Texas cotton getting a genetic 'tune-up'

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Can you imagine trying to build a competitive race car with old parts? Chances are, the entry would not fare well at the Indy 500. Very much the same thing might be said about today's crops, according to a Texas A&M AgriLife Research scientist.

"Contemporary crops such as Texas cotton are like finely tuned racing machines—they need high quality parts to perform optimally," said Dr. David Stelly, AgriLife Research cotton geneticist in College Station. "And they constantly need new ones to replace ones that are no longer functional, as well as those that are still effective but no longer at the cutting edge of competition."

Stelly said his role in the AgriLife Research cotton breeding program is to infuse new genes and gene combinations into the genetics and breeding research arena, "so that we can utilize natural genetic resources to help meet the many challenges breeding programs face."

Transferring genes into a cultivated crop from a wild species "is like swimming upstream, one is fighting all sorts of biological and genetic barriers," he said. For years, he and his long-time research assistant, Dwaine Raska, have been transferring the alien genes by a special breeding process called "chromosome substitution."

"Using chromosome substitution, we can target one pair of cultivated cotton chromosomes at a time, and replace it with the corresponding pair of chromosomes from a wild species chosen as the donor. On average, each substitution replaces about 2,000 cotton genes with donor genes," Stelly said.

Having already developed chromosome substitution lines for many chromosomes from three donor species, Stelly is working in collaboration with a former graduate student, Dr. Sukumar Saha, now with the U.S. Department of Agriculture-Agricultural Research Service unit at Mississippi State University, and his associates, to document their effects on cotton plant and fiber improvement.

Stelly noted that the chromosome substitution breeding and research was made possible only because of teamwork among researchers and research supporters, especially AgriLife Research, the Texas State Support Committee, Cotton Inc., the Texas Department of Agriculture's Food and Fiber Research Commission and the Agricultural Research Service.

To significantly advance the cotton industry's "racing machines," breeders must shop around to find the best parts, and figure out how to optimize their contributions to performance, he said.

"Fortunately, nature provides a plethora of genetic variation," Stelly said. "It's up to us to find it, move it into agronomically useful types, and to figure out how to use it wisely. Whether mechanical or genetic, making one change often requires that others be made to achieve superiority."

Contemporary production of cotton in Texas and elsewhere requires cotton seed with superb genes, plus good production infrastructure and technology, superb growers and a good dose of luck, he said.

"If a grower sows cotton seeds lacking a fantastic set of genes that confer high production, high fiber quality, resilience to stresses, pests and pathogens, expectations for the crop would be less than good from the outset."

The grower's requirements pose an extreme challenge for cotton breeding programs that release cultivated varieties, because producers must buy elite genetic types that are good-to-great for all traits, Stelly said.

Because of the ever-present pressure for rapid development of successful cultivars, U.S. breeding programs have historically relied heavily on previously developed cultivars and closely related lines as parents, he said. This recycling of genes from relatively few historically elite agricultural types of cotton has created a genetic "bottleneck."

"We have excellent genetic types of cotton and excellent cotton breeders, but we need 'new blood' or new cotton genes, to create lots of new genetic combinations, of which a few are likely to yield significant improvements," Stelly said.

While Texas leads the U.S. in cotton production, producing about 25 percent of the nation's crop on about 6 million acres, there is competition to this No. 1 cash crop for the state, Stelly said.

"Industrial technologies and competition from synthetic petroleum-based fibers demand significant modifications and enhancements to cotton fiber physical and chemical properties, especially those that affect dying and high-speed processing," he said.

Also, ongoing climate changes will alter the scope and scale of the challenges found in current production areas, and probably lead to production in new areas with new sets of biotic and abiotic problems, Stelly said.

"We can use genes to address these challenges and competition in the field," he said.

Genetic improvements or modifications can help keep pests and pathogens at bay, fight off abiotic stresses such as cold, heat, water deficiencies, salt and nutrient deficiencies, Stelly said.

Stelly sees the opportunities for genetic improvements as almost unlimited, and very exciting.

"A key ingredient, in almost all scenarios, is the availability of ample amounts of genetic variation that is available to the breeder to mold new, improved genetic types using the combinatorial 'magic' of Mendelian heredity," Stelly said. "We are concomitantly developing high-throughput DNA marker methods for cotton to expedite that follow-through work with the chromosome substitution lines."

Traditional breeding methods are not very effective for infusing wild germplasm into cotton, he said, because during the back-crossing process, "we think that the alien genes get eliminated very quickly." Stelly uses a modified method for chromosome substitution to avoid those problems almost completely.

The effects differ among each alien chromosome, he said, ultimately depending on which genes are present on that substituted chromosome, and how they interact with the other approximate 58,000 genes found in Upland cotton.

Stelly said they are beginning to apply genomics tools to determine which genes are present, which are expressed and how they interact. Once developed, the lines produced by the project can be screened and "used by anyone … and for essentially any trait subject to genetic control," he said.

"The resulting advances will enable the baseline performances of cotton to be elevated, and could lead to unforeseen revolutionary advances."

Stelly said one of the group's main activities at present is to recruit partners – breeders, physiologists, pathologists – in studying these new chromosome substitution lines.

"We are actively seeking partners to help breed derived types that can help the research community pinpoint single-gene and multi-gene effects in manners complementary to other means of genetic analysis," he said. "My expectation is that with the aid of marker-based selection, the cotton breeding community will be able to use these new kinds of wild germplasm resources far, far more effectively than in the past. It just keeps getting more and more exciting."

Provided by Texas A&M University

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