PRESENTATION

Session:
A LOOK AT BREEDING AND AGRICULTURE

Title:
Current state of cotton biotechnology and potential benefits for crop production and sustainability

Speaker:
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Current State of Cotton Biotechnology and Potential Benefits for Crop Production and Sustainability

Ryan W. Kurtz
Vice President, Ag & Environmental Research
Cotton Incorporated
Cary, NC, USA

Cotton Incorporated

Increase the demand for & profitability of cotton through research & promotion


Farm


Gin


Manufacturer


Brand


Retail


Consumer

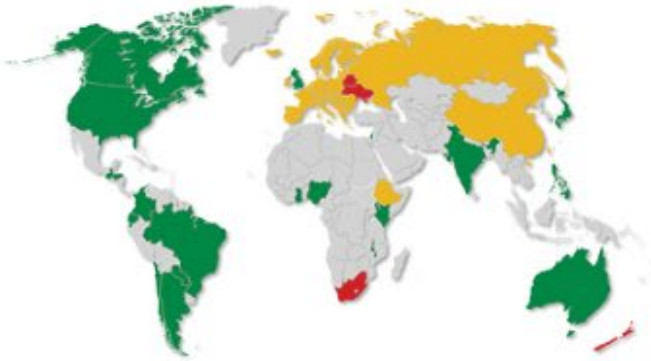
Fiber → Product → Consumer

Definitions

- GMO: organism in which one or more changes have been made to the genome, typically using high-tech genetic engineering, to alter the characteristics of an organism.
- Transgenic: being or used to produce an organism of one species into which one or more genes of another species have been incorporated
- Cisgenic: the genetic modification of a recipient organism with a natural gene from a crossable—sexually compatible organism.
- Genome Editing: a method for making specific changes to the DNA of a cell or organism. It can be used to add, remove or alter DNA in the genome.

GLOBAL REGULATORY LANDSCAPE FOR GENE-EDITED CROPS

Established regulatory criteria for new breeding innovations in different world regions in the past decade



Countries where products are likely to be regulated as conventional new varieties after recent regulatory policy updates.

Countries where there are noticeable policymaking discussions over proposals to treat SDN1 as conventional new varieties.

Countries where SDN1 products should be treated as GMO according to court interpretations based on old regulations.

NORTH AMERICA

US & CANADA AMONG FIRST COUNTRIES WITH CONCRETE REGULATORY DECISIONS ON NEW BREEDING INNOVATIONS

SOYBEANS PRODUCING HIGH-OLEIC SOYBEAN OIL SOLD AS CALYNO

FIRST COMMERCIALIZED GENE-EDITED CROP IN THE US IN 2019 DEVELOPED USING TALENs

EUROPE

EU PROPOSAL ON NEW GENOMIC TECHNIQUES RELEASED IN JULY 2023

UK'S PRECISION BREEDING BILL

INTRODUCED IN MAY 2022; BECAME A LAW IN MARCH 2023 AFTER RECEIVING ROYAL ASSENT

INTRODUCES SCIENCE-BASED AND STREAMLINED REGULATORY SYSTEM TO FACILITATE RESEARCH

AFRICA

4 COUNTRIES WITH ESTABLISHED GUIDELINES ON NEW BREEDING INNOVATIONS:

NIGERIA (FEBRUARY 2022)
KENYA (MARCH 2022)
MALAWI (AUGUST 2022)
GHANA (OCTOBER 2023)

LATIN AMERICA

8 COUNTRIES WITH ESTABLISHED CRITERIA OF NEW BREEDING INNOVATIONS:

BRAZIL • CHILE • COLOMBIA • ECUADOR GUATEMALA HONDURAS • PARAGUAY ARGENTINA

ARGENTINA PIONEER REGULATION ISSUED IN 2015

GENE-EDITED NON-BROWNING POTATO DEVELOPED USING CRISPR RELEASED IN 2018

ASIA AND THE PACIFIC

AUSTRALIA, JAPAN, PHILIPPINES, AND INDIA

ISSUED IMPLEMENTING REGULATIONS AND SOME APPROVED THEIR FIRST GENE-EDITED PRODUCTS

JAPAN

STARTED SALE OF GENE-EDITED HIGH GABA TOMATO IN 2021

PHILIPPINES

REDUCED BROWNING GENE-EDITED BANANA DETERMINED AS NON-GMO IN 2023

FIRST GENE-EDITED PRODUCT TO GO THROUGH THE PHILIPPINES' GENE EDITING REGULATORY PROCESS

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For more information, visit:
www.isaaa.org

Sources:
ISAAA. 2021. Breaking Barriers with Breeding: A Primer on New Breeding Innovations for Food Security. *ISAAA Brief* No. 56.
ISAAA Biotech Updates. https://www.isaaa.org/kc/cropbiotechupdate/

Updated January 24, 2024

SDN1: site-directed nuclease
GMO: genetically modified organism
TALENs: transcription activator-like effector nucleases
CRISPR: clustered regularly interspaced short palindromic repeats
GABA: gamma-aminobutyric acid

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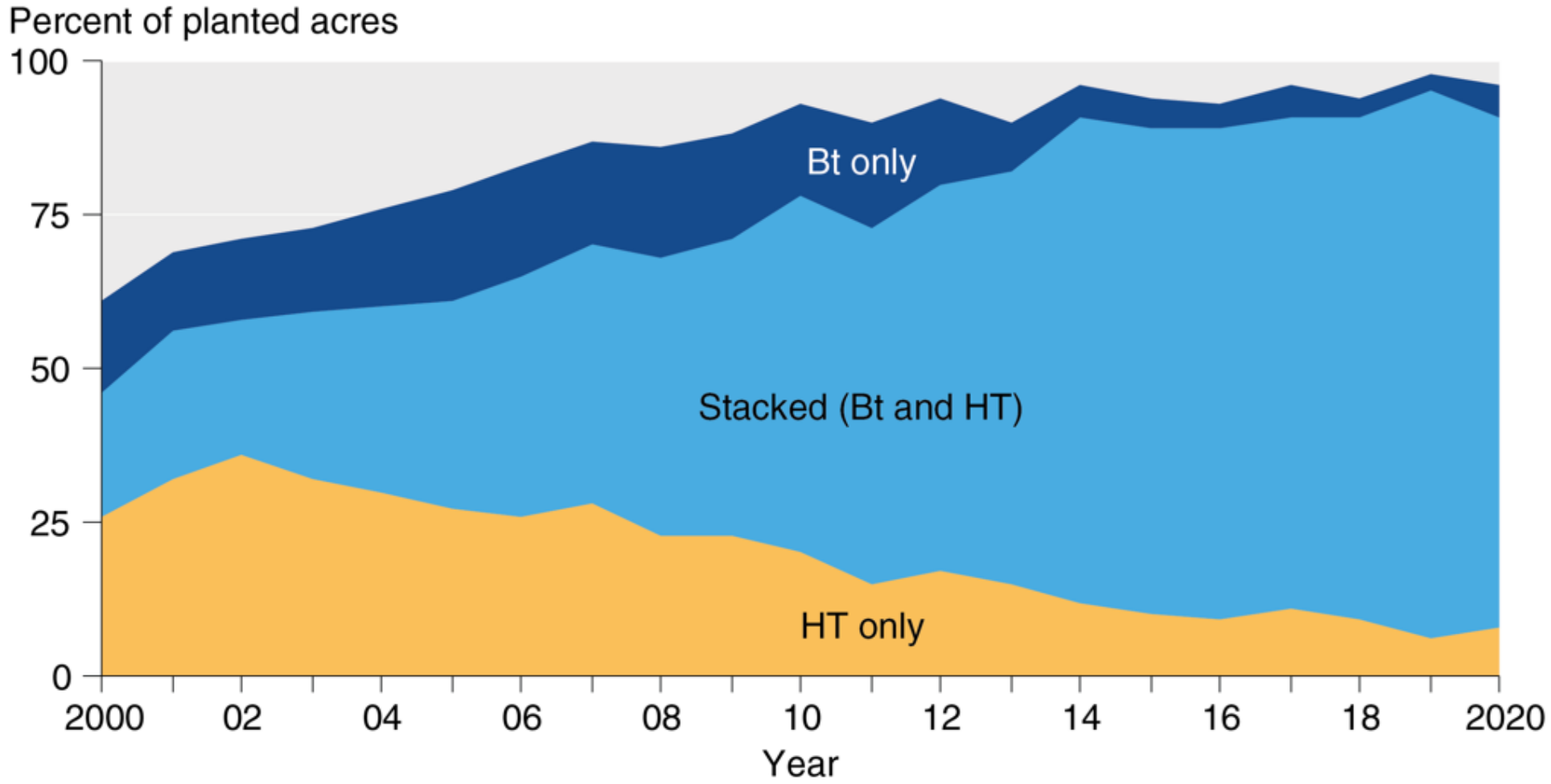
NOW AVAILABLE!

GLOBAL REGULATORY LANDSCAPE FOR GENE-EDITED CROPS

DOWNLOAD AND SHARE NOW!

bit.ly/GeneEditingInfog

Transgenic Cotton Cultivation in the United States



Note: HT = herbicide tolerant. Bt = insect resistant. Total GE cotton acreage measured as the sum of all Bt only, Ht only, and stacked (both HT and Bt traits) acreage.
Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, annual June Agricultural Survey, 2000-20.

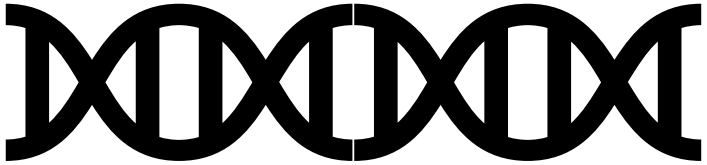
Present

Mulitple transgenic events conveying insect resistance and herbicide tolerance

Insect Resistance: *Bacillus thuringiensis* (Bt) based Cry and Vip proteins provide protection from lepidopteran and thysanopteran pests

Herbicide Tolerance: Genes providing tolerance to foliar applications of glyphosate, glufosinate and ALS herbicides.

Future



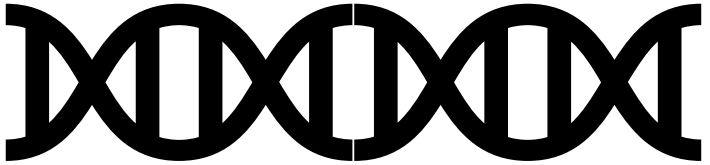
- Cotton produced both food (oil and protein) as well as fiber.

- Enhance yield potential and quality targeting genes that:
  - Impact fiber characteristics: length, strength, uniformity, fineness, etc.
  - Impact oil characteristics: content, composition and quality

- Protect genetic yield gains:
  - Abiotic stress: heat, cold, wind, drought, salinity, etc.
  - Biotic stress: insects, nematodes, bacterial and viral pathogens, weeds, etc.

- Can we improve yield and quality while reducing cotton's environmental impact through gene editing?

Genome Editing



- Multiple Tools: ZFNs, mega-nucleases, TALENs, and CRISPR/Cas9
- Methods allow specific changes to the DNA of a cell or organism and can be used to add, remove or alter DNA in the genome.
- Deletions (knock-out) are easier than base substitutions due to off target effects
- Cotton is recalcitrant/difficult to edit. Largely using C312 and then backcrossing which is slow.
- Resulting organisms may or may not be Transgenic
- Requires clear, validated, and robust knowledge about which specific genes to edit

Plant Biotechnology Journal
Open Access

Plant Biotechnology Journal (2020) **18**, pp. 2002–2014 doi: 10.1111/pbi.13356

Genomic signatures and candidate genes of lint yield and fibre quality improvement in Upland cotton in Xinjiang

Zegang Han[1,2], Yan Hu[2], Qin Tian[3], Yiwen Cao[2], Aijun Si[3], Zhanfeng Si[2], Yihao Zang[1], Chenyu Xu[1], Weijuan Shen[1], Fan Dai[2], Xia Liu[4], Lei Fang[2], Hong Chen[3] and Tianzhen Zhang[1,2,*]

[1]*State Key Laboratory of Crop Genetics and Germplasm Enhancement, Nanjing Agricultural University, Nanjing, China*

[2]*Zhejiang Provincial Key Laboratory of Crop Genetic Resources, Institute of Crop Science, Plant Precision Breeding Academy, College of Agriculture and Biotechnology, Zhejiang University, Hangzhou, China*

[3]*Key Laboratory of China Northwestern Inland Region, Ministry of Agriculture, Cotton Research Institute, Xinjiang Academy of Agricultural and Reclamation Science, Shihezi, China*

[4]*Esquel Group, Wanchai, Hong Kong, China*

ORIGINAL RESEARCH article

Front. Plant Sci., 30 January 2024

Sec. Functional and Applied Plant Genomics

Volume 14 - 2023 | https://doi.org/10.3389/fpls.2023.1320638

Phylogenetic and functional analysis of tiller angle control homeologs in allotetraploid cotton

Foster Kangben[1†] Sonika Kumar[1†] Zhigang Li[1] Avinash Sreedasyam[2] Chris Dardick[3]

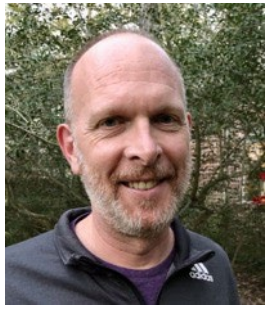
Don Jones[4] Christopher A. Saski[1*]

Introduction: Plants can adapt their growth to optimize light capture in competitive environments, with branch angle being a crucial factor influencing plant phenotype and physiology. Decreased branch angles in cereal crops have been shown to enhance productivity in high-density plantings. The Tiller Angle Control (TAC1) gene, known for regulating tiller inclination in rice and corn, has been found to control branch angle in eudicots. Manipulating TAC1 in field crops like cotton offers the potential for improving crop productivity.

Cotton Genome Editing for Improved Insect Management

Greg Sword
TAMU

Anjel Helms
TAMU



Spencer Behmer
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Mike Thompson
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Keyan Zhu-Salzman
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Keerti Rathore
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Ryan Kurtz
Cotton Incorporated

TEXAS A&M UNIVERSITY

Mason Clark
PhD Student

Hobson Allen
PhD student

United States Department of Agriculture
National Institute of Food and Agriculture

Two Parallel Cotton Gene Editing Projects

Target #1: Volatile Terpene Biosynthesis (What cotton smells like)

"Modifying volatile emissions from cotton to enhance insect resistance using a transgene-free CRISPR/Cas9 approach"

PIs: A. Helms, G.A. Sword & M. Thompson

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

Target #2: Phytosterol Biosynthesis (Limits nutritional quality)

"Cotton genome editing for insect pest management"

Cotton Incorporated

PIs: G.A. Sword, K. Rathore, S.T. Behmer, K. Zhu-Salzman, M. Thompson

Reduced aphid reproduction on HYDRA1 silenced cotton.

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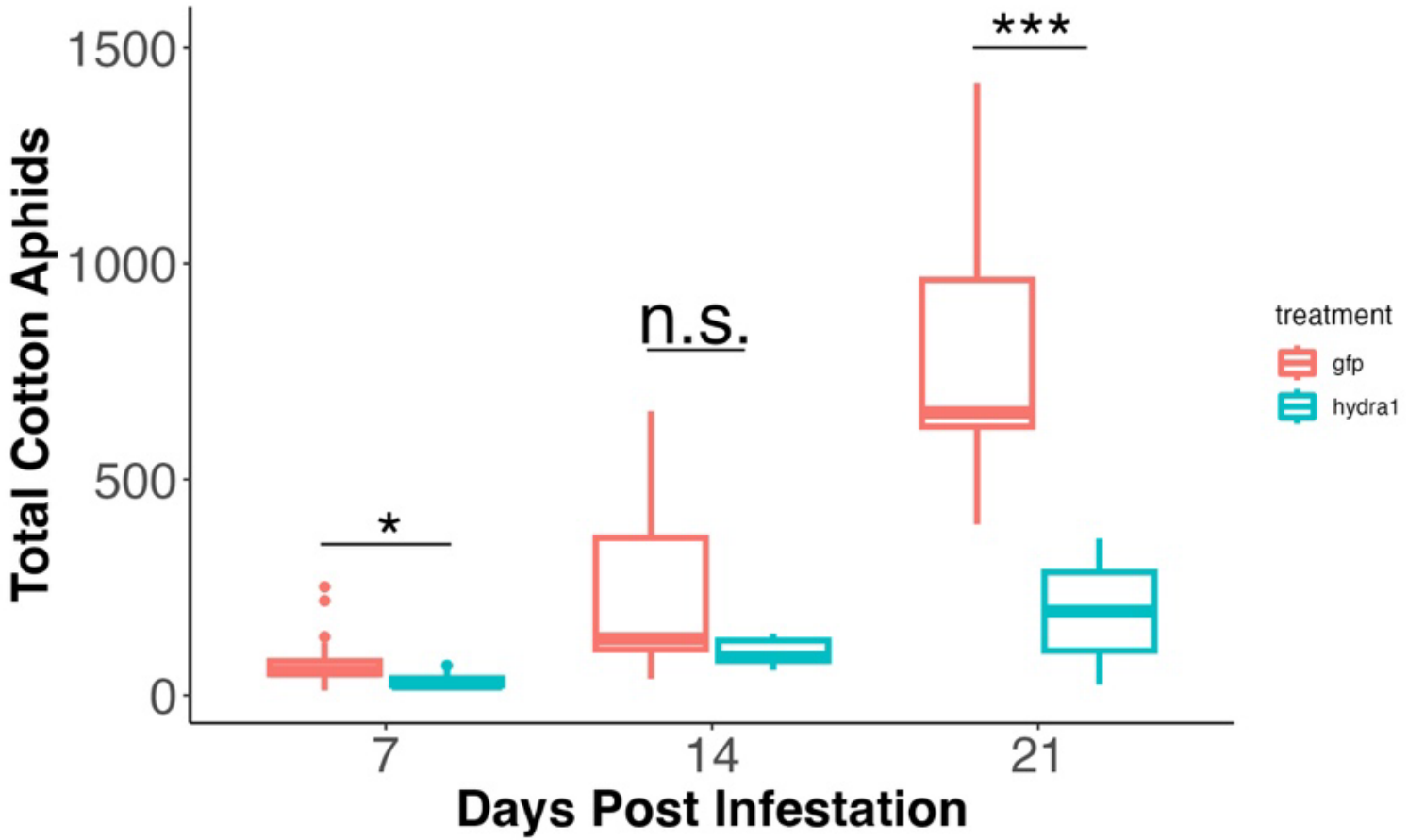
Mason Clark
PhD Student

<u>Target #2</u>: Phytosterol Biosynthesis



APHIS Issues Regulatory Status Review Responses

Published: Dec 21, 2023

WASHINGTON, December 21, 2023 – The U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) recently reviewed four plants modified using genetic engineering to determine whether they posed an increased plant pest risk as relative to non-modified comparators:

- BioHeuris, modified cotton and modified soybean for herbicide resistance.
- PlantArcBio, modified soybean for herbicide resistance.
- Bayer Crop Science, modified corn for herbicide resistance.

APHIS found these modified plants were unlikely to pose an increased plant pest risk compared to other cultivated plants. As a result, they are not subject to regulation under 7 CFR part 340. From a plant pest risk perspective, these modified plants may be safely grown and bred in the United States.

https://www.aphis.usda.gov/aphis/newsroom/stakeholder-info/sa_by_date/sa-2023/rsr-responses

Pairwise Introduces Conscious™ Greens into U.S. Restaurants

Durham, N.C. – May 16, 2023 – Pairwise, a pioneering food startup, announced today the launch of its inaugural product, Conscious™ Greens, under its Conscious Foods brand. The product is the first food introduced in the U.S. that was developed with CRISPR technology. Conscious Greens Purple Power Baby Greens Blend, which will be co-branded with Performance Food Group's Peak Fresh Produce® brand, is a mix of colorful Superfood leafy greens with a unique, fresh flavor and up to double the nutrition of romaine.*

ISAAA Inc.

GENE EDITING SUPPLEMENT

A biweekly update on genome editing research, regulations, and impact produced by ISAAA Inc.

Nine Gene-edited Berries from Pairwise Receive USDA Confirmations

January 31, 2024

The new nine exemptions bring the total number of Pairwise's confirmed trait exemptions for berries to 19, which include seedless, thornless, and higher-yielding traits in blackberry and black raspberry. The company's total number of confirmed exemptions is now 21, which it achieved in 15 months.

According to USDA, plants with edits that meet the requirements for these exemptions are "achievable by conventional breeding." The berry exemptions are part of a larger batch from the USDA, signifying the breadth and depth of the application of CRISPR and other gene editing techniques to both increase biodiversity and deliver new varieties of crops based on meaningful traits.

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Biotech Updates

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Biotech Updates (March 6, 2024)

Read the latest:

Biotech Updates (March 6, 2024)

Gene Editing Supplement (February 28, 2024)

Gene Drive Supplement (February 22, 2023)

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https://www.isaaa.org/kc/cropbiotechupdate/default.asp

Benefits for Sustainability

Yield is the denominator in most sustainability metrics

Goal is to improve yield and quality while using inputs more efficiently (water, nutrient, etc.)

Can lead to reduce pesticide use through improved host plant resistance

Results in a more resilient crop that provides enhanced nutritional quality through oil and protein as well as fiber

Comment | Published: 07 April 2022

Genome-edited crops for improved food security of smallholder farmers

Kevin V. Pixley, Jose B. Falck-Zepeda, Robert L. Paarlberg, Peter W. B. Phillips, Inez H. Slamet-Loedin, Kanwarpal S. Dhugga, Hugo Campos & Neal Gutterson

Nature Genetics **54**, 364–367 (2022) | Cite this article

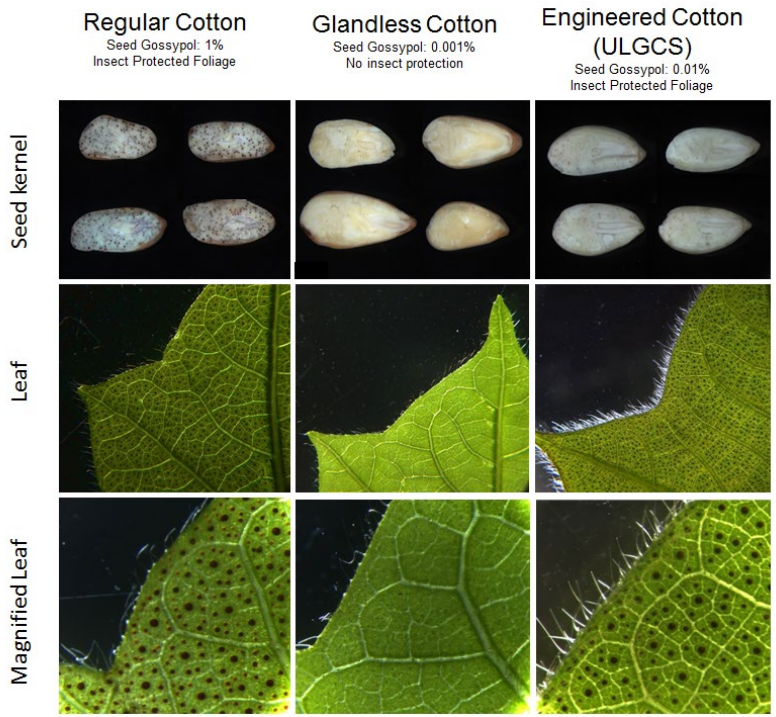
Widespread enthusiasm about potential contributions of genome-edited crops to address climate change, food security, nutrition and health, environmental sustainability and diversification of agriculture is dampened by concerns about the associated risks. Analysis of the top seven risks of genome-edited crops finds that the scientific risks are comparable to those of accepted, past and current breeding methods, but failure to address regulatory, legal and trade framework, and the granting of social license, squanders the potential benefits.

CRITICAL REVIEWS IN PLANT SCIENCES
2020, VOL. 39, NO. 1, 1–29
https://doi.org/10.1080/07352689.2020.1724433

Taylor & Francis
Taylor & Francis Group

Ultra-Low Gossypol Cottonseed: Selective Gene Silencing Opens Up a Vast Resource of Plant-Based Protein to Improve Human Nutrition

Keerti S. Rathore[a,b], Devendra Pandeya[a], LeAnne M. Campbell[a], Thomas C. Wedegaertner[c], Lorraine Puckhaber[d], Robert D. Stipanovic[d], J. Scott Thenell[e], Steve Hague[b], and Kater Hake[c]



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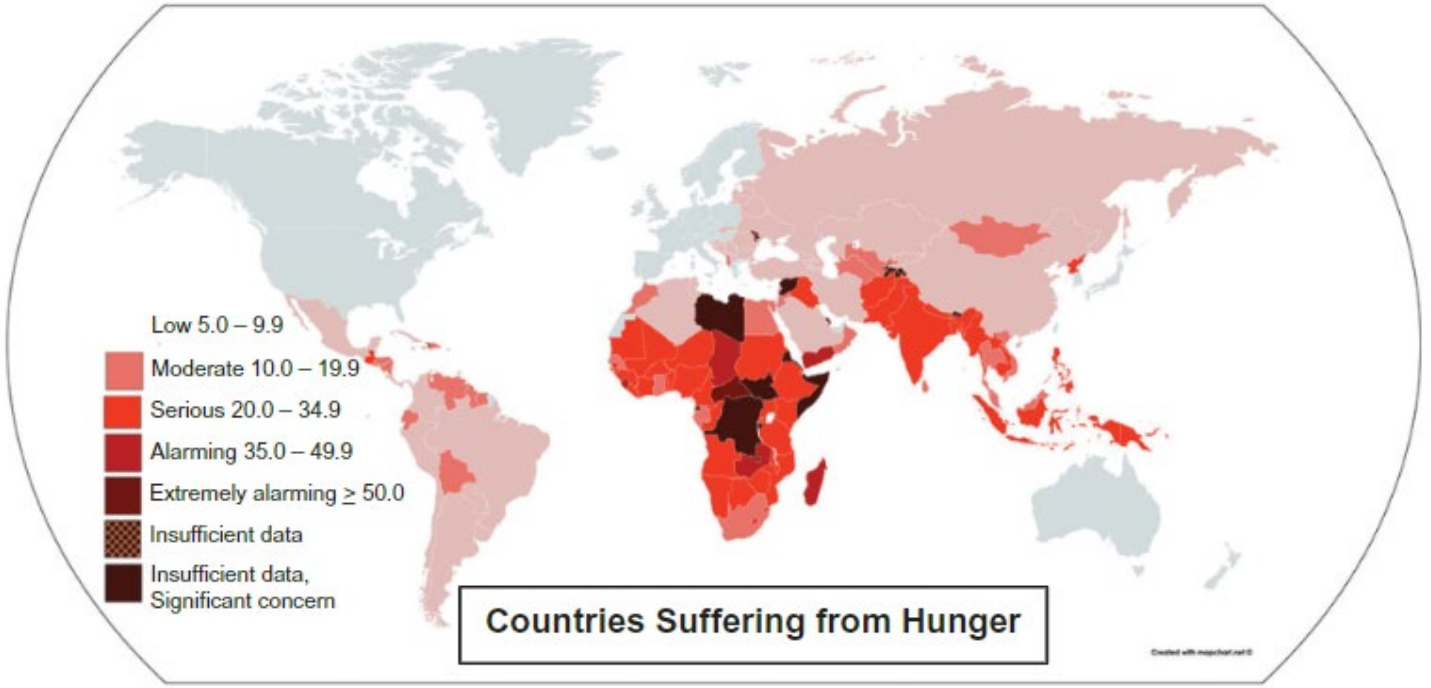

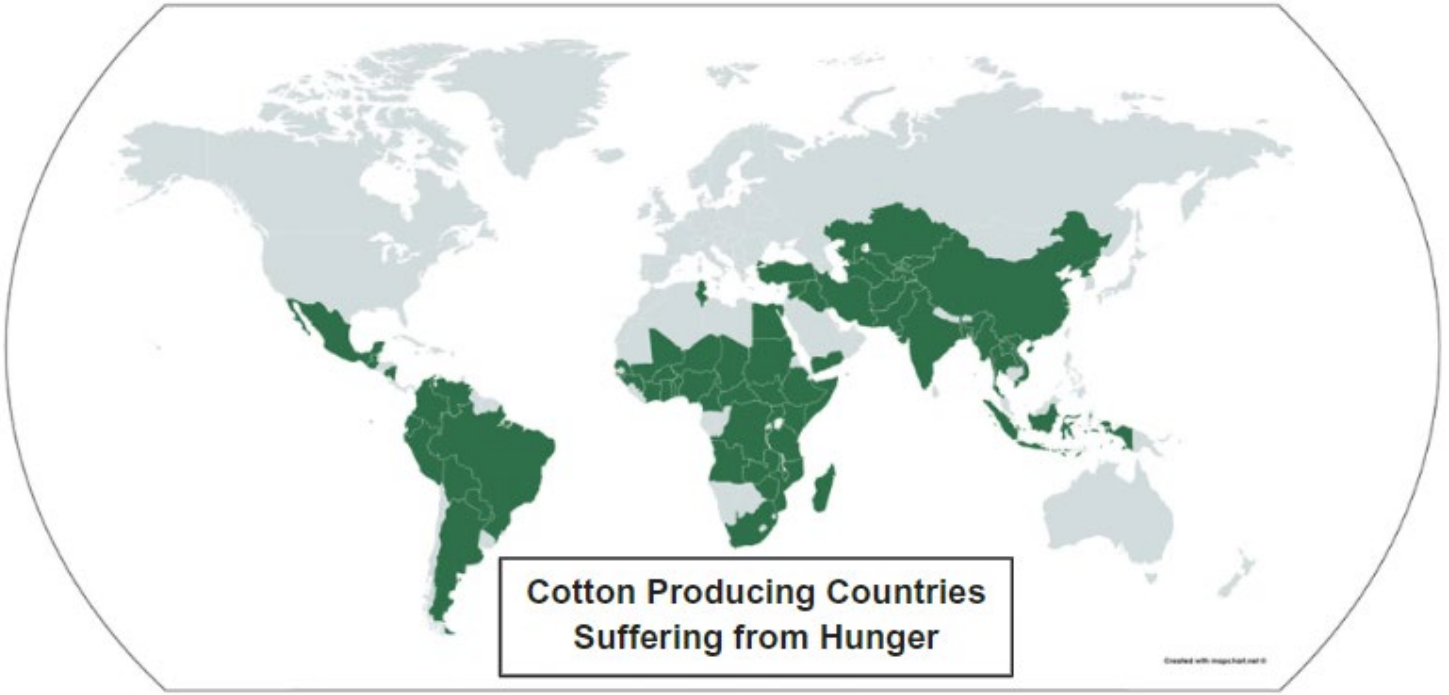

Ultra-low Gossypol Contact:
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2020, VOL. 39, NO. 1, 1–29
https://doi.org/10.1080/07352689.2020.1724433

Thank You