The economy of water

Can plant physiology and breeding research work collectively to develop more water-efficient and drought tolerant plants that will benefit the green industry?

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Columnar Norway maples beautify the urban environment of downtown Portland and provide shade to offset the heat island effect.

By Ryan Contreras and Jim Owen

Breeding programs for ornamental plant improvement have historically been focused on beautification, with the added benefit of providing green space in the urban environment.

Although not the direct focus of breeding efforts, plants have been used for ecosystem services such as storm water mitigation and providing shade that combats the heat island effect in urban environments. Green spaces provided by plants also serve to improve quality of life of those who see or use the landscape.

To further bolster the environmental benefit of ornamental landscape plants, there has been a push for development of more sustainable production practices of ornamental crops that use fewer resources with minimal environmental impact. These production practices have led to research into increased energy efficiency, carbon sequestration, environmentally sound production practices, and evaluation and selection of low-input ornamental plants for the home and urban landscape.

Little to no research has been conducted to utilize genetic resources for development of ornamental cultivars to provide enhanced ecosystems services. Of particular interest are cultivars that can be produced and grown with less water and survive drought events. This is one area of research that we believe could result in the creation of new cultivars that could be grown by nurseries

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and greenhouses with fewer inputs and would be more attractive to consumers because of their increased economic and environmental efficiency.

We are planning research to breed for cultivars that show superior ability to grow using less water and survive during times of water shortage. If successful, this could provide new ornamental crop cultivars that would benefit both producers and consumers of plants grown in urban and home landscapes.

Breeding for economy of water

The problem …

The United Nations has predicted by 2020, a shortage of water and not oil will be a source of conflicts in the world. Throughout the United States, water used to irrigate crops has become increasingly less available and under greater public scrutiny.

Numerous water shortages have occurred in the last decade from the southeastern to western U.S. that have resulted in water scarcity and loss of crops.

Municipalities and the U.S. Environmental Protection Agency have created new regulations (ordinances) or certification programs (WaterSense), respectively, for water efficient landscapes that focus on water conservation via efficient irrigation practices and site adapted, low water use plants. And consumers are increasingly aware of limited resources resulting in preferential purchasing of products that minimize environmental impact and yield sustainable practices in the home.

The term "economy of water" refers to the ability of a plant to be produced and maintained with less water and to be tolerant of drought conditions in the landscape. Previous research has focused on identifying plants that have higher water use efficiency than plants of the same or related species; however, this often translates poorly from containers to the field or landscape. This means that plants with high water use efficiency in containers do not necessarily perform well during water stress in the ground.

To achieve the goal of improving ornamental crops' water economy via traditional breeding, three key factors must be determined. First, water use efficiency. This is a measurement of how efficiently a plant uses water and is most simply stated as the unit of tissue produced per unit of water. Second, crop response to varying soil moisture will be measured. This addresses the question of how dry can the growing substrate get before the plant stops growing. The final factor is drought tolerance and prolonged plant response to drought events.

These factors equate into a trait, albeit a complex one, for which we can select. For improvements to be made, specific genes do not have to be individually identified for each of the cultivars studied. Instead, differences in cultivars for overall water economy provides an estimate of the underlying genetic differences.

Feasability

Little is known about the heritability of traits that affect water economy in ornamental woody plants, including water use efficiency and drought resistance. At this time we are uncertain of feasibility. We remain hopeful, however, since similar successes have repeatedly occurred in agronomic crops.

As with many traits, information on breeding for increased water use efficiency is available for several agronomic crops but is generally lacking for woody ornamentals. Studies that have investigated issues of water use in woody ornamentals have only addressed water use efficiency, which may have little impact on how well a plant will perform under drought stress in the landscape.

Water economy is a complex trait that likely involves many genes. However, information on ability to select for such a trait can be obtained by evaluating the performance of the parents and their offspring without exact determinations of the genes responsible. To date, a genetic solution has not been pursued to identify ornamental species or cultivars that combine the ability to efficiently use water and survivability under low water, or even drought, conditions.

Breeding for complex traits, such as water economy, calls for different techniques than breeding for easily selected traits, such as flower color. In these types of simple traits, it is pos-

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Norway maples growing in a difficult site in downtown Portland.

sible to identify the gene responsible and predict how many of a plant's offspring will carry it. It is difficult to identify specific genes responsible for quantitative traits but we can calculate estimates of how much improvement may be expected from one generation to the next. This approach is well established and has been successfully used to improve complex traits such as yield and plant height of crops such as corn, soybean and wheat.

The future

We hope to think big, but begin small. We want to assess the concept of crop improvement using a shade tree that is widely adapted and can be found throughout the American landscape.

Red and freeman maple cultivars

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are widely distributed, making them a good candidate to identify cultivars with the highest economy of water under various environments. We could then use these cultivars to determine how easily we can select for the traits that contribute to economy of water and also determine whether we can use the traits to select for economy of water in other plant species.

The first result of this work would be to identify red and Freeman maple cultivars that survive, grow, and thrive with the least amount of water. After we identify these cultivars and study how they pass traits for economy of water to their offspring, we can use this information to select other woody ornamental taxa with improved economy of water.

Ultimately, we hope to contribute to increasing the number of choices available to homeowners and municipalities wishing to convert to landscapes that use less water, survive drought or provide other unforeseen ecosystem services.

In the end, we all win with trees with improved water economy.

Growers benefit by being able to provide a product, which commands a premium price on the market and is produced with less water. Municipalities benefit by using less potable water for landscapes while still providing public green spaces that enhance quality of life of citizens.

Homeowners benefit by spending less money on water while still maintaining a high quality landscape. As a bonus, they often can receive rebates on the purchase of drought-tolerant trees through programs that are expanding around the country.

Ryan Contreras is an assistant professor of ornamental plant breeding at Oregon State University. He can be reached at contrery@hort.oregonstate.edu. Jim Owen is an assistant professor of nursery crops for Virginia Tech. He is stationed at the Hampton Roads Agricultural Research and Extension Center in Virginia Beach, Va., and can be reached at 757-363-3900.