SORGHUM
State of the Art
and Future
Perspectives

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Photo by Stephen R
Ausmus/USDA-ARS
Worldwide, sorghum is among the top-five cereal grains in both production and acreage, making it a key crop for food security. *Sorghum bicolor* is the most commonly cultivated of the 25 species within the *Sorghum* genus. Sorghum and sorghum hybrids are grown for a range of uses: grain sorghum is a high-protein staple food, forage sorghum can be grazed or used for silage, and other cultivars are used to produce syrup and for bioenergy. This diversity of uses and wide range of growing conditions make sorghum an appealing crop at scales from subsistence farming to commercial agriculture.

“Food security goals vary among nations and their economic development,” says Ignacio Ciampitti, Associate Professor in Crop Production and Cropping Systems Specialist at Kansas State University. “In developing countries, the challenge is not only to improve crop yields but also to ensure adequate food distribution and accessibility. Sorghum is a key player under high-stress environments, ensuring productivity and access to food when other crops fail on this task.”

Recognizing that there have been advances in technology and the discovery of new traits in sorghum over the past decade, Ciampitti and fellow sorghum researchers are working on a book titled, *Sorghum: State of the Art and Future Perspectives*. The book is currently in press with many chapters already available online at [http://bit.ly/20YmNtw](http://bit.ly/20YmNtw). “The last publication that presented a close-to-complete summary for sorghum was published in 2000 (*Sorghum: Origin, History, Technology, and Production*),” Ciampitti says. “Therefore, the concepts and topics presented in this book will provide a needed update and also include new relevant topics for all the sorghum scientific community.”

**Water**

In some regions, precipitation provides ample water to support crops. When precipitation alone is insufficient, irrigation water is sourced from aquifers and reservoirs. However, changing climate conditions may reduce precipitation, increase temperatures, and increase the frequency of droughts. The potential for limited water supplies and changes in policies that determine water use may make it difficult to maintain production of thirsty crops like corn in semi-arid regions. Simultaneously, a growing human population will demand more food and animal feed.

With origins in Africa, sorghum is adapted to grow in semi-arid environments. Growing sorghum requires less water than some other crops, and sorghum can survive drought conditions. This new book includes chapters focused on water, including topics like water use efficiency and transpiration efficiency. Author Vincent Vadez says understanding the theory “opens up new opportunities to increase water use efficiency from plant traits that were unexplored until recently.”

Vadez also describes the methods to measure water use efficiency and current investigations into increasing water use efficiency in

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**Relationship between crop evapotranspiration and grain yield for corn and sorghum.** Data are adapted from Klocke et al. [2011](http://bit.ly/2YJXrvY) and [2012](http://bit.ly/2g8Q9GG). The blue line is data from Kansas for the response of corn to water use. The red line is data from a similar experiment using sorghum from Kansas. The data for sorghum in Texas were reported in Klocke et al. (2012). **Legend**

- **1 - 10k**
- **10k - 150k**
- **100k - 500k**
- **500k - 750k**

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**Grain yield (kg m⁻³)**

- **Corn Kansas**
- **Sorghum Kansas**
- **Sorghum Texas**
Sorghum is grown for food, animal feed, and bioenergy around the world.

Because it is adapted for semi-arid regions, sorghum is a suitable crop for dryland production or in areas where water resources are limited.

A soon-to-be-published book presents the state of the science and introduces new sorghum research.

Sorghum has a great deal of genetic diversity in both cultivated and wild species. Conservation of genetic diversity in genebanks, like the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), is important for future breeding efforts. Hari Upadhyaya and co-authors provide an overview of germplasm collections in a chapter on sorghum genetic resources (see http://bit.ly/2xVhxQA). Upadhyaya says this chapter also presents “traits and factors shaping landraces diversity, the impact of mating systems on gene flow and diversity, ethnolinguistic diversity impacting conservation and distribution of on-farm diversity, genomic resources, and developing a mini-core collection to identify multiple-trait germplasm that can be used to develop high-yielding, nutritionally dense cultivars with resistance to biotic and abiotic stresses and a broad genetic base.”

Mutant lines of sorghum provide another genetic resource. The sequenced reference inbred line BTx623, which was mutagenized with ethyl methane sulfonate (EMS), is described by Zhanguo Xin and co-authors in a chapter they wrote (see http://bit.ly/2fRjKYz).
Genetic sequencing of the resulting “mutant library” revealed more than 1.8 million canonical EMS-induced mutations where almost all (>97%) were novel. Xin says, “Consistent with the sequencing result, many novel traits, such as multi-seeded and erect-leaf mutants, have been isolated. This mutant library provides a unique resource to identify novel traits to accelerate sorghum improvement.”

An improved understanding of genetics also improves modeling. For example, Graeme Hammer and co-authors present the use of the sorghum model in the Agricultural Production System simulator (APSIM) for both breeding and agronomic applications (see http://bit.ly/2gbwuGL). Hammer says, “In agronomy, the understanding and modeling of water and nitrogen dynamics have already enabled credible modeling applications exploring production–risk trade-offs associated with management operations and climate risk. In breeding, the putative role of crop growth and development modeling as a support technology has now been tested intensively.” Having accurate models can improve the efficiency of breeding programs and aid growers in making management decisions, which Hammer describes as “the new frontier for crop modeling.”

Making the right management decisions to achieve high sorghum grain yields will vary by region. Closing the yield gap for sorghum (potential minus actual yields) will require a deeper understanding of the complexity of interactions among genotype, environment, and management practices, or G×E×M, explains Ciampitti. Ciampitti and co-authors present a summary of regional data on sorghum yield interaction with practices like planting date, row spacing, and nitrogen dynamics (see http://bit.ly/2knBqg5). “We present the best management practices for improving grain sorghum yields under diverse environments across the U.S. sorghum-producing areas,” he says. “Major factors affecting grain sorghum yields and a review–analysis on nitrogen use efficiency are also discussed.”

A gallery of selected mutant phenotypes. Only a fraction of selected mutant phenotypes are presented to illustrate the diversity of phenotypes observed from the sorghum mutant library. WT, wild type. Source: The chapter, “Pedigreed Mutant Library—A Unique Resource for Sorghum Improvement and Genomics,” by Zhanguo Xin and co-authors.