

GENOME EDITING IN PLANTS

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GENEVA, 30 JUNE 2017



Agriculture feeds humans



PLANT BREEDING



- GROWING HUMAN POPULATION
- CLIMATE CHANGE AND DISEASES

PLANT BREEDING:

Makes use of **genetics** to change the traits of plants in order to **produce desired characteristics**

CROPS ARE SUBJECTED TO CONTINUOUS BREEDING TO IMPROVE:

- Crops **yield** and **yield stability**
- Resistance to **changing environmental conditions**
- Resistance to **patogens**
-

Rice is the main cereal harvested for human consumption



**RICE IS THE FOCUS OF EXTENSIVE
SCIENTIFIC RESEARCH WORLDWIDE**



Rice breeding



1) CROSSING

2) RANDOM MUTAGENESIS

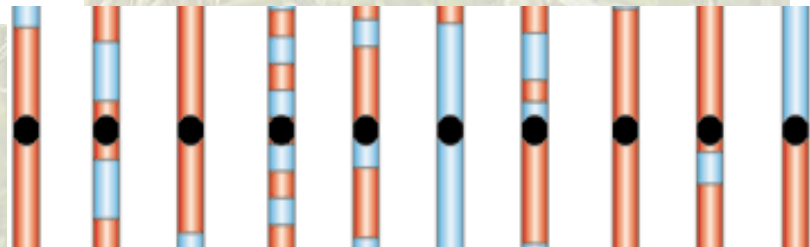
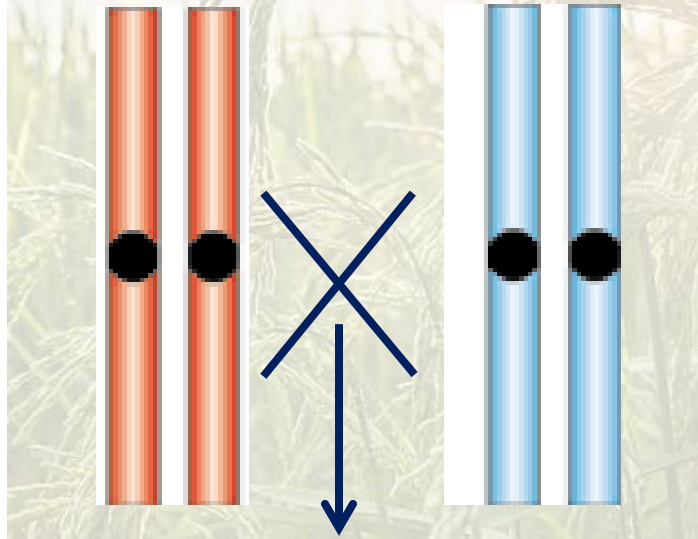
3) NEW BREEDING TECHNOLOGIES or
PRECISION BREEDING or *GENOME
EDITING*

1) CROSSING

**ELITE
VARIETY**



**VARIETY WITH A
POSITIVE TRAIT**



8-10 YEARS

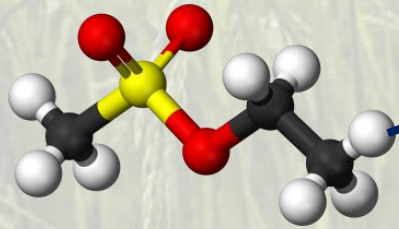
**TIME CONSUMING –
UNEXPECTED RESULTS**

2) RANDOM MUTAGENESIS

γ - rays

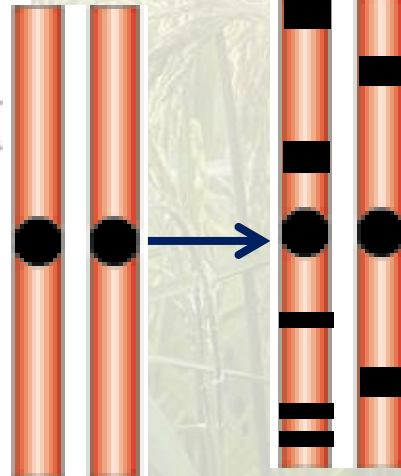


Randomly
break and
mutate the
DNA



Chemical
compounds

**ELITE
VARIETY**



**RANDOMLY
MUTATED
ELITE
VARIETY**

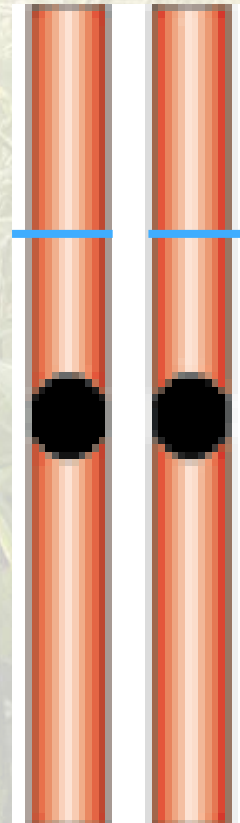


**TIME CONSUMING -
UNEXPECTED RESULTS**

3) NEW BREEDING TECHNOLOGIES or PRECISION BREEDING or *GENOME EDITING*

**IMPROVED
VARIETY**

- **Technology**
- **Knowledge**



The “ideal breeding”
Fast and precise

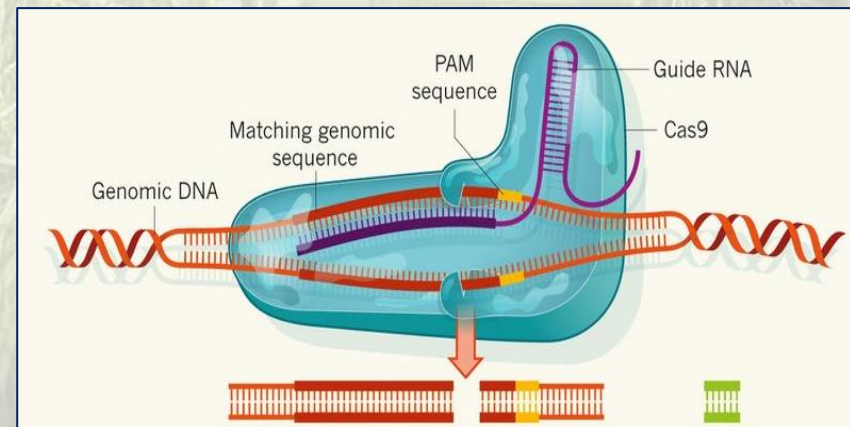
Technology



INVENTION
FROM BASIC
RESEARCH IN
BACTERIA

CRISPR/CAS9 (and subsequent modifications)

- Easy to use
- Precise
- Versatile



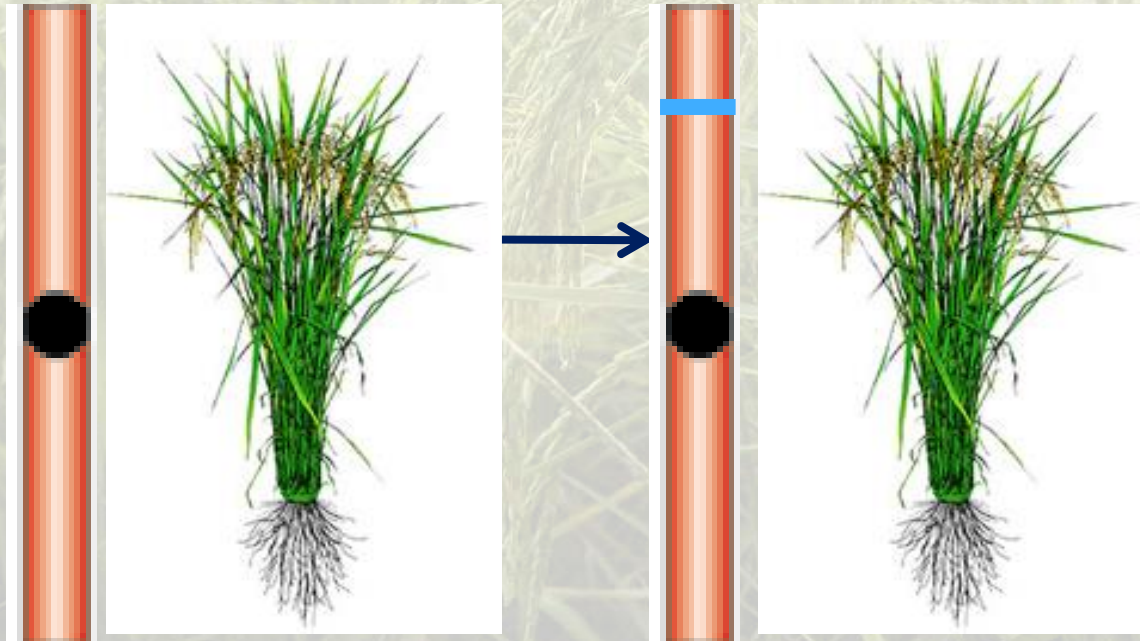
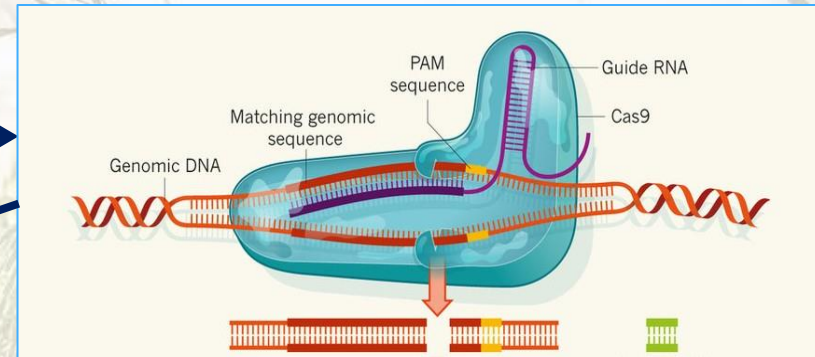
Knowledge

- **RESEARCH IS WORLDWIDE VERY ADVANCED**
- **WE KNOW THE MOLECULAR AND GENETIC BASES OF MANY TRAITS**



GENOME EDITING

Knowledge
from research



**VARIETY
IMPROVED
ONLY FOR
THE TRAIT
OF
INTEREST**

RICE FLOWERING

Allows shortening of
the cropping season

Important breeding
trait for European
rice

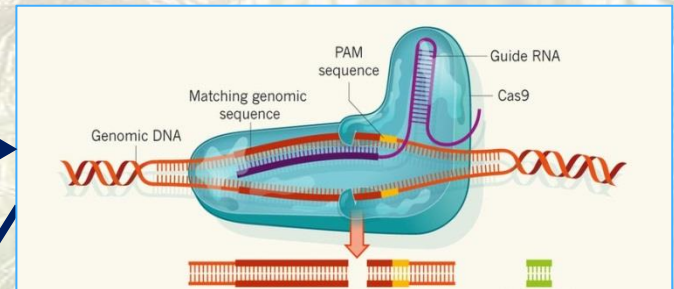


RICE FLOWERING

WE IDENTIFIED TWO GENES
THAT DELAY FLOWERING

WE USED CRISPR TO
INACTIVATE THEM

BZIP9	208	ACCAAGTAGCCAGCAGCATCAGCCGGCTCGGGCTCTCTGGGCGAGGGAGCATCAGATG	267
BZIP42	250	ATCGCGGGCCAGTC---TCAGCCGGCCCTGGGGCTGAGCGCCAGGGAGCATCAGATG	306
BZIP9	268	CCGCCTGAGCTCAGCAAGAAGACGCTGGACGAGGTGTGGAAGGGGATCCAGGCTGCTCCG	327
BZIP42	307	CCTCGGAGCTGAGCAAGAAGACGCTGGATGAGGTGTGGAAGGGATCCAGGATGTGCCG	366
BZIP9	328	AAGAGGAATGCCGAAAoggggggggggggggggggggggagaggggggAGAGAGGCAG	387
BZIP42	367	AAGAGGGGTGCTGAGGAGGGTGGC-----CGGTGGAGG-----CGGAGAGGCAG	411
BZIP9	388	CCGACGCTTGGGAGGTGACGCTCGAGGATTTCCTGGTCAAAGCTGGGGTTGTCA	447
BZIP42	412	CCGACCTTGGGAGGTGACGCTTGGAGATTTCCTGGTCAAAGCTGGGGTTGTCA	467
BZIP9	448	GGATCTCTCAAGGAGCTTAGTGATGTAGGCAATGTGGATCCGGTTGGAAGAGGTGTACA	507
BZIP42	468	GGATCCG--AACGA--TTTGCCA-----GGAACATGATGTGGTAGGGGCGCTGCTGG	519
BZIP9	508	GC---AACCGGGACTGTGGATCTGGCACCTGGATCACACTGGATAGACAGTATAAGCAG	564



- **FAST: 6 MONTHS**
- **100% Efficiency:** all plants recovered had both genes inactivated
- **Specificity:** no off targets were found



Original plants

Early flowering plants

RICE TRAITS IMPROVED BY CRISPR

GENES	TRAIT	REFERENCE
OsBADH2	Aroma	Shan et al. (2013)
SWEET1a-1b-11-13	Resistance to <i>Xantomonas oryzae</i>	Zhou et al. (2014)
Gn1a, GS3, IPA1	Increased yield	Li et al. (2016)
DEP1	Increased yield	Wang et al., 2017
.....		

EVERY WEEK NEW TRAITS ARE ADDED TO THE LIST!

Genome editing is used to improve several crop species

Mushroom-Yang 2016



Corn-Dupont 2016



Tomato-Nekrasov 2017



Potato-Andresson 2017



Wheat-Liang 2017



Soy - Demorest 2016



“did not detect off-target mutations”

“no off-target mutations are detected in the mutant plants”

Thanks to all the young scientists of the rice lab group at the University of Milan



Fabio Fornara

Martina Cerise

Micol Aldrovandi

Francesca Giaume



A wide-angle photograph of a vibrant green rice paddy field. The field is filled with young rice seedlings, and a narrow, dark, muddy path winds through the left side. In the background, a traditional building with a tiled roof and a small tower is visible, surrounded by trees and a clear sky. The text "Thank you" is overlaid in the center of the image.

Thank you