Agricultural biotechnology for food and climate security

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Connecting ag biotech to sustainability, climate resilience, and food security

- Refresher: broadly understand old and new biotech capabilities
- Innovations
 - Climate resilience
 - Food security
 - Managing soil health and fertilizer replacements
 - Novel foods/novel production methods
 - Biobased products
- Looking ahead: new research, products, and developers
- Policy environment



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Ag biotech crops are grown around the world



Refresher: Why do we use biotechnology?







Adapted from:

https://www.apsnet.org/edcenter/disimpactmngmnt/labexe rcises/PlantBiotechnology/Article%20Images/fig37.jpg

Icons from Biorender.com

Why were commodity crops early targets for genetic engineering?





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Seeing is believing: tolerance and resistance trait efficacy easily observed



Wayne Parrot, UGA, <u>http://parrottlab.uga.edu/SIVB/HTML/DSC_4609.html</u> https://creativecommons.org/licenses/by-nc-nd/3.0/deed.en_US



Anderson, J.A., 2019, https://www.frontiersin.org/articles/10.3389/fbioe.2 019.00024/full

Older GE tech: useful traits but lower precision

- Transgenic organisms contain a gene(s) from another species (*e.g.* Bt) introduced by genetic engineering
- Older tools/techniques imprecise
- Transgene insertion requires several generations of backcrossing to get final product

Scientific advances set up future success

Latest

The Atlantic

SCIENCE

Scientists Finally Crack Wheat's Absurdly Complex Genome

Their efforts will make it much easier to breed new varieties of the world's most important crop.

By Ed Yong

https://www.theatlantic.com/science/archive/2018/08/wheatgenome-is-best-thing-since-sliced-bread/567673/

2018

New technology: beyond transgenics

• Whole genome sequences are critical

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- New tools can make more precise edits in targeted locations...small changes can have big effects
 - **CRISPR**, TALENS, Site Directed Nucleases
- But new tools can also be used to introduce transgenes
- Genome editing often refers to a specific subset of genetic engineering

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Classical and new traits can contribute to climate goals and food security



Pest resistance



Herbicide tolerance



Non-browning



Increased shelf life



Same feed, more mass



Heat-tolerance

Climate resilience: HB4 drought tolerant wheat



Watson G., 2020, HB4 White paper https://s26.q4cdn.com/783252186/files/doc_presentations /2020/08/White-Paper-Aug-2020.pdf

- Increases yield by 20% and CO2 sequestration by 7% during growth seasons affected by drought.
- Regulatory decisions around the world allowing cultivation or use as food/feed

Food security: Bt Cowpea

- Developed by African scientists, local food staple
- Approved for cultivation, food, feed in Nigeria
- Higher yield
- Reduced crop loss
- Reduced pesticide spraying



https://allianceforscience.cornell.edu/blog/2019/12/nigeria-clears-bt-cowpea-for-farmers-use/

Managing soil health reduces climate impacts: CoverCress

- Pennycress plant, genome-edited for oil production and covercrop capabilities
- Serves as oilcrop for food, feed and fuel
- Growth between corn and soy rotations
- Maintains soil water, nutrients
- Reduces need for fertilizer
- Developed via public-private partnership



CoverCress in April, https://www.covercress.com/threecrops2years.php

Environmental release of microbes: wildtype and GE

- Uses
 - Pest control
 - Biostimulant
 - Replace synthetic fertilizer
- Regulations for GE/edited
 - Some countries have in place
 - Many still drafting
 - USDA drafting guidance



Fertilizer, ag biotech, and climate change



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- Environmental impacts
 - Methane required
 - GHG emissions during production
 - Runoff into deadzones
- Supply chain disruptions
- Biotech and non-biotech options can support better crop production

N2

Microbial plant biostimulants: future fertilizer substitute

N2

N2

Novel food/production: Microbially derived chymosin to make cheese

- Chymosin is an enzyme that curdles milk
- Required for cheese production
- Historically derived from calf stomachs
- Now 90-99% from GE yeast



Novel food/production: GE microbes combating climate change

• Whey protein without the cow



• Palm oil similar without the palms







Novel food production: Who are some of the players and what is the value?

IMPOSSIBLE Global enzyme market for food and beverage use estimated at \$2.3billion BASF We create chemistry (Deckers, M., *et al*, Foods 2020) BAYER Zero Cow Factory **Perfect Day** Eden *TurtleTree* Abbott **Nourish Ingredients GINKGO** BIOWORKS" novozymes*** DELICIOUSLY Z zymergen ANIMAL-FREE **Rethinking Dairy**

DAIRY

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GE crops in biobased products: substituting non-renewable with renewable sources



U.S. Botanical Garden

https://www. usbg.gov/ex hibits

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Future products: recalling 2023 Early Career Researcher Symposium



Erwin Arcillas (The Philippines)- increased Zn content in rice for improved nutrition



Christina Gregg (Australia)- improved nitrogen fixation in plants to reduce fertilizer use



Panaya Kotchaplai (Thailand)- engineered microbes to turn biomass into vanillin

Future products: recalling 2023 Early Career Researcher Symposium- developers



Bernard Pollack- editing fruit trees for sustainable future at Meristem Bio in Chile



Shimpei Takeshitaimproving nutrition in produce at Sanatech Seed in Japan



Rebecca Catlettreducing food loss and waste at Okanagan Specialty Fruits in Canada

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From lab to market: enabling environments required



Are genome-edited products "GMOs"?

All biotech are "GMOs"



Use of a template



Conv breeding/foreign DNA



The old global regulatory paradigm:



The new global paradigm?



Creating enabling environments for ag biotech

- Prevent or remove *barriers to* the international use and *trade* of products of agricultural biotechnologies.
- Facilitate *global acceptance* of agricultural biotechnology in support of APEC objectives.
- Enhance economies' capacity for *science-based decision-making* and participation in international trade.
- Support global *dialogue and diplomacy* related to agricultural biotechnology to improve awareness, build relationships, and inform decision-making.



Thanks!

