Multiple studies provide insight into drought tolerance of TAM wheat varieties

September 15 2014, by Kay Ledbetter

Dr. Qingwu Xue, a Texas A&M AgriLife Research crop stress physiologist in Amarillo, checks a wireless infrared thermometer in a wheat field. Credit: Kirk Jessup

Drought is the most important constraint limiting wheat yields in the

U.S. Southern High Plains, and the past four years of exceptional drought have provided a tremendous opportunity for research and genetic improvements.

Although wheat yield and drought tolerance have been improved over the years by the Texas A&M Wheat Breeding Program, the physiological mechanisms of drought tolerance among the TAM wheat cultivars have not been well understood, according to Texas A&M AgriLife Research scientists in Amarillo.

Three different AgriLife Research studies in Amarillo have been aimed at determining what traits within the TAM cultivars provide greater or less drought tolerance. The results have recently been published in three international journals.

"Physiology and Transcriptomics of Water-deficit Stress Responses in Wheat Cultivars TAM 111 and TAM 112" was published in Journal of Plant Physiology; "Cooler Canopy Contributes to Higher Yield and Drought Tolerance in New Wheat Cultivars" appeared in *Crop Science*; and "Effective Use of Soil Water Contributed to High Yield in Wheat in the U.S. Southern High Plains" appeared in the *Journal of Arid Land Studies*.

Leading the AgriLife Research efforts from Amarillo are Dr. Qingwu Xue, crop stress physiologist; Dr. Shuyu Liu, small grains geneticist; Dr. Jackie Rudd, wheat breeder; Dr. Srirama Krishna Reddy, assistant research scientist; and Dr. Gautam Pradhan, a former postdoctoral scientist with AgriLife Research and now a North Dakota State University research agronomist.

Additionally, Dr. Scott Finlayson, AgriLife Research molecular physiologist at College Station, and Dr. Paxton Payton and Dr. James Mahan, plant physiologists at the U.S. Department of Agriculture-

Agricultural Research Service in Lubbock, were a part of the projects. These studies were funded in part by Texas Wheat Producers Board, AgriLife Research and the USDA Ogallala Aquifer Program.

Rudd said it is not unusual for hard red winter wheat crops to experience moderate to severe drought stress, especially during the grain filling stage, resulting in significant yield losses.

TAM 111 and TAM 112 are widely grown wheat cultivars in the region specifically because of their drought tolerance, he said. While they share some of the same parentage and are always among the highest yielding under drought, they have distinct adaptationmechanisms under water-deficit conditions.

"We know that TAM 111 is the best performer under intermittent drought and TAM 112 tops the trial under long periods of sustained drought," Rudd said.

But because the physiological and molecular basis of their adaptation remained unknown, Liu and Reddy conducted a greenhouse study to understand the differences in the responses of the two cultivars to water-deficit.

Dr. David Verbree, while a doctorate student of Texas A&M University from 2009 to 2012, did thermal imaging work in the wheat research plots at Bushland. Credit: Dr. Qingwu Xue

Whole-plant data indicated that TAM 112 produced more biomass and grain yield than TAM 111 under water-deficit during grain filling. Leaf-level data indicated that TAM 112 had higher levels of the plant hormone abscisic acid, which results in partial stomatal closure to conserve water, as compared to TAM 111.

Sustained water-deficit also resulted in more changes in flag leaf metabolisms in TAM 112 than TAM 111. Many genes associated with metabolic processes and dehydration responses were uniquely regulated between cultivars, Reddy said.

"TAM 112 had three times more unique responsive genes than TAM 111," Liu said. "This could be a reason that TAM 112 performed better under longer periods of drought stress."

Studies under the supervision of Xue were conducted in the research field near Bushland. The canopy temperature depression study researched the difference between air and canopy temperatures, which has been suggested as a trait for identifying drought-tolerant genotypes.

The objective of this study was to investigate whether a cooler canopy temperature is one reason for higher yield in new drought-tolerant cultivars, Pradhan and Xue said. A crop that is cooler than the air temperature signifies a healthy crop and is generally associated with increased photosynthesis.

Field experiments were conducted with five genotypes, including TAM 111 and TAM 112, under dryland conditions in the 2010, 2011 and 2012 seasons. Canopy temperature was measured continuously from late jointing to the middle of grain filling using wireless infrared thermometers, Xue said.

Although canopy temperature varied with sky conditions, growth stage and time of day, the genotypic variation in canopy temperature was consistent, he said. In general, yield was negatively correlated with daytime canopy temperature, whether from a single clear day or a season-long mean.

"The cooler the canopy, the higher the grain yield," Xue said.

TAM 111 and TAM 112 had up to 5 F degrees lower canopy temperature and 31 percent more grain yield than the other genotypes, the study showed. Therefore, cooler daytime canopy might be the reason for higher yield in the two drought-tolerant cultivars under drought conditions, the study showed.

The second study under Xue's direction looked at the use of soil water to contribute to high yields. This study investigated the differences in soil water depletion among four TAM cultivars under dryland and irrigated conditions in two growing seasons. Cultivars included TAM 105, TAM 110, TAM 111 and TAM 112, which were released from the late 1970s to early 2000s.

Based on measurement of seasonal dynamics of soil water depletion, the newer cultivars – TAM 110, TAM 111 and TAM 112 – extracted more water from the soil profile than the older cultivar, particularly from the deeper soil profile, Xue and Pradhan concluded.

The direct benefit with more water extraction is that these cultivars can maintain a cooler canopy and higher photosynthesis under water deficit conditions, which supports the results from the first field study, Xue said.

"Since the soil water extraction is determined by root growth and development, we recommend further studies on root traits to elucidate the different behaviors of new and old cultivars under extreme drought, moderate drought and irrigated conditions for soil water content," he said.

"We know that drought tolerance is a part of the increasing popularity of TAM wheat cultivars in the High Plains, but these studies have been the first to provide concrete evidence," Rudd said.

The data indicates that TAM 112 has an active response to drought and conserves water during drought periods, whereas TAM 111 is not as sensitive to environmental stimuli and will continue to grow and use water until a critical water deficit is reached resulting in premature death, he said.

"This explains our past observations that TAM 112 is relatively better under a sustained drought and TAM 111 is best under intermittent drought," Rudd said. "I am proud to be part of this outstanding research team, and I have no doubts that these studies have greatly increased our breeding efficiency to develop TAM wheat with even higher yield and better drought tolerance."

More information: "Physiology and transcriptomics of water-deficit stress responses in wheat cultivars TAM 111 and TAM 112." Reddy SK, et al. *J Plant Physiol*. 2014 Sep 1;171(14):1289-98. DOI: 10.1016/j.jplph.2014.05.005. Epub 2014 Jun 6.

"Cooler Canopy Contributes to Higher Yield and Drought Tolerance in New Wheat Cultivars." Gautam P. Pradhan, et al. *Crop Science*. DOI: 10.2135/cropsci2013.11.0788

Provided by Texas A&M University

Citation: Multiple studies provide insight into drought tolerance of TAM wheat varieties (2014, September 15) retrieved 6 May 2024 from https://phys.org/news/2014-09-multiple-insight-drought-tolerance-tam.html