STEPHEN AUSMUS (K11324-17)

Salt-Worthy Flowers Are Stunning—and Sensible

A flower grower in the Coachella Valley of southern California looks doubtfully at the water easing its way down his field's irrigation furrow. He's using reclaimed drainage water, but he suspects it's infused with multiple salts and trace elements—rendering it unfit for his just-emerging, tender crop of ornamental sunflowers.

Use of lesser-quality waters is common practice for many growers in the water-deprived western United States. But these waters, often recycled after use on other crops, may contain dissolved salts and ions that can hinder plant growth. Compounding the problem is that many growers and nurseries along the California coast must also contend with seawater intrusion into neighboring fresh groundwater sources.

Because of the difficulties facing farmers and growers in accessing high-quality water, researchers with the nation's premier salinity research facility—ARS's George E. Brown, Jr., Salinity Laboratory in Riverside, California—are working to find crops that can endure degraded, often saline, groundwater and wastewater without suffering stunted growth or other salt-induced problems.

A scientist who's investigated salt-tolerant, or halophytic, crops and plants extensively is Catherine M. Grieve, plant physiologist and research leader of the Plant Science Research Unit at the Riverside laboratory. For more than 20 years, she's been evaluating the salt-hardiness of a wide range of grain, orchard, and vegetable crops.

More recently, Grieve turned her attention to floricultural crops—the bright and dazzling fresh flowers that make their way into decorative vases, wedding chapels, and well-groomed backyards. And she's discovered an attractive bouquet of options for growers. Many of these floral crops do tolerate water loaded with salts, and some even appear to be fond of it.

A Pretty Plan

Research into salt-resistant flowers stemmed from an initiative started 6 years ago to bring relevant ARS research to the country's fast-growing floricultural and nursery industries. Second only to corn and soybeans in terms of U.S. cash value, these businesses—many small and family-owned—are busy greening up American streets and backyards. But, while prolific, the industries face a host of nagging problems—from damaging, exotic insects to diminishing water resources.

CHRISTY CARTER (K11382-1)

Chief Rose, *Celosia argentea* var. *cristata.* A relatively salt-tolerant plant, *Celosia* thrives in the brutal heat of Southern California summers.

In California, where cut flowers and foliage for bouquets make up a $300-million-a-year industry, growers are having a hard time accessing their most precious resource—water. Demand for high-quality water continues to increase through competition between urban and agricultural users. This means growers may need to rely more on low-quality water resources. This water, sometimes recycled two or three times, can accumulate high levels of dissolved salts and ions.

Growers along the California coast have another hurdle. Seawater intrusion, in which ocean waters trickle into adjacent underground freshwater sources, has become a problem in southern California. These saline waters get pulled into local aquifers as wells and groundwater supplies are overdrawn.

The laboratory's research into floral species that can withstand waters high in salts or other ions and produce viable, commercially acceptable flowers should help growers to conserve resources, cut costs, and become more efficient.

The environment and public would also win. Reusing greenhouse effluents for cut-flower production would reduce discharge of fertilizer, inorganic salts, and pesticides into streams, rivers, tidal pools, and other sensitive areas.

The researchers' strategy is smart, but not new. Centuries ago, farmers in the Middle East dealt with salinity by replacing salt-sensitive crops, such as wheat, with more salt-tolerant ones, like barley. But while many studies have focused on vegetables and grains that can tolerate salty waters and soils, little work has been done to investigate salt resistance in flowers and nursery crops.

Not All Waters Are Created Equal

One of the researchers' first projects was to create different kinds of water. Specifically, they had to decide on the compositions of waters used to irrigate flower species of interest.

Producing water with a particular chemical profile was the job of soil scientist Donald L. Suarez, director of the salinity laboratory. He's an expert at predicting changes in the chemical composition of increasingly saline waters.

Salts play an important role in plant development. Too much salt may stunt

At the USDA-ARS George E. Brown, Jr., Salinity Laboratory, plant physiologist Catherine Grieve (left) and halophyte biologist Christy Carter measure the height of stock *(Matthiola incana)* growing in special sand tanks.

STEPHEN AUSMUS (K11325-7)

Christy Carter (left) and Catherine Grieve weigh salt amounts to be added to irrigation waters for upcoming zinnia experiments.

growth, or even kill a plant, while some salt compositions may lead to nutritional deficiencies.

This was a critical step in the research because the water available to growers in different regions of the state varies in its makeup. These differences result from geology, geography, and other factors. For example, waters found in the state's lower, inland valleys of Imperial and Coachella differ from those available along the coast.

"Well water that's contaminated by seawater intrusion contains more sodium and chloride," says Suarez, "while concentrated Colorado River water, existing as reclaimed drainage from other crops, contains relatively more magnesium and sulfate."

For the experiments, the researchers first used high-quality water to establish the plants. Then, the seedlings were irrigated regularly with laboratory-made solutions containing gradually increasing concentrations of salts—chlorides and sulfates of calcium, magnesium, sodium, and potassium. The lab's sand tanks, filled with washed river sand, supported the plants and mimicked the systems used by commercial greenhouses.

STEPHEN AUSMUS (K11326-1)

Technician John Draper prepares a greenhouse sand tank to receive plantings of *Zinnia elegans*. Others pictured are Clyde Wilson, Pamela Watt, and Xuan Liu.

Florist Favorites

One of Grieve's first floral subjects was statice, a plant with small, paper-like, blue or lavender flowers. Statice is a staple flower crop, with 3.7 million bunches of it sold in 1998, at a value of almost $4.5 million. An added bonus, its flowers are long lasting, retaining bright, funnel-shaped flowers that often deepen in color when dried. Grieve studied two species of statice: *Limonium perezii,* cultivar Blue Seas, and *L. sinuatum,* cultivar American Beauty.

"In much of the literature, statice is said to be halophytic, or salt-loving," she says. "And its native environments include sand dunes and beaches. So I was surprised it didn't do better."

Both species of statice were able to complete their life cycles under highly saline conditions. But stem length and other qualities important for floriculture production were diminished. The researchers found Blue Seas to be salt sensitive and American Beauty to be only moderately salt tolerant.

Grieve notes that this finding shouldn't preclude use of the two cultivars in other horticultural settings. "While these statice plants weren't able to obtain optimal growth under highly saline conditions, both have great value as bedding or landscape plants in problem areas," she says.

Another flower found in almost all flower shops, and commonly spotted in

perennial gardens, is stock, or *Matthiola incana*. This plant, with its stalks of small, bunchy flowers, is known in the industry for its spicy-sweet fragrance.

Grieve put two different stock cultivars, Cheerful White and Frolic Carmine, to the salt test. Like statice, the stock studies revealed the unexpected. "We found stock to be surprisingly salt-tolerant, contrary to what was previously known about it," she says.

The ability to produce stock with a less-costly, saline water source should be good news for California stock growers, who supplied the country's florists with 24 million stems of the flower last year.

STEPHEN AUSMUS (K11327-2)

In a large room located under the sand tanks are 24 reservoirs containing about 2,000 liters of varying-strength saline solutions used to irrigate test plants. Don Suarez, salinity laboratory director, and Christy Carter measure and record pH and electrical conductivity.

Traditional and Exotic

Bright and bold, sunflowers are native to North America and often sold at farmer's markets across the country. Grieve studied two different ornamental sunflower cultivars, Moonbright and Sunbeam, and found that excess salts didn't affect the diameter of the flowers. Her test waters were typical of those used for irrigation in the Coachella Valley, where sunflowers are grown as a field crop.

"The saline conditions did affect stem length," says Grieve. "But the size of the salt-stressed sunflowers, 4- to 5-inch heads on 28- to 30-inch stems, makes them completely acceptable for the bouquet market."

The genus *Celosia,* of the amaranth family, offers blooms that satisfy the florist or gardener who's looking for a more unusual plant. Grieve, along with halophyte biologist Christy T. Carter, studied *Celosia argentea,* var. *cristata.* Its velvety, oversized flowers are crinkled, suggesting the wavy surface of brain coral.

The researchers found the Chief Gold variety of *Celosia* to be highly salt tolerant—and versatile. "It can be produced with waters contaminated with seawater, like those found along the coast, and with concentrated river water available in the Imperial and Coachella valleys," says Grieve. "The other variety we examined, Chief Rose, is better suited for production with concentrated Colorado River water. It should feel right at home in the inland valleys; it's compatible with their waters and high temperatures."

From Lab to Grower

Flower growers like Michael Mellano, senior vice president of Mellano & Company in San Luis Rey, California, are eager to reap the benefits of the Riverside lab's research. "Our company, which cultivates an array of cut flowers, including sunflowers and stock, has access to reclaimed waters in Carlsbad, California, north of San Diego. But we've been unsure whether we could use this water because of the salts it contains. The ARS research is of great interest to us."

Looking ahead, Grieve would like to see how various container crops and shrubs fare under salty conditions. But first, she and Carter are studying whether certain cut-flower crops can endure solutions high in nitrogen and other fertilizer effluents—typical of those released from nursery operations.

"This research could open the door to more on-site water recycling and decreased runoff from field and greenhouse operations," says Grieve.—By **Erin Peabody,** ARS.

This research is part of Water Quality and Management (#201) and Plant Biological and Molecular Processes (#302), two ARS National Programs described on the World Wide Web at www.nps.ars.usda.gov.

Catherine M. Grieve is at the USDA-ARS George E. Brown, Jr., Salinity Laboratory, 450 W. Big Springs Rd., Riverside, CA 92507; phone (909) 369-4836, fax (909) 342-4963, e-mail cgrieve @ussl.ars.usda.gov. ★