GROWING KNOWLEDGE

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Leaves of tetraploid (left two) *Acer ginnala* are thicker and darker green than diploid (right two). Evaluation is underway to determine if polyploidy also confers increased drought stress that will make new cultivars more resilient in urban conditions. PHOTO COURTESY OF OREGON STATE UNIVERSITY

Urban-strength plants

Ornamental Plant Breeding Program developing new cultivars for city settings

BY RYAN CONTRERAS, LLOYD NACKLEY, AND CAROLYN SCAGEL

Since 2009, the The Oregon State University Ornamental Plant Breeding Program has been dedicated to developing seedless varieties of resilient plant species that were previously considered invasive. This approach is crucial because when we introduce plants to urban and suburban areas, we need them to thrive despite facing challenging conditions such as limited soil space, poor-quality soil, compaction, intense heat, and drought.

Native plants as a solution?

Some suggest that native plants are the perfect solution, arguing that plants naturally found in a region are always better suited to the environment.

However, urban environments, with their disrupted soil, vast stretches of concrete, and modern challenges such as power lines and underground pipes, hardly resemble natural habitats.

Therefore, many newly developed and selected plants are exceptionally well-suited for thriving in modern urban settings, despite not being native species. Of the seven plants the program has introduced, there are two cultivars of native species and another native hybrid.

Native plants are often beautiful, resilient, and perfectly adapted to their native habitats, but therein lies the rub: our urban environments are not their native habitat, and climate change is pushing the two further apart. As such, developing seedless cultivars of plants that not only survive but thrive in difficult conditions is among the main approaches we are using to breed for the future.

The taxa for which we have seedless selections or are working toward that goal includes several species of *Acer*, *Berberis thunbergii*, *Buddleja* (often complex hybrids), *Hibiscus syriacus*, *Phellodendron amurense*, *Prunus laurocerasus* and

P. lusitanica (developing hybrids), and *Spiraea japonica*. Many of these are important at every step in the chain — they are economically important for growers, mainstays for commercial landscapers, and desired by consumers. The common thread often is their ease of production, beauty, and resilience.

Polyploidy, fertility, and physiology

For most of these examples, we are developing plants with additional sets of chromosomes (known as polyploids) that exhibit abnormal meiosis, which renders them seedless (or nearly so). This is the same reason that bananas do not set seeds; they are triploids, which means they have three sets of chromosomes.

Using this method we have developed seedless cultivars of Amur and Norway maples, Japanese spirea, althea, and Japanese barberry. It is exciting to

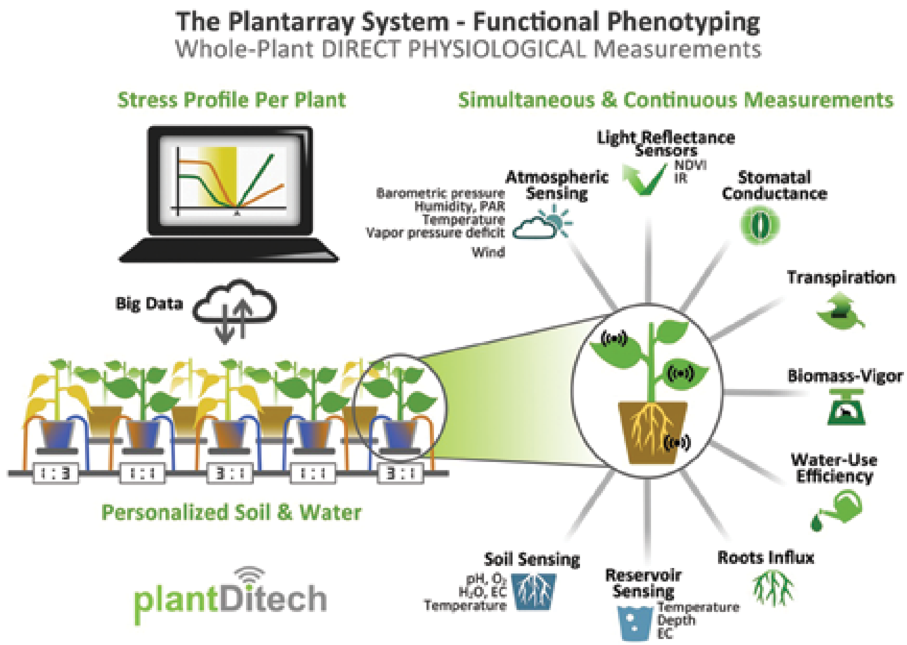

Fig. 1. Schematic overview of automated phenotyping system to impose specific drought stress and evaluate physiological response. Data collected includes key indicators of plants' ability to withstand drought stress, which are used by the software to assemble a complete picture of each plant over time. PHOTO COURTESY PLANT-DITECH.COM

think about the relatively near future of deploying these cultivars to support our industry. But what is additionally exciting is the potential that we have simultaneously improved their response to heat and drought stress while also rendering them as little to no ecological threat.

The notion that polyploids might confer an adaptive advantage is well-established. Following the influential paper by Blakeslee and Avery in 1937, numerous studies induced polyploidy in plants, aiming to develop new cultivars. However, outcomes varied widely, and the vision of "super-producing" forests remained unfulfilled. In fact, many conifer polyploids exhibit poor growth performance. Also, there are inconsistent results when considering how polyploidy impacts fruit size and quality.

What was less studied early on was how polyploidization impacted physiology. Scientists quickly measured stomata and found that polyploids have larger but fewer stomata, which logically may impact how plants use water since these are the organs for gas exchange (carbon dioxide in, oxygen and water vapor out). Indeed, reduced gas exchange has been observed in polyploids of petunia, phlox, feverfew, sage, chrysanthemum, and marigold (Ghasemi et al., 2021).

We have documented reduced stomatal index in polyploids of *Hibiscus syriacus* (Lattier et al., 2019) and *Prunus lusitanica* (Schulze and Contreras, 2017) but gas exchange was not measured. However, there is sufficient evidence to be excited about the prospects of improved drought stress and conduct future studies on the many polyploids we have.

New technology changed the game

Plant breeding is a multidisciplinary field in which the breeder must have some understanding of genetics, physiology, pathology, production, entomology, etc. but may only have true expertise in one or a few areas.

Related to the current topic, to accurately and reliably measure physiological response of plants to drought it is essential to collaborate with physiologists. »

Collaboration makes better science for many reasons, but in the case of physiology it is imperative to properly design and apply treatments and carefully measure plant response using specific tools at specific times.

These studies are more complex than simply growing plants and giving two treatments differing amounts of water over time. This has limited evaluation of our polyploids because of the labor-intensive nature of the work.

Additionally, traditional tools to measure physiological parameters provide a snapshot of how the plant is responding at the instant the measurement was taken. Of course, many observations assembled over time can create a better picture of response, but this increases labor and only so many collection times are feasible.

A recently developed product called the Plant Array (Fig. 1, Page 34) was introduced by Plant Ditech to change how researchers conduct drought stress phenotyping. Instead of challenging instrumentation that often requires coding knowledge or labor-intensive repeated measurements to ensure accurate application of intended drought stress, this new system is fully automated with off-the-shelf software designed with plant breeders in mind.

The data is collected instantaneously and continuously over the whole experiment. This allows for a full profile of the plant response instead of a snapshot. Data collection is fully automated, which prevents errors in data input and allows larger experiments to be conducted.

Two disclaimers are necessary. First, we own no stock in this company and have no conflict of interest. This system simply presents a new opportunity to conduct this work and we are excited to put it to the test. Second, we have yet to install the system and begin using it. So, the excitement is all based on its promise. However, there are more than 50 scientific articles citing these tools such that we have high confidence of success (**Plant-Ditech.com/References/Academic-Articles**).

Current use and looking ahead

We are beginning this work on a suite of four polyploid taxa that are different geographically, phylogenetically (from four different orders), and functionally. They include deciduous shrubs (*Hibiscus syriacus* and *Spiraea japonica*), an evergreen shrub (*Vaccinium ovatum*), and a deciduous tree (*Acer ginnala*).

We are starting with these polyploids because there is a reasonable expectation that we will observe differences between ploidy levels, as described above. Additionally, these include already introduced cultivars (*Hibiscus syriacus* Petite Pink Flamingo™ and *Vaccinium ovatum* 'Cascade Jewel') as well as selections we hope to introduce soon.

The plan is to expand the size of our system in the future so that larger populations can be evaluated including species from different climactic regions, different provenances of a single species, new hybrids, and likely more polyploids.

The horizon of this work hopefully includes evaluating gene edited selections that have been modified to increase gene expression associated with increased drought and heat stress. The preliminary efforts of that work are just beginning but the promise and potential for future application gives one excitement for tomorrow!

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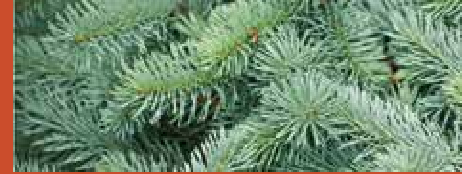

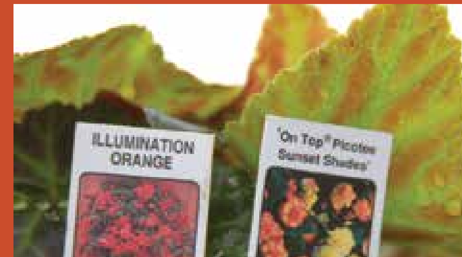

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