Seed Congress of the Americas

SAA Seed Association of the Americas

Genome editing

Uses, benefits & opportunities: An introduction to the topic

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Executive Director
ChileBio

- ✓ **CHILEBIO STANDS FOR** THE ENTITY RESPONSIBLE TO PROMOTE AND SUPPORT **AGBIOTECH** IN CHILE
- ✓ **PURPOSE:** COMMUNICATE THE NEED FOR **SCIENCE** IN THE **AGRICULTURE** OF THE FUTURE
- ✓ **ADVOCACY AND OUTREACH** ARE THE FOUNDATIONS OF CHILEBIO **STRATEGY**

- ✓ IN A CONTEXT OF MISPERCEPTION ABOUT AGBIOTECH AND PLANT BREEDING, CHILEBIO INTENDS TO SERVE AS A **BEACON IN THE DARK** FOR DIFFERENT AUDIENCES
- ✓ MORE THAN 12 YEARS **COMMUNICATING SCIENCE** AND **PROMOTING INNOVATION** IN AGRICULTURE

Every year we conduct:

- ✓>50 talks, lectures, seminars
- ✓>80 appearances on press media
- ✓High-impact scientific articles
- ✓Book chapters
- ✓Strong community on social networks

55K
11K
10K
2K
YouTube 3.8K

Challenges for a sustainable agriculture

- Increase food production for a growing population considering a less availability of arable lands
- Be more friendly to the environment and reduce deforestation
- Reduce crop losses from pests, weeds, diseases, and climate crisis
- Reduce food waste
- Increase the nutritional content and food safety
- Ensure farmers welfare

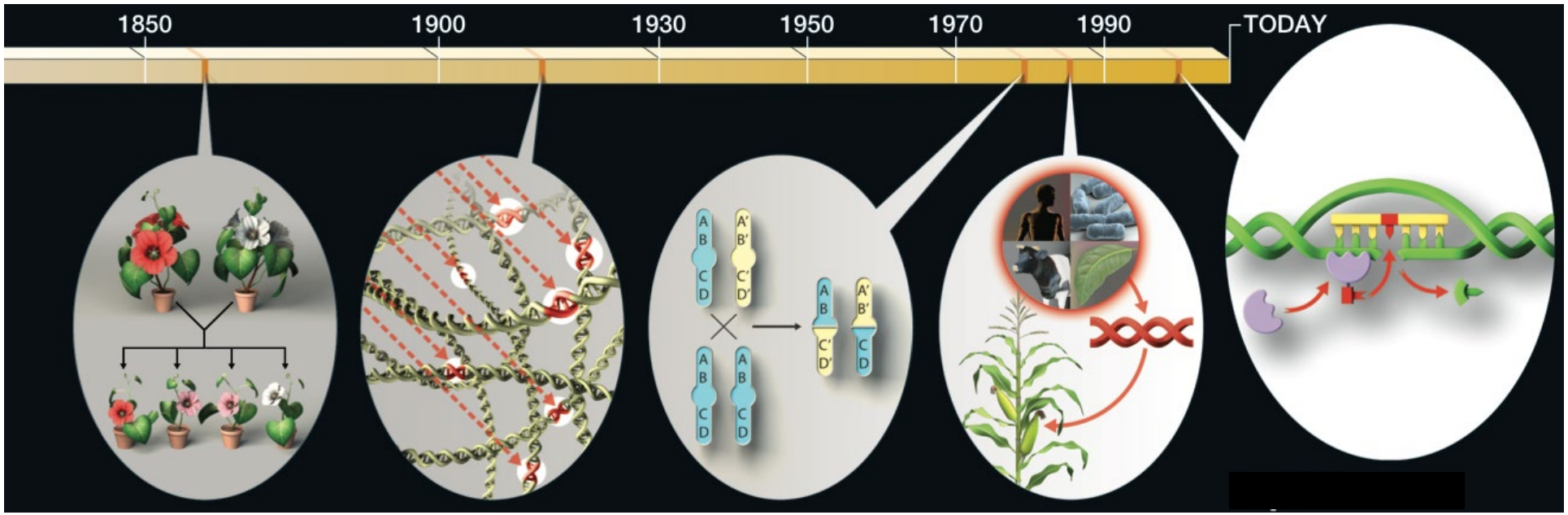
✓ Reconciling sustainability with agricultural productivity in the face of climate change relies strongly on the development of resilient, high-yielding crops of superior nutritional value that can be grown more resource efficiently.

Innovation in plant breeding has gained unprecedented importance

- ✓ *Plant breeders are continuously integrating the latest methods in plant biology and genetics into their breeding toolbox to more efficiently use existing diversity but also to induce new genetic variation.*

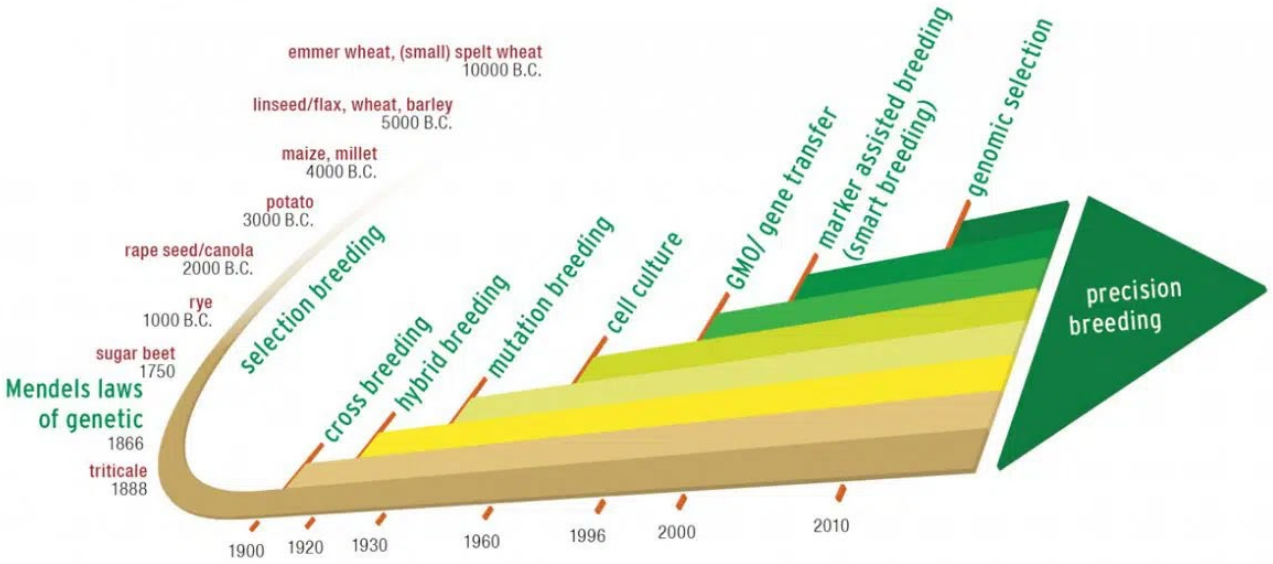
- ✓ *Over the past years, ever more precise and efficient plant breeding methods have been developed.*

CONVENTIONAL TECHNIQUES | **BIOTECH TECHNIQUES**



CROSS-BREEDING | **MUTAGENESIS** | **MOLECULAR MARKER-ASSISTED SELECTION** | **GMOs (Transgenics, Cisgenics, RNAi)** | **GENOME EDITING**

Innovation in plant breeding has gained unprecedented importance

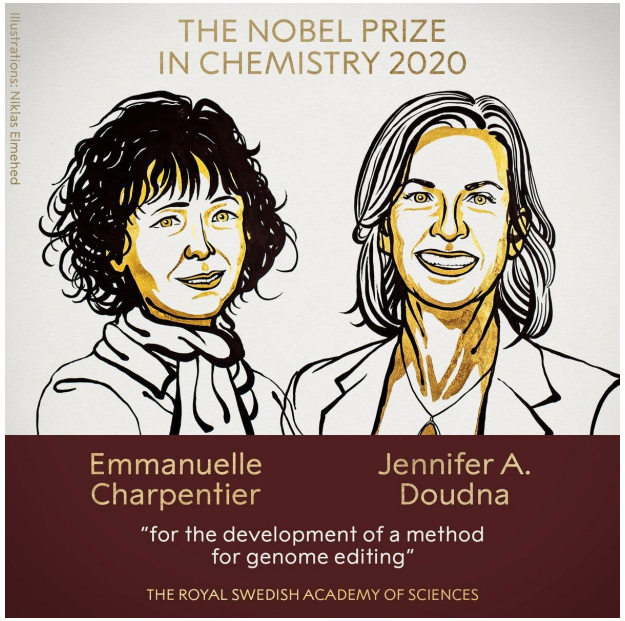


- ✓ This plant breeding innovation leap is based on an in-depth understanding of plant genomes and refinement of breeding methods, enabling more efficient, more precise and faster progress in achieving the desired breeding goals.
- ✓ These plant breeding innovations are rapidly being developed and utilized internationally and across the seed sector, public and private research, plant species and markets.

Genome editing tools for plant breeding

SDN: Site-Directed Nucleases

- EMN — Manipulation of mega nucleases seemed difficult
- ZFNs — Manipulate applied and basic genomic research
- TALEN — Complex construction
- CRISPR/Cas9 — Simplest, cost-effective, and versatile
- CRISPR/Cpf1 — Potential for both RNA processing and DNA nuclease activity

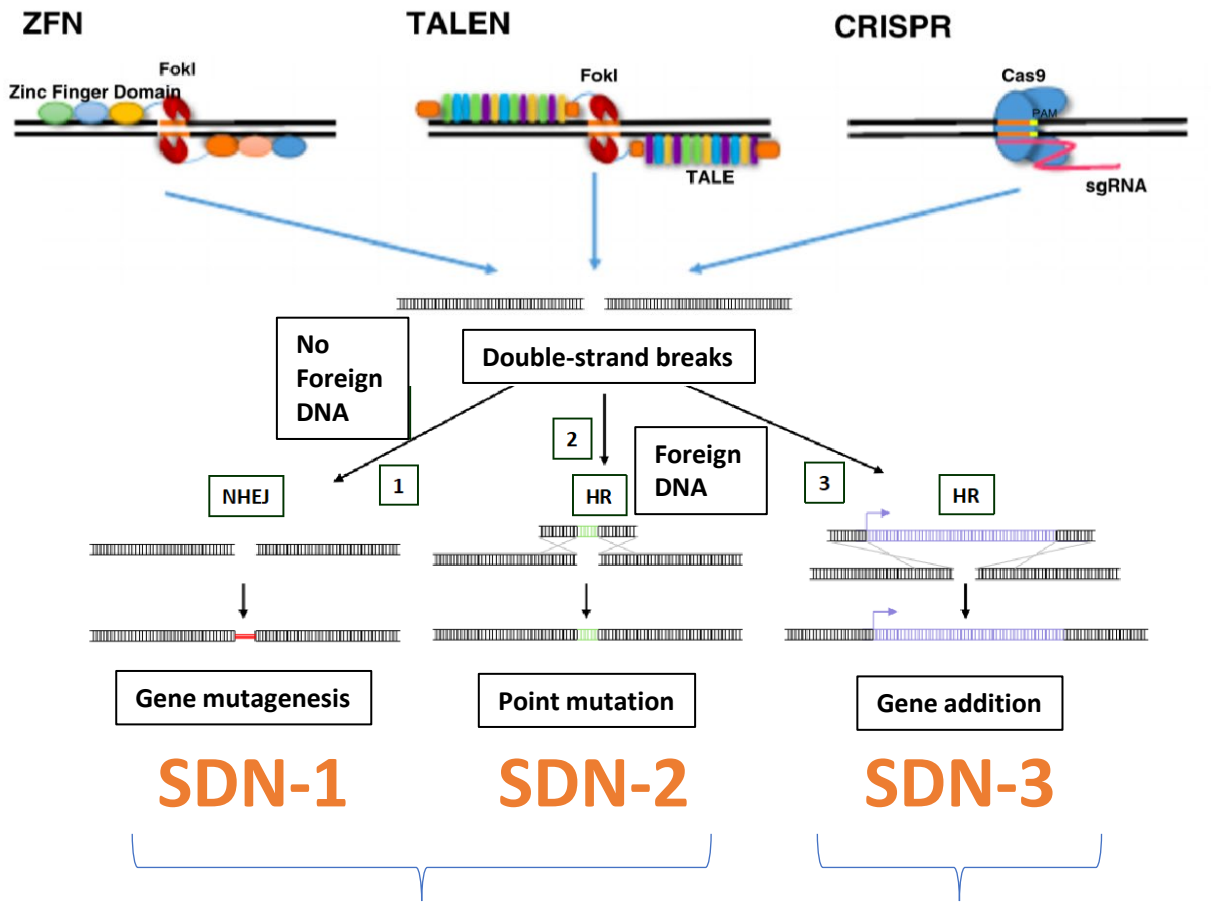


CRISPR, the Genetic Revolution of the 21st Century

- ✓ Easiest design and construction
- ✓ Lowest time for construction
- ✓ Lowest cost of development
- ✓ High efficiency

Genome editing techniques allow to get different types of products

SDN: Site-Directed Nucleases



- ✓ Through genome editing techniques it may or may not involve the transitory introduction of foreign DNA sequences, may or may not result in GMO, and may or may not generate products that substantially differ from varieties bred through conventional breeding.

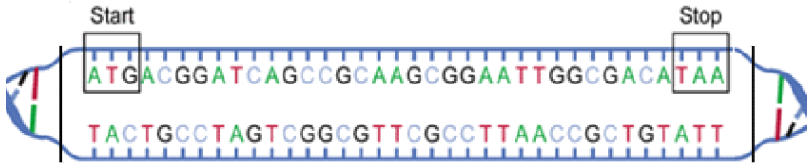
*However, with biotechnology plant breeding gets:

- ✓ accuracy and avoids random
- ✓ no impacts on other traits

Genome editing versus Genetically Modified Organisms

GMO

Transfer gene from another organism

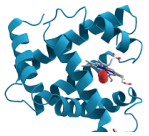


GENE EDITING

X

*"Turn off" a gene
(stop producing a specific protein)

*Change a specific nucleotide
(Modify range of action of a specific protein)



Produce a specific protein

IMPROVE A TRAIT

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Some gene editing companies changing the future of biotech

Clinical diagnosis

MammothBiosciences

SHERLOCK BIOSCIENCES

CASPR BIOTECH

Medicine

Beam THERAPEUTICS

editas MEDICINE

Intellia THERAPEUTICS

exonics THERAPEUTICS

CASEBIA THERAPEUTICS

verve THERAPEUTICS

REFUGE biotech

CARDEA

CRISPR THERAPEUTICS

GENEDIT GENE THERAPY DELIVERED

Nucleases

INSCRIPTA

scribe THERAPEUTICS

hera BioLabs

GRAPHITE BIO

Cell transformation

EMENDO BIOTHERAPEUTICS

LOCUS BIOSCIENCES ENGINEERING PRECISION MEDICINES

SPOTLIGHT THERAPEUTICS

NTrans TECHNOLOGIES

SNIPRBIOME A CRISPR COMPANY

POSEIDA THERAPEUTICS

Ligandal

KSQ Therapeutics

Xenotransplantation

egenesis ENGINEERING LIFE

Microalgae

viridos

Plants

PLANTEDIT DNA-FREE GENOME EDITING

PAIRWISE

CARIBOU BIOSCIENCES

INARI A Flagship Pioneering Company

Yield10 BIOSCIENCE

intrexon better DNA

HUDSON RIVER Biotechnology

Tropic Biosciences

CIBUS

calyxt

Crop protection

AGRAGENE

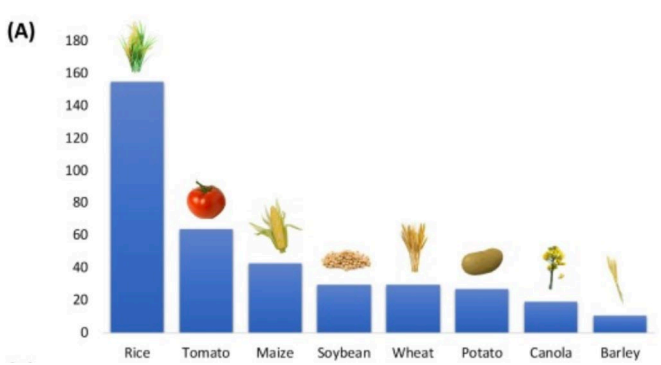
Democratization of technology and wide variety of benefits

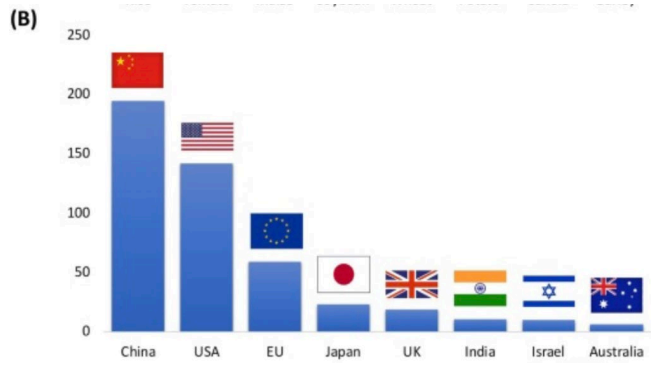
- ✓ Genome-editing technologies are widely accessible and could help democratize the benefits of science.
- ✓ They are relatively inexpensive to implement
- ✓ They are being used to diversify agricultural systems and improve major and minor crops, including so-called orphan crops.
- ✓ They are used by public institutions to develop public goods and to bring the benefits of the technology to smallholder farmers.

Publican base de datos interactiva con más de 500 cultivos editados genéticamente a nivel global

Chilebio / 10 junio, 2022

La Red Europea de Agricultura Sostenible Mediante la Edición del Genoma (EU-SAGE) ha publicado una gran base de datos interactiva sobre cultivos editados. La base de datos muestra que la edición del genoma se utiliza en una gran variedad de cultivos para mejorar diversas características, muchas de las cuales van dirigidas a agricultores y consumidores y pueden contribuir a una agricultura más sostenible.



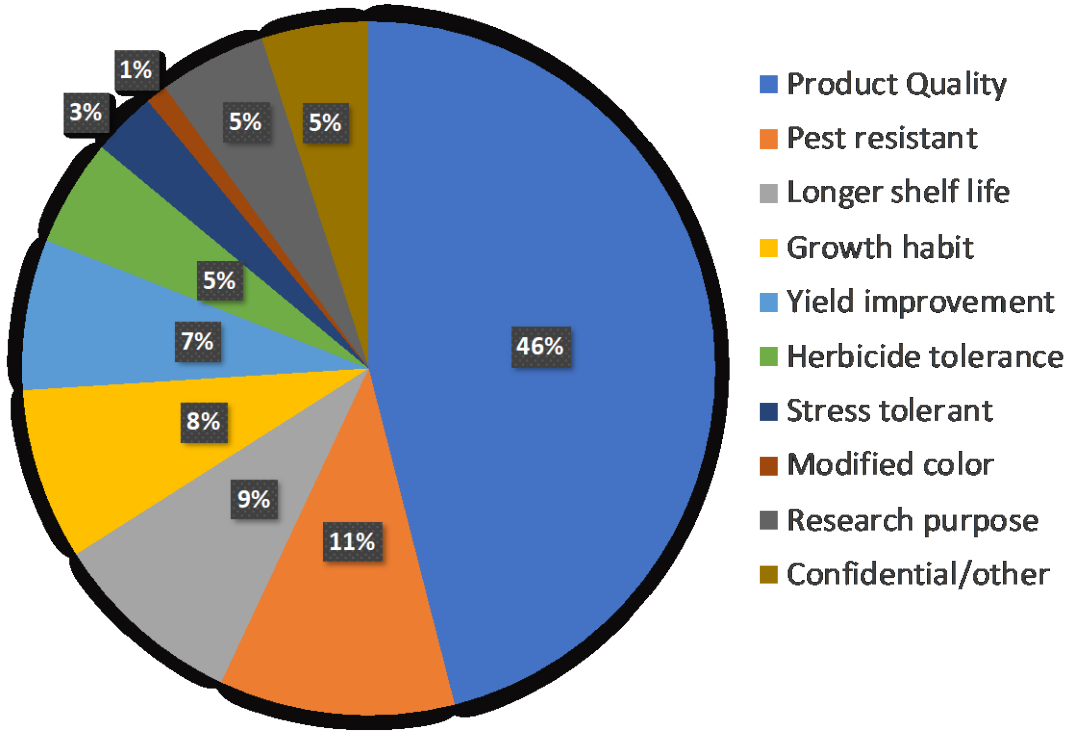


Applications of genome editing in plants

Applications promise benefits for:

- ✓ Consumers: nutritional enhancement, improved food safety and reduced food waste
- ✓ Farmers: resistance to disease, weeds and pests, greater seed affordability due to cheaper seed production, and enhanced climate resilience including tolerance to drought
- ✓ Society: ecosystem services such as increased biodiversity in cropping systems

USDA: Up to 2020, **72 completed opinions** in wide range of crop types including soy, potato, corn, rice, wheat, tomato, avocado, lettuce, strawberry, peas and citrus

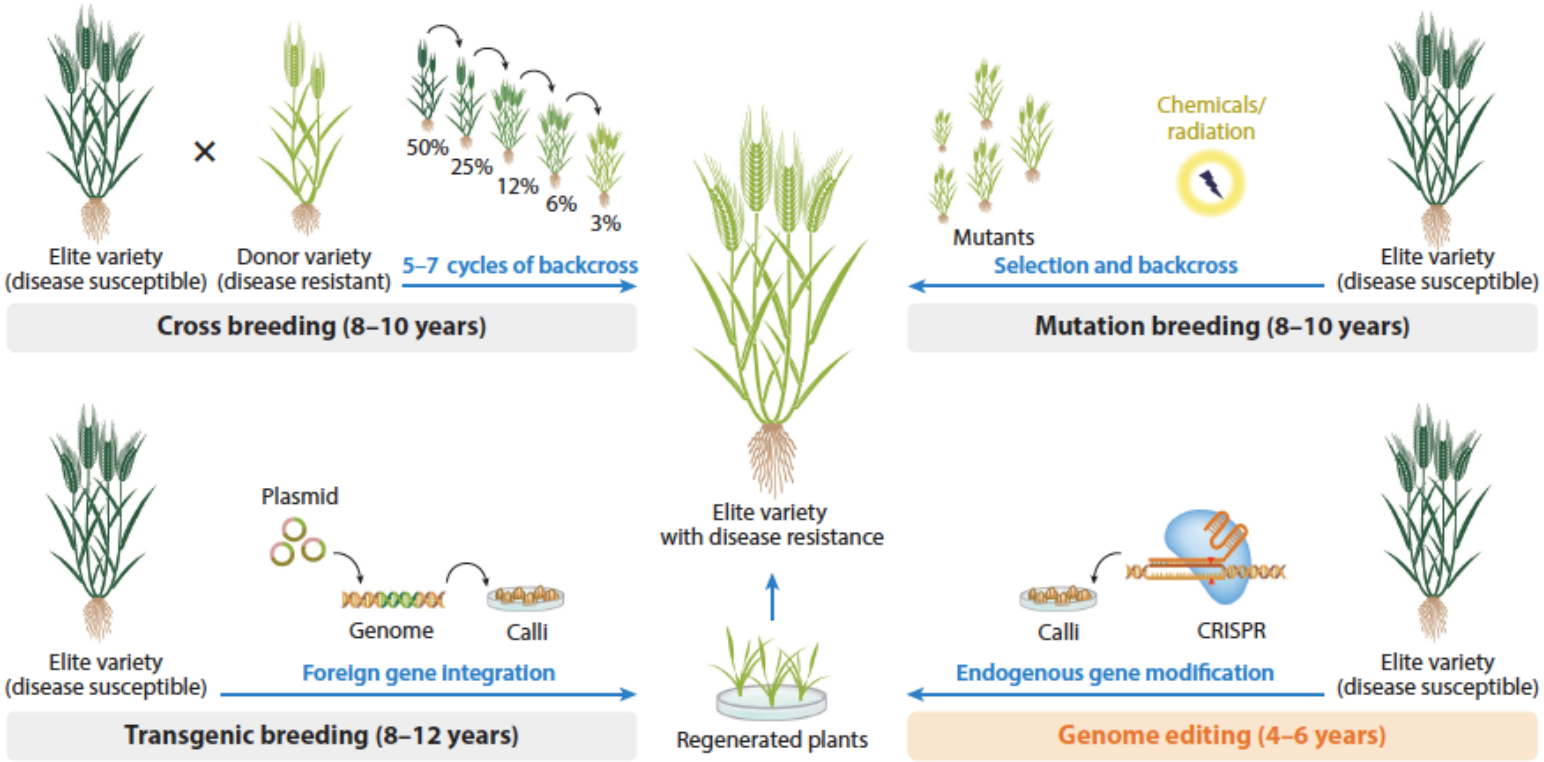


Elaborated from APHIS/USDA (https://www.aphis.usda.gov)

Advantages of using genome editing

- ✓ It can accelerate the delivery of improved varieties. Genes can be edited directly in elite breeding lines or commercial varieties, eliminating the need for backcrossing.

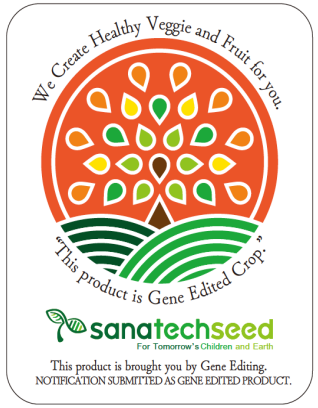
- ✓ This reduces the time needed to develop an improved variety and eliminates linkage drag caused by non-elite residual genes from the donor parent, which are impossible to eliminate by conventional backcross breeding.



Annu. Rev. Plant Biol. 2019. 70:667–97

There are already commercial products obtained by genome editing

- ✓ Tomatoes contain high amounts of γ-aminobutyric acid (GABA), by targeted mutagenesis through CRISPR/Cas9
- ✓ GABA can help prevent high blood pressure.



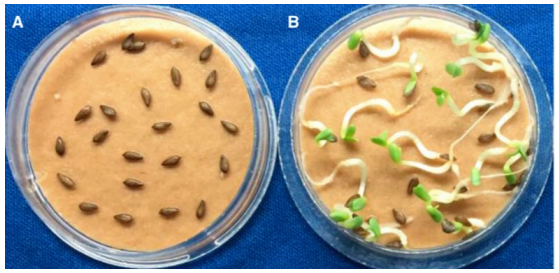
筑波大学
University of Tsukuba

- ✓ Improved soybean oil quality by targeted mutagenesis through TALEN
- ✓ Calyno oil contains approximately 80% oleic acid (ω-9) and up to 20% less saturated fatty acids compared to commodity soybean oil.

calyxt

Examples of products obtained by genome editing not commercialized yet

Lettuce seeds able to germinate at 37°C
CRISPR/Cas9
UC Davies (USA)



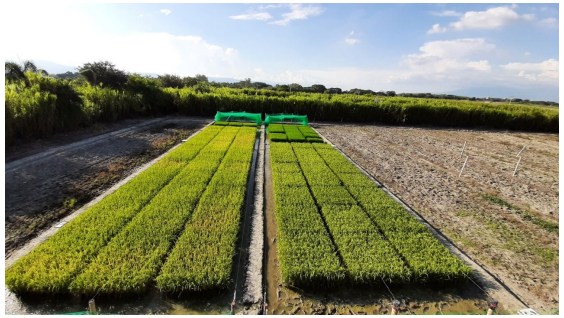
Low-gluten wheat
CRISPR/Cas9
CSIC (Spain)

Fungal-resistant grapes
CRISPR/Cas9
Northwest A&F University and Ministry of Agriculture (China)

Improved quality of blackberries and raspberries
CRISPR/Cas9
Public/private partnership

pairwise · NC STATE UNIVERSITY · USDA · UNIVERSITY OF ARKANSAS

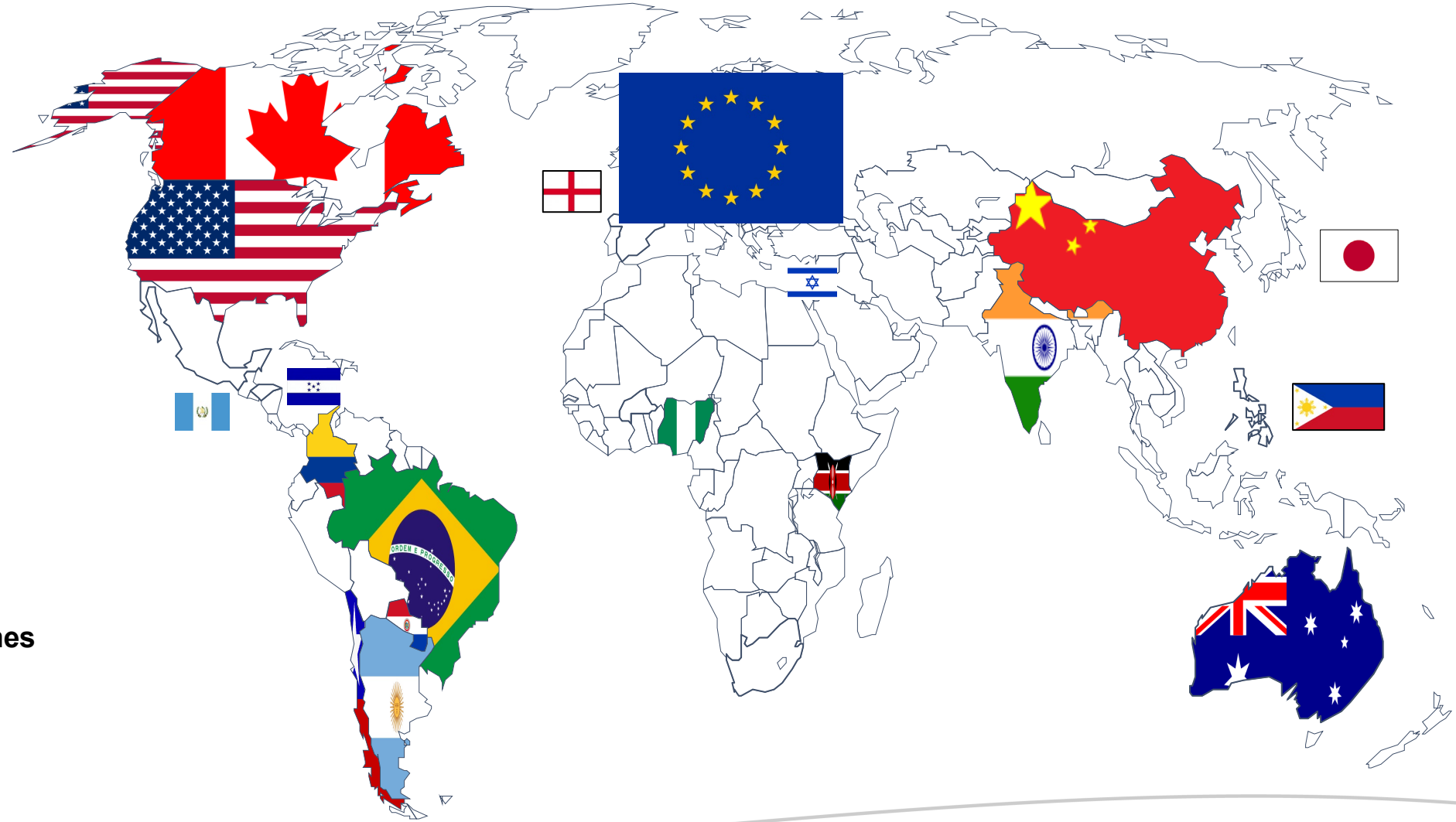
CORNELL UNIVERSITY FOUNDED A.D. 1865 · Plant Sciences · Agriculture and Agri-Food Canada



Disease-resistant rice
CRISPR/Cas9
-University of Missouri
-Donald Danforth Plant Science Center
-University of Florida
-Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) [Colombia]
-Institut de Recherche pour le Développement (IRD) [France]
-International Rice Research Institute (IRRI) [the Philippines]

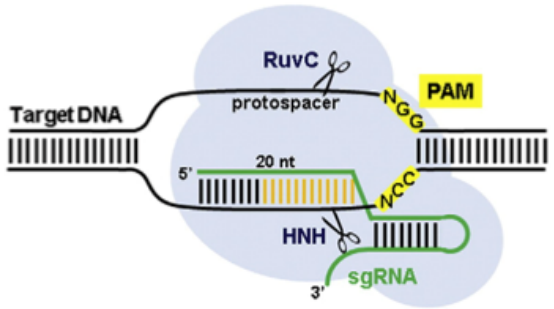
Countries with regulations enabling the use of plant genome editing-derived products

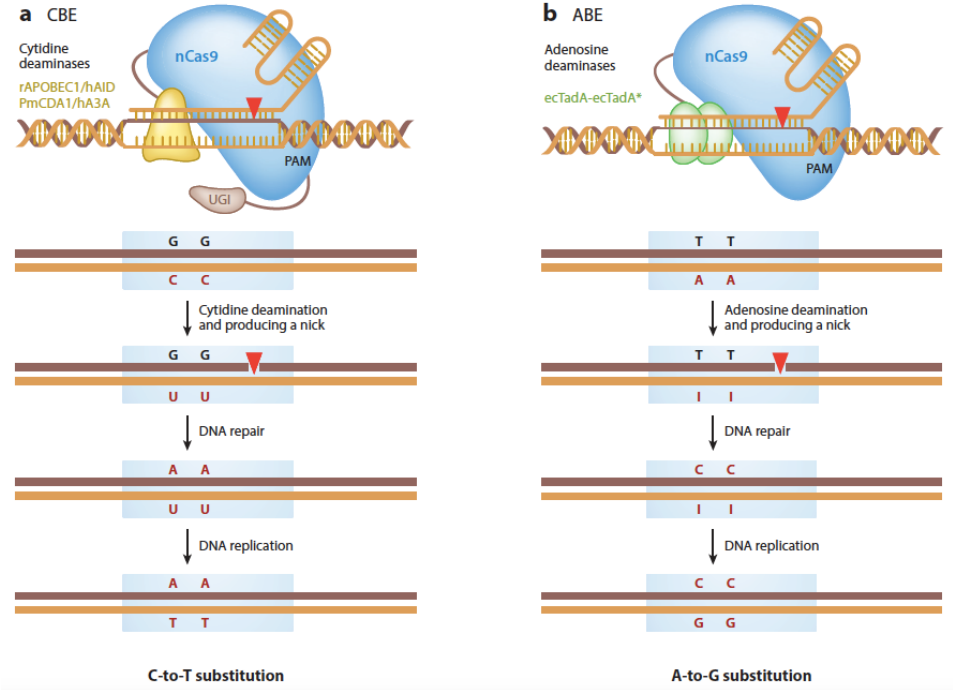
1. Canada
2. USA
3. Guatemala
4. Honduras
5. Colombia
6. Brazil
7. Paraguay
8. Argentina
9. Chile
10. Nigeria
11. Kenia
12. Israel
13. Australia
14. The Phillipines
15. Japan
16. China
17. India
18. England

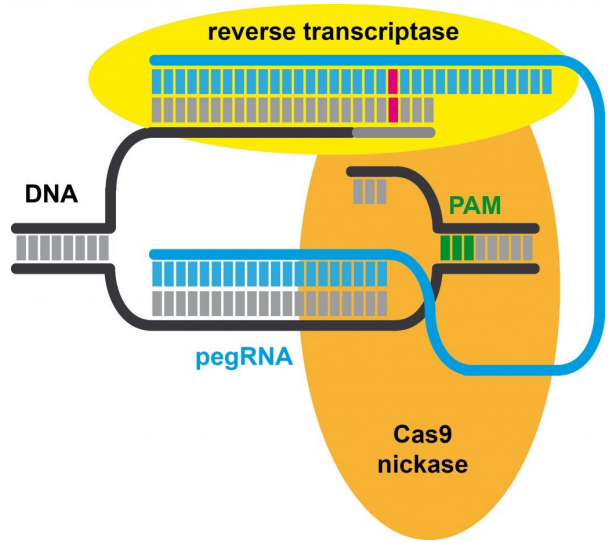


Evolution of genome editing with CRISPR: To the infinity and beyond

CRISPR/Cas9 → **BASE EDITORS** → **PRIME EDITING**

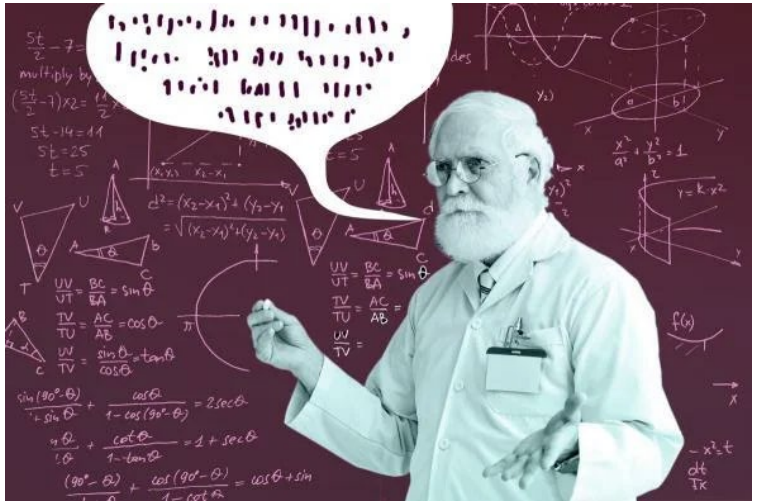






Communication is key to avoid mistakes of the past

- ✓ Precise consistent use of accurate terminology to transparently explain the process, products, benefits and potential risks and mitigation strategies is essential to build public trust and consistent regulatory oversight of technologies, including genome editing.



Conclusions (1 of 2)

- ✓ Plant breeding is key area to boost farm productivity, adapt agriculture to climate crisis and enhance nutritionally foods, by generating genetic variability and new plant varieties.

- ✓ Genome editing is about the targeted and deliberate introduction of genetic variability in a precise way, without impairing other traits, and in time periods considerably shorter than conventional breeding.

- ✓ Among other techniques CRISPR is an essential revolutionary tool for genome editing, in constant evolution, being attractive for plant breeders because of its simplicity, versatility, efficiency, precision, and low costs compared to other tools.

Conclusions (2 of 2)

- ✓ Applications of genome editing in plants promise benefits for consumers, farmers and society
- ✓ Genome-editing technologies are widely accessible and could help democratize the benefits of science.
- ✓ The regulatory approach that countries have adopted on genome editing (non-GMO) could help promote innovation, farming productivity, improve food quality, and strengthen food safety.
- ✓ Effective scientific communication is essential for the acceptance of genome editing in agriculture and food production.

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Thank you!

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