CAST

APPLICATIONS, BENEFITS, AND CHALLENGES OF GENOME EDITED CROPS

Applications, Benefits, and Challenges of Genome Edited Crops

Presented by
Sarah Evanega

Date:
April 3, 2024

CAST Quick Facts

- 501(c)3 membership-supported nonprofit
- Formed in 1972 as a result of 1970 National Academy of Sciences Report
- Nonpartisan and apolitical
- Membership includes 27 scientific societies; 20 universities; 19 libraries; 45 nonprofits; 21 companies; and over 500 individuals from 46 states and 7 countries
- Celebrated its 50th anniversary in 2022

CAST®

The Science Source for Food, Agricultural, and Environmental Issues

Mission

CAST convenes and coordinates networks of experts to assemble, interpret, and communicate credible, unbiased, science-based information to policymakers, the media, the private sector, and the public.

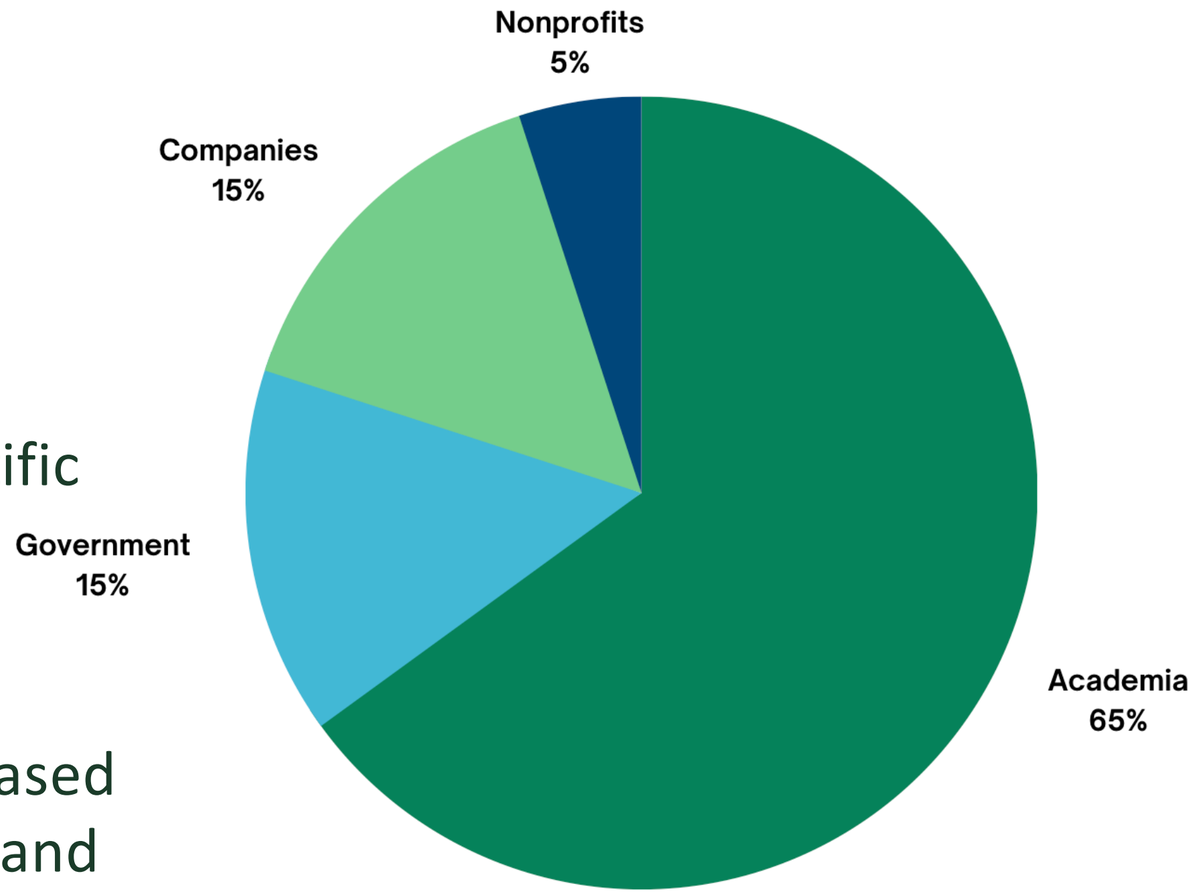
Vision

A world where decision making related to agriculture, food, and natural resources is based on credible information developed through reason, science, and consensus building.

How CAST Accomplishes Its Mission

With the help of many volunteer contributors:

- 65 Board Members representing scientific societies, companies, nonprofits, and universities
- Nearly 200 active task force members working on CAST reports yet to be released
- Volunteer scientific experts as authors and reviewers—more than 1800 volunteers since 2008



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Why now?

- Project was launched at 5-year anniversary of first CAST paper
- Ten years since CRISPR-Cas system was described
- New tools and capabilities
- First products have reached commercialization
- A rapidly changing regulatory landscape
- New consumer trends


CAST Issue Paper
Number 60
July 2018

Genome Editing in Agriculture: Methods, Applications, and Governance

A paper in the series on
The Need for Agricultural Innovation to Sustainably Feed the World by 2050


CAST Issue Paper
Number 74
March 2024

Applications, Benefits, and Challenges of Genome Edited Crops

Abstract

The tools of genome editing were described more than a decade ago as promising ways to accelerate crop improvement in addition to applications for human and animal health. Now, a decade later, we are seeing applications of genome editing across a range of different crops and trait combinations that will bring benefits to producers and consumers. Countries around the world are actively engaged in updating regulatory frameworks to govern this new technology adequately. In this paper, we describe recent advances in genome editing tools, review select applications underway, consider the benefits of the technology, and offer a perspective on significant

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Genome Edited Crops

Applications

- Tool advances enabling greater capabilities
- Applications in the public sector and in LMICs
- Agronomic & consumer traits & end-use quality traits

Benefits

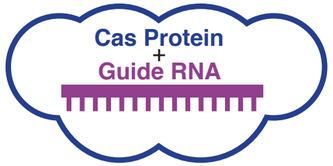
- Environmental
- Social
- Economic
- Increasing variation
- Adds value to unadapted germplasm

Challenges

- Consumer acceptance
- Governance
- Global regulatory alignment

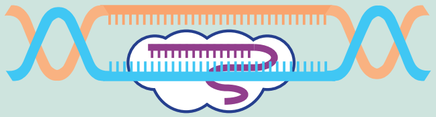
Applications: Three examples of commonly pursued CRISPR approaches

1 A CRISPR complex is comprised of a Cas protein and a guide sequence that is programmed to recognize a specific site. Cas9 is the most common, but different Cas proteins offer different potential outcomes.

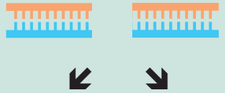


Nuclease-based Editing Systems

2 Cas nuclease directed to genomic location with guide sequence.



3 Double-strand break.

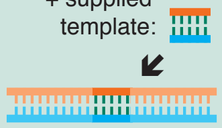


4

Cellular repair:

Small InDel changes at break point.

Cellular repair + supplied template:

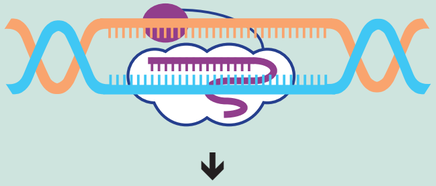


Incorporation of template sequence at break point.

Base Editing Systems

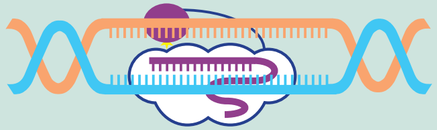
2 Fully or partially deactivated (nicking) Cas enzyme linked with a base editing domain is directed to the genomic location with guide sequence.

base editing domain



3 Modification of target base.

base editing domain



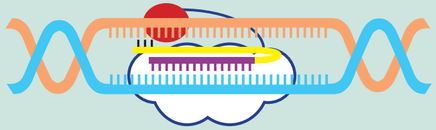
4 Cellular repair:

Conversion of target base.

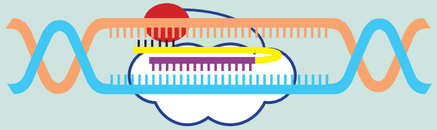
Templated Editing Systems

2 Active or partially deactivated Cas enzyme linked to a polymerization domain is directed to genomic location with guide sequence that contains desired edit as a template.

polymerization domain



3 Synthesis of template.



4 Cellular repair:

Incorporation of desired edit sequence into genomic target.

Applications: Examples of successful product development through genome editing

Calyno High Oleic Soybean Oil by Calyxt (TALENS)

Waxy Corn by Corteva (CRISPR)

Sicilian Rouge High Gaba Tomato from Sanatech Seeds (CRISPR)

Conscious Greens from Pairwise (CRISPR)

Diversity of applications underway, globally

‘‘It is urgent to close the yield gap in staple crops and enhance food production to feed the world. The application of genome editing can improve agricultural productivity, thus boosting food security.”
-Dr. Leena Tripathi

IITA
Transforming African Agriculture

CGIAR

Benefits

Environmental

Climate adaptation and reducing ag footprint

- Disease–resistant crops with reduced pesticide use
- Increase abiotic stress tolerance including salinity and drought
- Benefits of sustainable intensification
- Reduced post-harvest loss and food waste

Economic

Economic gains through yield increases and scale

- Genome editing is being used to develop a wheat variety that produces up to 30% more grain than current commercial varieties and in corn a 20% increase in the number of kernel rows
- Protecting crop yield through disease resistance

Social

Addressing nutritional insecurity and dietary challenges

- By improving the nutritional quality of crops by increasing levels of vitamins and micronutrients, eliminating toxicants, or introducing beneficial compounds
- Improvements in fruits and vegetables to make healthy eating more convenient

Delivering benefits to consumers

Several independent studies suggest US consumers don't know much about genome editing but when they learn more about benefits, the majority feel positive about it.[1,2]

US consumers are especially excited about the role of genome editing in[1]:

- Making food more nutritious
- Reducing pesticide use
- Reducing water use

Sources: [1]Alliance for Science, 2022 , https://bit.ly/3Qfto2l, [2] FMI, 2020,

Challenges

Consumer Acceptance

The first few such products are just starting to enter markets.

- Public perceptions of genome editing in agriculture will be strongly conditioned on how and what actual products are deployed within food systems.

- Consumers are embracing of food tech that will offer personal nutrition benefits or environmental sustainability benefits.
- Conscious Greens well received in consumer activation events

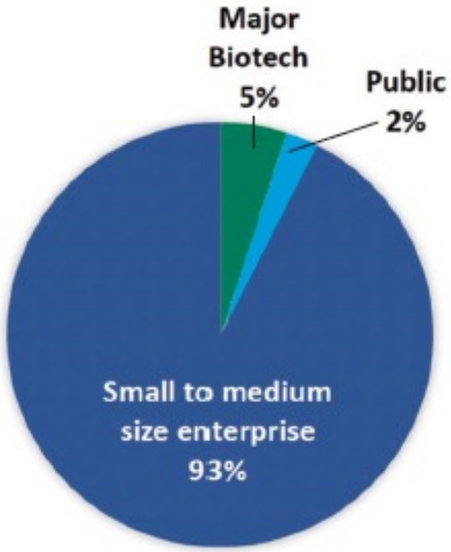
Governance

Lack of global harmonization has slowed the commercialization of crops developed with genome editing.

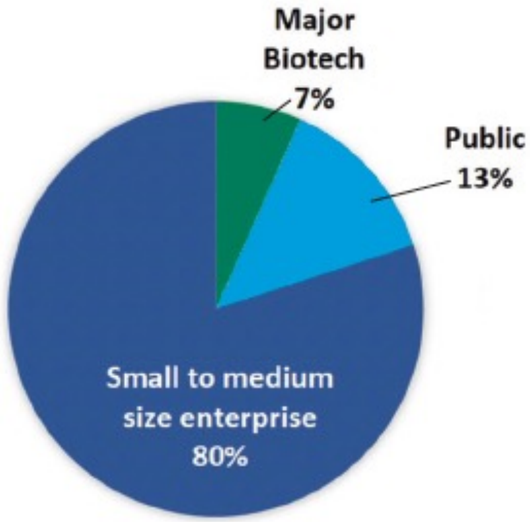
- Base regulatory outcomes on product outcomes, not on the process or technology used.
- Many frameworks distinguish genome edited crops from transgenics.
- In the European Union regulations regarding genome edit plants are under revision

The current regulatory environment in the US is poised to support innovation by more diverse technology developers

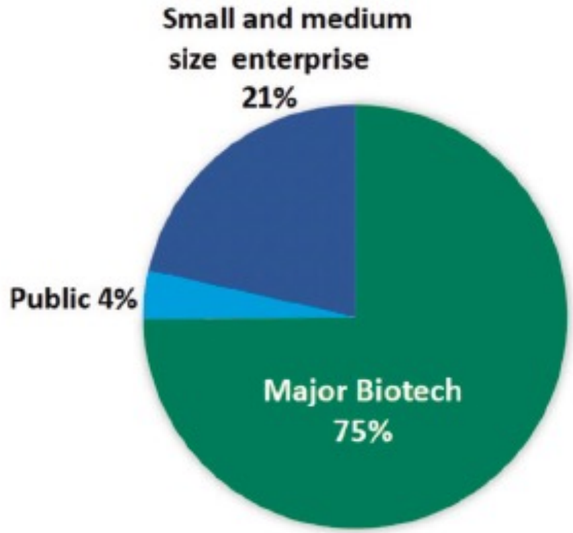
REVISED REGULATIONS
FY23 COMPLETED
CONFIRMATION REQUESTS



REVISED REGULATIONS
FY23 COMPLETED
REGULATORY STATUS REVIEWS



LEGACY REGULATIONS
COMPLETED PETITIONS



Small to medium size enterprise is defined as a business with no more than 250 employees and $1B in annual revenue.

Based on data presented at the United States Department of Agriculture (USDA), Biotechnology Regulatory Services Annual Stakeholder Meeting, Nov 15, 2023, https://www.aphis.usda.gov/brs/pdf/2023-stakeholder-meeting.pdf

5 Recommendations to ensure societal benefits

1. Public investment in R&D and specialty crops

Increase public investments that incentivize R&D in specialty and minor use crops, identifying areas of genetic vulnerability of these crops to extend applications beyond the major commodity crops and agronomic traits that will be served by the private sector

2. Invest in basic trait discovery

Increase public investments in genomics, trait discovery, and the understanding of the genetics that inform those desirable traits to ensure applications that translate into products that serve and benefit society

3. Incentivize start-ups and SMEs

Create incentives for start-up companies using new breeding tools to develop products that address consumer demands

4. Incentivize positive environmental impacts

Create incentives for developing products that have a significant positive environmental impact, especially in large acre crops that confer big scaling opportunities.

5. An enabling regulatory environment

Ensure a clearer, transparent, predictable, product-based coordinated regulatory system in the United States that does not discriminate against specialty crops and minor use applications

Realizing the future of crop improvement with genome editing

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Thank you

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