Improving a garden classic

Targeted breeding efforts with rose-of-Sharon aim for new combinations of form and color

A flower of the hexaploid cultivar H. I. 'Flogi' (Pink Giant®), which is being used to develop potentially sterile cultivars due to their odd ploidy levels.
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By Ryan Contreras and Jason D. Lattier

Rose-of-Sharon, or althea (*Hibiscus syriacus* L.), has graced American gardens since colonial times with its large tropical blooms and bright colors.

Modern cultivars of althea can be found in gardens from coast to coast and are prized for their winter hardiness, plethora of colors, and unique forms including single-flowered, double-flowered, and anemone types.

This fantastic diversity of flowering traits, combined with the short generation time from seed to flower, provides an excellent opportunity for breeding. Noted horticulturist Dr. Michael Dirr stated, "*Hibiscus syriacus* is a gold mine for a breeder because of the potential for myriad flower forms quickly and fully expressing their attributes" (Dirr, 2009).

Even with the wealth of cultivars available, possibilities for new combinations and improvements still exist. We are not the first to take note of potential in this species. There have been many before us who have made substantial improvements that we hope to build upon.

U.S. National Arboretum cultivars

Unfortunately, many cultivars are prolific seed producers that self-sow and can be a nuisance in the garden.

Don Egolf of the U.S. National Arboretum (USNA) attempted to address this issue by releasing four cultivars ('Aphrodite', 'Diana', 'Helene' and 'Minerva') that were reported to be sterile or nearly sterile triploids (Egolf, 1981; 1986; 1988). However, since their release, these cultivars have been observed to produce seed.

First in the series to be released in 1970, 'Diana' has pure white flowers that lack eye spots. Egolf's other three cultivars have prominent eye spots with white ('Helene'), lavender-pink ('Minerva') and pink ('Aphrodite') flowers.

Cultivar release information for these cultivars states that they are sterile or nearly sterile triploids that resulted from doubling the chromosomes of the diploid cultivar 'William R. Smith' to develop a tetraploid, which was then crossed with various diploid cultivars (Egolf, 1981; 1986; 1988). However, the natural ploidy level (number of chromosome sets) in rose-of-Sharon is tetraploid ($2n = 4x = 80$).

If 'William R. Smith' was actually doubled, the result would have been an octoploid ($2n = 8x = 160$). Crosses with untreated tetraploids would have resulted in hexaploid progeny ($2n = 6x = 120$).

It is unclear how the original polyploids were identified other than based on morphology, which is an unreliable method. Therefore, the ploidy level of the original treated 'William R. Smith' plant is in doubt.

What is particularly interesting about this story is Egolf was an accomplished cytogeneticist and certainly understood ploidy manipulation and its use in a breeding program. In fact, Egolf's Ph.D. dissertation at Cornell University (1956) was titled "Cytological and interspecific hybridization studies in the genus *Viburnum*."

Polyploids

Historically, polyploids were identified based on their morphology, which often includes thicker and darker leaves and flowers that are often twisted or otherwise malformed. However, this is not always the case and relying on gross morphology alone can lead to misidentification. ▶

An ongoing series provided by Oregon State University in partnership with OAN

Another tool used by plant breeders to identify polyploids is to measure specialized epidermal cells known as stomata. Measuring stomata is useful for identifying the ploidy level of the epidermis, but provides no information on the germ layer from which pollen and eggs are derived. Using either morphology or stomatal measurements may lead to erroneously identifying plants that breed as polyploids.

Today, breeders have the advantage of using flow cytometry to accurately and quickly identify ploidy levels and relative genome sizes, a tool that was not available to Egolf.

Flow cytometry measures fluorescence of plant nuclei to calculate ploidy and relative genome sizes, and can also be used to identify chimeras. Without this tool, it would have been more difficult for Egolf to identify chimeras in which some of the cells or cell layers have doubled chromosomes, while the germ layer remained unaffected.

Still, what remains a mystery is why the original selections showed such a marked reduction in fertility if they were not triploids, or at least plants of an odd ploidy level.

Assessing fertility and ploidy level

To begin answering that question, we set out to quantify the levels of male and female fertility in available cultivars, including the purported triploids from the USNA. We performed reciprocal crosses among nine rose-of-Sharon cultivars being grown in a glasshouse.

Our data showed that there is no substantial reduction in overall fertility in any of the four USNA cultivars compared to other industry standards (Contreras et al., 2013). However, we did observe very low fertility in the cultivar 'Flogi' (Pink Giant®), which produced only 0.08 and 0.5 seedlings when used as a female and male parent, respectively.

We followed up these results with flow cytometry analyses of these nine cultivars to determine their ploidy level. We found that all cultivars, including the purported triploids, were actually tetraploids, with the notable exception of Pink Giant, which was a hexaploid ($2n = 6x = 120$) (Contreras et al., 2013).

The fact that this cultivar with higher ploidy level exhibits reduced fertility supports the idea that ploidy manipulation in rose-of-Sharon remains a viable option for developing sterile cultivars. After its identification as a hexaploid, Pink Giant has become an important parent in our breeding program.

Research greenhouse at Oregon State University, where numerous commercial cultivars of rose-of-Sharon are being used in controlled crosses. PHOTO BY JASON LATTIER

Exciting new phenotypes

Of course, sterile cultivars will be of great utility to gardeners, but seedless cultivars do not necessarily get one's heart racing!

To create excitement, we are working toward new combinations of flower colors and forms. With a flurry of new releases on the market, it may be said that there has never been a better time to be a rose-of-Sharon breeder.

With little effort we put together a germplasm of nearly 30 top-performing cultivars representing many combinations of colors, flower forms, and presence or absence of eye spots. This collection includes cultivars that have been commercially available for some time as well as many new releases including the garden dwarf Lil' Kim™ from Monrovia, four Smoothie™ altheas from Garden Debut, and four cultivars in the island series (Hawaii™, Bali™, Fiji™ and Tahiti™) from First Editions.

As our breeding program grows, we will continue to incorporate the full array of new colors and forms from current nursery releases.

But, how does one go about developing a specific new look? Breeding new nursery crops often involves knowledgeable experts (aka plant geeks) identifying new phenotypes that arise by chance mutations in large nursery populations. In addition, new phenotypes often are identified by serendipitous genetic recombination occurring through open pollination on the nursery or farm.

There is nothing wrong with this process. Thousands of introduced cultivars are evidence of how effective it can be. But is there a better way to improve rose-of-Sharon? Can we set out to achieve a dwarf cultivar that has pure white double flowers with no eye spots? We think the answer is yes.

We are working on assessing the inheritance of traits including plant height, flower color, flower texture (single, anemone, double), and eye spot.

Crosses during 2012 and 2013 consisted of nearly 100 unique combinations of both older and modern cultivars. Flower traits such as single, anemone and double flowers in all color combinations were included in these crosses. Other unique traits, such as flowers lacking eye spots, plants with dwarf habits, and plants with different ploidy levels, also were crossed in different combinations.

Pollinations were made in a controlled greenhouse to exclude pollinators. Accidental self-pollinations were easily avoided because flowers of rose-of-Sharon have heavy, sticky pollen that is physically separated from the receptive stigma. Seeds in 2012 and 2013 were collected, counted and germinated over winter. Nearly 1,200 seedlings were field planted and are currently being evaluated for form, flower color and reduced fertility.

Evaluating progeny from hybrid crosses allows breeders to make predictions about progeny obtained from future crosses between specific parents. Self-pollinations and reciprocal crosses were made for most parents in our crossing study.

Reciprocal crosses, or crosses between two plants using each plant as both male and female parent, allow breeders to determine maternal or paternal effects on gene expression.

Self-pollinations are useful because they allow you to elucidate the variability of a trait in the plant's genome. For instance, if you self-pollinate a white-flowered rose-of-Sharon and all of the progeny produce white flowers, then you can predict that your parent is true breeding for white flowers. If you cross the same plant with a blue-flowered rose-of-Sharon and find that only a small fraction of the progeny have white flowers, you can predict that white flowers are weakly expressed (recessive) when combined with the genes from the blue-flowered parent.

No formal studies have been published on inheritance patterns in rose-of-Sharon; however, Dirr (2009) reports that an open-pollinated 'Blue Bird' produced progeny that flowered in a range of colors (white, pink, rose, lavender and blue). It is unclear if this pattern of inheritance is due to segregation of genes present in 'Blue Bird' or if perhaps the pattern Dirr observed was due to outcrossing.

Meeting the demand for new cultivars

These types of progeny tests have been used since the days of Mendel and will allow us to determine the inheritance patterns for flower colors, forms and eye spots in rose-of-Sharon. Knowing how traits are inherited will allow us to utilize a targeted breeding ▶

approach to meet the demands for new cultivars in the nursery industry.

Long-term evaluations of hybrids will allow us to calculate combining abilities for parents and identify hybrids with improved growth habits and increased bloom time. In the years ahead, we hope to provide gardeners new combinations of color, form and texture on sterile, hardy shrubs that behave well in the home garden.

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A small sample of the amazing diversity of flower colors and forms found in rose-of-Sharon.
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