

The *Camellia azalea* Breeding Program at Longwood Gardens

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After being discovered in China in 1986, the ever-blooming *Camellia azalea* Wei. created a new realm of breeding possibilities for camellias. The highly desirable ever-blooming trait of this species seeded the potential for year round color. Most *Camellias* grace us with color for one to two months of the year. They do not bloom for long periods of time since they grow in phases of vegetative or reproductive growth. *C. azalea* blooms every month of the year and is very different from other members of the genus in that it produces continual asynchronous flushes of vegetative and reproductive growth. If a plant is large enough, all stages of growth from small flower buds to full open flowers are present on the plant most of the year.

In 2000, this rare species was obtained by Longwood Gardens in Kennett Square, PA and is the oldest specimen of *C. azalea* in the United States (Harbage, 2003). Initially, breeding with *C. azalea* was not a high priority, but Longwood Gardens attempted some crosses to combine the ever-blooming trait with improved hardiness and plant vigor. *C. azalea* is native to zone 10 and also grows poorly outside of its native soil. Prior to 2008, Longwood Gardens' breeding program produced four hybrid crosses with *C. pitardii* as the maternal or seed parent and four hybrids with straight *C. japonica* as the paternal or pollen parent. Unfortunately, none of the *C. pitardii* × *C. azalea* hybrids survived. The *C. azalea* × *C. japonica* hybrids have grown well, currently range from two to four feet tall and bloom two to three times a year under greenhouse conditions (Figure 1 and



Figure 1 *c. azalea* x *c. japonica*

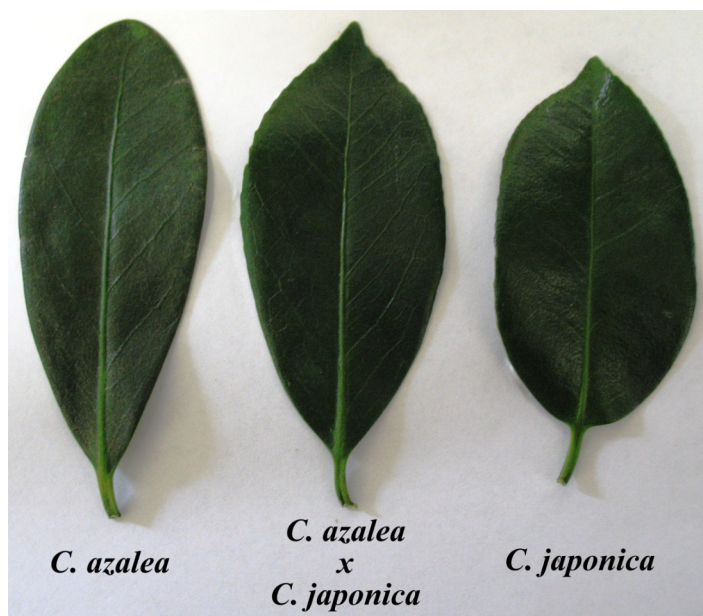


Figure 2 - Leaves of *C. azalea*, *C. azalea* × *C. japonica* and *C. japonica*

2). In the past few years, the *C. azalea* breeding program at Longwood Gardens has intensified and creating new hybrids is a higher priority. *C. azalea* flowers on Longwood's breeding stock are rarely seen open since most are emasculated upon bud coloration to prevent self-pollination. An occasional flower is left to open for the purpose of pollen collection. Since 2008, over 2200 crosses have been made with *C. azalea*. Many different species and cultivars have been used for breeding with *C.*

azalea at Longwood Gardens with a range of compatibility (Table 1).

Based on fruit production, *C. azalea* as a maternal or seed parent seems somewhat compatible with many other species and cultivars. Of the 18 paternal parents shown in Table 1, 12 led to the production of fruit. Although this seems promising, many of the seeds inside the fruit were completely empty and not viable. Of the seeds that did contain internal/embryonic material, 100% were considered non-viable and placed into an embryo rescue program.

With *C. azalea* as the paternal parent, five of the 14 maternal parents used also produced fruit. Yet, only the species *C. japonica* produced viable seed.

Once fruit matures, seed is collected and tested for viability via the "float test". This involves dropping the seed into a cup of water. If the seed sinks it is considered viable and sown into a pot. As of August 2010, a total of 411 seeds have been collected and 129 have been determined to be viable. All viable seed has *C. japonica* as the maternal parent and to date, 85 of these seeds have germinated (Figure 3). Viable seed is sown immediately after harvest into a commercial peat and perlite media and has taken an average of 105 days to germinate.

If the seed floats and is considered non-viable, the seed coat or testa is removed. With *C. azalea* as the maternal parent, the testa of the "nonviable" seed is often deformed or cracking

(Figure 4). Once the testa is removed, the seed is surface sterilized and transferred to sterile tissue culture for a process called embryo rescue. This process rescues weak or immature seed that would not survive natural conditions. In a sense, it is a neonatal intensive care unit for plant seeds.

Once in tissue culture several things can happen. The most undesirable outcome is that the culture gets contaminated by microorganisms. This can



Figure 3. *C. japonica* × *C. azalea* hybrid seedlings



Figure 4. Underdeveloped seed with cracking testa from cross with *C. azalea* as the maternal parent (Photo – Jason Lattier)

happen if the seed is not properly sterilized or if a single fungal spore gets into the culture tube before it is sealed in the transfer hood. The second most unwanted outcome is that the seed simply sits there. Since there are no microorganisms to breakdown and consume the non-viable tissue, the seed can remain in a state of homeostasis for liter-



C. azalea hybrid seedling that germinated in culture and will be planted into a pot.



Figure 6. *C. azalea* hybrid seed that has begun to germinate in culture and will be planted into a pot.

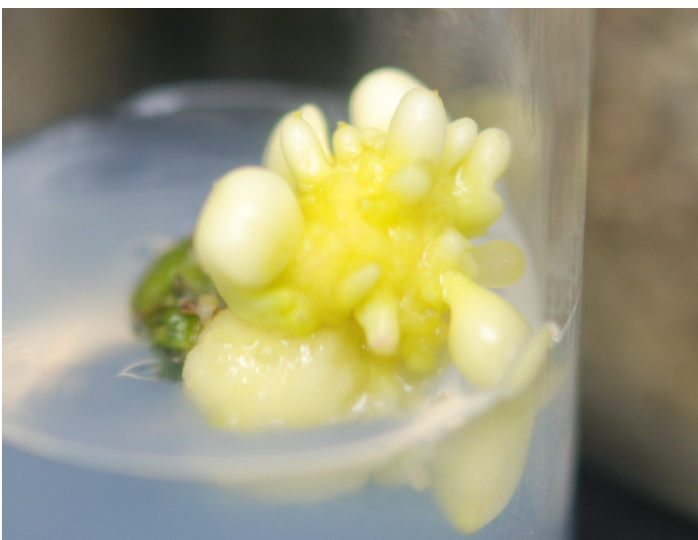


Figure 7. Somatic embryos forming on a hybrid seed of *C. azalea* x *C. japonica* 'Maiden of Great Promise'. (Photo – Bud Easler)

ally years. The ideal situation is that the seed germinates in culture and grows into a small plant (figures 5 and 6). If this occurs, the germinating seed or the resulting small plant is brought out of the test tube, planted into a pot and placed in the greenhouse.

A fourth outcome of placing a seed into tissue culture is somatic embryogenesis, which is defined as the production of embryos from vegetative tissue. Plant cells have the ability to revert to different tissue types. Depending on the type and concentration of plant hormones in the tissue culture media, the epidermal cells of camellia seeds can revert into embryonic cells.

Once this occurs, these cells will begin to divide and form a *somatic embryo* (figure 7). The newly formed embryos can then potentially germinate into a plant. This outcome is another way to rescue hybridized genetic material from certain crosses that would have otherwise died if placed into natural conditions. Some of the crosses that are made with *Camellia azalea* only produce nonviable seed and using somatic embryogenesis is the only way to obtain a hybrid plant from that particular cross.

Currently, Longwood has several hundred somatic embryos or small plantlets from somatic embryos growing in culture. The next hurdle with this process is bringing the plants out of culture into the greenhouse. In culture, the plants have an optimal environment with ideal light, water, fertilizer and vitamins. They are also isolated, so there is no possibility of attack from insects or disease causing organisms. The transition from this ideal environment to the greenhouse can be difficult and small plants will often not survive.

Longwood Gardens is the first and only known organization using embryo rescue and somatic embryogenesis to develop new hybrids with *Camellia azalea*. In order to optimize these procedures Longwood staff and volunteers are carrying out many research projects trying to optimize somatic

Table 1. Percentage of crosses that produced fruit from a minimum of 5 crosses with *C. azalea* as the maternal and paternal parent.

<i>C. azalea</i> as the maternal or seed parent	
Cold hardy Ackerman hybrids	0
<i>C. albogigas</i>	10
<i>C. anlungensis</i>	40
<i>C. japonica</i>	37
<i>C. japonica</i> 'April remembered'	0
<i>C. japonica</i> 'Longwood Centennial'	37
<i>C. japonica</i> 'Longwood Valentine'	43
<i>C. japonica</i> 'Maiden of Great Promise'	7
<i>C. japonica</i> 'Mrs. Nellie Eastman'	60
<i>C. japonica</i> × <i>C. lutchuensis</i> 'Spring mist'	0
<i>C. nitidissima</i> × (<i>C. japonica</i> × <i>C. reticulata</i>) 'Ki-no-moto'	0
<i>C. nitidissima</i> × <i>C. japonica</i> 'Kiho'	0
<i>C. oleifera</i> 'Winters Star'	17
<i>C. pitardii</i>	50
<i>C. ptilosperma</i>	50
<i>C. sasanqua</i> 'Narumigata'	5
<i>C. sasanqua</i> × <i>C. oleifera</i> 'Survivor'	0
<i>C. × williamsii</i> 'Aida'	15
<i>C. azalea</i> as the paternal or pollen parent	
Ackerman hybrids	0
<i>C. albogigas</i>	3
<i>C. anlungensis</i>	0
<i>C. japonica</i>	30
<i>C. japonica</i> 'Longwood Centennial'	60
<i>C. japonica</i> 'Longwood Valentine'	80
<i>C. japonica</i> × <i>C. lutchuensis</i> 'Spring mist'	0
<i>C. nitidissima</i> × (<i>C. japonica</i> × <i>C. reticulata</i>) 'Ki-no-moto'	0
<i>C. lutchensis</i> 'Koto-No-Kaori'	0
<i>C. nitidissima</i> × <i>C. japonica</i> 'Kiho'	0
<i>C. odorata</i>	0
<i>C. ptilosperma</i>	0
<i>C. sasanqua</i> 'Narumigata'	0
<i>C. wenshanensis</i>	5

embryo production, somatic embryo germination, rooting of plantlets and transfer from culture to the greenhouse.

The ever-blooming characteristic of *C. azalea* is arguably the most intriguing trait for breeding in the *Camellia* world. Based on the crosses carried out at Longwood Gardens and information in the literature, *C. japonica* types seem to be the most compatible with *C. azalea* for hybridization (Gao et al. 2008, Gao et al. 2009, King 2007 and Taylor 2010). Other species have shown some indication of compatibility, but more crosses must be performed to determine the extent. Embryo rescue and somatic embryogenesis improves the chances of obtaining hybrids from less compatible crosses. These techniques may also shorten the time to reach the goal of an ever-blooming hardy *Camellia* that is easier to propagate.

References

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