TEXAS A&M AGRILIFE RESEARCH | EXTENSION

TEXAS A&M UNIVERSITY

TEXAS A&M PLANT BREEDING BULLETIN

January 2020

TEXAS A&M UNIVERSITY--EDUCATING AND DEVELOPING PLANT BREEDERS WORLDWIDE TO ALLEVIATE HUNGER AND POVERTY THROUGH GENETIC IMPROVEMENT OF PLANTS

Cotton is the number one natural fiber that is used in a plethora of predominately textile products but the fiber and the seeds are used in a number of other processed products. Cotton is an "oilseed" crop and on average contains about 23 % protein and about 18 % oil. Soybean, on the other hand, has approximately 37 % protein and about 19% oil. In the production year of 2017-18, global production of cotton seeds was 44.98 million metric tons which is enough to supply the annual protein needs of approximately 550,000,000 people at 50 g/day, not considering planting seeds and other current uses of cotton seeds. The protein found in this 44.98 metric tons also is equivalent to the protein found in 1.22 trillion eggs.

However, all cotton grown globally is grown for its fiber and the seeds are a byproduct that comprises from 5 to 10% of the crop farmgate value. This byproduct status is because cotton seeds, as well as all other plant parts of the cotton plant, contain gossypol, a terpenoid that is toxic to non-ruminant animals such as human beings. Cotton seeds are crushed for oil extraction and the gossypol remains in the meal which is then used as a ruminant feed and the refined oil is used for human consumption. Whole cotton seeds are fed to dairy cattle as a part of their ration and fed free-choice to beef cattle and the gossypol is rendered harmless through microbial activity in the animal's rumen. Obtaining viable gossypol-free cotton seeds has been a breeding objective for decades.

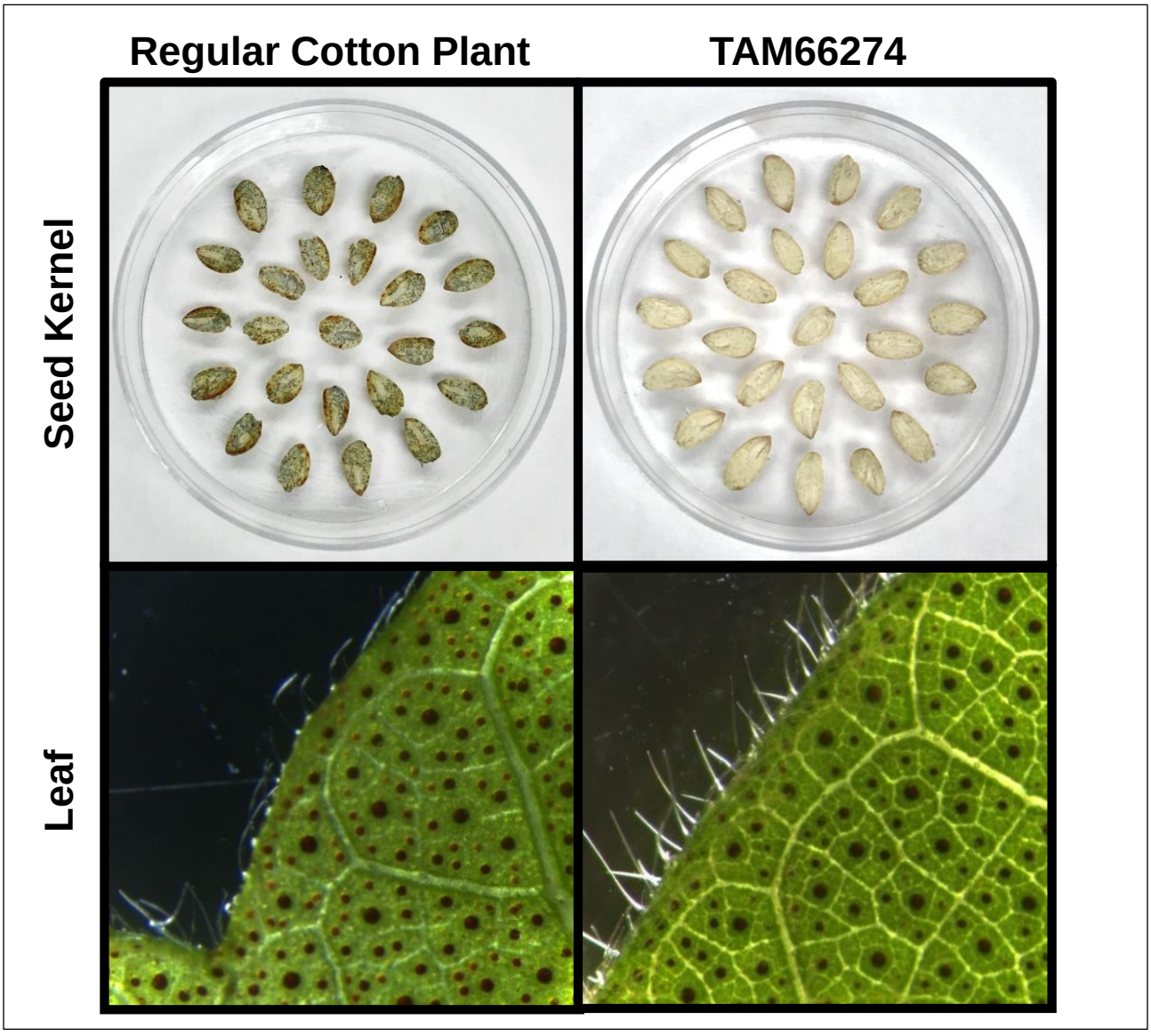
In 1954, S.C. McMichael reported the discovery of a mutant in a cultigen grown by Native Americans of the Hopi tribe in Arizona that was devoid of gossypol-bearing glands throughout the plant, including the seeds. This phenotype became known as "glandless" and the trait is controlled by two recessive genes. Considerable research followed

this discovery by McMichael but commercialization was hindered because the glandless foliage rendered the plant more susceptible to a number of herbivores from bollworms to deer. A couple of glandless cultivars were planted on the High Plains of Texas but the trait was doomed to failure because of the increase in pest susceptibility. The ideal glandless plant would be a plant that has normal, or even increased, gossypol content in the foliage but is devoid of gossypol in the seeds.

Such a trait has been reported in a couple of wild diploid species of *Gossypium* (commercial cotton is an allotetraploid), most notably *Gossypium sturtianum*, a diploid native to Australia. However, several attempts to move this glanded-plant-glandless-seed trait into tetraploid cotton ended in failure. Thus, the potential of cottonseed in contributing to the nutrition requirements of the burgeoning world population remained unrealized.

Dr. Keerti Rathore, Professor in Soil and Crop Sciences and the Texas A&M Institute for Plant Genomics and Biotechnology took a biotech approach to solving this problem. He utilized RNA-interference under the control of a seed-specific promoter to selectively silence a critical gene (δ-cadinene synthase) to reduce gossypol levels in the seed ONLY by 97 % without affecting the levels of gossypol and related protective terpenoids in the rest of the plant where they are needed for defense against insects and some diseases. The resulting Ultra-low Gossypol Cottonseed (ULGCS), with gossypol reduced to ~300 ppm from an average level of ~10,000 ppm, is considered safe as food for human nutrition or as feed for the monogastric animals (FDA guidelines) that are 3 – 7 times more efficient in terms of converting feed protein into edible animal protein

compared to ruminant animals. Field trials conducted over multiple years in multiple states in the U.S. confirmed the stability and heritability of the trait with no diminution of fiber/seed yield or quality and agronomic performance of the plants. A ULGCS event, TAM66274, was deregulated by USDA-APHIS in October 2018 and FDA approved the use of its seeds for food and feed for all animals in October 2019.



Global adoption of TAM66274, with more efficient and expanded usage of its protein, has the potential to significantly improve nutrition security and boost farmers' income without requiring additional input or acreage under cultivation. By serving as a source of protein for

aquaculture species, it will alleviate pressure on the forage fish that are being harvested at an unsustainable rate to meet the industry demand for feed protein, thus improving the health of our oceans. Availability of cottonseed protein, as an alternative to other vegetable proteins, should also help reduce deforestation, currently underway to grow more protein-rich crops as a source of feed for various farm animals. Thus, ULGCS represents a unique biotechnology trait that will benefit farmers, the cottonseed processing industry, the environment and human health.

Dr. Rathore's research interests are in the genetic improvement of important dicot (cotton, potato and tomato) and monocot (rice and sorghum) crops important to Texas. He has developed protocols for the efficient delivery of genes, optimal expression of transgenes, genome editing and rapid recovery of engineered cotton, potato, rice, and sorghum plants while at Texas A&M.

When not working, Keerti enjoys photography, videography and traveling.

Congratulations Fall 2019 Plant Breeding Graduates

Gulten Girgin: MS with Drs. Russell Jessup and Jim Muir

Christian Hitzelberger: MS with Dr. David Stelly

Holly Lane: MS with Dr. Seth Murray

Jeremy Stiles: MS Distance with Dr. Steve Hague

Ali Ullrich: MS with
Dr. Wayne Smith

Fouth Quarter, 2019

Publications by Soil & Crop Sciences Plant Breeding Faculty

Chandra: M. Meeks, A. Chandra. 2019. Drought response and minimal water requirements of diploid and interploidy St. Augustinegrass under progressive drought stress.*Crop Sci.* https://doi.org/10.1002/csc2.20012

Ibrahim and Rudd: Anil Adhikari, Amir M. H. Ibrahim, Jackie C. Rudd, P. Stephen Baenziger, Jean-Benoit Sarazin. 2019. Estimation of heterosis and combining abilities of US winter wheat germplasm for hybrid development in Texas. *Crop Sci.* https://doi.org/10.1002/csc2.20020.

Ibrahim and Rudd: Amanda C. Easterly, Walter S. Stroup, Nicholas Garst, Vikas Belamkar, Jean-Benoit Sarazin, Thierry Moittié, Amir M. H. Ibrahim, Jackie C. Rudd, Edward Souza, R. Stephen Baenziger. 2019. Determining the Eddicacy of a Hybridizing Agent in Wheat (*Triticum aestivum* L.). *Scientific Reports* 9:20173.

Murray and Xu: Jacob J. Pekar, Seth C. Murray, Thomas S. Isakeit, Brian T. Scully, Baozhu Guo, Joseph E. Knoll, Xinzhi Ni, Hamed K. Abbas, Paul Williams, and Wenwei Xu. 2019. Evaluation of Elite Maize Inbred Lines for Reduced *Aspergillus flavus* Infection, Aflatoxin Accumulation, and Agronomic Traits. *Crop Sci.* doi:10.2135/cropsci2019.04.0206.

Murray: Luke S. Pruter, Michael J. Brewer, Mark A. Weaver, Seth C. Murray, Thomas S. Isakeit, Julio S. Bernal. 2019. Association of Insect-Derived Ear Injury with Yield and Aflatoxin of Maize Hybrids Varying in Bt Transgenes. *Environmental Entomology* https://doi.org/10.1093/ee/nvz112

Murray: Gustavo Hugo Ferreira de Oliveira, Seth C. Murray, Luis Carlos Cunha Júior, Kássoio Michell Gomes de Lima, Camilo de Lelis Medeiros de Morais, Gustavo Henrique de Almeida Teixeira, Gustavo Vitti Môro. 2019. Estimation and classification of popping expansion capacity in popcorn breeding programs using NIR spectroscopy. 2019. *Journal of Cereal Sci.* https://doi.org/10.1016/j.jcs.2019.102861

Murray: Gustavo Hugo Ferreira de Oliveira, Seth C. Murray, Luis Carlos Cunha Júnior, Kássio Michell Gomes de lima, Camilo De lelis Medeiros-De-Morais, Gustavo Henrique de Almeida Teixeira, and Gustavo Vitti Môro. 2019. Estimation and Classification of Popping Exansion Capacity in Popcorn Breeding Programs Using NIR Spectroscopy. *Journal of Cereal Sci.* 91:102861.

Murray and Xu: Celeste M. Falcon, Shawn M. Kaeppler, Edgar P. Spalding, Nathan D. Miller, Nicholas Hasse, Naser AlKhaifah, Martin

Bohn, Edward S. Buckler, Darwin A. Campbell, Ignacio Ciampitti, Lisa Coffey, Jode Edwards, David Ertl, Sherry Flint-Gacia, Michael A. Gore, Christopher Graham, Candice N. Hirsch, James B. Holland, Diego Jarquín, Joseph Knoll, Nick Lauter, Carolyn J. Lawrence-Dill, Elizabeth C. Lee, Aaron Lorenz, Jonathan P. Lunch, Seth C. Murray, Rebecca Nelson, Cinta M. Romay, Torbert Rocheford, Patrick S. Schnable, Brian Scully, Margaret Smith, Nathan Springer, Mitch Tuinstra, Renee Walton, Teclemariam Weldekidan, Randall J. Wisser, Wenwei Xu, Nathalia de Leon. 2019. Relatve utility of agronomic, phenological, and morphological traits for assessing genotype-by-environment interaction in maize inbreds. *Crop Sci.* https://doi.org/10.1002/csc2.20035.

Murray: Gerald N. De La Fuente, Ursula K. Feri Benjamin Trampe, Jiaojiao Ren, Martin Bohn, Nicole Yana, Anderson Verzegnazzi, Seth C. Murray, Thomas Lübberstedt. 2019. A diallel analysis of a maize donor population response to *In vivo* maternal haploid induction II: haploid male fertility. *Crop Sci.* https://doi.org/10.1002/csc2.20021.

Murray and Xu: Randall J. Wisser, Zhou Fang, James B. Holland, Juliana E. C. Teixeira, John Dougherty, Teclemariam Weldekidan, Natalia de Leon, Sherry Flint-Garcia, Nick Lauter, Seth C. Murray, Wenwei Xu, and Arnel Hallauer. 2019. The Genomic Basis for Short-Term Evolution of Environmental Adaptation in Maize. *Genetics* 213:2.

Rooney: Erin L. Maxson, Michael J. Brewer, William L. Rooney, James B. Woolley. 2019. Species Composition and Abundance of the Natural Enemies of Sugarcane Aphid, *Melanaphis sacchari* (Zehner) (Hemiptera: Aphididae), on Sorghum in Texas. 2019. *BioOne* https://doi.org/10.4289/0013-8797.121.4.657

Rooney: George L. Hodnett, Sarah Ohadi, N. Ace Pugh, Muthukumar V. Bagavathiannan & William L. Rooney. 2019. *Sorghum biciolor* x S. *halepense* by the frequency of 2n gametes in S. *bicolor*. *Scientific Reports* 9:17901.

Rooney: Jennifer Kimball, Yaya Cui, Dongqin Chen, Pat Brown, William L. Rooney, Gary Stacey & Peter J. Balint-Kurti. 2019. Identification of QTL for Target Leaf Spot resistance in *Sorghum bicolor* and investigation of relationships between disease resistance and variation in the MAMP response. *Scientific Reports* 9:18285.

Rooney and Awika: C. Waters, R. K. Kerth, C. Z. Alvarado, J. M. Awika, and W. L. Rooney. 2019. Sorghum Bran as an Antioxidant in pre-Cooked Ground Pork and Poultry Products. *Meat and Muscle Biology* 1(2):72.

Rudd and Liu: Sushil Thapa, Qingwu Xue, Kirk E. Jessup, Jackie C. Rudd, Shuyu Liu, Ravindra N. Devkota, Jason A. Baker. 2019. Soil water extraction and use by winter wheat cultivars under limited irrigation in a semi-arid environment. *Journal of Arid Environments* https://doi.org/10.1016/j.jaridenv.2019.104046.

Stelly: Johnie N. Jenkins, Jack C. McCarty, Russell W. Hayes, David M. Stelly, and Sukumar Saha. 2019. Registration of RMBHMTUP-C4, a Random-Mated Cotton Population Contatining Alleles from Four *Gossypium* Species. *Journal of Plant Registrations* 13(3):411-415

Stelly: Mauricio Ulloa, Luis M. De Santiago, Amanda M. Hulse-Kemp, David M. Stelly, John J. Burke. 2019. Enhancing Upland cotton for drought resilience, productivity, and fiber quality: comparative evaluation and genetic dissection. *Molecular Genetics and Genomics* https://doi.org/10.1007/s00438-019-01611-6

Stelly: Olufemi Joseph Alabi, Thomas Isakeit, Robert Vaughn David Stelly, Kassie Conner, Brianna Gaytan, Cecilia Villegas, Christian Hitzelberger, Luis De Santiago, Cecilia Monclova-Santana, and Judith K Brown. 2019. First report of *Cotton leafroll dwarf virus* infecting upland cotton (*Gossypium hirsutum* L.) in Texas. *Plant Disease* https://doi.org/10.1094/PDIS-09-19-2008-PDN.

Stelly and Hinze: Abdelraheem Abdelraheem, Hanan Elassbli, Yi Zhu, Vasu Kuraparthy, Lori Hinze, David Stelly, Tom Wedegaetner, Jinfa

Zhang. 2019. A genome-wide association study uncovers consistent quantitative trait loci for resistance to Verticillium wilt and Fusarium wilt race 4 in the US Upland cotton. 2019. *Theoretical and Applied Genetics* https://doi.org/10.1007/s00122-019-03487-x.

Tabien and Samante: Haiya Cai, Rodante E. Tabien, Deze Xu, Chersty L. Harper, Jason Samford, Yuanuan Yang, Aiqing You, Stanley Omar P. B. Samonte, Leon Holgate, Chinhai Jiao. 2019. Grain Quality and Yield of Rice in the main and Ratoon Harvests in the Southern U.S. *Journal of Agriculture Science* 11:15.

Meetings of Interest

National Association of Plant Breeders, NAPB will hold their annual meeting at the University of Nebraska, August 16-19, 2020. More information will be available soon at https://www.plantbreeding.org.

Texas A&M Plant Breeding

Symposium. Foresight 2020: Tuning Crops for Future Needs. A Corteva Agriscience Plant Sciences Symposia Series Event. Thursday, February 20, 2020 on the campus of Texas A&M University-College Station, TX.
http://plantbreedingsymposium.com/

Distance Plant Breeding at Texas A&M Graduate Degrees

Distance Plant Breeding at Texas A&M Graduate Degrees

M.S. and Ph.D. degree programs at Texas A&M.

Visit https://scsdistance.tamu.edu/plant-breeding-distance-education/ for details.

Please direct comments concerning this bulletin to Wayne Smith, cwsmith@tamu.edu or 979.845.3450.

Distance Plant Breeding at Texas

A&M – Continuing Education

For more information visit https://scsdistance.tamu.edu/ or contact LeAnn Hague, Distance Education Coordinator in Soil and Crop Sciences at leann.hague@tamu.edu or (979) 845-6148.