The 2022 EU Agricultural Outlook Conference

Plant Breeding Tools to Increase Crop Yield

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We must more than double crop production by 2050 for food security (10 billion people).

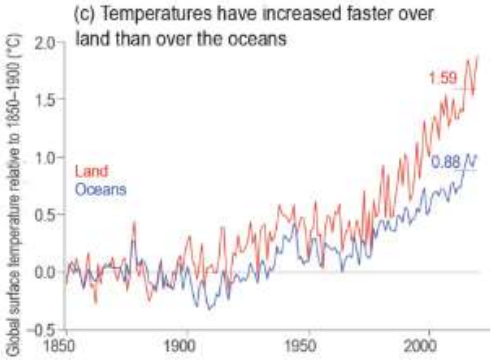
Lands are more and more arid.

Agriculture lacks water or the land is flooded with salt water.

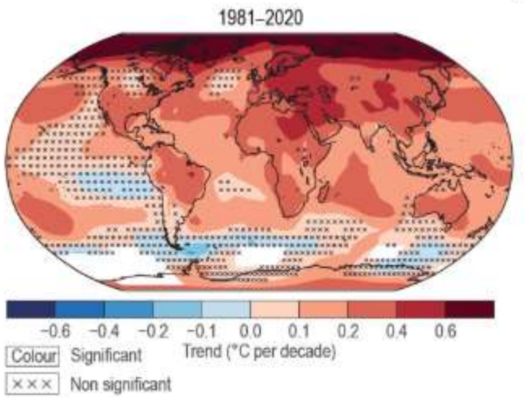
Agriculture needs to decrease the use of fertilizers and pesticides to reduce greenhouse gases and the amounts of inputs.

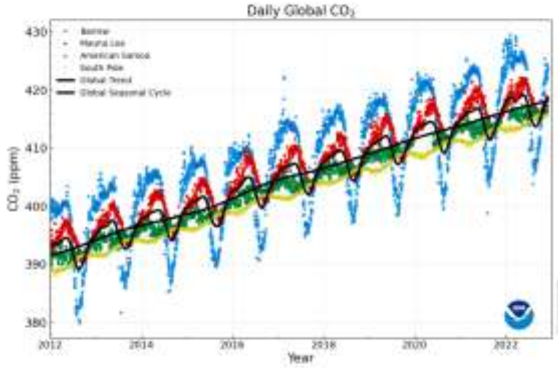
- One of the environmental issues of greatest concern to scientists is **climate change**, with a direct impact on crop yields.

- Improving crop yields to meet the food needs of a growing world population is a major challenge for **plant breeding.**



IPCC AR6, WG1, Chap 2





NOAA Mauna Loa data

Modifications can be made to plants for

- improving photosynthesis and CO_2 fixation;
- increasing root mass to capture carbon and water;
- optimising their growth;
- enabling cereals to use atmospheric nitrogen;
- using fewer phytosanitary products in a sustainable way.

Source : *wikipedia*

Ricroch *et al.* 2022 *New Biotechnology*

A toolbox for plant breeding

The goal of plant breeding is to produce crops with improved traits by changing their genetic makeup.

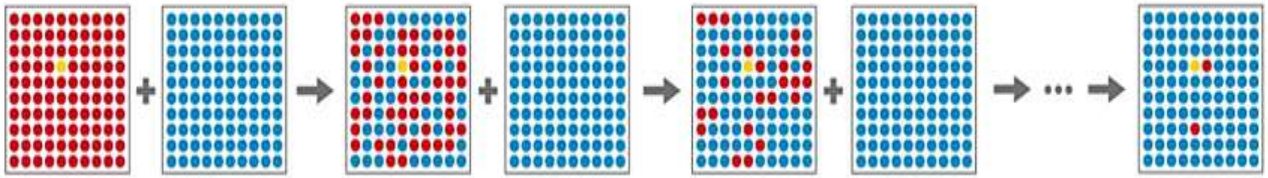
- **Conventional breeding** achieves it by crossing together plants with relevant traits, and selecting the offspring with the desired combination of traits, as a result of particular combinations of genes inherited from the two parents.

- **Transgenesis** achieves this by adding a new gene or genes to the genome of a crop plant.

- and **New Genomic Techniques** (CRISPR-cas) achieves this by changing the gene within the genome.

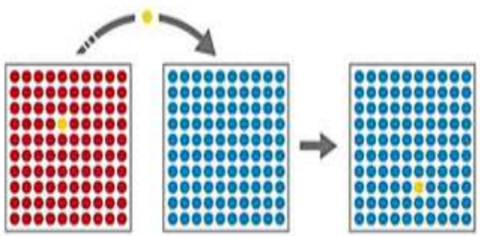
Source: *The Royal Society*, UK

Conventional Breeding

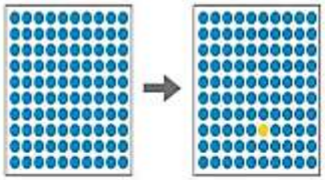


multiple generations, and therefore several years

Transgenesis



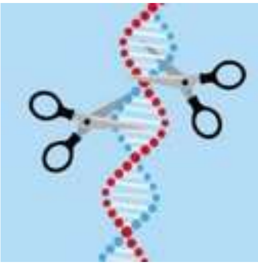
Gene Editing (CRISPR-cas)



Clustered Regularly Interspaced Short Palindromic Repeats

gene of interest

Gene editing (CRISPR-cas) could significantly speed up the progress of breeding programmes: **benefits to all.**



Nobel Price in 2020

Acceleration of the selection

- Conventional breeding = 7 to 25 years
- Edited plant = 1 to 3 years

from 7-25 years to as few as 1-3 years since its target-specificity effectively bypasses the need to go through a number of plant generations to achieve a particular genetic combination.

Friedrichs *et al.,* 2019. *Transgenic Res*

The need to produce crops

- resistant to pests and diseases,
- tolerant to abiotic stress (drought),
- with nutritional quality

has led scientists to apply new, convenient and fast breeding techniques.

Pest and disease control:

benefits for farmers and consumers

Biotic stress resistance is one of the most needed application

in agriculture.

Control

Tamlo-R32 wheat

Mutant wheat

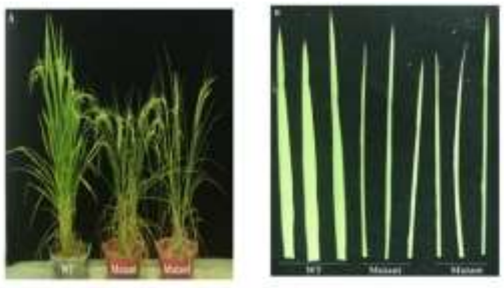
Tamlo-R32 wheat exhibits immunity to powdery mildew without growth and yield penalties.

Powdery mildew resistant wheat

Li *et al*. 2022 *Nature*

Tolerance to abiotic stress (drought, cold, salinity, floods, extreme temperatures, nitrogen deficiency): benefits for farmers

Apart of soybean, cotton, corn and rapeseed, other crops like potato, rice, sugarcane, tomato, and wheat are being developed with tolerance to different stress.



Mutant Controls Mutant Controls

Drought tolerance in rice

(Liao *et al*. **2019** *Agronomy* China)

Drought tolerance in TELA maize (field trials, Africa)

https://www.aatf-africa.org/tela-maize-project/

The french SME *Florimond Desprez* and argentina *Bioceres* created the transgenic HB4 Wheat tolerant to drought conditions or salt stress

- Commercially authorized for production and consumption in Argentina.
- Increases wheat yields by an average of 20% in water-limited conditions.
- Facilitates double cropping, which seasonally rotates soy and wheat, an environmentally friendly farming system that is otherwise limited by water availability.
- The FDA's conclusion follows recent approvals for HB4® Wheat by Brazil, Colombia, Australia, and New Zealand for use in food and feed.

- Hahb-4 gene from *Helianthus annuus* is introduced in **wheat** and also in **soybean.**

The results from work in Europe benefit farmers elsewhere (from where the EU then imports crops).

Genome editing tools are a democratic method.

The low cost and the fast production allow

not only **private companies and multinationals** to develop new biotech crops,

but also **public-private consortia**.

They could open up the field to **smaller companies**.

Now already it is in use by numerous **teams in public laboratories.**

Biotech crops can also help sustainable agriculture and farmers who want to implement more sustainable practices.

Lynch & Schneider; Burns *in* Ricroch, Chopra & Kuntz 2021 *Plant Biotechnology.* Springer Nature

Regulation

benefits for all?

€

The high cost of regulation and the time required to complete the dossier could be barriers to innovation.

In the EU, the cost of approval is between 11 and 17 million €.

Menz *et al.* 2020 *Front. Plant Sci*

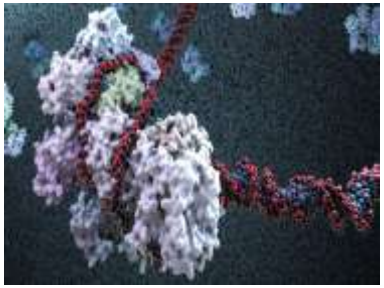
In North America, the cost of discovery, development and authorisation of a new plant biotechnology-derived genetic trait commercialised in the period from 2017 to 2022 is $115.0 million (10.3 million Registration & Regulatory Affairs).

CropLife 2022

New Genomic Techniques (NGTs) are Precise Tools for Green Biotechnology Applications

- CRISPR-Cas-based technique is **revolutionary** and very **successful** with public and private researchers/breeders.
- **Still evolving** (*e.g.* base editing).
- **Not very expensive** and **quick to implement**.

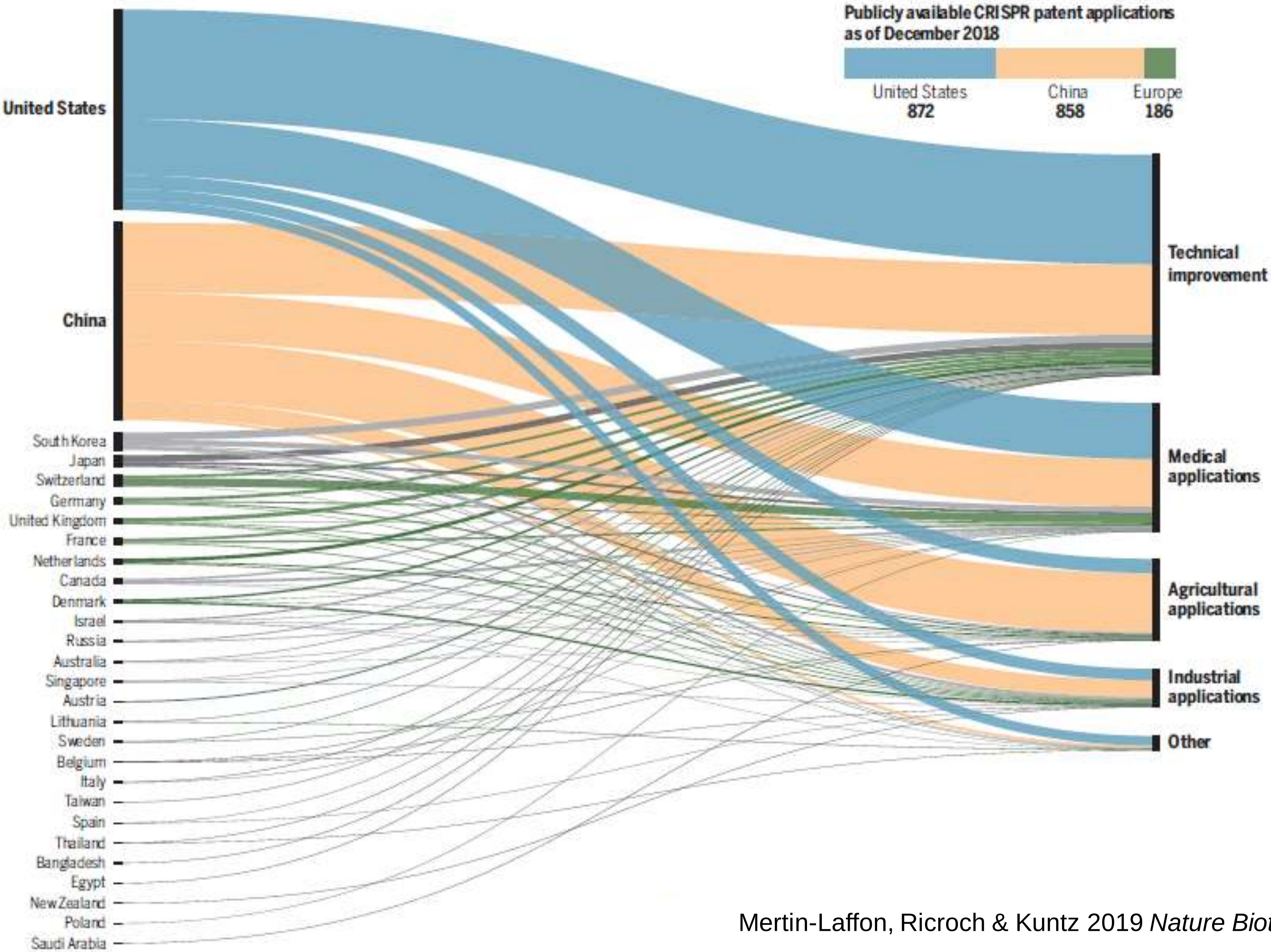
This is why there are so many patents (USA and China far ahead of EU)…



Source: *Science*

Invention inventory

In a recent analysis of more than 2000 patent applications for distinct inventions that involved CRISPR, the United States barely edged out China. Applications from China have climbed rapidly in recent years, and the country dominates in the agricultural and industrial realms.



Mertin-Laffon, Ricroch & Kuntz 2019 *Nature Biotechnology*

In EU, gene editing is regulated as transgenesis under the 2001/18 GMO Directive.

- If we want new varieties quickly, regulation might not hamper the **originality of researchers** by prohibitive costs.

- In order to **reap the benefits** of gene-editing (keeping small and medium-sized enterprises in Europe, having researchers do their field trials not outside Europe and thereby **avoid brain drain and loss of jobs**), regulatory costs need to be reasonably low.

Thank You!

Q&A

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