Takes a village

IT

(of ARS scientists working together to develop new wheat varieties)

By Camille M. Steber and Daniel Z. Skinner

nyone can put paint to canvas. Anyone can chip a piece of marble. And yes, anyone with the knowledge of plant breeding can develop a new wheat variety. But to develop a variety that will be remembered and provides exceptional value, takes skill, patience and, yes, artistry.

At the U.S. Department of Agriculture-Agricultural Research Service (ARS), a portrait of cooperation is something scientists attempt to develop at every stage of the process. The ARS group, hosted by Washington State University (WSU) since 1931, has expanded over the years to include 16 lead scientists dedicated to wheat variety improvement and production practices. These ARS scientists have forged a strong partnership with their state-funded colleagues, but serve the entire Western U.S., not just Washington.

The seven lead scientists in the Wheat Genetics, Quality, Physiology and Disease Research unit focus on weaving together the genetic crosses and basic and applied research that will provide the stress tolerance, disease resistance and end-use quality wheat growers seek in their varieties.

Historically, USDA-ARS scientists have had a strong impact on Washington and worldwide agriculture. The Green Revolution had its beginnings at WSU in 1961 thanks to the 20 percent yield increase from semi-dwarf wheat varieties developed by USDA-ARS wheat breeder Orville A. Vogel. Varieties developed by Vogel and other ARS breeders, Clarence Peterson and Robert E. Allan, have served as a foundation for the USDA-ARS and WSU



ARS Scientist Camille Steber, left, studies genes controlling drought tolerance and seed germination with help from graduate student Elizabeth Schramm.



ARS Scientist Xianming Chen studies all aspects of foliar disease and stripe rust, including characterizing new stripe rust races as they arise, identifying sources of wheat genetic resistance and developing procedures for anti-fungal application.

wheat breeding programs.

ARS varieties are big business in Washington. The ARS variety "Madsen" released by Allan in 1987 has contributed billions of dollars to the Northwest economy. Associate Dean Kim Kidwell acknowledges Allan's mentorship during her early years as the WSU spring wheat breeder.

"When I started in 1994, WSU did not have a spring club breeding program. Based on grower interest, I partnered with Dr. Allan to convert existing winter club varieties to spring types. Bob provided much of the germplasm used to create the program and showed me the nuances associated with breeding club wheat. 'JD,' our latest spring club variety, is an outcome of that work," she said.

ARS scientist Xianming Chen studies all aspects of foliar disease and stripe rust, including characterizing new stripe rust races as they arise, identifying sources of wheat genetic resistance and developing procedures for anti-fungal application. Stripe rust can have a devastating impact on wheat. In 2010, the U.S. lost about 88 million bushels, worth about \$609 million, to the disease. That year genetic resistance saved roughly 73 million bushels in Washington alone. ARS wheat varieties Madsen and Cara were among the most resistant last year.

Chen also coordinates a nationwide monitoring effort to detect newly emerging races of rust pathogens. He serves public and private breeding programs throughout the nation and screens over 15,000 new lines of wheat and barley lines for resistance to specific stripe rust races each year. According to WSU spring wheat breeder Michael Pumphrey, "Dr. Chen's is the only program in the U.S. that does routine analysis of stripe rust races. He is recognized as one of the world's leading stripe rust pathologists, and his program is critical to breeding efforts and protection of the U.S. wheat crop."

Environmental stresses are another yield-limiting challenge confronting wheat in the field. ARS scientist Camille Steber studies genes controlling drought tolerance and seed germination. Wheat and other cereals have problems with pre-harvest sprouting when rain occurs prior to harvest. Steber aims to increase pre-harvest sprouting tolerance without compromising seedling emergence—an important yield component. ►

It's all in the staffing

The Agricultural Research Service of the U.S. Department of Agriculture includes the equivalent of 129 full-time positions staffed by 140 federal employees in seven management units in Pullman. Payroll for the group stands at \$16.5 million in salaries and support in permanent funds.

Another 150 employees (approximately) are hired each year on funds transferred to WSU (which may include temporary grant funds). ARS is currently supporting 31 graduate students at WSU.

The seven management units within the Pullman ARS location are:

- Wheat Genetics, Quality, Physiology and Disease Research (Dan Skinner, research leader)
- Root Disease and Biological Control (David Weller, research leader)
- Land Management and Water Conservation (Brenton Sharratt, research leader)
- Plant Germplasm Introduction and Testing (Jinguo Hu, research leader)
- Grain Legume Genetics and Physiology Research (George Vandemark, research leader)
- Animal Diseases Research (Don Knowles, research leader) and
- Location Administrative Support Staff (Curtis Hoesing, administrative officer)

The Agricultural Research Service also has research stations in Prosser, Wapato and Wenatchee, Wash. In total, the Agricultural Research Service employs the equivalent of 230 full-time federal positions in Washington, including 68 research scientists and their support staff working on problems confronting Washington's diverse agriculture.



Kim Garland Campbell, left, USDA-ARS geneticist and club wheat breeder, works closely with ARS Scientist Camille Steber on various projects including hormonal control of seed germination and pre-harvest sprouting.

ARS Scientist Daniel Skinner is an expert in wheat frost tolerance. He and ARS Geneticist and Club Wheat Breeder Kim Garland-Campbell screen hundreds of breeding lines each year for freezing



Deven See heads the Western Regional Small Grains Genotyping Laboratory (WRSGGL) in Pullman. The lab provides researchers and scientists the ability to follow molecular markers in wheat genes.

tolerance. WSU winter wheat breeder Arron Carter said each year, they submit about 100 breeding lines to the ARS for cold-tolerance testing. "Cold testing under artificial conditions allows us to push the extreme and find the upper limit to cold tolerance," he said.

Since 50 percent of U.S. wheat is exported, high-yielding lines are not enough to keep U.S. wheat competitive in international markets. That's why the ARS Western Wheat Quality Lab (WWQL) in Pullman evaluates various wheat classes for quality before they're in the field.

"It isn't enough to check varieties before they are released," said ARS Cereal Chemist Craig

Morris, director of the WWQL. "We have to evaluate early breeding lines to guarantee that breeders don't waste effort on lines that won't make the cut."

The WWQL evaluates 4,500 samples per year, supporting breeding

California. This data is published online for grower's convenience at www.wsu.edu/~wwql/. Morris and ARS Cereal Chemist Brian Beecher also research factors controlling traits critical to acceptance of U.S. wheat in the global marketplace such as water absorption, discoloration and nutritional value of wheat flours.

All of this work depends on the genetics of the wheat plants. Thousands of genes contribute to the ability of a given wheat line to yield well and produce high-quality products. Thanks to the ability to follow these genes using "molecular markers," a new era in wheat breeding has begun. However, complex equipment and significant man hours are needed to take advantage of new techniques. The Western **Regional Small Grains Genotyping** Laboratory (WRSGGL), headed by ARS Scientist Deven See, provides access to this technology in support of wheat and barley breeding and research efforts in Washington, Oregon, Idaho, California, Utah and Montana. Each year the WRSGGL provides over 400,000 data points to breeding programs.

"The Pullman genotyping lab is very important for our wheat breeding efforts. They do tens of thousands of samples a year for us. They have been very collaborative," said University of California Wheat Breeder Jorge Dubcovsky.

Daniel Z. Skinner, the ARS research leader in Pullman, believes few people realize the "jackof-all-trades" expertise a breeder must bring to bear in pursuit of developing a new variety, but that "Kimberly Garland-Campbell excels



ARS Scientist Daniel Skinner is an expert in wheat frost tolerance

at this balancing act."

In addition to breeding wheat and performing research on cold, drought and disease resistance, Garland-Campbell also coordinates the Uniform Western Regional Cooperative Nurseries evaluation. Four nurseries consisting of 100 public and private lines within two to three years of release are planted and evaluated in 15 locations nationwide for traits, including among others cold tolerance, resistance to many diseases, quality and agricultural traits. The Western regionals also enable cooperative trait evaluation and the free exchange of germplasm under the wheat workers code of ethics.

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