables 3, 4, and 5. Sugar contents of fruit collected by Arjona et al. (1991) and Senter et al. (1993) were substantially less than the range in this study. However, important distinctions should be made. The cited studies were done 25 to 30 years ago under different climate conditions, in different locations, and with different maypop selections. All of these factors would likely impact the comparative results. Even so, the differences help to illustrate the diversity within *P. incarnata* and the untapped potential for breeding improvements.

All floral measurements were significantly different among locations (Table 6). IL and OK had the longest sepal length and IL had the widest sepal. OK had the longest petals and IL the widest. Both also had the longest corona filaments. These measurements indicate larger flower size. Visually, OK and IL flowers are substantially larger than flowers of FL vines. It is unknown if size equates to more insect visitation or other advantage in *P. incarnata* but larger flowers often produce more, yet less concentrated, nectar (Krosnick et al., 2017).

Further measurement of reproductive components within the flowers revealed significant differences among the locations (Table 7). MS had the shortest ovary, and IL and OK had the widest ovaries. The larger size of the ovary for IL and OK flowers is in line with the overall larger size of the other floral components, as described in Table 6. IL also had the widest stigma. FL and MS had the shortest styles. OK had the longest anthers and was similar to IL for anther width. Interestingly, despite its overall larger flower size, OK had the shortest filament, along with MS. Androgynophore length (height) was highest for IL and OK, with OK having the widest androgynophore. Androgynophore size plays a role in pollination, as taller size means that a larger insect is required to ensure adequate transfer of pollen. It may be a breeding benefit to select for shorter androgynophore length to potentially diversify the types of insects that can act as pollinators. All measurements were similar to those reported by Krosnick et al. (2017) on *P. incarnata* in Tennessee.

Self-incompatibility is separated into two divisions, heteromorphic, a physical difference that creates a barrier for pollination, and homomorphic, a condition often controlled by the multiallelic S-locus (Madureira et al., 2014). Homomorphic self-incompatibility is further divided into two groups: gametophytic and sporophytic (de Nettancourt, 1997). Previous work in *Passiflora* has shown self-incompatibility to be homomorphic sporophytic (Bruckner et al., 1995) and gametophytic (Suassuna et al., 2003). Although *P. incarnata* and *P. edulis var. flavicarpa* are both considered self-incompatible, there is precedent to show hybridization within a self-incompatible species has resulted in some fertile progeny (Bruckner et al., 1995; Rego et al., 1999; Suassuna et al., 2003). However, the problem is complex, and there is much more to learn about how these species, especially *P. incarnata*, function. In some instances, the ovary will grow to a normal size, not develop seeds, and the interior will be completely empty. This is a result of incompatible pollen (Amela Garcia and Hoc, 2011), which was not common in this study, but has been observed by the author in wild vines and in other controlled crosses.

There is still much to be learned about the potential of *P. incarnata* in breeding. Although cold hardness is one of the primary reasons to use it, other important traits could come to the fore, such as disease tolerance, fruit quality characteristics (i.e., thin rind, high sugar content, lower acidity), and easier vine management compared with *P. edulis* because of smaller vine sizes. Growers desire a self-fertile smaller vine to reduce the need for hand pollination and to improve overall pollination success. Presently, many passion fruit vines are grown from seed, thus not clonal, or self-propagated. Using multiple cultivars for pollination is common in other fruit crops, such as raspberry blueberry (*Vaccinium virgatum* Aiton), pecan (*Carya illinoinensis* Wangenh. K. Koch), and muscadine (*Vitis rotundifolia* Michx.), and could be done with passion fruit as long as sufficient pollinator species are present.

Much of the U.S. domestic market is not familiar with passion fruit, especially as a table fresh product. This could be a barrier to adoption, but it could also prove to be an opportunity to create a niche within the present market and expand it. Although maypop fruit quality is not equal to that of *P. edulis*, selecting superior wild genotypes with desirable attributes to be used in future intra- and interspecific breeding is possible based on the results of this study.

### Literature Cited


