Seed Congress of the Americas

Promoting Seed Business in the Americas

Sept. 30-Oct. 2, 2024
Buenos Aires
Argentina

ChileBio
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From science to markets: The path of gene editing

October 2, 2024

Miguel Sánchez, PhD, MA
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COMMUNICATION IS THE ESSENCE OF OUR WORK

- ✓ **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**

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

Main activities per year:

- ✓>50 talks, lectures, seminars
- ✓Politicians, regulators, academics, physicians, farmers, journalists, consumers
- ✓>100 appearances on press media (content management)
- ✓High-impact scientific articles
- ✓Book chapters
- ✓Strong community on social networks

55 K followers

11 K

11 K

9.5 K

YouTube 4.5 K

CHALLENGES TO 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

*** Unproductive agriculture is not sustainable, and**

agriculture without technology is not sustainable either

✓ Reconciling sustainability with agricultural productivity in the face of climate change relies strongly on developing 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.*

Using genetic engineering:

- ✓ More precise and efficient techniques
- ✓ Genetic changes are known
- ✓ Shorter times
- ✓ Lower costs

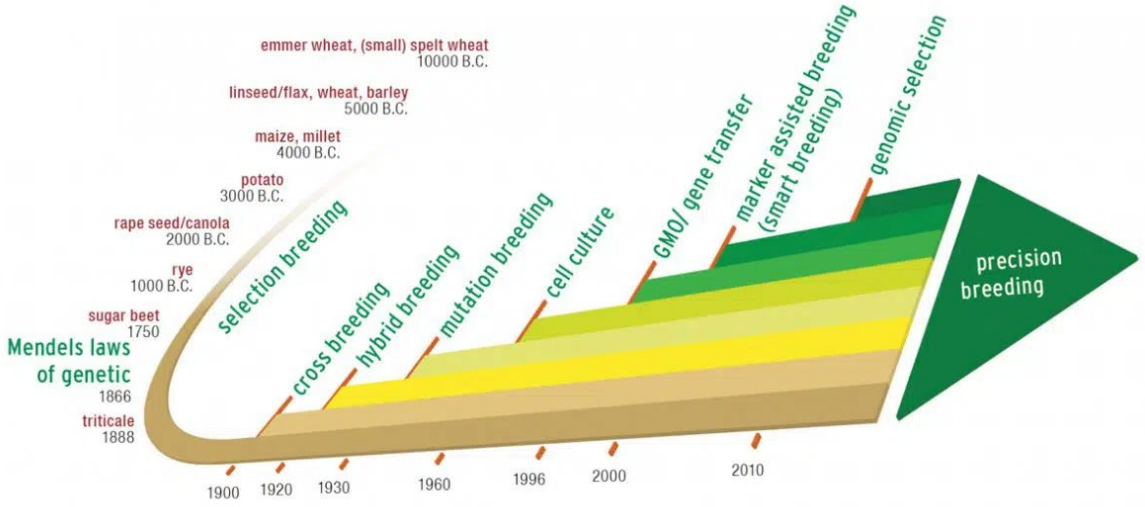
INNOVATION IN PLANT BREEDING HAS GAINED UNPRECEDENTED IMPORTANCE

Review > Trends Plant Sci. 2022 Apr;27(4):391-401. doi: 10.1016/j.tplants.2021.10.006.
Epub 2021 Nov 12.

Twenty years of plant genome sequencing: achievements and challenges

Yanqing Sun [1], Lianguang Shang [2], Qian-Hao Zhu [3], Longjiang Fan [4], Longbiao Guo [5]

Over the past 20 years the sequences of over 1000 plant genomes have been published, representing 788 different species with a high level of diversity.



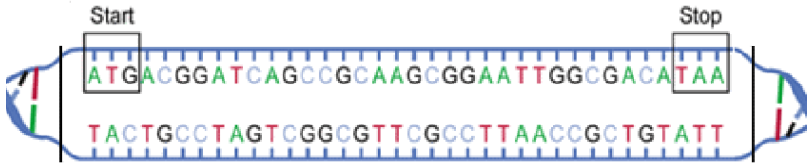
- ✓ This plant breeding innovation leap is based on an in-depth understanding of plant genomes and refinement of breeding methods, enabling more efficient, more precise and faster progress in achieving the desired breeding goals.

- ✓ 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 VERSUS GENETICALLY MODIFIED ORGANISMS

GMO

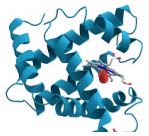
Transfer gene from another organism



GENE EDITING

X

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



*Change a specific nucleotide
(-Modify the range of action of a specific protein
-Erase a recognition site of pathogen proteins)

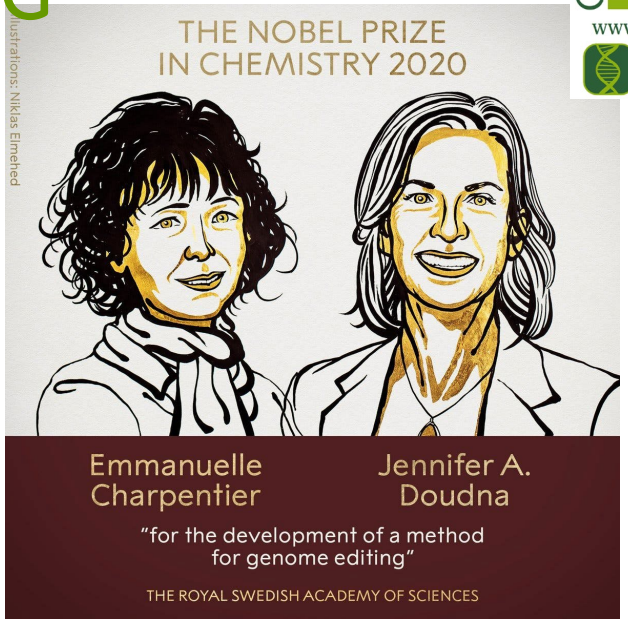
Produce a specific protein

IMPROVE A TRAIT

SOME 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

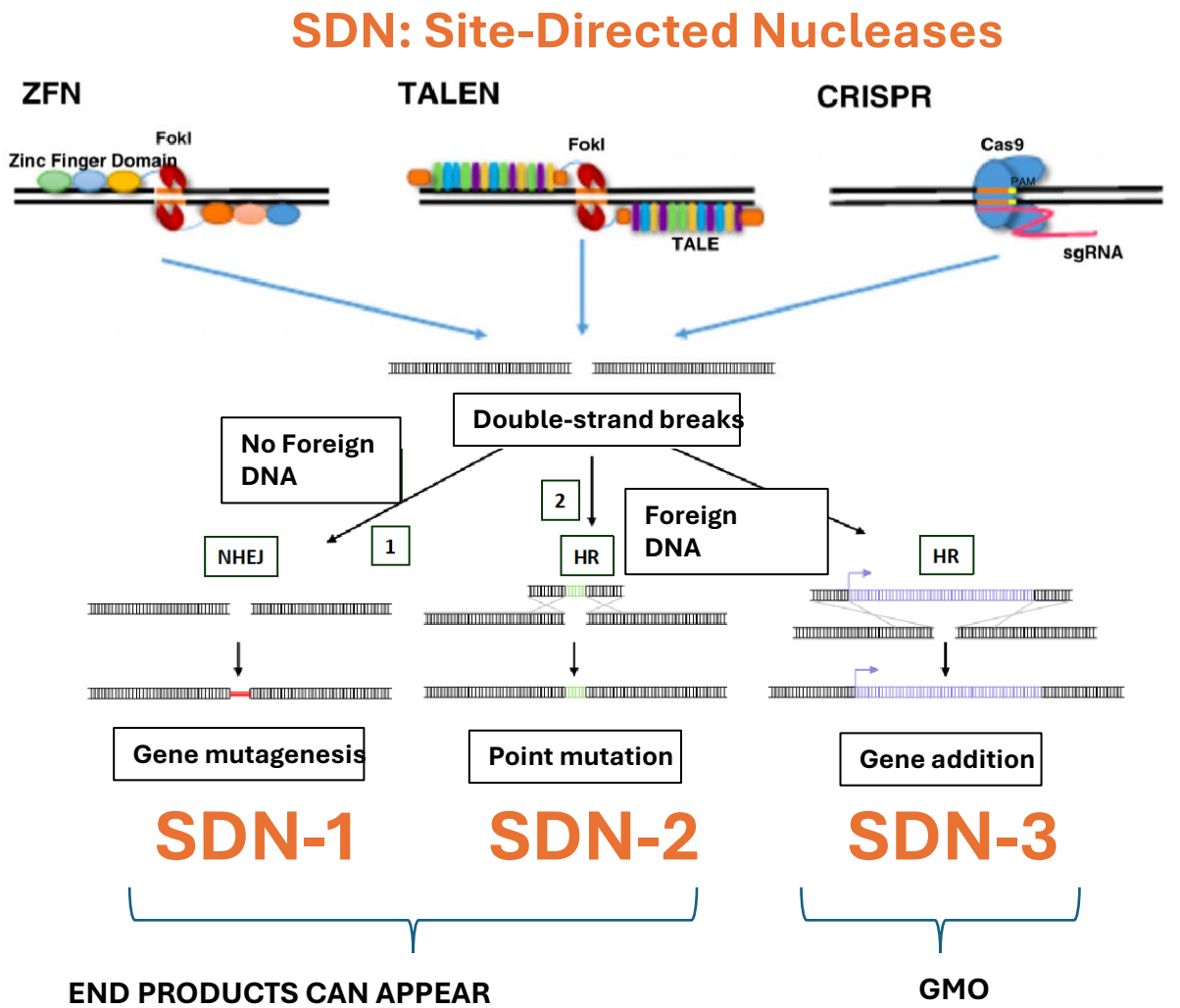


CRISPR, the Genetic Revolution of the 21st Century

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

GENOME EDITING ALLOW TO GET DIFFERENT TYPES OF PRODUCTS

*Methodological approach used mostly until now



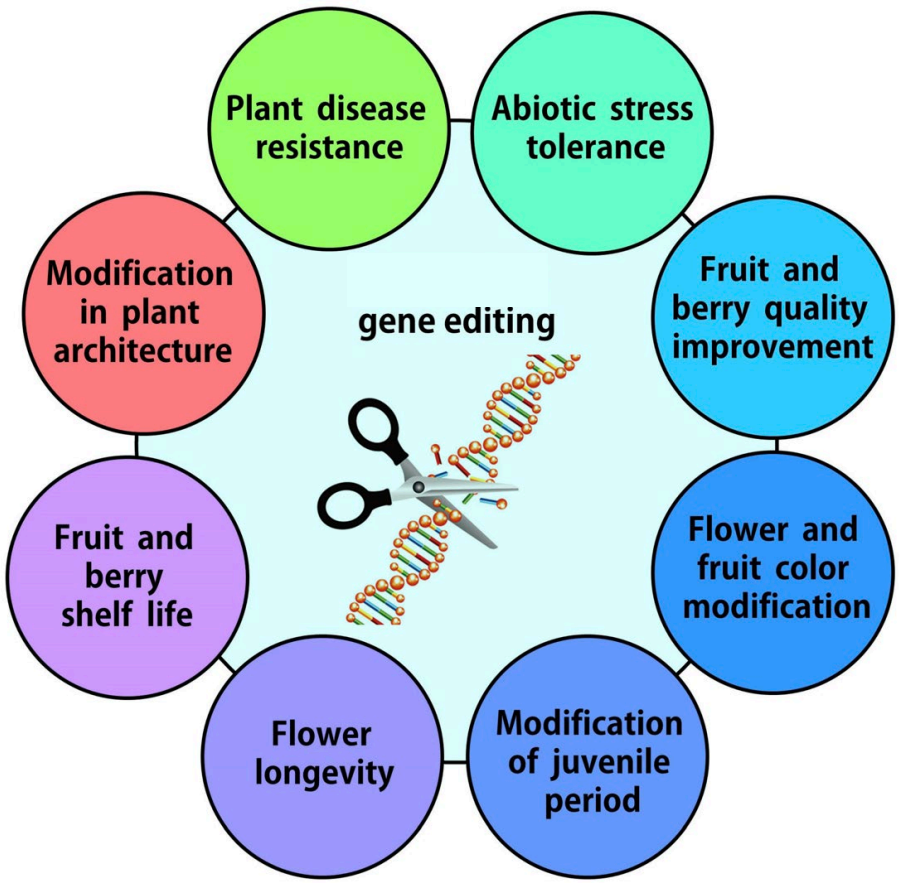
❖ May or may not:

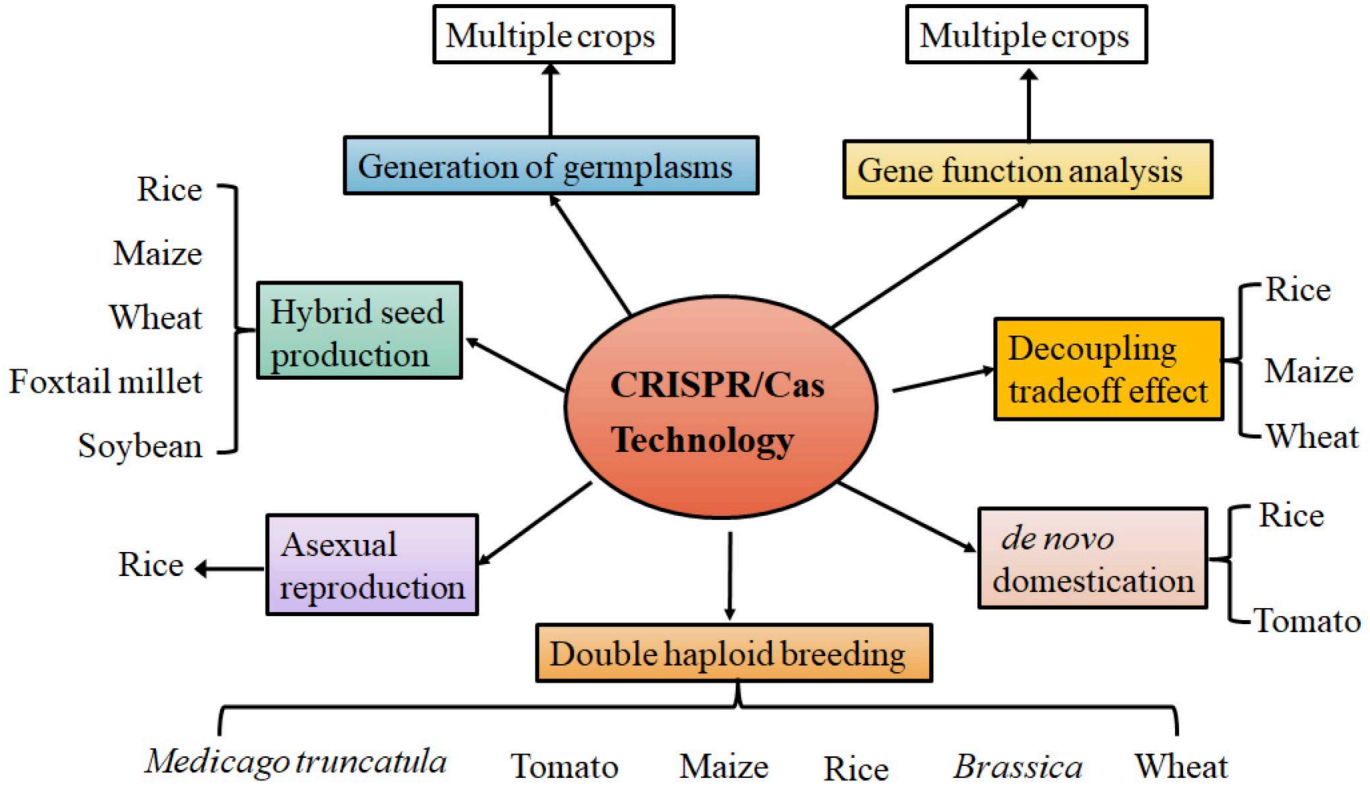
- ➢ Involve the transitory introduction of foreign DNA sequences
- ➢ result in GMO
- ➢ generate products that substantially differ from varieties bred through conventional breeding.

*However, with biotechnology plant breeding gets:

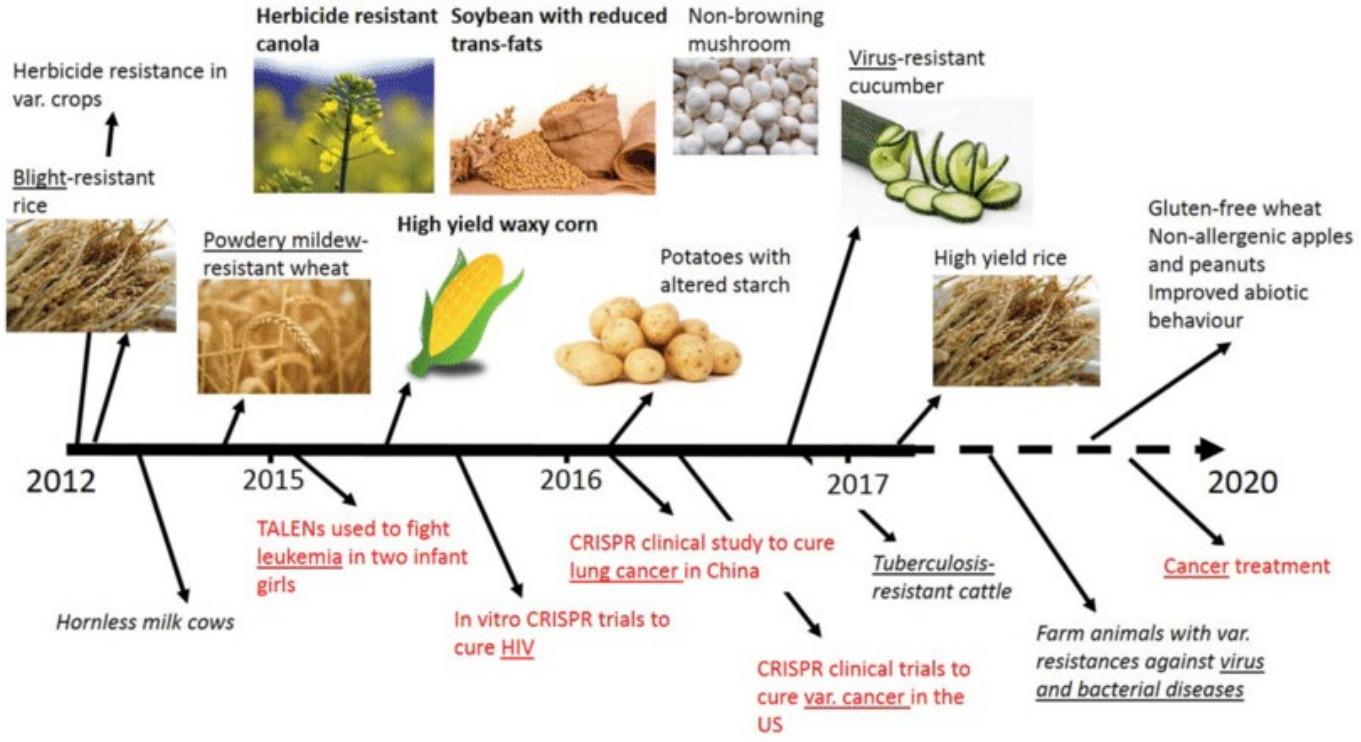
- ✓ accuracy and avoids random
- ✓ no impacts on other traits

AREAS OF INTEREST
WHERE GENOME EDITING IN PLANTS IS BEING EXPLOITED

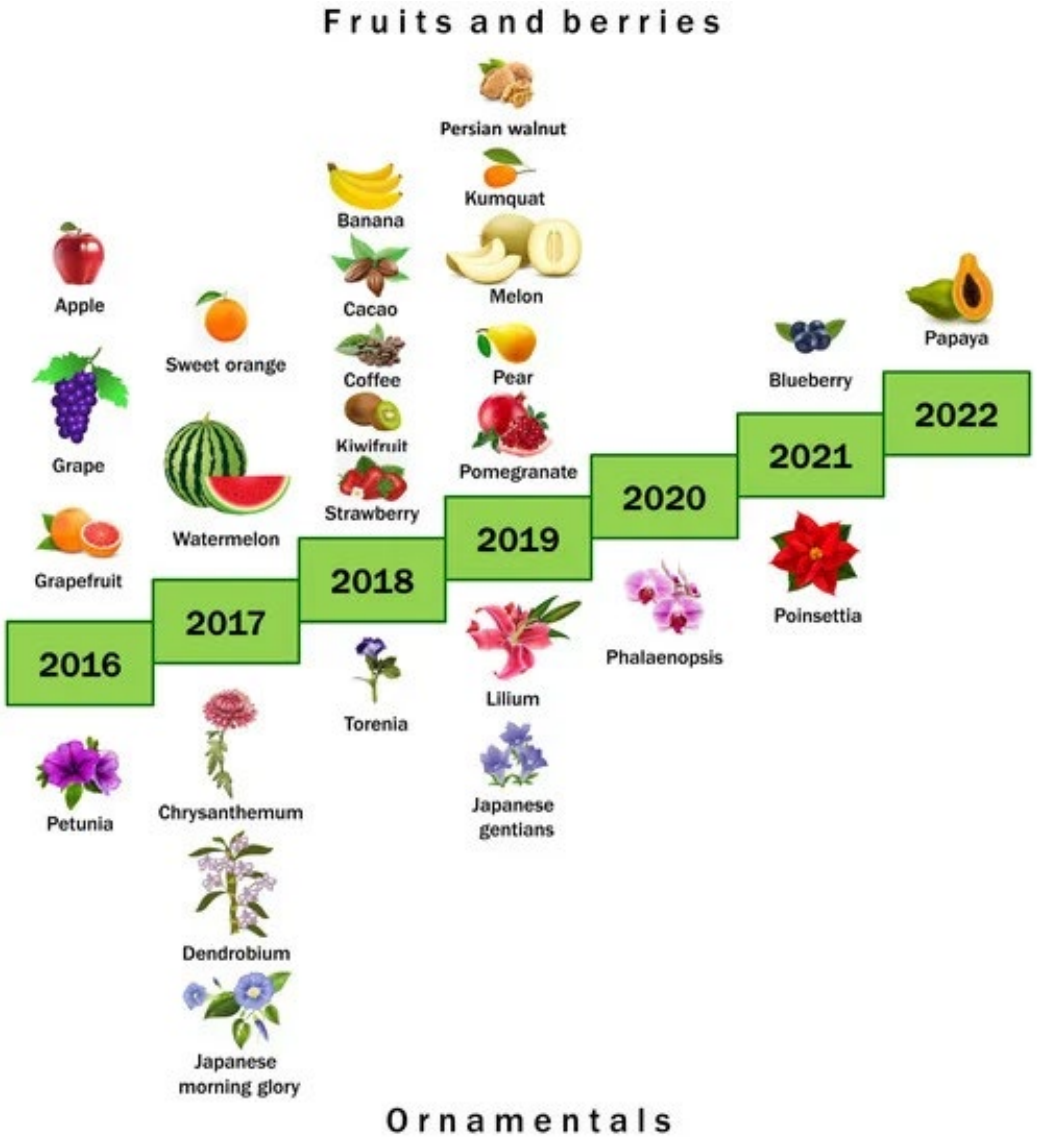




THE RAPID ADVANCEMENT OF GENE EDITING IN PLANTS



Duensing 2018; Frontiers in Bioengineering and Biotechnology. 6.



Rukavtsova 2023; Horticulturae 9(1), 38

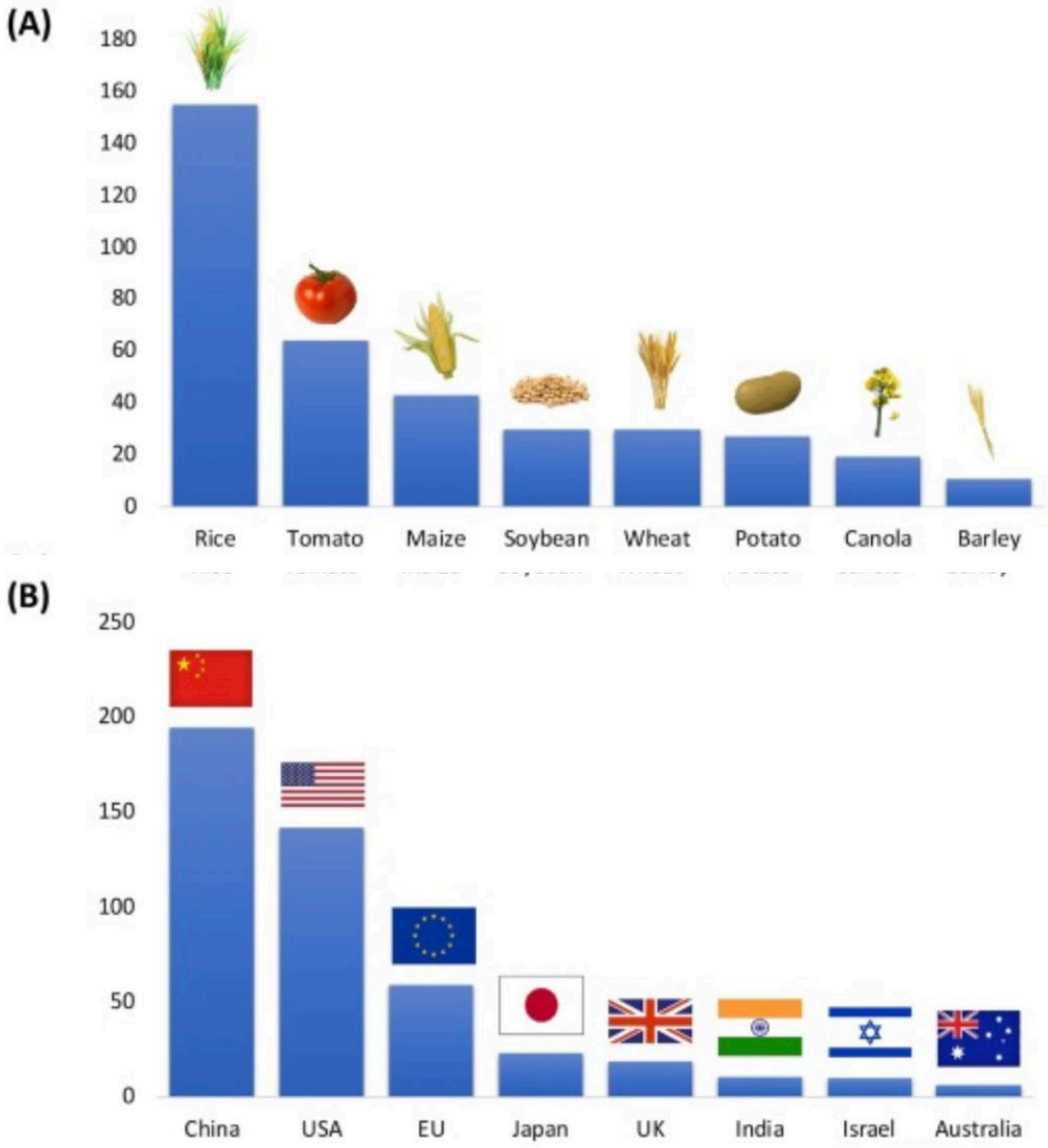
EXPECTATIONS FOR PLANT BREEDING AND GENETIC EDITING ARE HIGH

- ✓ The significance of sustainable crop production and the lowering cost of genomic solutions are two factors that are anticipated to propel the plant breeding and CRISPR plants market ´s development.

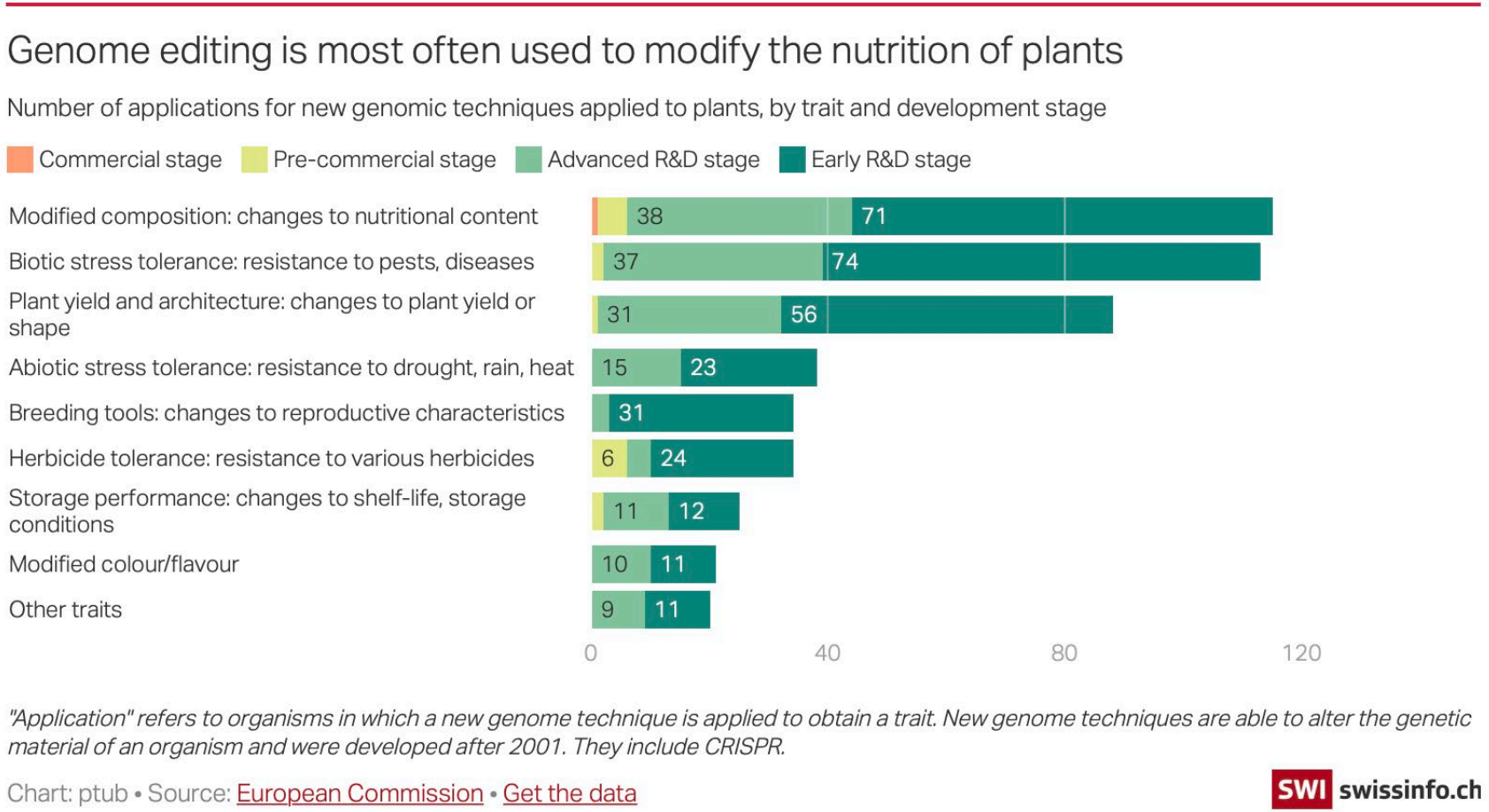
*Key role for food security and climate change adaption

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.



APPLICATIONS OF GENOME EDITING IN PLANTS



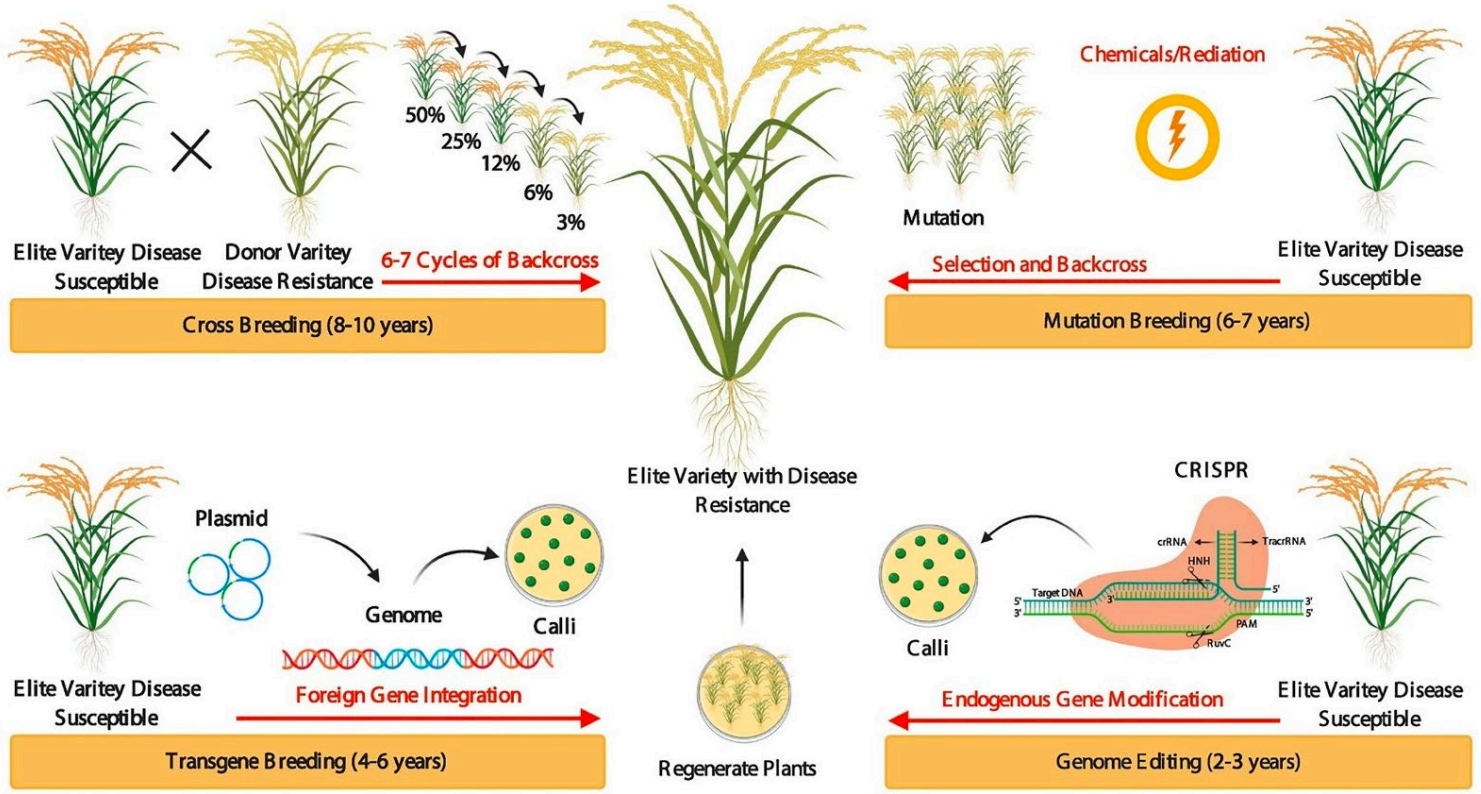
Applications promise benefits for:

- ✓ 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

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.



Wang et al, 2022. Cells, 11, 3928.

PLANT GENOME EDITING-DERIVED PRODUCTS THAT HAVE REACHED THE MARKET

- ✓ SU Canola has sulfonylurea tolerance by targeted mutagenesis through ODM.
- ✓ Specific single nucleotide mutation in two genes (acetohydroxyacid synthase (AHAS)).

- ✓ Improved soybean oil quality by targeted mutagenesis in 2 genes 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

- ✓ Tomatoes contain high amounts of γ-aminobutyric acid (GABA), by targeted mutagenesis in 2 genes through CRISPR/Cas9.
- ✓ GABA can help prevent high blood pressure.

We Create Healthy Veggie and Fruit for you.
"This product is Gene Edited Crop."
sanatechseed
For Tomorrow's Children and Earth
This product is brought you by Gene Editing.
NOTIFICATION SUBMITTED AS GENE EDITED PRODUCT.

筑波大学
University of Tsukuba

PLANT GENOME EDITING-DERIVED PRODUCTS THAT HAVE REACHED THE MARKET

- ✓ Mustard greens with better flavor (eliminated pungency), by knocking out all functional copies (17) of the type-I myrosinase multigene using CRISPR/Cas9.
- ✓ Mustard greens provide a greater amount of nutrients than other green salads (flavonoids, β-carotenes, lutein, vitamins A, C, E, K).

pairwise™

- ✓ Lettuce with delayed oxidation, by editing 5 PPO genes using CRISPR/Cas9
- ✓ Post-harvest shelf life increased from 7-14 days to 21-28 days when stored refrigerated.

GreenVenus™

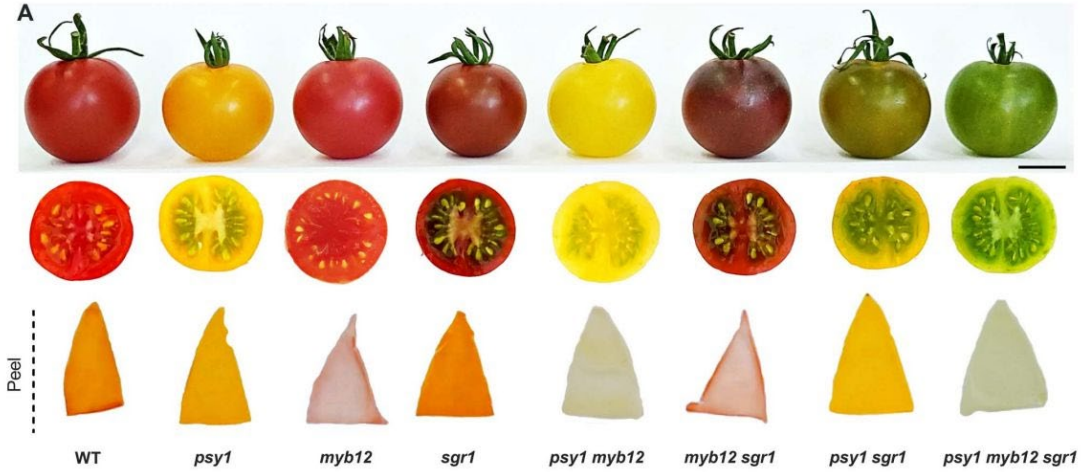
ANNOUNCEMENTS FOR PRODUCTS OBTAINED BY GENE EDITING NOT YET COMMERCIALIZED

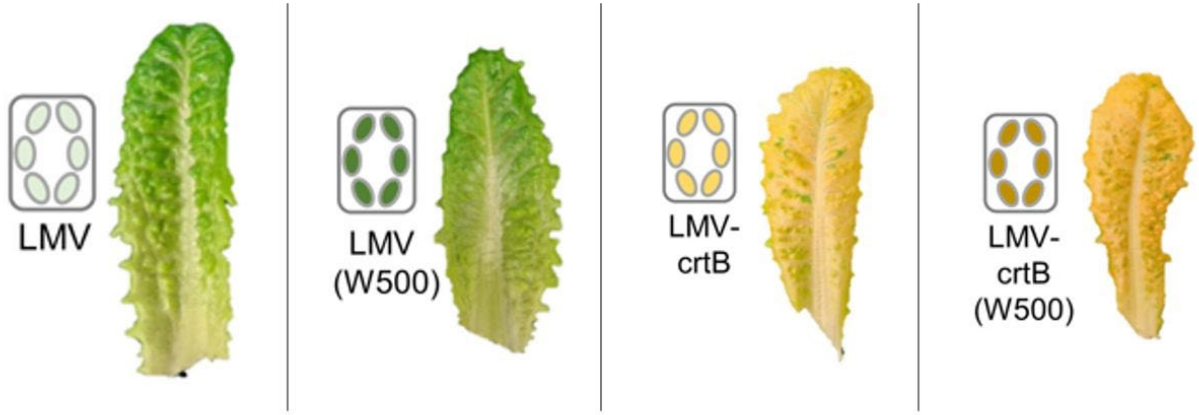
GreenVenus™

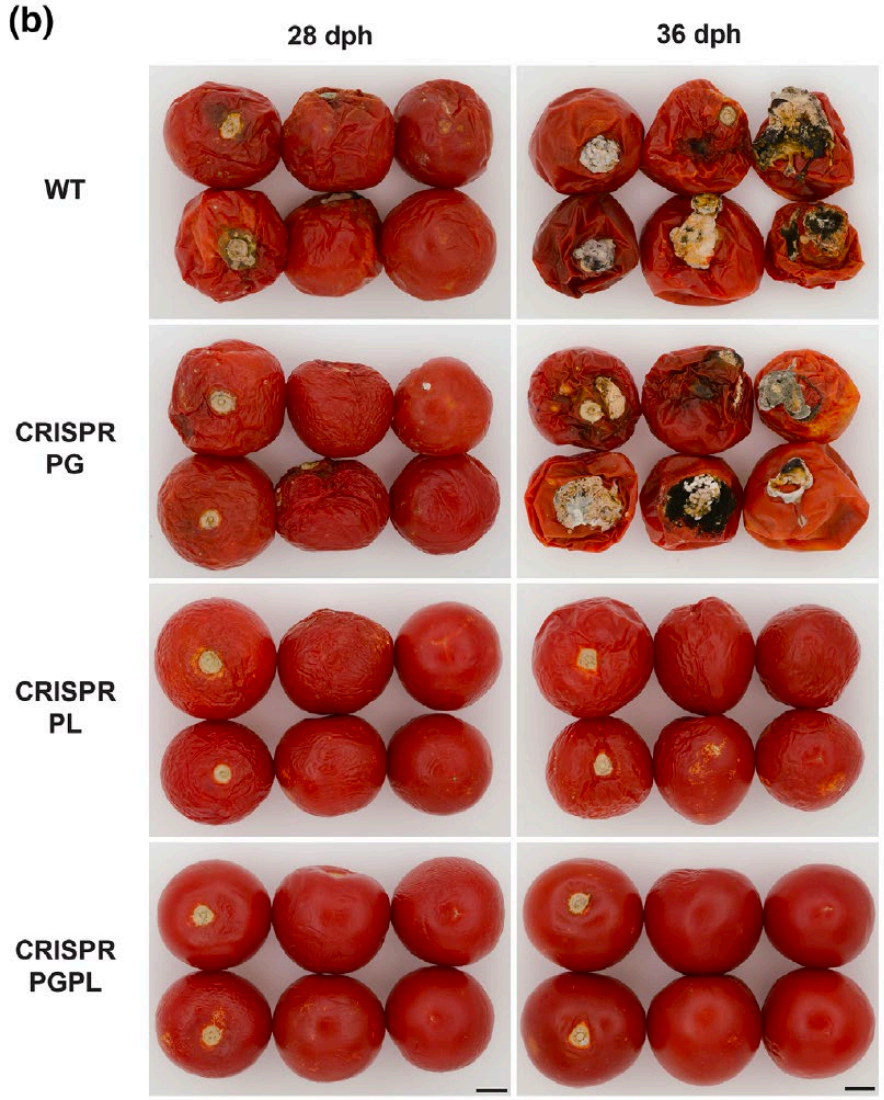
Tropic Biosciences™

*Reference images (not from the real development)

EXAMPLES OF PRODUCTS OBTAINED BY GENOME EDITING NOT COMMERCIALIZED YET







EXAMPLES OF PRODUCTS OBTAINED BY GENOME EDITING NOT COMMERCIALIZED YET

- ✓ In multi-year and multi-site field trials in China, two *ric1a/2a* lines had improved grain yield (10-20%), protein content (1-2%), and sustained oil content, demonstrating that gene editing towards optimal nodulation improves soybean yield and quality.

nature plants

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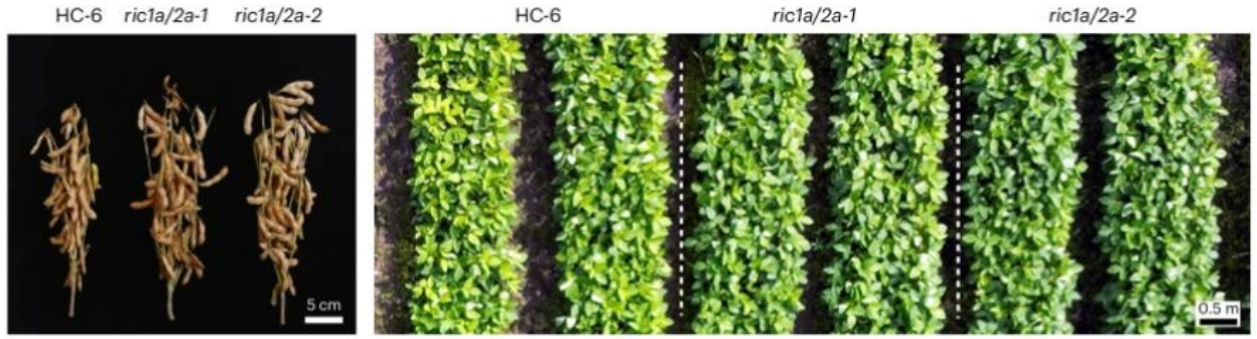
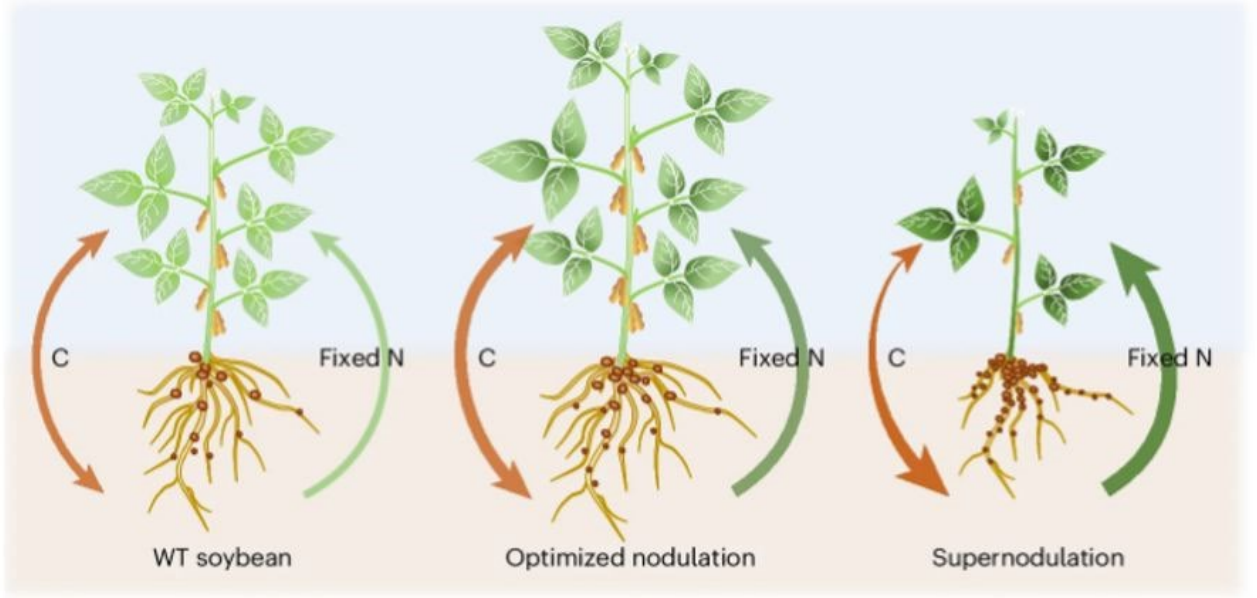
Brief Communication | Published: 09 May 2024

Genetically optimizing soybean nodulation improves yield and protein content

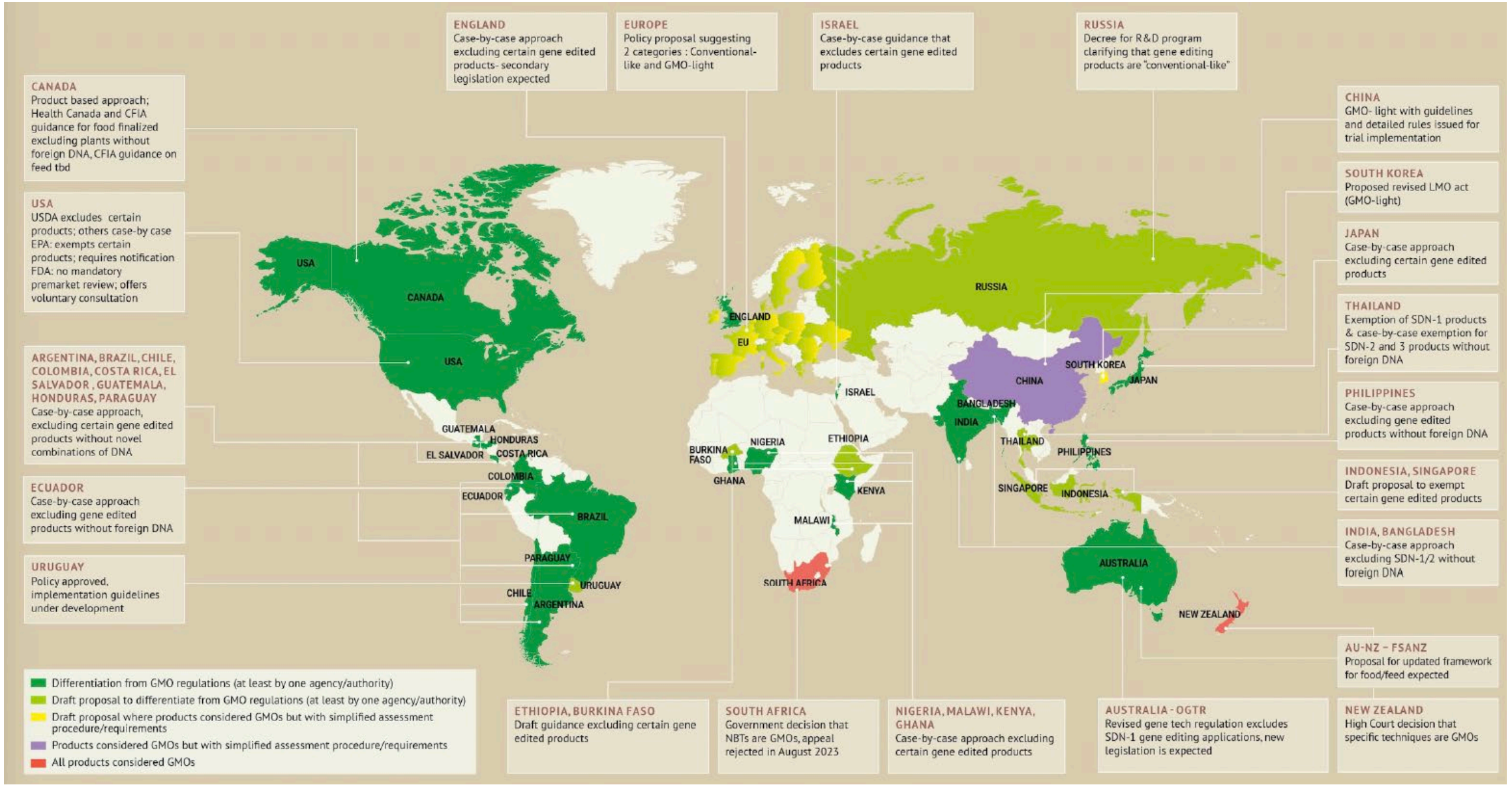
Xiangbin Zhong, Jie Wang, Xiaolei Shi, Mengyan Bai, Cuicui Yuan, Chenlin Cai, Nan Wang, Xiaomin Zhu, Huaqin Kuang, Xin Wang, Jiaqing Su, Xin He, Xiao Liu, Wenqiang Yang, Chunyan Yang, Fanjiang Kong ✉, Ertao Wang ✉ & Yuefeng Guan ✉

Nature Plants **10**, 736–742 (2024) | Cite this article

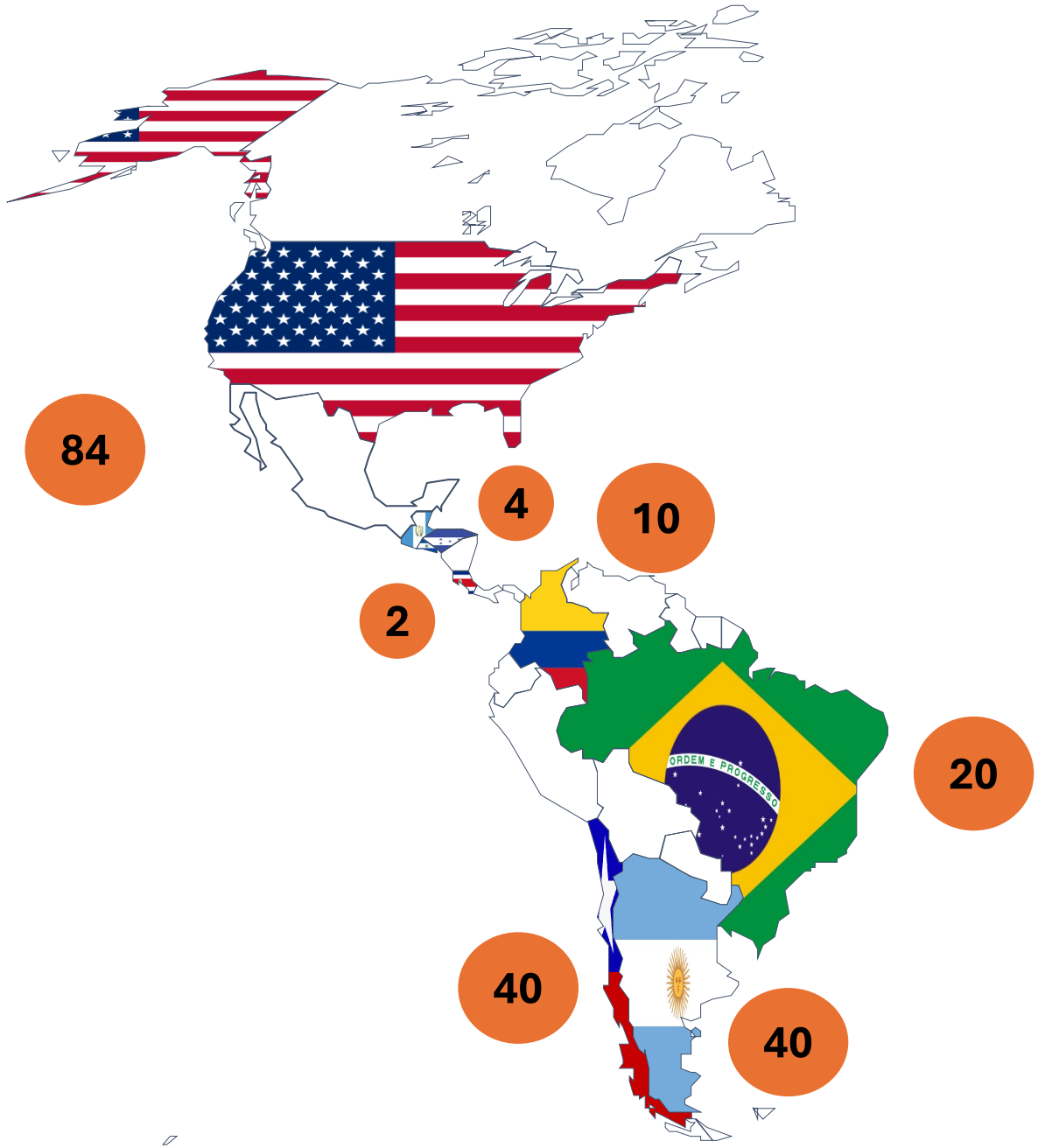




COUNTRIES WITH REGULATIONS ENABLING THE USE OF PLANT GENOME EDITING-DERIVED PRODUCTS



PLANT GENOME EDITING-DERIVED PRODUCTS NOT CONSIDERED GMO



*Number of consultations with positive answers

GENOME EDITING IN ANIMALS

Table 2
List of GnEd animal products that have undergone regulatory review.

Country	Common name	Trait	Gene	Year
Argentina	Nile Tilapia	Increased yield	Myostatin	2018
	Beef cattle	Heat tolerance	Prolactin receptor	2020
	Dairy cattle	Heat tolerance	Prolactin receptor	2020
	Cattle	Increased yield	Myostatin	2021
	Various species	Undisclosed as not required for non-GMO products		
Brazil	Nile Tilapia	Increased yield	Myostatin	2019
	Beef cattle	Heat tolerance	Prolactin receptor	2021
	Dairy cattle	Heat tolerance	Prolactin receptor	2023
	Cattle	Increased yield	Myostatin	2021
	Pig	PRRS-resistance	CD-163	2024
Colombia	Pig	PRRS-resistance	CD-163	2023
Japan	Red Sea Bream	Increased yield	Myostatin	2021/2022
	Tiger Pufferfish	Faster growth	Leptin receptor	2022
	Olive Flounder	Faster growth	Leptin receptor	2023
USA	Cattle*	Heat tolerance	Prolactin receptor	2022

* Enforcement discretion was given for two specific beef cattle. If an Enforcement Discretion decision is made, the developer is not expected to submit a drug approval application for the IGA.

The Veterinary Journal 305 (2024) 106142

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journal homepage: www.elsevier.com/locate/tvjl

Global status of gene edited animals for agricultural applications

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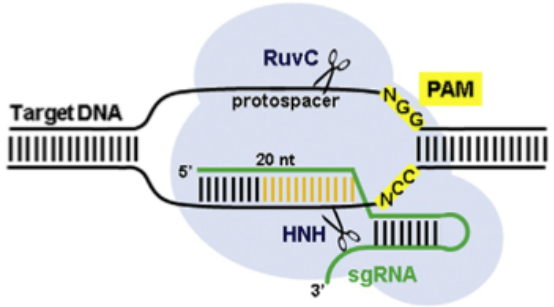
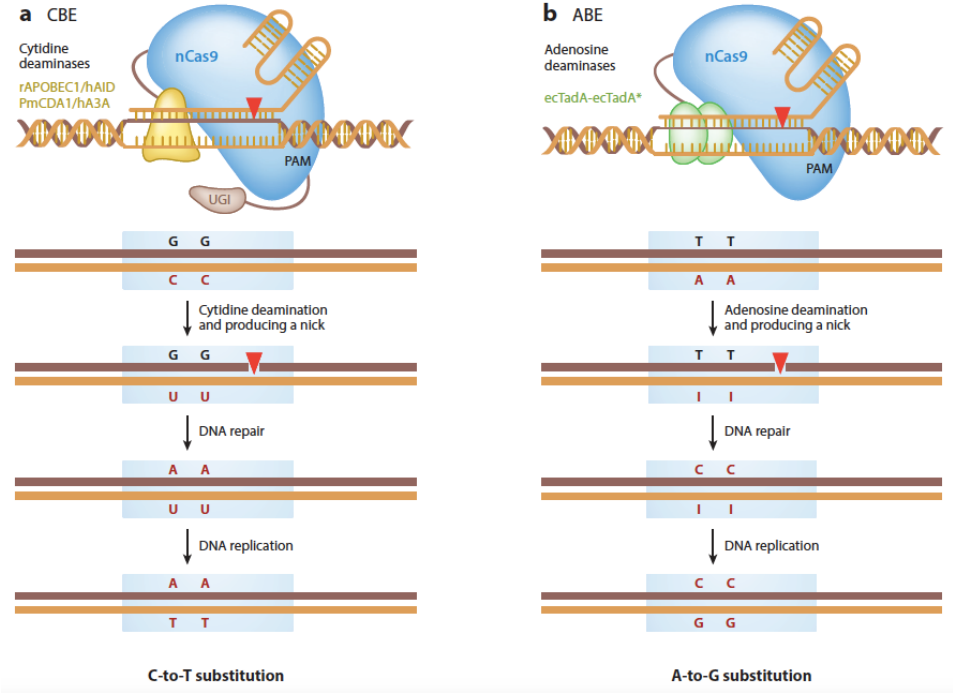
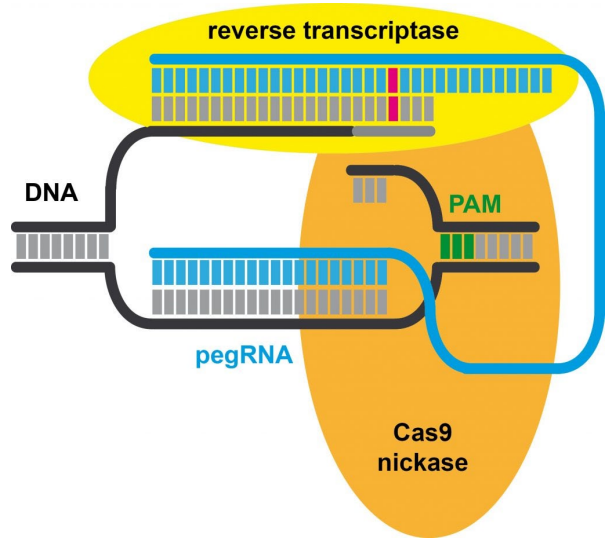
Department of Animal Science, University of California, Davis, CA 95616, USA

EVOLUTION OF GENOME EDITING WITH CRISPR: TO THE INFINITY AND BEYOND

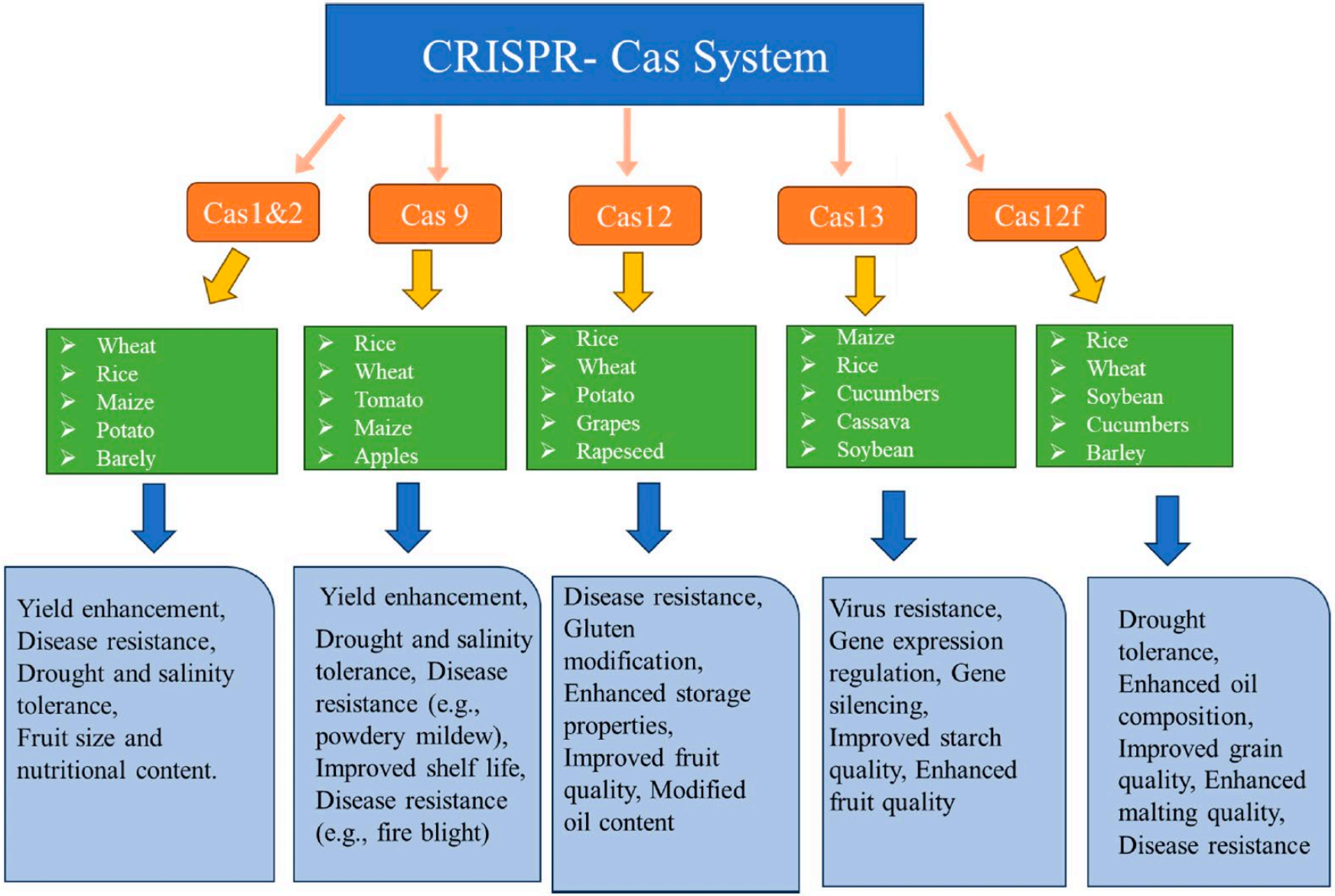
CRISPR/Cas9 → **BASE EDITORS** → **PRIME EDITING**







USE OF CRISPR-CAS SYSTEM IN DIFFERENT CROPS



Mishra et al, 2024. Plants, 13, 1884.

IMITATING ALL KINDS OF NATURAL MUTATIONS

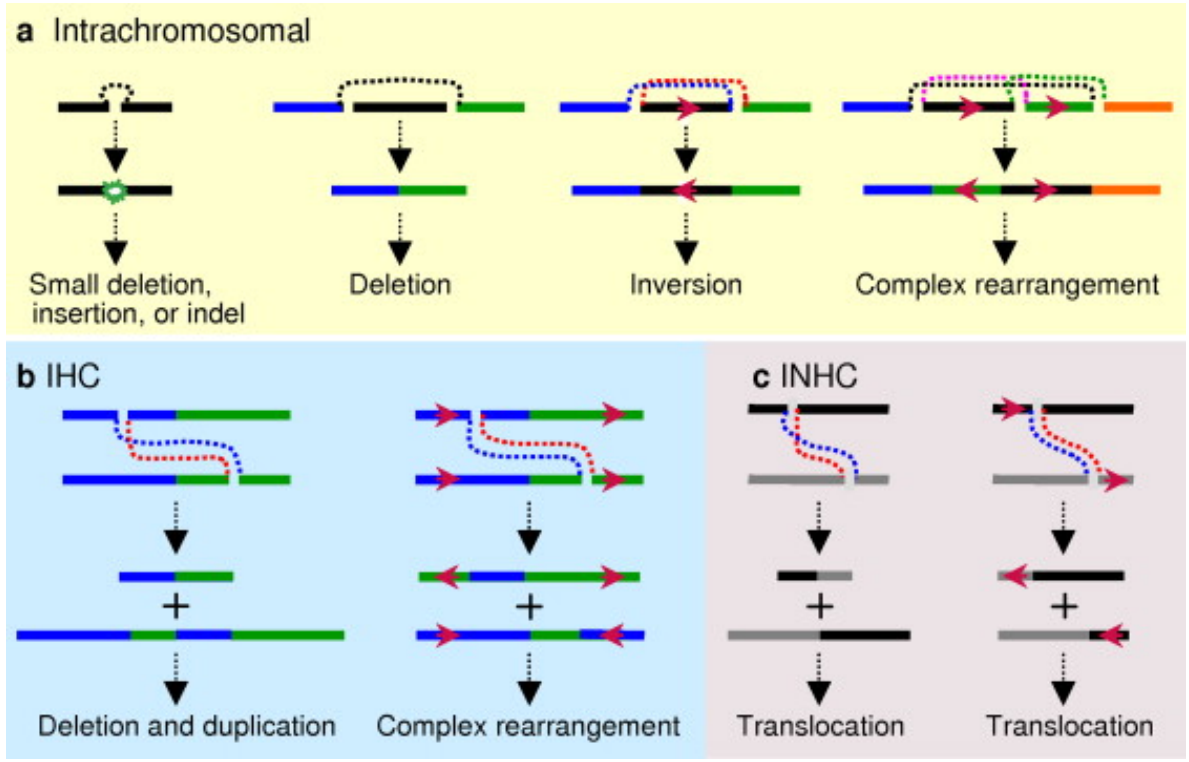
From gen inactivation and small edits to more natural complex rearrangements

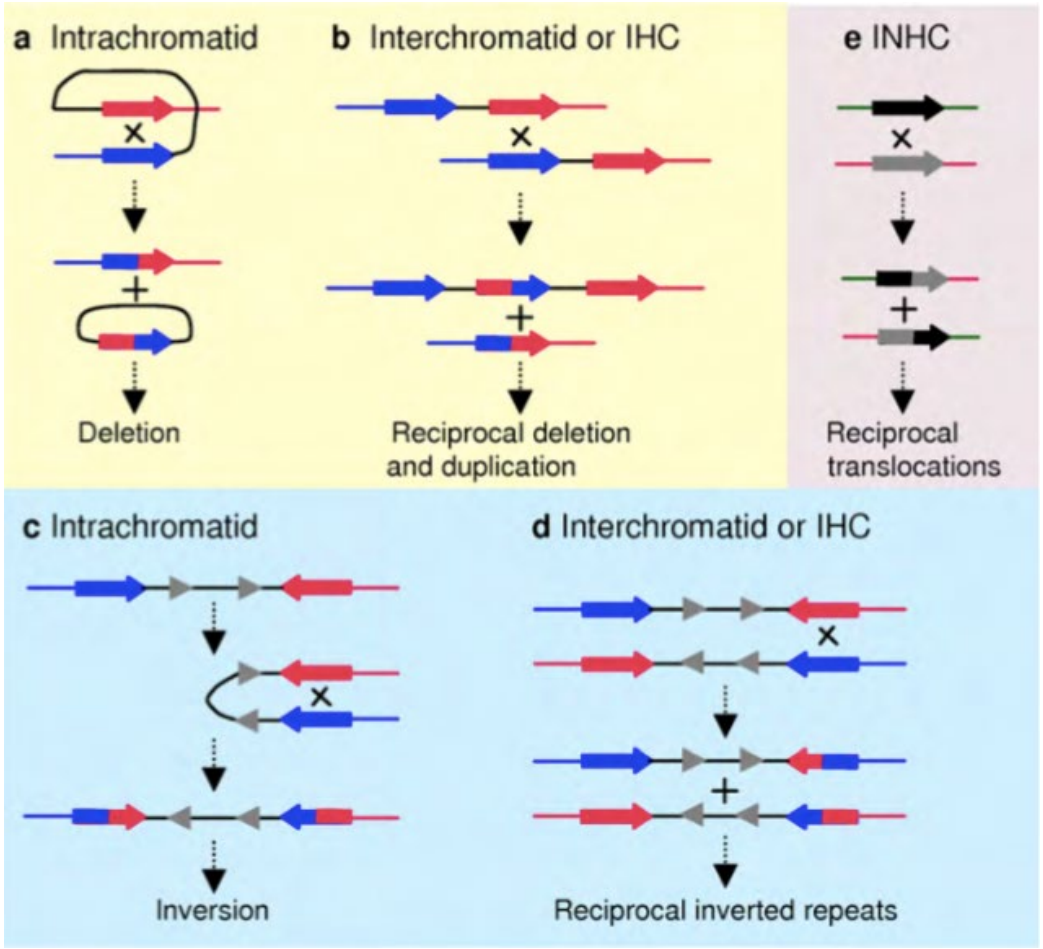
From
SDN1, SDN2

to

- ✓ Chromosomal changes (inversions, translocations, duplications)
- ✓ copy number variations
- ✓ epigenetic changes

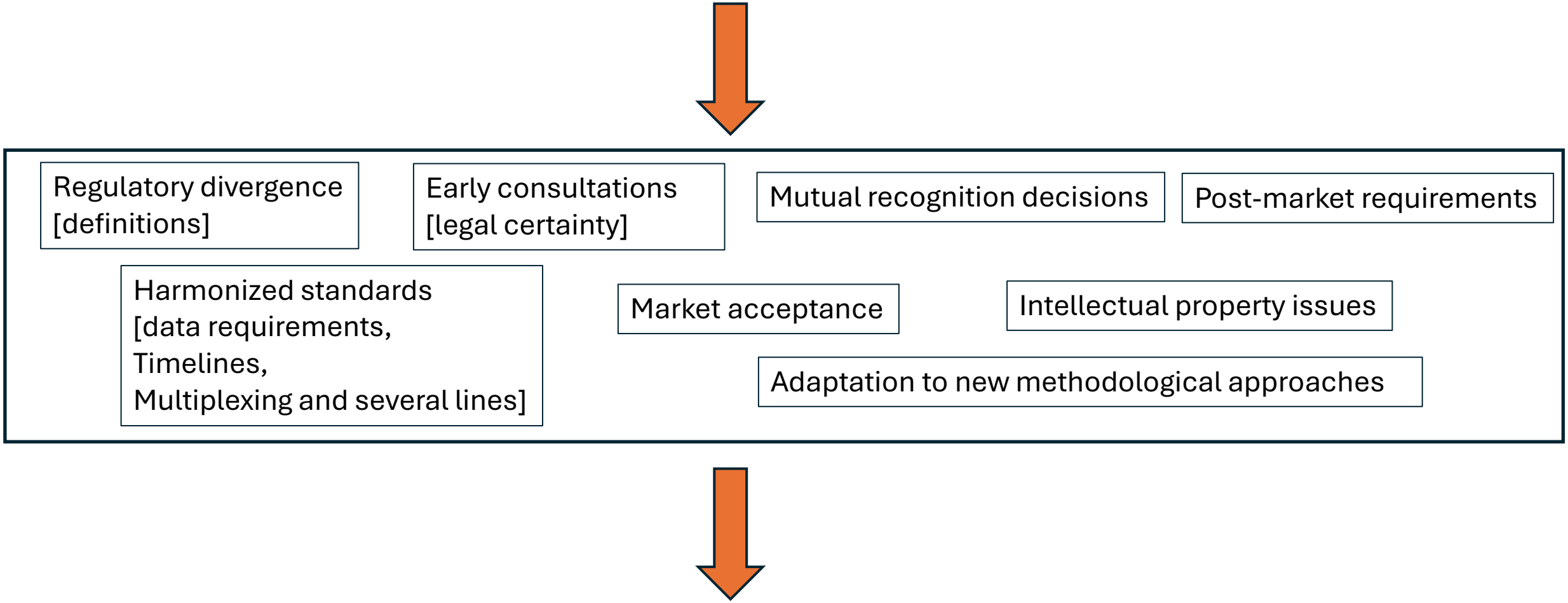
Are regulatory frameworks ready for this?





TRADE CHALLENGES

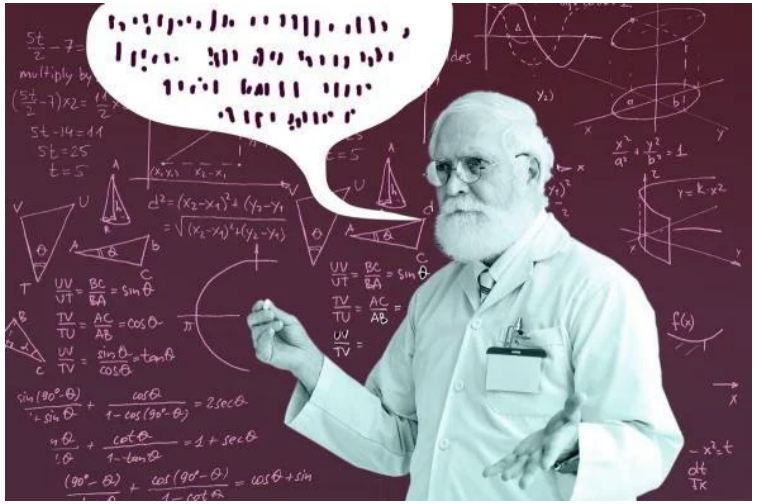
Genome editing technology



Benefits for farmers, consumers, and the environment

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.
- ✓ Regulatory approaches need to be flexible (definitions) so as not to hinder the adoption of technological advances
- ✓ Effective scientific communication is essential for the acceptance of genome editing in agriculture and food production.

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From science to markets: The path of gene editing

October 2, 2024

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