SUSTAINABLE PRODUCTION

Session 2

THE 2019
EU AGRICULTURAL OUTLOOK CONFERENCE

Sustainability from Farm to Fork

European Commission

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New plant breeding techniques for disease-resistant crops

Gene editing with CRISPR/Cas in plant breeding

Dr. M.J.M. (René) Smulders, Plant Breeding

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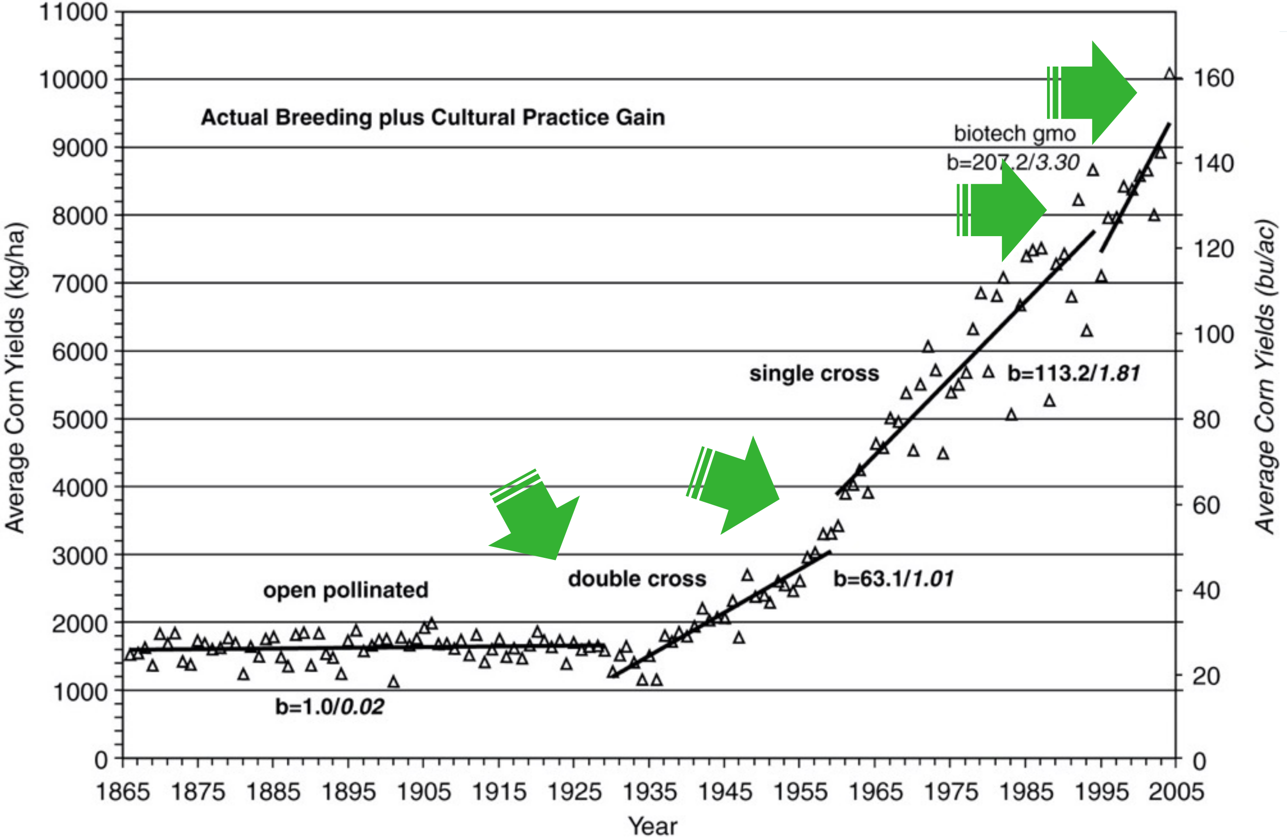
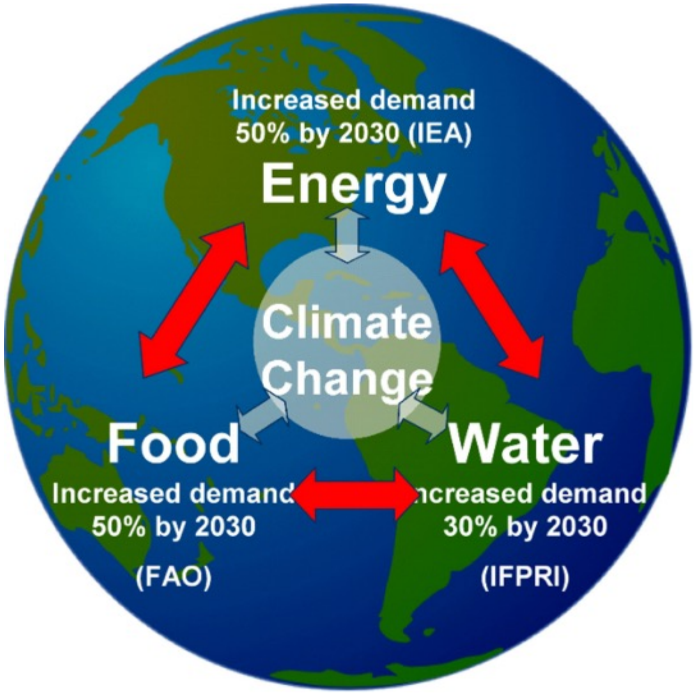
Plant breeding = exploiting genetic diversity in crops for our benefit

Maize yield and 20th century innovations in plant breeding and crop cultivation practices



Challenges for agriculture in the 21st century – greater than ever before



Sir John Beddington, 2012

1. Increase food production
2. Energy through biobased crops
3. Using less water
4. Fewer other inputs
5. Adapted to changing climate

2x more with 2x less

-> We'll need to employ all the tools in the plant breeders' toolbox

-> but 21th century breeders' tools face regulatory hurdles in the EU

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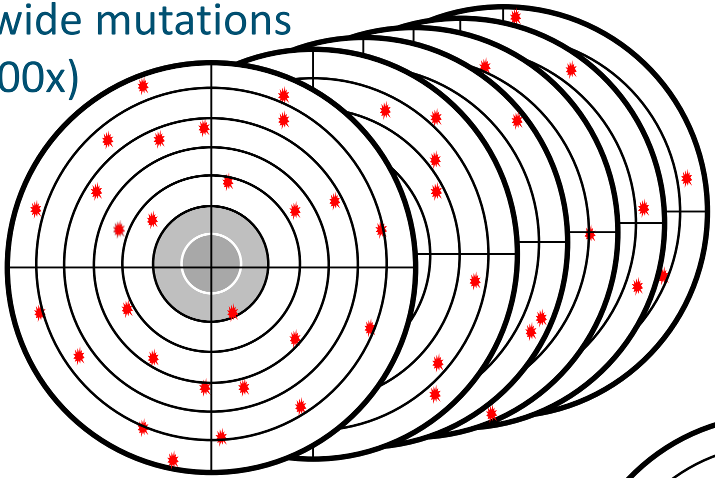
Tool: increase variation with mutation breeding

~ 3000 varieties worldwide since the 1930's

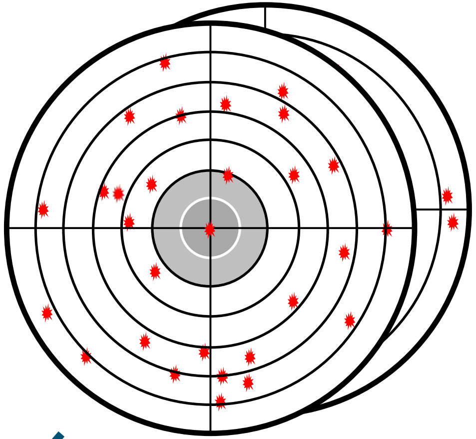
Example: seedless grapefruit

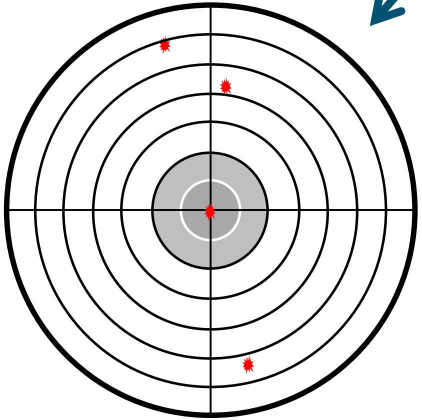
Random mutagenesis is truly random

Population of plants with genome-wide mutations (e.g. 17,000x)



Select plants with mutations on target

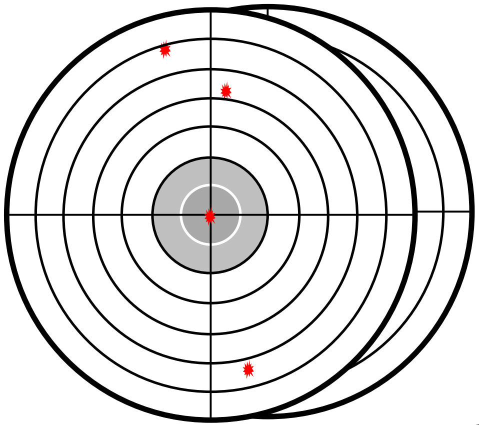




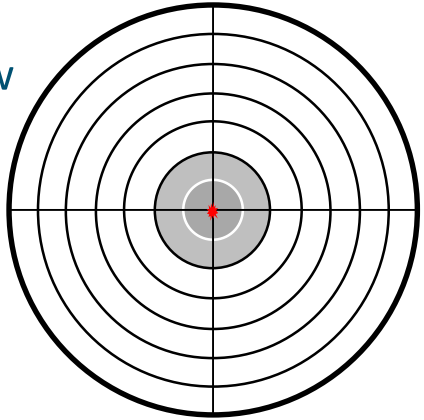
Breeding for removal of undesired mutations and homozygous state

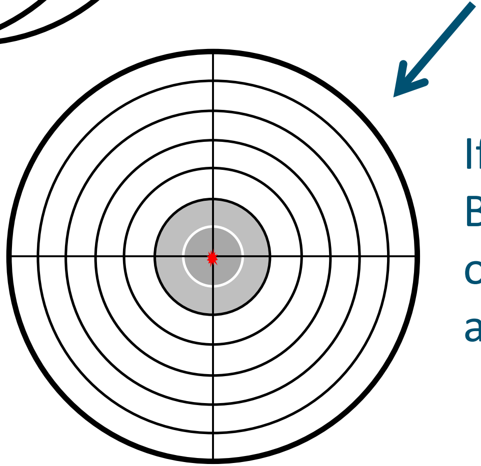
What if we could direct it?

Few plant with target mutations (e.g. 5x)



Select plants with no or few off-target mutations

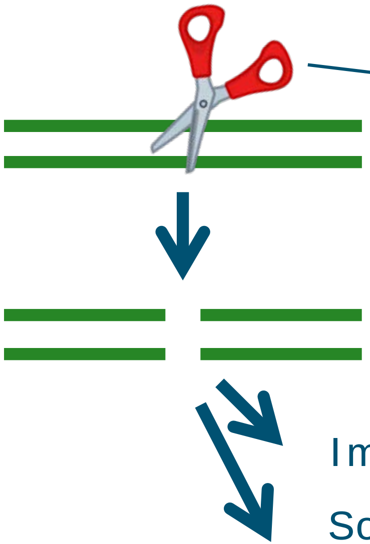


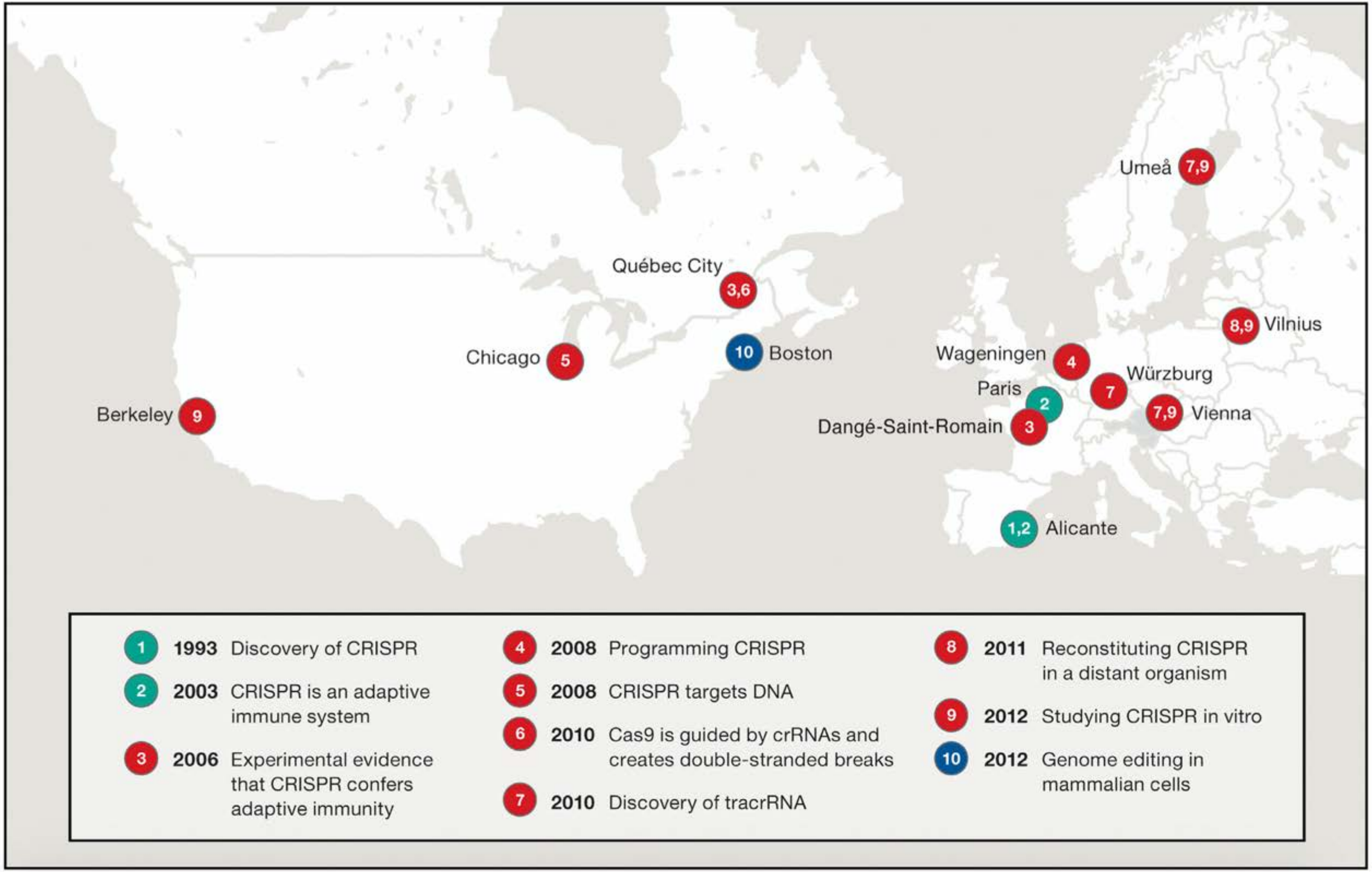


If necessary:
Breeding for removal of CRISPR-Cas9 DNA-construct and/or off-target mutations

2012: Gene editing using CRISPR/Cas

- CRISPR/Cas induces a double strand break at the specific target site in genomic DNA




Umeå 7,9
Québec City 3,6
8,9 Vilnius
10 Boston
Chicago 5
Wageningen 4
Würzburg 7
Paris 2
Berkeley 9
7,9 Vienna
Dangé-Saint-Romain 3
1,2 Alicante
1 1993 Discovery of CRISPR
2 2003 CRISPR is an adaptive immune system
3 2006 Experimental evidence that CRISPR confers adaptive immunity
4 2008 Programming CRISPR
5 2008 CRISPR targets DNA
6 2010 Cas9 is guided by crRNAs and creates double-stranded breaks
7 2010 Discovery of tracrRNA
8 2011 Reconstituting CRISPR in a distant organism
9 2012 Studying CRISPR in vitro
10 2012 Genome editing in mammalian cells

Lander 2016

Nature Biotechnology 37 , 1251–1252 (October 2019) news

With CRISPR and machine learning, startups fast-track crops to consume less, produce more

Small players take on big seed conglomerates with next-generation non-GMO crops.

Agbiotech newcomer Inari has raised $89 million to pursue an ambitious goal: to challenge the status quo in agriculture. Inari, based in Cambridge, Massachusetts, plans to use the total $144 million it has raised so far to develop crops that are more productive and consume less water and fertilizer than those currently produced by seed conglomerates. The company will focus on major crops such as corn, soybean, wheat and tomato. "All the genetics [for these crops] are owned by just a couple of multinational companies, and we want to challenge that," says Ponsi Trivisvavet, CEO of Inari. "We want to bring back genetic diversity to make seeds that are better for the environment and the farmer," she says.

Inari is one of a several small companies with similarly lofty goals who are capitalizing on new editing technologies, such as CRISPR, and computational methods for predictive modeling. Such tools make crop development faster and less expensive, and potentially could give startups a shot at competing with the big players by sidestepping onerous and expensive regulatory oversight.

Just a few years ago, a seed developer could plan on spending a decade and up to $100 million on bringing one new

Plants edited with the new genome editing tools will incorporate useful traits and will not be classed as GMOs. Credit: reHAWKEYE / Alamy Stock Photo

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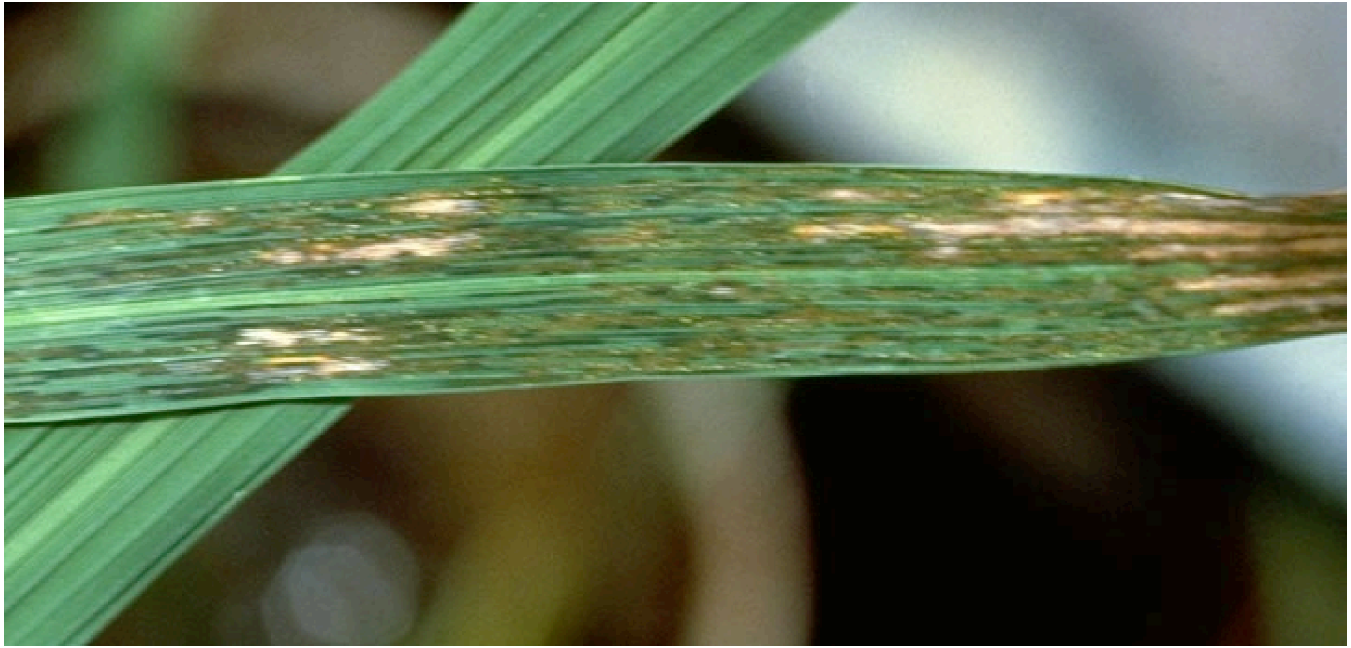
Bacterial blight (Xanthomonas) in rice



The case of the hijacked genes

T.W. Mew - IRRI, Los Baños (PH)

ARTICLES

https://doi.org/10.1038/s41587-019-0267-z

nature biotechnology

OPEN

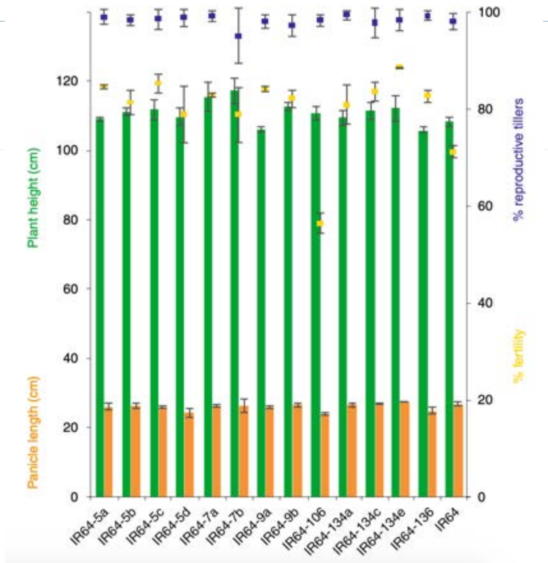
Broad-spectrum resistance to bacterial blight in rice using genome editing

Ricardo Oliva[1,12]*, Chonghui Ji[2,12], Genelou Atienza-Grande[1,10,12], José C. Huguet-Tapia[3,12], Alvaro Perez-Quintero[4,11,12], Ting Li[5], Joon-Seob Eom[6], Chenhao Li[2], Hanna Nguyen[1], Bo Liu[2], Florence Auguy[4], Coline Sciallano[4], Van T. Luu[6], Gerbert S. Dossa[7], Sébastien Cunnac[4], Sarah M. Schmidt[6], Inez H. Slamet-Loedin[1], Casiana Vera Cruz[1], Boris Szurek[4], Wolf B. Frommer[6,8]*, Frank F. White[3] and Bing Yang[2,9]*

63 Xoo strains sequenced

Which rice sequences do they target?

CRISPR/Cas of all these promotor regions in IR64 and Ciherang-Sub1



Set of 30 lines with
- 21 alterations in SWEET promotors
- Disease-resistant
- Normal growth

Select and sequence the rice lines

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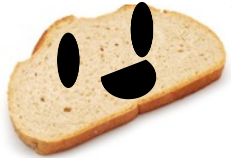
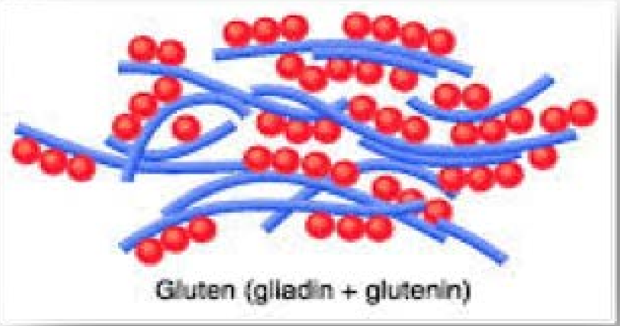
Dual-use “Oil+protein” crops

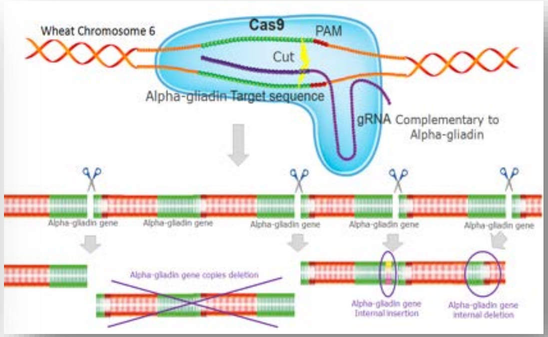
- Crambe abyssinica (for European farmers)
    - Modify fatty acid profile
        - Improved quality for industrial use
    - Avoid production of glucosinolates
        - For the seed meal to be protein-rich animal feed
    - in Crambe’s two genomes with CRISPR

Removing epitopes from gluten to make bread wheat safe for people with coeliac disease



- While retaining baking quality
- Mutations are identical to ‘natural’ mutations
- Difficult to do with random mutagenesis, as there are more than 100 targets
- One PhD student: up to 1/3 removed

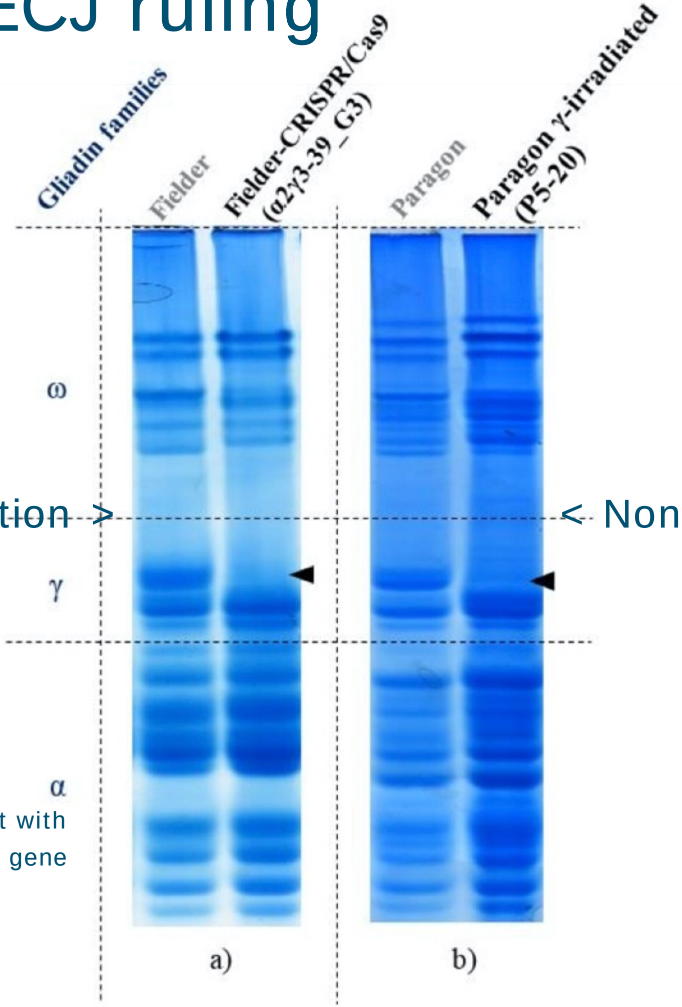




But - Consequence of the ECJ ruling

- Gene editing to be regulated as GM, while ‘traditional’ mutagenesis is exempted, despite being less precise
- Europe will miss out on opportunities

GM regulation >



< Non-GM

Jouanin et al. (2018) Development of wheat with hypoimmunogenic gluten obstructed by the gene editing policy in Europe.
Frontiers in Plant Science (2018)
doi: 10.3389/fpls.2018.01523

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Questions?

http://edepot.wur.nl/357723

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