

Cotton Vision 2030

John Zhihong Yu, USA

ICAC Researcher of the Year 2019



Dr. John Zhihong Yu is a Research Geneticist with USDA-ARS in College Station, Texas. He earned his PhD in plant genomics and

molecular genetics at Cornell University and has been working with the USDA-ARS since 1995. Dr. Yu has demonstrated outstanding dedication, with 36 years of professional experience, and received significant recognition as an international authority in cotton genomics for developing genetic resources that are currently being used by scientists worldwide. He made major contributions to cotton genomics and germplasm, including genome mapping and sequencing, characterization of gene pools, and identification of QTLs for molecular breeding. Dr. Yu developed the world's first integrated genetic, physical and transcript maps of cultivated tetraploid cotton chromosomes with large insert DNA clones, molecular markers, and EST genes; and high-density cotton genetic maps of portable SSR and SNP markers. Dr. Yu led international efforts to develop and release genome sequences for *G. arboreum*, *G. herbaceum*, *G. raimondii* and *G. hirsutum*, among other cotton species. The research opens a new paradigm in cotton genomics

that revolutionizes the genetic improvement of cotton plants through better exploitation of genetic variation otherwise buried in *Gossypium* germplasm. His discovery of gene-rich islands and sub-genomic roles in upland cotton provides critical information for genetic applications. His development of new concepts and methodologies for standardising characterization of *Gossypium* germplasm makes it possible for cotton researchers worldwide to collaborate, relate and utilise genetic diversity data among cotton germplasm collections.

Dr. Yu was twice elected in 2005 and in 2015 to serve as the Chairman of the International Cotton Genome Initiative (ICGI). He is a member of USDA National Life Science Patent committee. He has received several national and international awards and published more than 100 peer-reviewed papers, with more than 10,000 citations. Dr. Yu has also delivered more than 60 presentations to the global scientific community.

The Three Big Challenges for the Cotton Sector in the Next Decade

The global cotton sector will face many challenges in the next decade. Among the biggest ones are the climate change, trade barriers, and polyester (a non-renewable petroleum product). Additional challenges for the cotton sector include the recurrence of an emerging pandemic or natural disaster and the current lack of an international cotton research institute like those established for food crops.

Novel Production Technologies that Can Break Yield Barriers

Cotton yield has been stagnating but its potential barriers can be broken by broadening the cultivars' genetic base with favourable alleles and by exploiting the heterosis in desirable hybrid cotton. Free exchange and utilisation of cotton germplasm is essential for cotton breeders to broaden the genetic base of cultivated cottons. The ideal cultivation management system should be designed for and practiced in each production environment.

Promising Recent Advances in the Science of Genomics, Genetics and Plant Breeding

Since a wild diploid species, *Gossypium raimondii*, was first sequenced in 2012, more than a dozen *Gossypium* species have been sequenced, including all cultivated cotton species and all tetraploid cotton species. These advances provide fundamental knowledge and genomic resources for cotton molecular breeding. Molecular breeding can empower cotton producers with an efficient means of improving fibre yield and quality — but only if accurate marker-trait association is developed. Now the global cotton research community is positioned to launch a post-genomics era in which such advances will soon bring the focus back to the functional traits of the cotton plant.

Contribution of Genomics Research for Yield Enhancement and Fibre Quality Improvement

Cotton is comprised of many genetically complex species and is experimentally difficult to tackle. In the most cultivated

tetraploid species *Gossypium hirsutum*, approximately one half of the 77,000 protein-coding genes directly or indirectly contribute to the development and growth of upland cotton fibre. These genes are often organised as clusters or islands in the cotton genome and they function through gene networks or pathways at the initiation, elongation, and secondary cell wall biosynthesis of cotton fibre. Many DNA markers associated with fibre yield and quality traits are developed and they are being used to guide cotton breeding efforts to improve cotton yield and fibre quality.

How Can Cotton Combat Climate Change?

Climate change causes profound environmental stress to a developing cotton plant. In addition to deploying the best management practices to cotton cultivation, breeding for more abiotic-stress-tolerant cotton is essential. In the *Gossypium* genus, many wild species likely contain undiscovered genetic elements for tolerance to drought, heat, and other environmental stresses. Exploiting the *Gossypium* germplasm for such desirable genetic elements is necessary to develop cotton cultivars that can adapt to and perform well in undesirable environments due to climate change.

Novel Technologies to Fight Insect Pests, Weeds and Diseases

To minimise the amount of chemical spraying that otherwise pollutes the environment and increases production costs, identification and incorporation of resistance genes into elite cotton cultivars can be achieved through transgenic breeding or marker-assisted selection. While transgenic strategy usually takes advantage of major genes, a marker-assisted approach is being designed for a range of mono-genic to polygenic resistance. Cotton genomics advances provide an opportunity to incorporate that new resistance to insect pests, weeds and diseases.

Cotton Transgenic Technologies and the Way Forward

Cotton transgenic technologies are powerful tools for cotton improvement. Progress has been made, from incorporation of

single genes to multiple genes in genomes that are subsequently backcrossed into an elite cotton cultivar. Future transgenic advances may be possible with cotton genomic knowledge and tools, if the physical location and targeted function of cotton transgenes can be determined precisely.

Role of Robotics, Electronics and Communication Technologies for Cotton

In the next decade, the use of robotics for phenotyping traits in the cotton field will increase so as the use of electronic notebook to record and monitor the cotton production. Contemporary communication and database technologies make information exchange quicker and more efficient, which will translate into enhanced cotton productivity. Cotton producers will have more support as it becomes available online.

Any Other Exciting Novel Innovations and Game-Changing Technologies

Currently, gene-editing technology is the most exciting new innovation that has the potential to create desirable genetic variation for cotton improvement. This technology is being applied in cotton and genome sequences, including gene annotations, are released to the public. Knocking out or editing genes in the same species are not considered transgenic, thus simplifying the improvement and production of modified cotton cultivars.

Advice to Young Cotton Scientists: How to Gear Up for the Challenges of 2030

In the history of humanity, challenges often turn out to be a benefit in disguise. As long as a challenging problem is clearly identified and well understood, scientists should be able to develop a cutting-edge technology to tackle it. Many big challenges in the coming decade will require collaborative research across multiple disciplines. We must envision the whole landscape as we search for the solutions to our problems. Persistence in research, collaboration and coordination will prevail as the cotton sector faces new challenges and opportunities over the next decade.