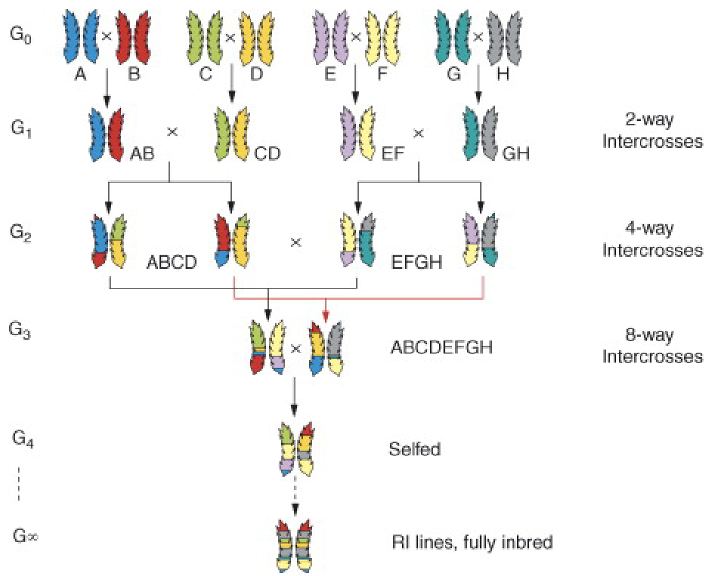
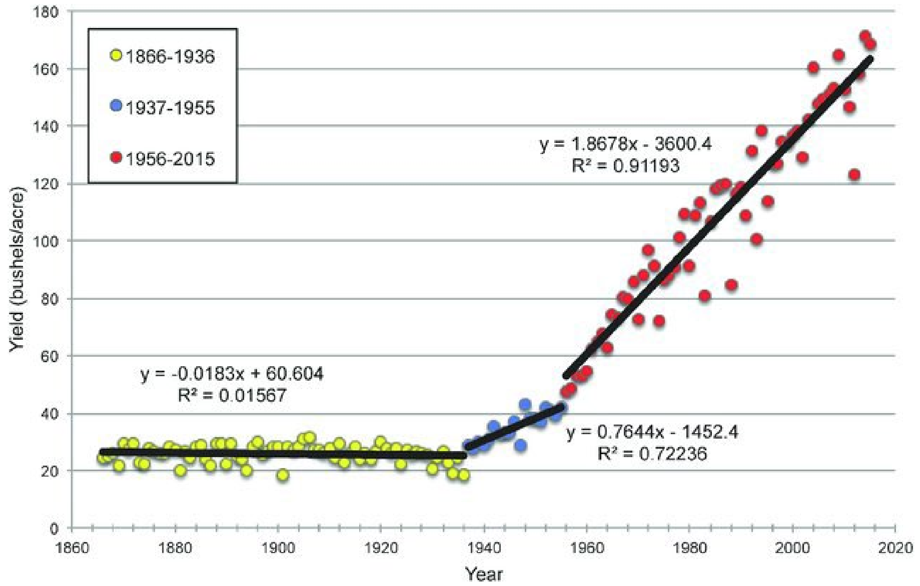
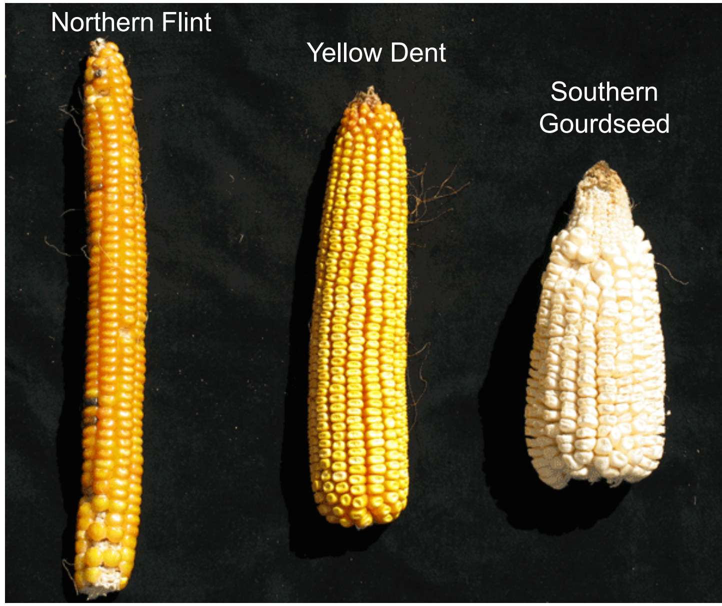
PRO-GRACE

PROMOTING A PLANT GENETIC RESOURCE COMMUNITY FOR EUROPE

Breeding and pre-breeding







Jaime Prohens
Universitat Politècnica de València, Valencia, Spain

What is Plant Breeding?

Plant Breeding is an applied science that tries to harness the genetic potential of plants for the benefit of humans.

Other definitions:

Vavilov (1920s): "Breeding is human-directed plant evolution"

Frankel (1958): "Plant breeding is the genetic manipulation of plants in the service of humans"

Simmonds (1979): "The breeder is an evolutionist directed toward well-defined goals, using reasonably understood scientific methods."

Sánchez-Monge (1984): "The breeder is, ultimately, nothing more than an imitator of natural evolutionary processes, but directing the processes he imitates towards the creation of the genotypes he projects"

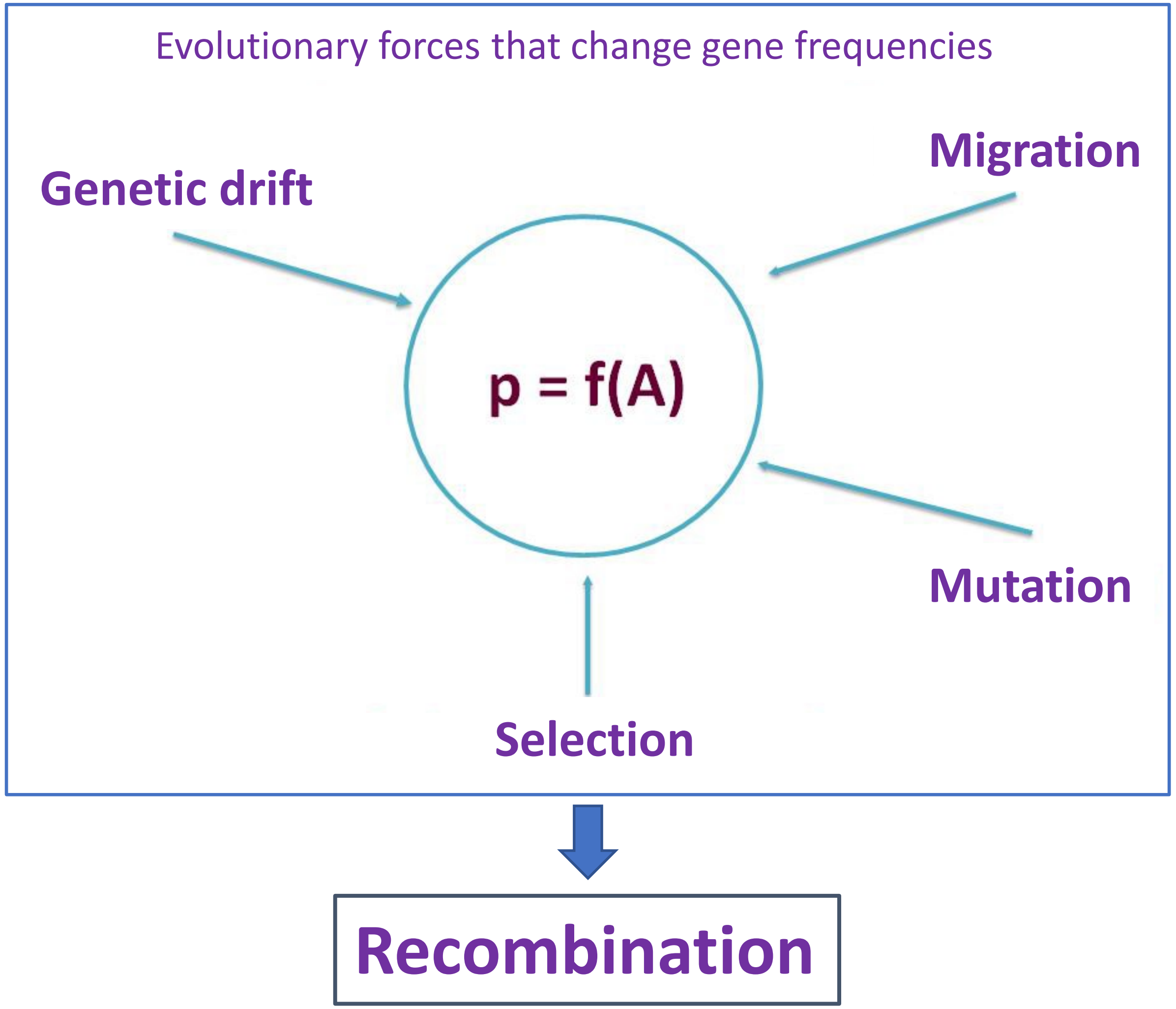
Fehr (1993): "Plant breeding is the art and science of plant breeding"

Acquaah (2007): "Plant breeding is the branch of agriculture that tries to manipulate the heredity of plants to develop new types of improved plants for use by society"

Breeding and pre-breeding

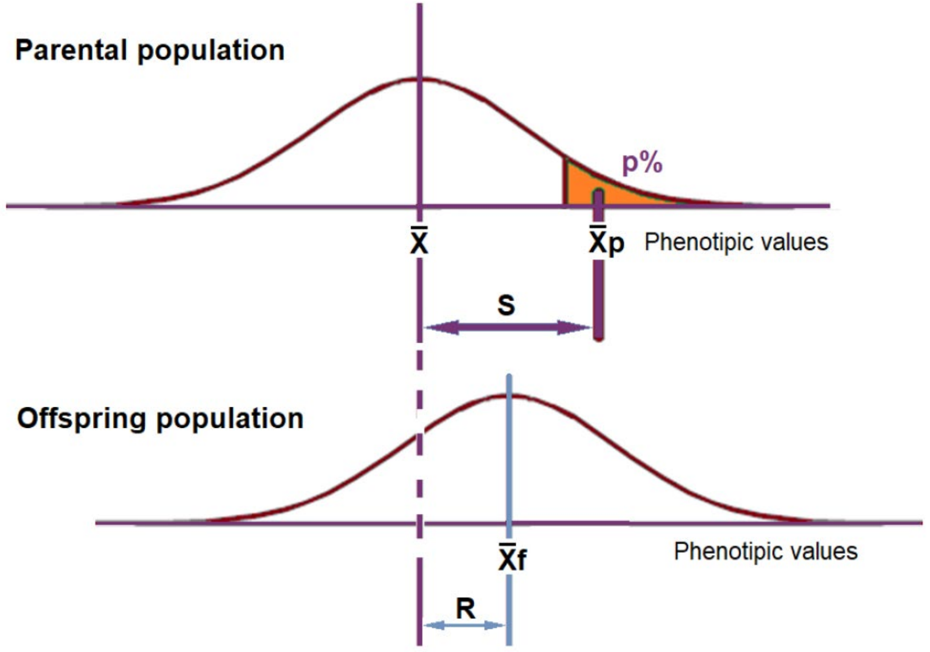
What is Plant Breeding?

The same evolutionary forces that act in natural selection also act in the plant breeding process.



The breeders' equation

$$R = S \cdot h^2$$



Breeding and pre-breeding

What is Plant Breeding?

Plant Breeding is an applied science that tries to harness the genetic potential of plants for the benefit of humans.

Main applications of Plant Breeding:
· Increase crop productivity
· Increase crop quality
· Reducing the environmental impact of agriculture
· Contributing to ecosystem services

The fundamentals of Plant Breeding are provided by Genetics
But other disciplines are of great relevance in Plant Breeding:

-Agronomy	-Botany	-Plant Physiology	-Entomology
-Biochemistry	-Plant Pathology	-Statistics	-Design of Experiments

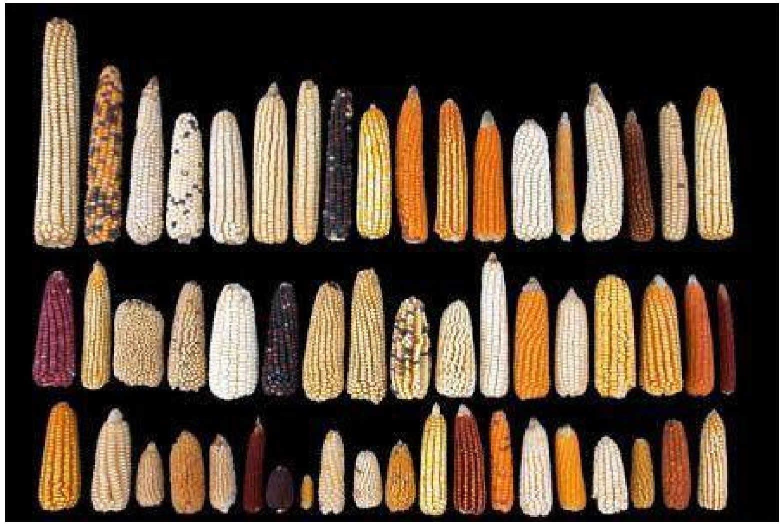
Breeding methods largely depend on:
-Reproductive system of the target species
-Trait heritability

Breeding and pre-breeding

<u>Genetic resources are the "raw materials" for Plant Breeding</u>

Plant Breeding applies different methods and techniques on plant materials (genetic resources) for their improvement or a basis of the development of new genetic materials with improved properties. The results of Plant Breeding depend on the genetic resources available and used in the breeding programmes

The genetic resources available for a breeder are:
-Presently grown commercial cultivars
-Obsolete commercial cultivars
-Traditional / landrace varieties
-Breeding lines and genetic stocks (mutants)
-Wild (and cultivated) relatives



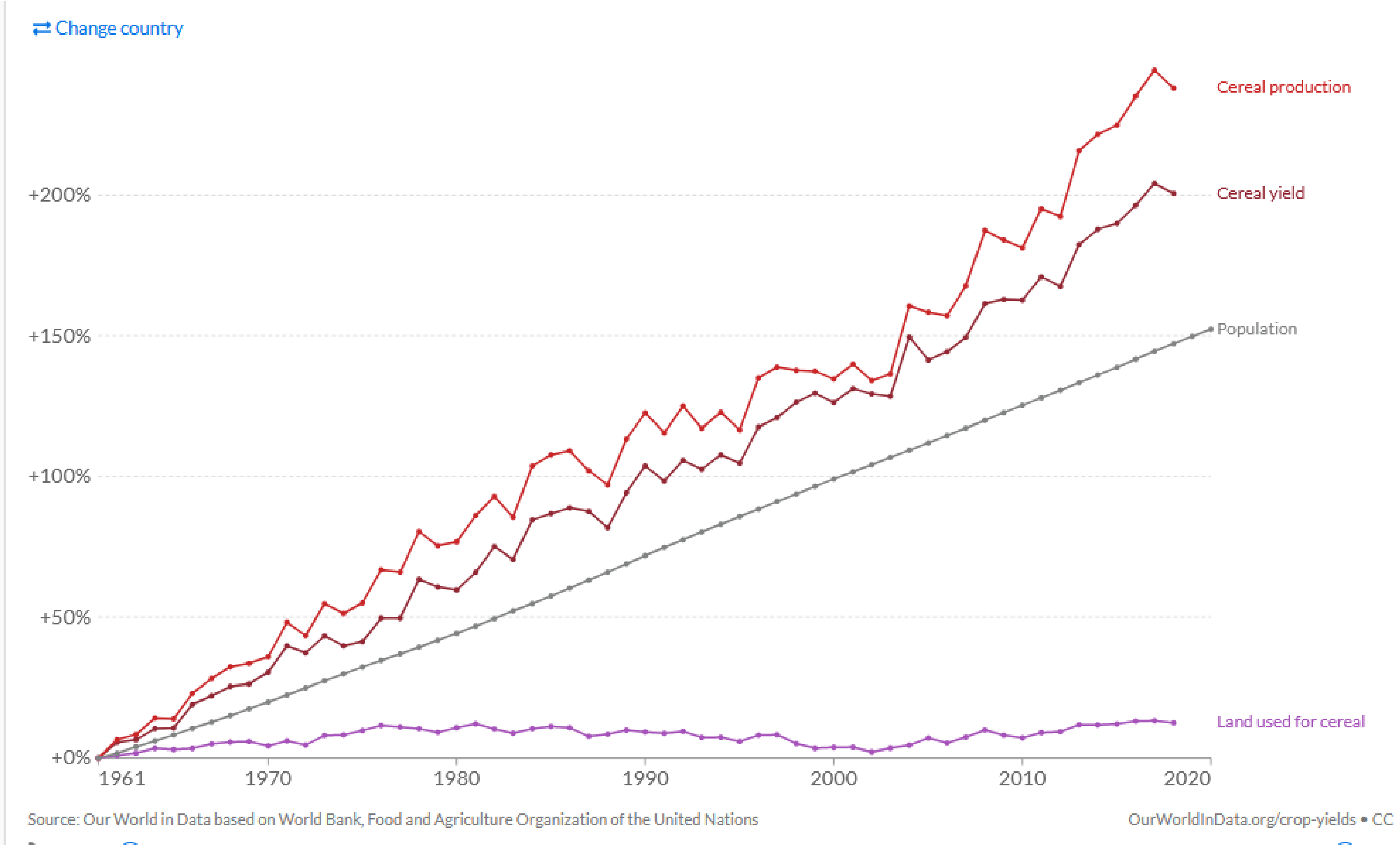
The genetic diversity for the trait/s of interest in the genetic resources used is a main determinant in the success of a breeding programme:

<u>The ceiling of potential genetic improvement is conditioned by the genetic diversity in the genetic resources used</u>

Results of Plant Breeding

Breeding has contributed around 50% to the increase in crop yields in the last century.

Cereals yield and production



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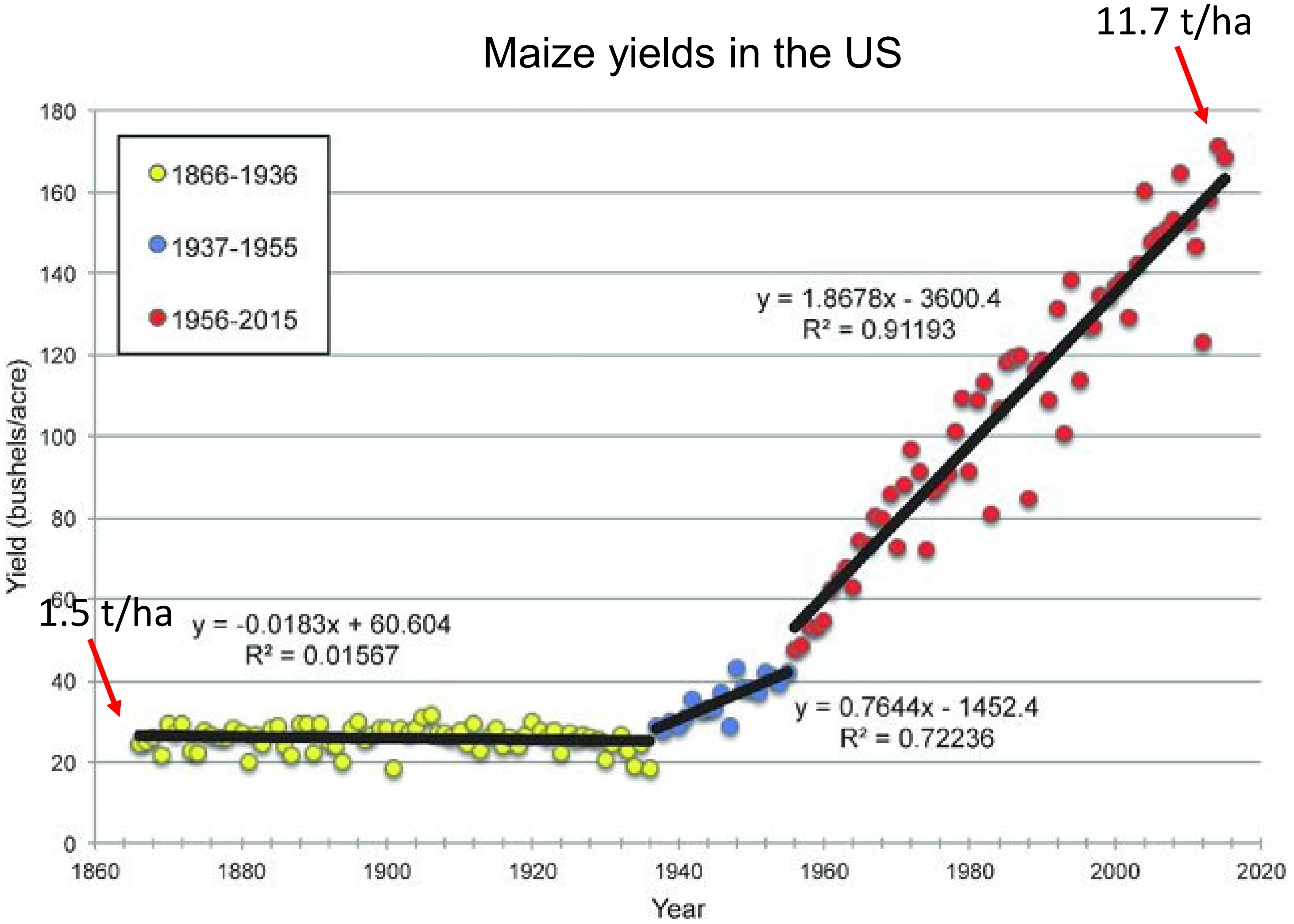
Results of Plant Breeding

Genetic Improvement has contributed 50% to the increase in crop yields in the last century.

Maize yields in the US



1 bushel/acre = 0.0673 t/ha

Breeding and pre-breeding

Results of Plant Breeding

Genetic Improvement has contributed 50% to the increase in crop yields in the last century.

Corn Yield Contest Winner

Grower Sets New World Record with Corn Yield of 616.2 BPA

12/20/2019 | 5:00 PM CST

By Emily Unglesbee , DTN Staff Reporter

Connect with Emily:

@Emily_Unglesbee

David Hula, of Charles City, Virginia, set his fourth world record with an irrigated corn yield of 616 bpa in the NCGA's 2019 National Corn Yield Contest. (DTN/Progressive Farmer file photo by Jim Patrico)

ROCKVILLE, Md. (DTN) -- After three world records, some folks might retire.

Not David Hula. With his irrigated corn yield of 616.20 bushels per acre (bpa), the Charles City, Virginia, farmer won the National Corn Growers Association's 2019 National Corn Yield Contest, but also set his fourth world record for the crop.

Why keep competing?

"It doesn't get old," Hula told DTN. "The excitement is still there. I feel like I'm a good steward of the crop and I have a lot of information I want to share yet. Trust me, I have failed more than most, and that's why I want to share what I've learned with growers."

This year the contest produced 27 national winners in nine separate production categories.

1 bushel/acre = 0.0673 t/ha

World record:
616.2 bushel/acre

↓

41.5 t/ha

Breeding and pre-breeding

Results of Plant Breeding

The socio-economic and environmental values of plant breeding in the EU and for selected EU member states (327 pages)

hffa RESEARCH

The socio-economic and environmental values of plant breeding in the EU and for selected EU member states

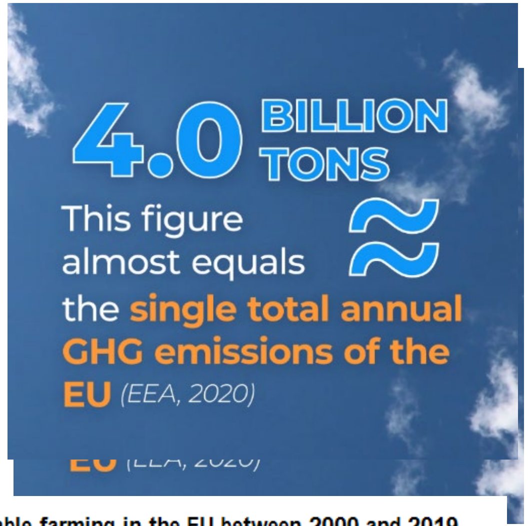
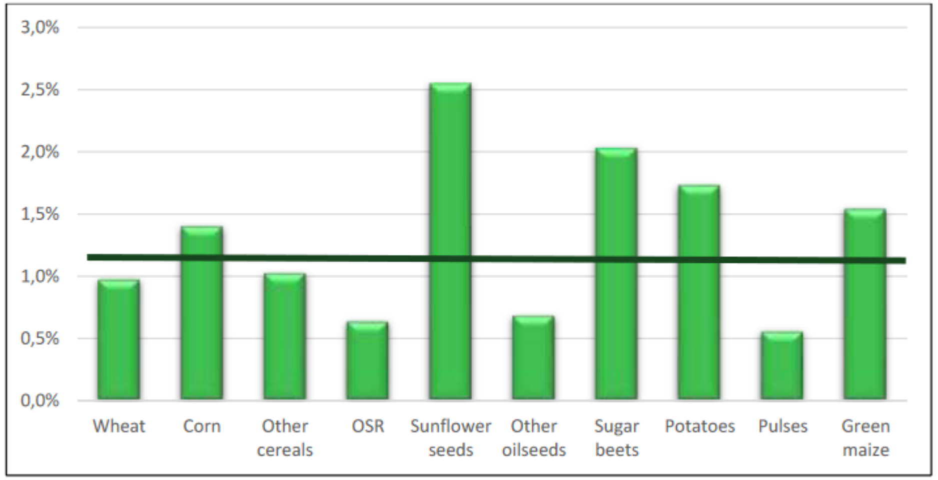


Figure 2.2: Annual yield growth rates of arable farming in the EU between 2000 and 2019



Source: Own calculations and figure based on FAO (2021) and Eurostat (2021b).

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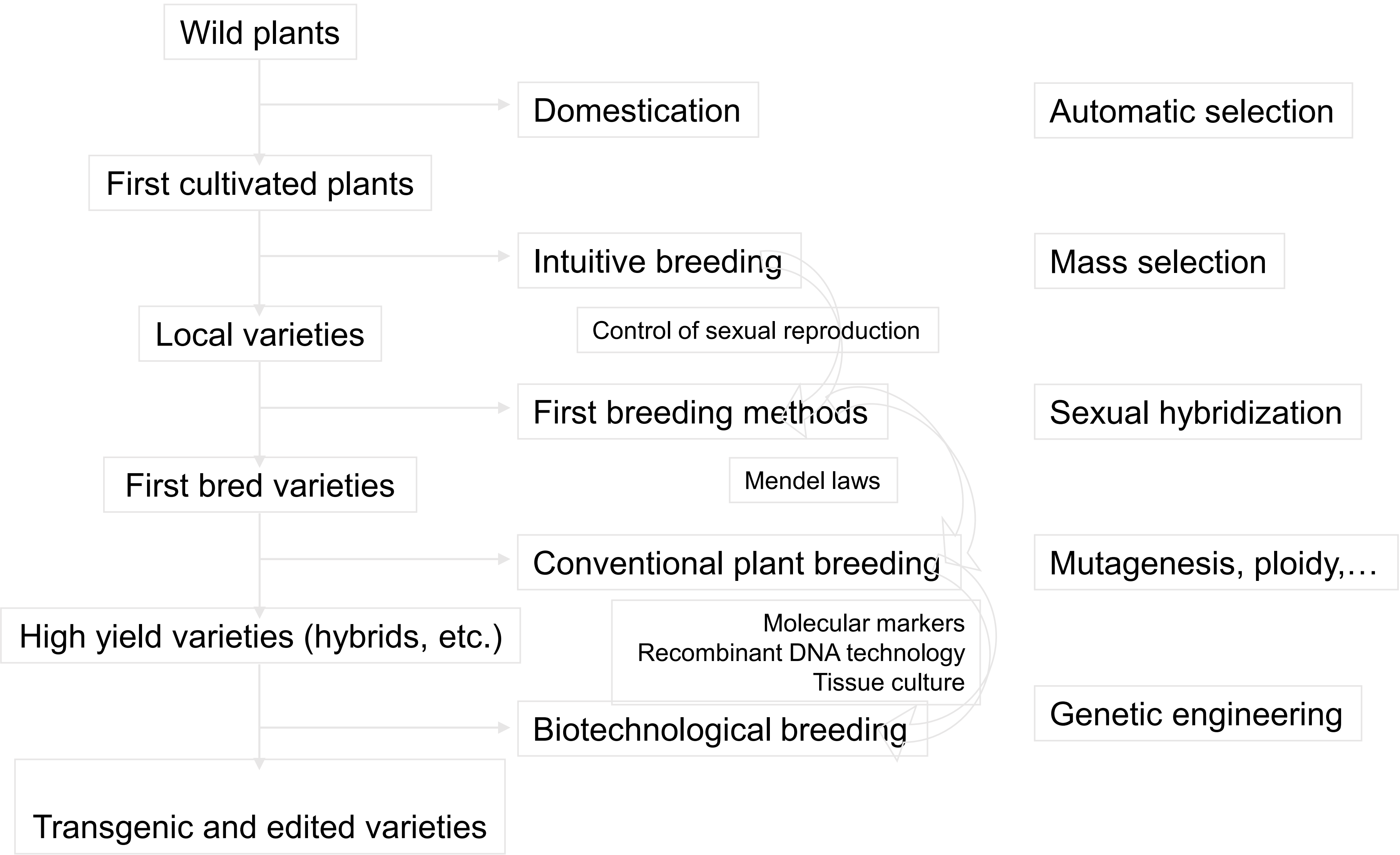
Breeding and pre-breeding

Evolution of Plant Breeding



First successes in scientific Plant Breeding

Sugar beet

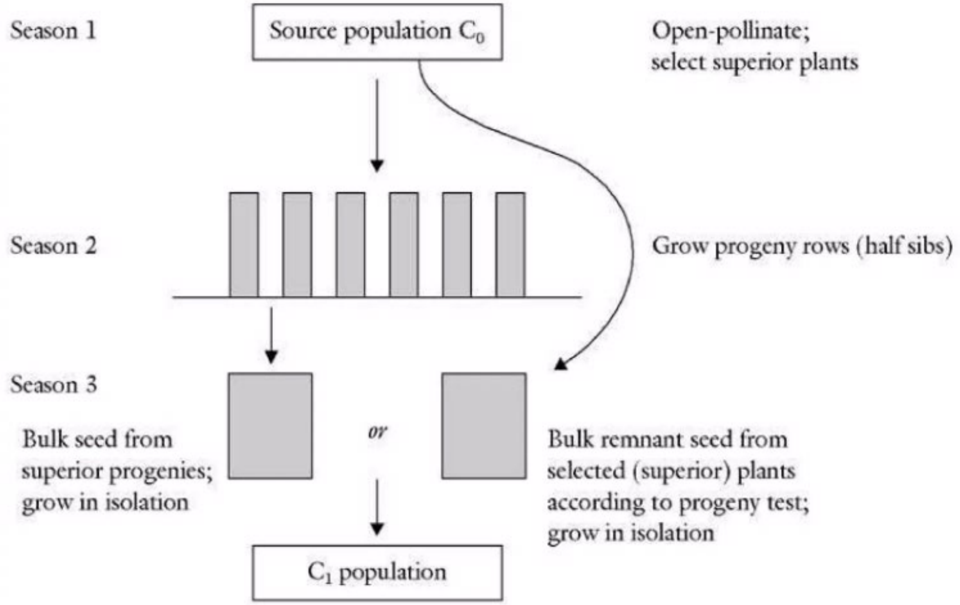
Around 1750 it is discovered (Andreas Margraff) that beetroot contains sucrose indistinguishable from that of sugar cane.

As a result of the English blockade during the Napoleonic Wars, the supply of sugar cane was cut off.

This encouraged the development of beets as a source of sugar.

André de Vilmorín developed and successfully applied the concept of proof of descent (plant-to-row method) to apply it to sugarbeet breeding

André de Vilmorin



Breeding and pre-breeding

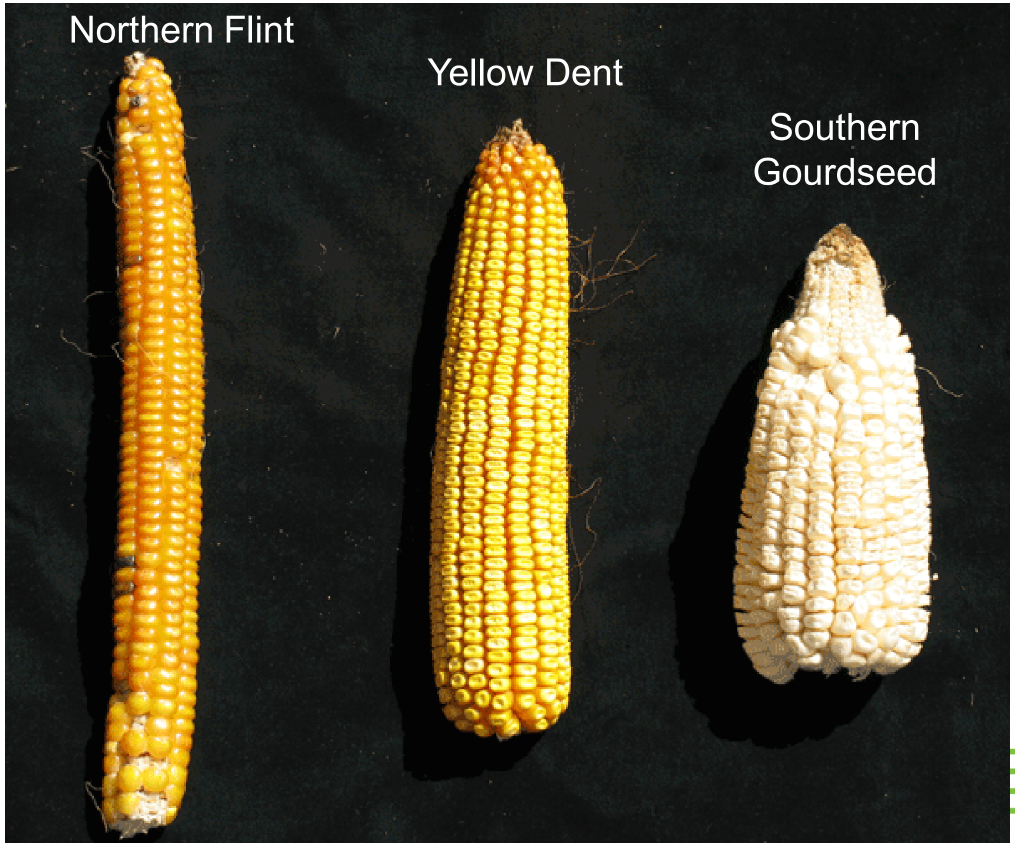
First successes in scientific Plant Breeding

Maize Yellow Dent

Lorain (1814) observes that the crossing between the Northern Flint variety and the Southern Gourdseed gives rise to hybrids of great productivity and quality: The Yellow Dent.

Yellow Dents are the basis of almost all corn hybrids.

Genetic resources used:
-Northern Flint landrace
-Southern Gourdseed landrace



Breeding and pre-breeding

Breakthroughs in conventional breeding

Nazzareno Strampelli

In the decade of the 1910s Strampelli made many crosses and evaluated their offsprings

One of the most successful was:

Akagomugi x [Wilhelmina Wheat x Rieti]

Akagomugi: semi-dwarf, early Japanese variety and very fertile

Wilhelmina Tarwe: large length of spike

Rieti: very good adaptation to Italian conditions

From this crossing derived many varieties that dominated the European wheat varietal spectrum until the arrival of CIMMYT wheat (green revolution)

Genetic resources used:
-Hundreds of wheat varieties
-Akagomugi, Wilhelmina Tarwe, Rieti varieties

Nazzareno Strampelli

Senatore Cappelli wheat

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Breakthroughs in conventional breeding

Norman Borlaug

Norman Borlaug (Peace Nobel Prize, 1970) developed new wheat semi-dwarf pathogen resistant wheat varieties insensitive to photoperiod that allowed dramatic improvements in yield, as they allowed higher fertilization rates without lodging.

As a result, some countries such as Mexico, India and Pakistan increased dramatically their production of cereals (transformation from so called "begging basket" to "breadbasket")

Norman Borlaug

Semi-dwarf wheat

Genetic resources used:
-Thousands of wheat materials
-Norin-10: semidwarf Japanese variety with Rht1 and Rht2 genes
-Brevor. Northamerican variety

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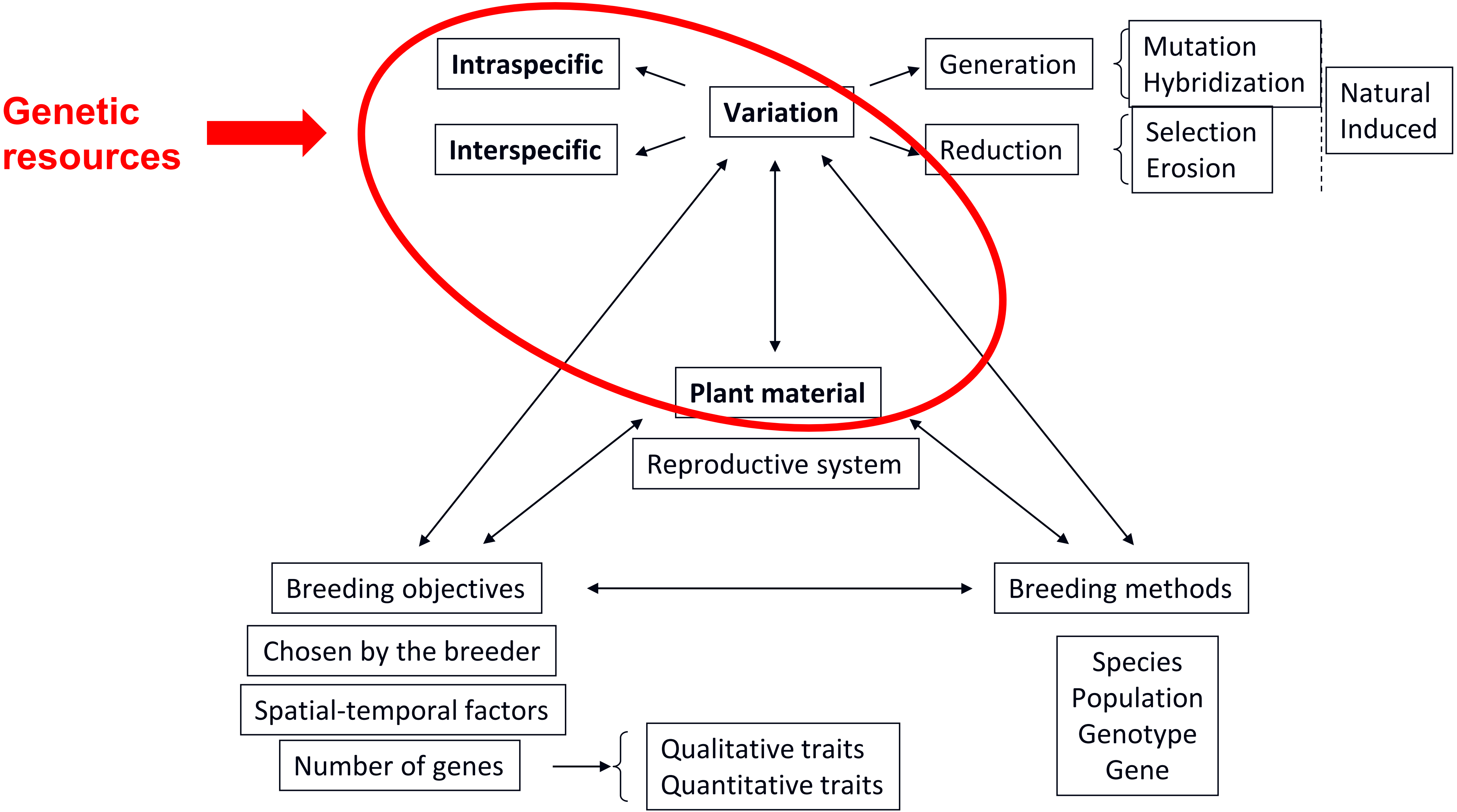
Determinants of Breeding Programmes



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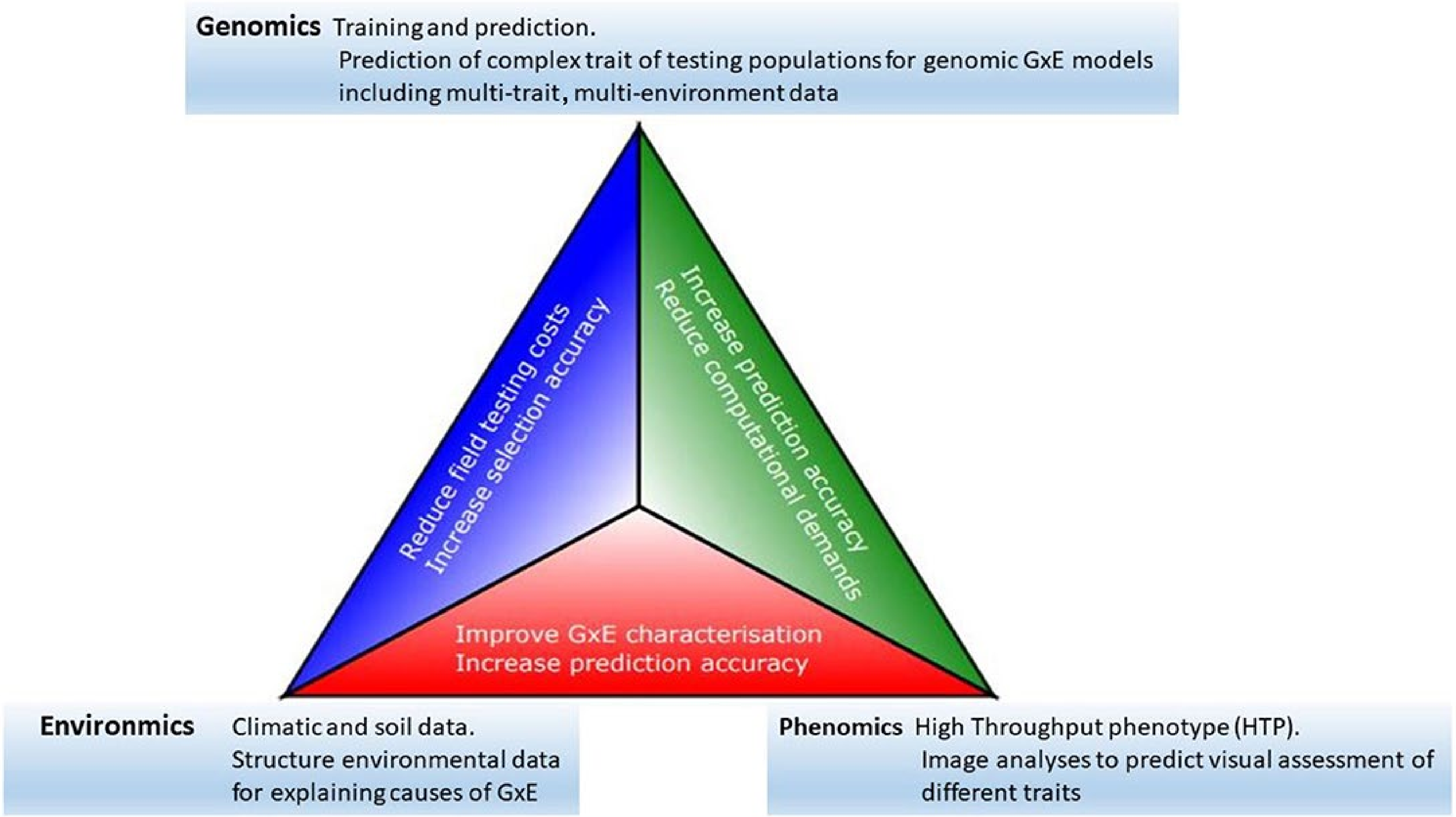
Breeding and pre-breeding

New perspectives in the use of genetic resources in Plant Breeding

The Breeding Triangle: Combining Phenomics, Genomics and Enviromics to make a more efficient use of genetic resources



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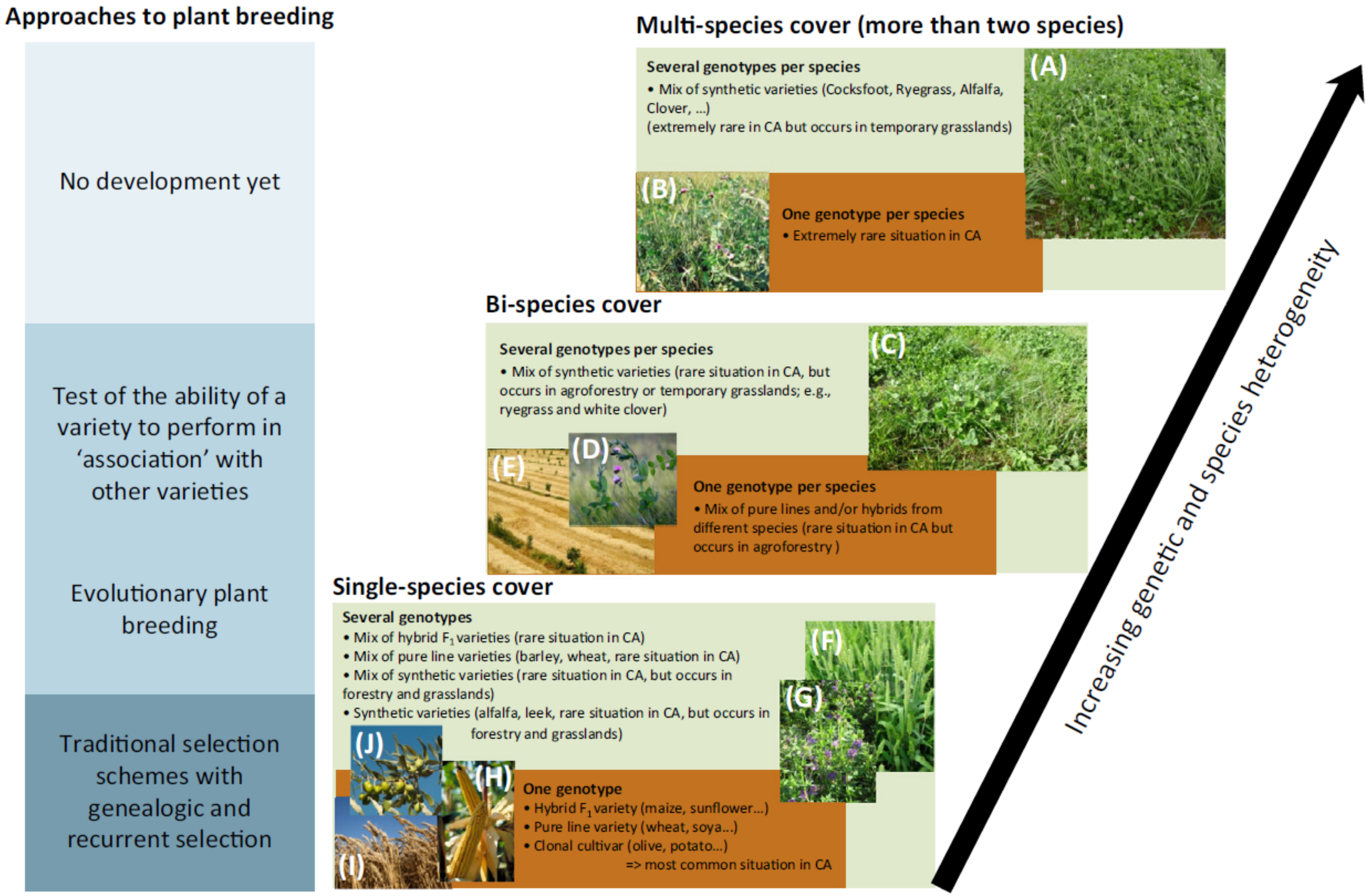
Breeding and pre-breeding

New perspectives in the use of genetic resources in Plant Breeding

Improvement of diversity of agricultural systems



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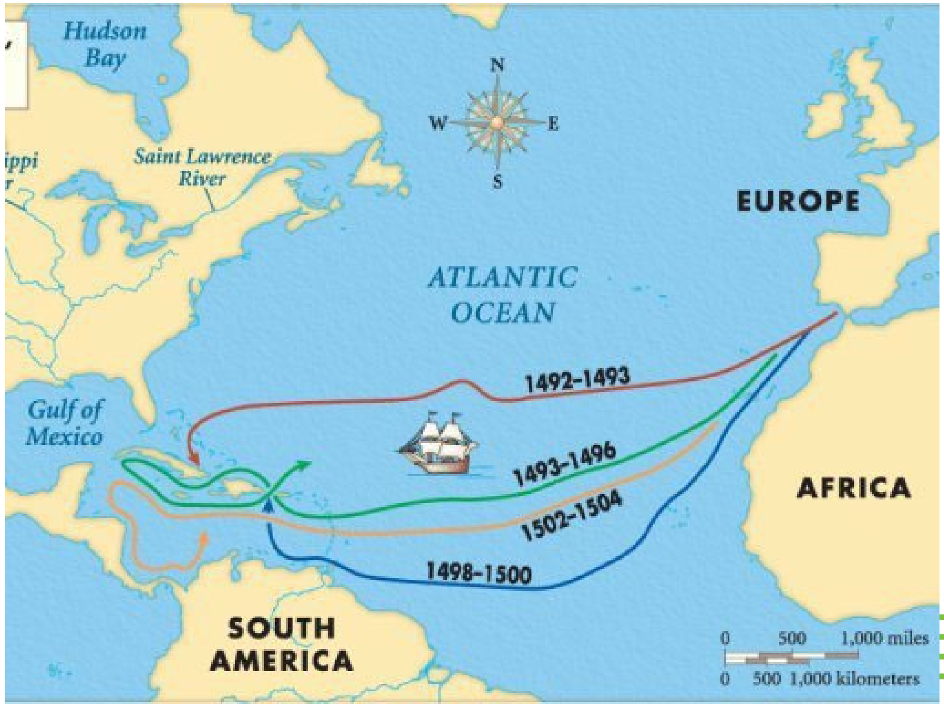
Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

The beginning of the story: Spanish arrival to America

Spain played a key role in the introduction of tomato in Europe.

The usefulness of New World plants gave rise to an intense traffic of vegetable products between America and Europe, centralized in its beginnings in **Seville**



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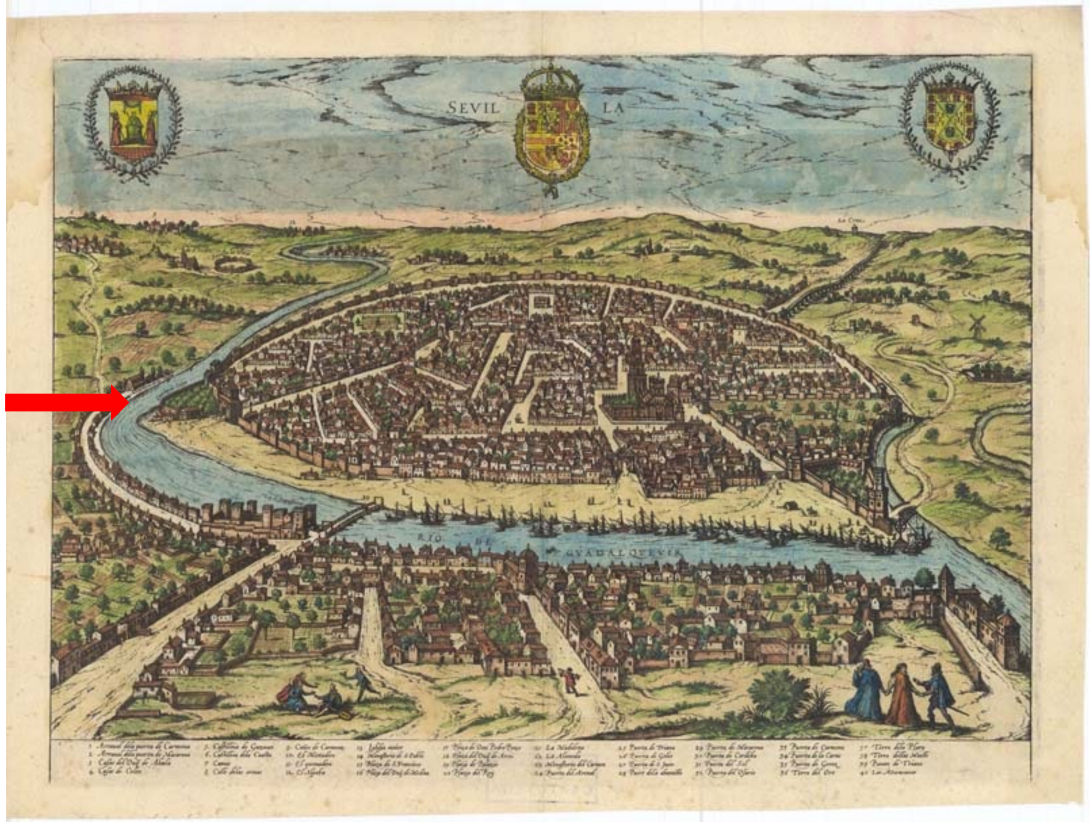
Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

This led to the creation of Gardens of Acclimatization of tropical plants for their adaptation to new environments: Gardens of Seville

Seville, thanks to the trade promoted by the Guadalquivir river, was one of the most prosperous cities in Europe



Sevilla in the Civitates Orbis Terrarum (1588). Place of the Botanic Garden of Hernando Colon (1488-1539)

An example of use of genetic resources in breeding: Tomato

The patient work of the farmers together with selection under local conditions gave rise to an explosion of diversity (genetic resources)

Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

A large part of this diversity of genetic resources is held in genebanks

Tomato treasure held in genebanks (Genesys)

Holding Institute	Nº accessions	Holding Institute	Nº accessions
TWN001	8591	ROM019	257
USA003	6400	SDN002	256
USA974	5770	HUN003	249
USA176	3514	ARM008	222
UKR021	2138	GBR006	210
CZE122	1391	ROM055	196
BGR001	1365	GBR017	185
NLD037	1337	ARM005	179
AUS165	1276	POL003	126
MDA011	619	ITA393	123
ROM007	375	ALB026	116
CRI001	346	SWE054	112
USA995	308	33 Institutions	866

TOTAL 36,527

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An example of use of genetic resources in breeding: Tomato

A large part of this diversity of genetic resources is held in genebanks

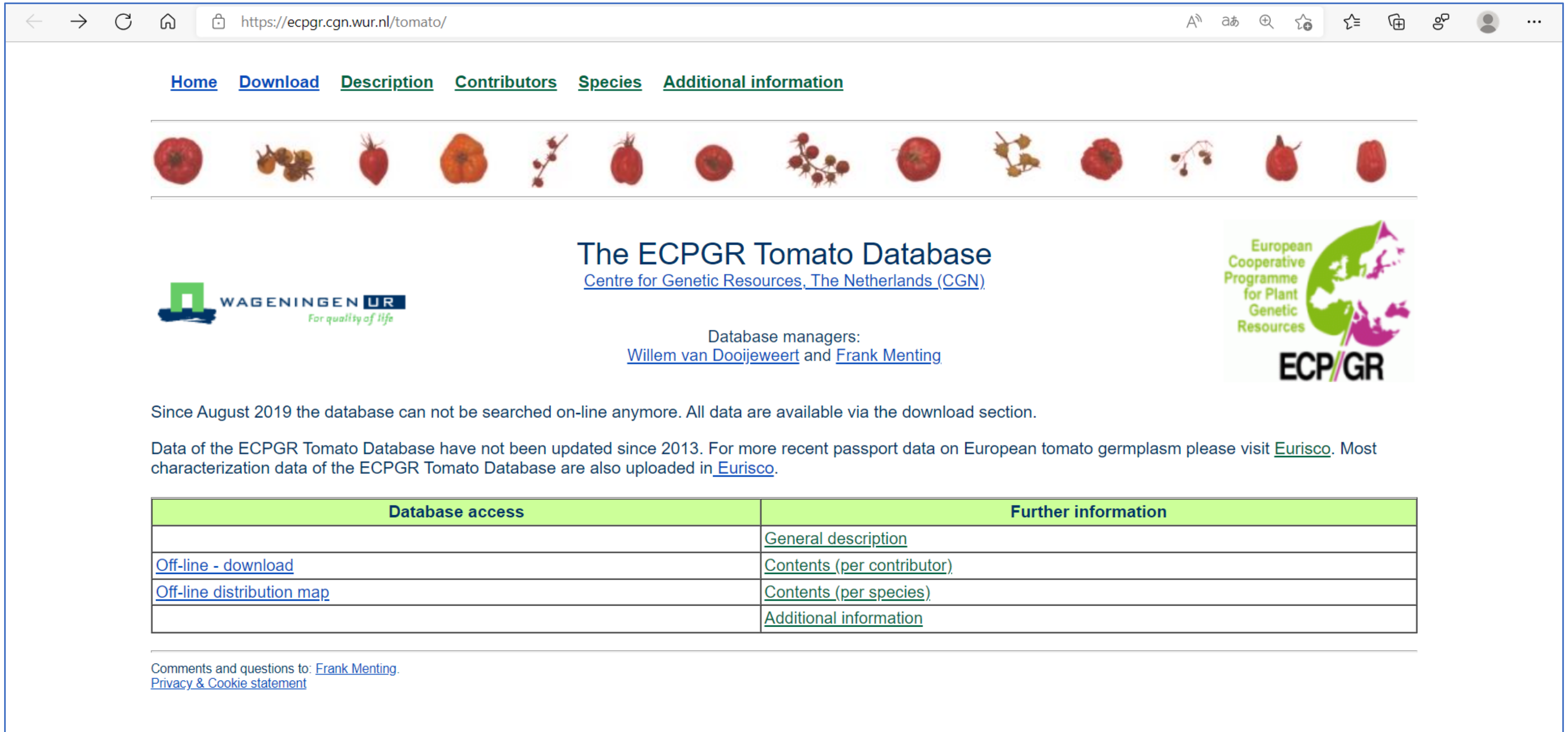
EURISCO: European Search Catalogue for Plant Genetic Resources

National Inventory	No Of Accessions	National Inventory	No Of Accessions
Albania	116	Italy	189
Armenia	396	Latvia	14
Austria	77	Lithuania	27
Azerbaijan	99	Moldova	601
Belgium	1	**Netherlands**	1230
Bosnia and Herzegovina	22	Nordic Countries	163
Bulgaria	1385	North Macedonia	42
Croatia	37	**Poland**	1372
Cyprus	11	Portugal	326
Czech Republic	1397	Romania	934
Estonia	22	Slovakia	126
France	55	**Spain**	5269
Germany	4215	Switzerland	39
Greece	22	**Ukraine**	1687
Hungary	1943	United Kingdom	459
Israel	27		

An example of use of genetic resources in breeding: Tomato

A large part of this diversity of genetic resources is held in genebanks

The ECPGR tomato database



https://ecpgr.cgn.wur.nl/tomato/

Home Download Description Contributors Species Additional information

The ECPGR Tomato Database

Centre for Genetic Resources, The Netherlands (CGN)

WAGENINGEN UR For quality of life

European Cooperative Programme for Plant Genetic Resources ECP/GR

Database managers:
Willem van Dooijeweert and Frank Menting

Since August 2019 the database can not be searched on-line anymore. All data are available via the download section.

Data of the ECPGR Tomato Database have not been updated since 2013. For more recent passport data on European tomato germplasm please visit Eurisco. Most characterization data of the ECPGR Tomato Database are also uploaded in Eurisco.

Database access	Further information
	General description
Off-line - download	Contents (per contributor)
Off-line distribution map	Contents (per species)
	Additional information

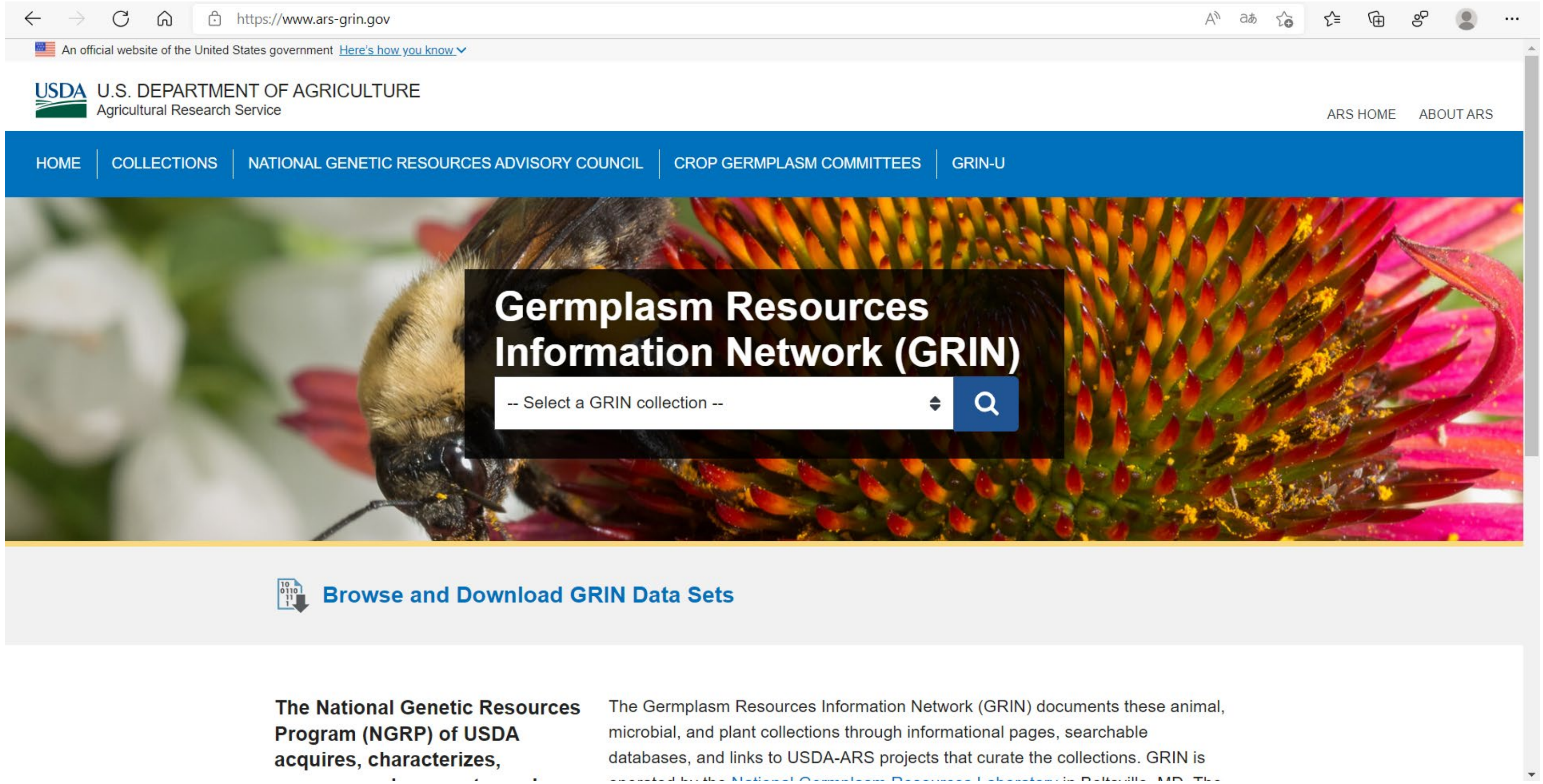
Comments and questions to: Frank Menting.
Privacy & Cookie statement

Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

A large part of this diversity of genetic resources is held in genebanks

The Germplasm Resources Information Network (ARS-GRIN)

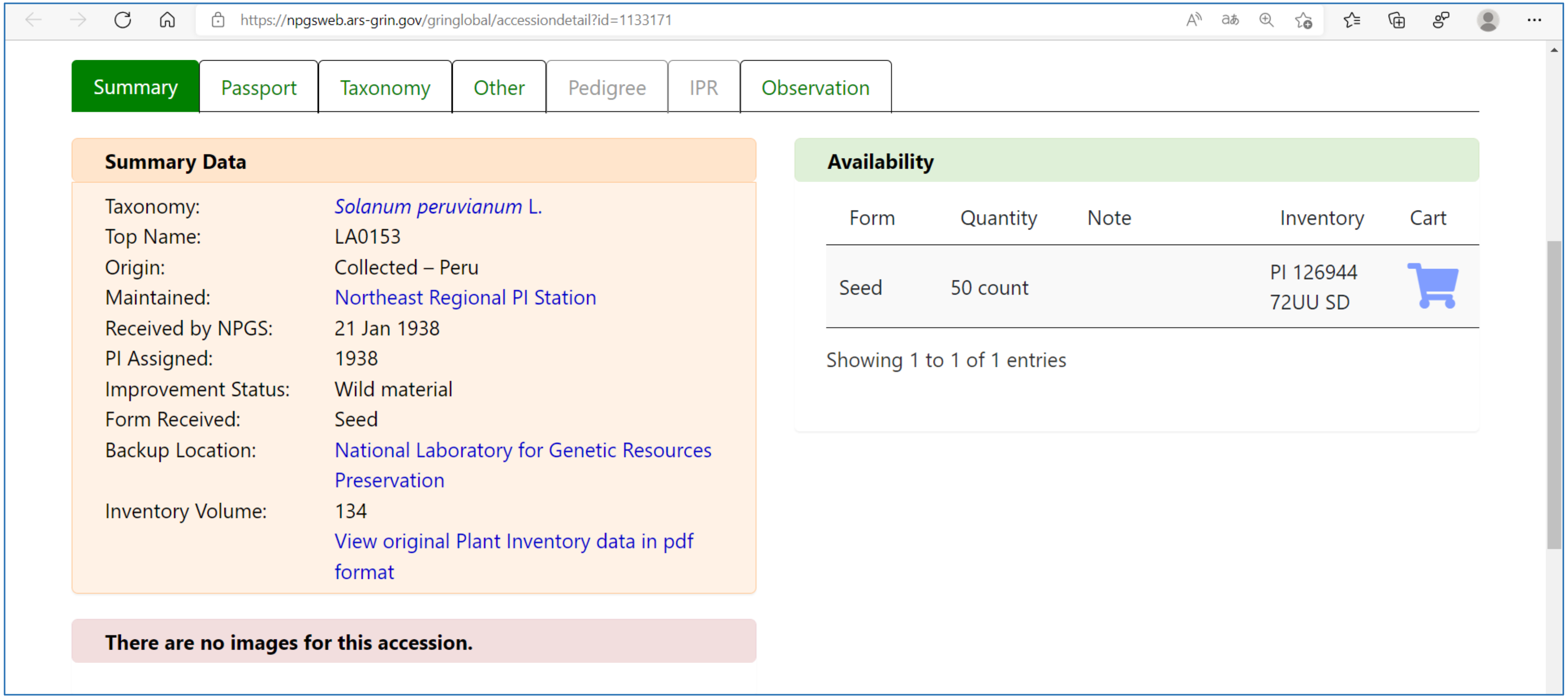


Plant Genetic Resources Unit (PGRU): Geneva, NY. 5141 tomato accessions

An example of use of genetic resources in breeding: Tomato

A large part of this diversity of genetic resources is held in genebanks

The Germplasm Resources Information Network (ARS-GRIN)


https://npgsweb.ars-grin.gov/gringlobal/accessiondetail?id=1133171

Summary | Passport | Taxonomy | Other | Pedigree | IPR | Observation

Summary Data

Taxonomy:	*Solanum peruvianum* L.
Top Name:	LA0153
Origin:	Collected – Peru
Maintained:	Northeast Regional PI Station
Received by NPGS:	21 Jan 1938
PI Assigned:	1938
Improvement Status:	Wild material
Form Received:	Seed
Backup Location:	National Laboratory for Genetic Resources Preservation
Inventory Volume:	134
	View original Plant Inventory data in pdf format

Availability

Form	Quantity	Note	Inventory	Cart
Seed	50 count		PI 126944 72UU SD	

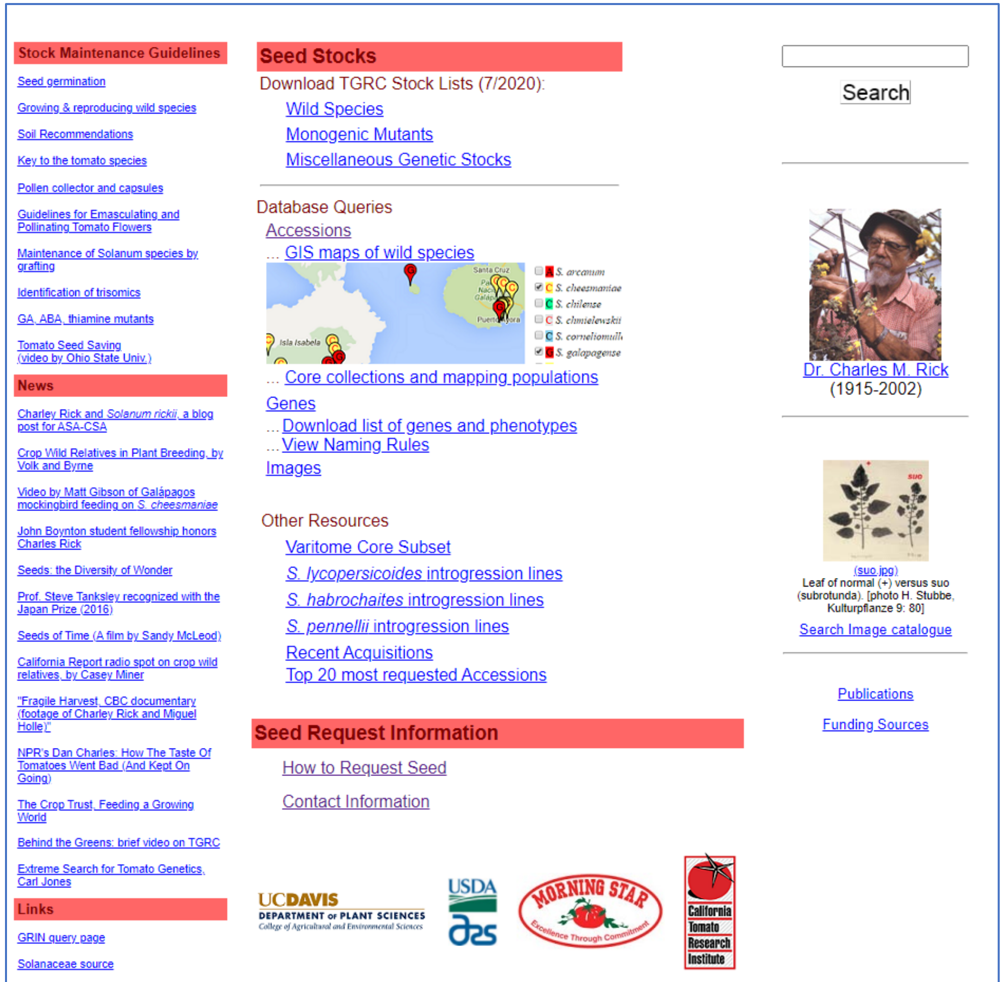
Showing 1 to 1 of 1 entries

There are no images for this accession.

An example of use of genetic resources in breeding: Tomato

A large part of this diversity of genetic resources is held in genebanks

The Tomato Genetic Resources Center



Species	nº accessions
S. arcanum	45
S. cheesmaniae	41
S. chilense	115
S. chmielewskii	16
S. corneliomulleri	53
S. galapagense	28
S. habrochaites	120
S. huaylasense	16
S. juglandifolium	5
S. lycopersicoides	23
S. neorickii	47
S. ochranthum	7
S. pennellii	47
S. peruvianum	69
S. pimpinellifolium	290
S. sitiens	13

TOTAL: 935

Monogenic mutants	1058
Modern cultivars	222
Latin American cultivars	349
Ils *S. pennellii*	83
ILs S. *habrochaites*	93
Ils lycopersicoides	97
RILs pimpi, pen, etc.	1353

TOTAL: 3255

An example of use of genetic resources in breeding: Tomato

The history of tomato breeding

1778	Vilmorin includes tomato in its catalogue
End 19^{th} century	High morphol variability: first landraces and Heirlooms
Beginning 20^{th} century	First efforts tomato breeding
1925	Tomato varieties common in commercial catalogues
Beginning 1940's	First interspecific hybrid (*S. pimpinellifolium)*
1943	Specific breeding programms for fresh consumption and industry
1946	Release of first F_1 hybrid «Single cross»

Breeding objectives:

1970	1980	1990	Today
Yield and resistance	Long shelf life	Taste	Nutritional quality

Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

Species included in *Solanum* section *Lycopersicon*

Group	Especie
Group *Lycopersicon*	*S. cheesmaniae* (L. Riley) Fosberg
	S. galapagense S.Darwin & M.I. Peralta
	S. lycopersicum var. *lycopersicum* L.
	S. lycopersicum var. *cerasiforme* L.
	S. pimpinellifolium L.
Group *Neolycopersicon*	*S. pennellii* Correll
Grupo *Eryopersicon*	*S. chilense* (Dunal) Reiche
	S. corneliomulleri J.F. Macbr.
	S. habrochaites S. Knapp & D.M. Spooner
	S. huaylasense Peralta & S.Knapp
	S. peruvianum L.
Group *Arcanum*	*S. arcanum* Peralta
	S. chmielewskii (C.M. Rick, Keisicki, Fobes & M. Holle) D.M. Spooner, G.J. Anderson & R.K. Jansen Spooner, G.J. Anderson & R.K. Jansen
	S. neorickii D.M. Spooner, G.J. Anderson & R.K. Jansen

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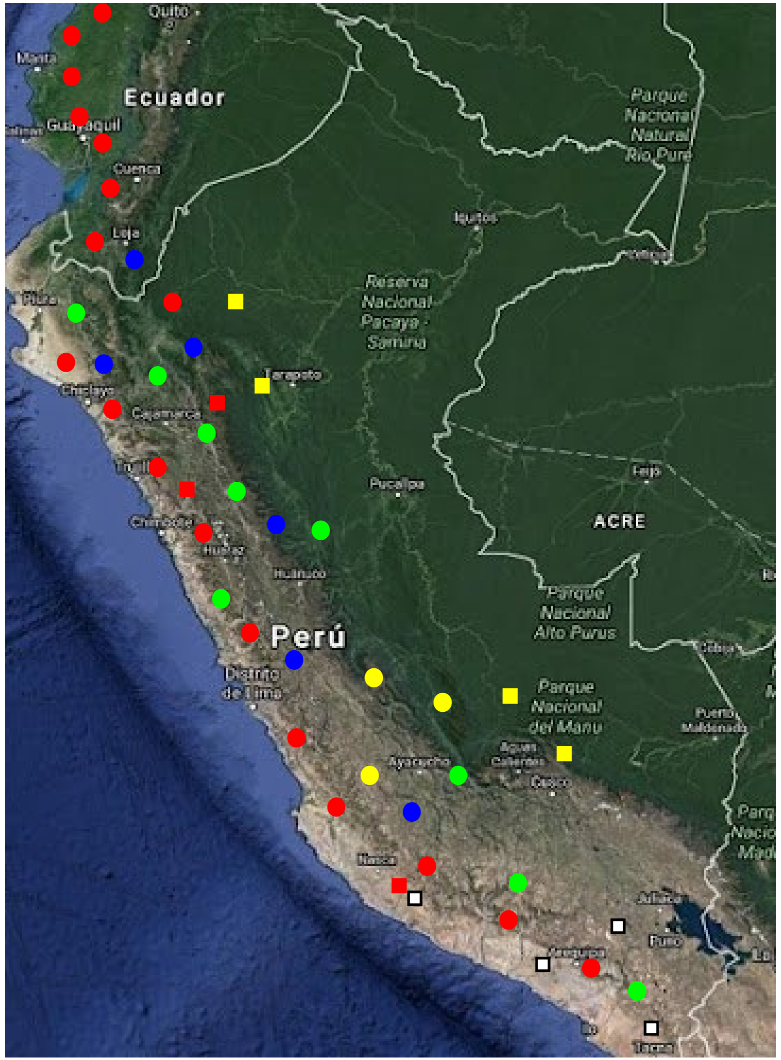
Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

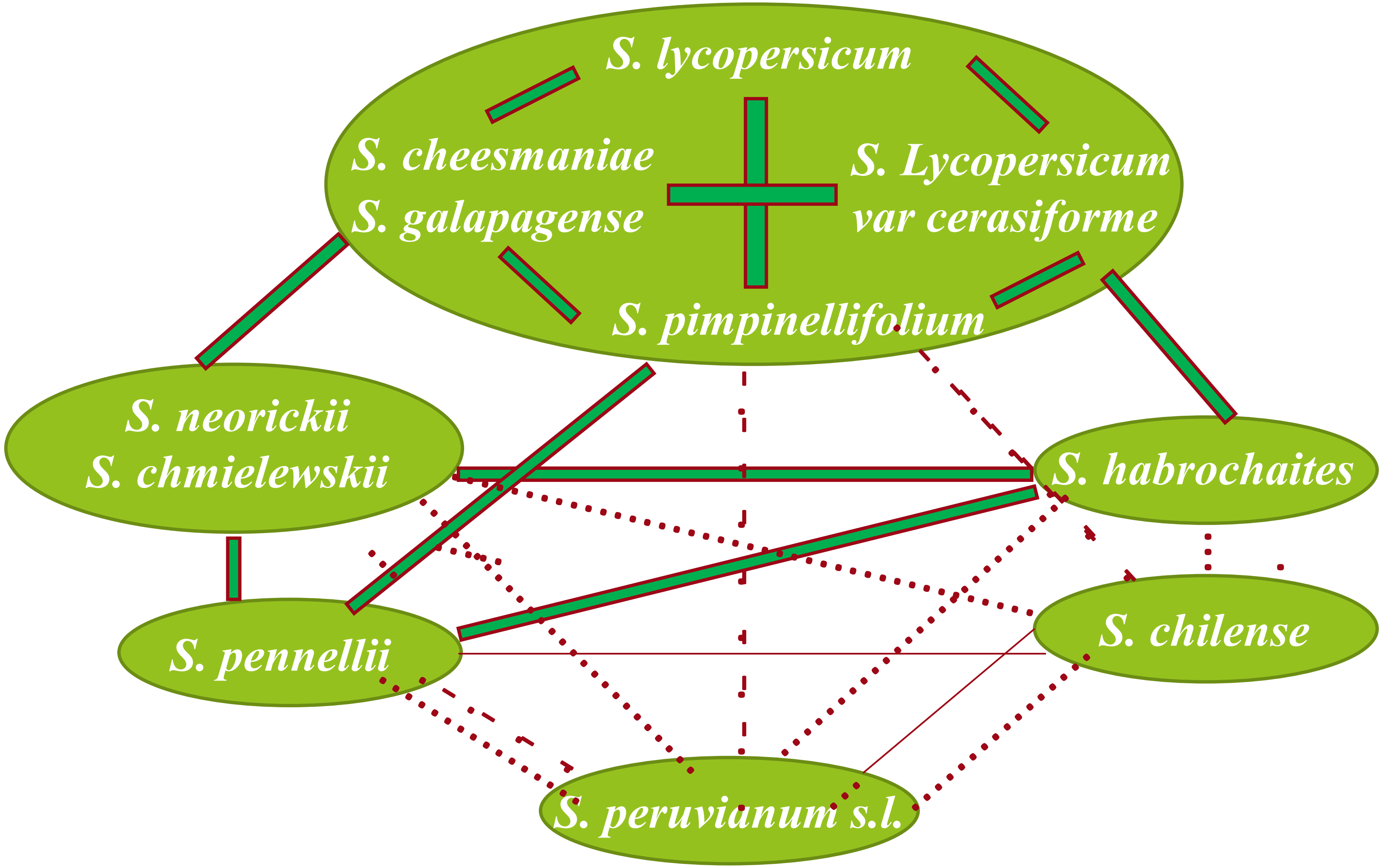
The wild relatives of the cultivated tomato are native to western South America



- ● *S. pimpinellifolium*
- ■ *S. pennellii*
- ● *S. chmielewskii*
- ■ *S. neorickii*
- ● *S. habrochaites*
- ● *S. peruvianum s.l.*
- □ *S. chilense*

An example of use of genetic resources in breeding: Tomato

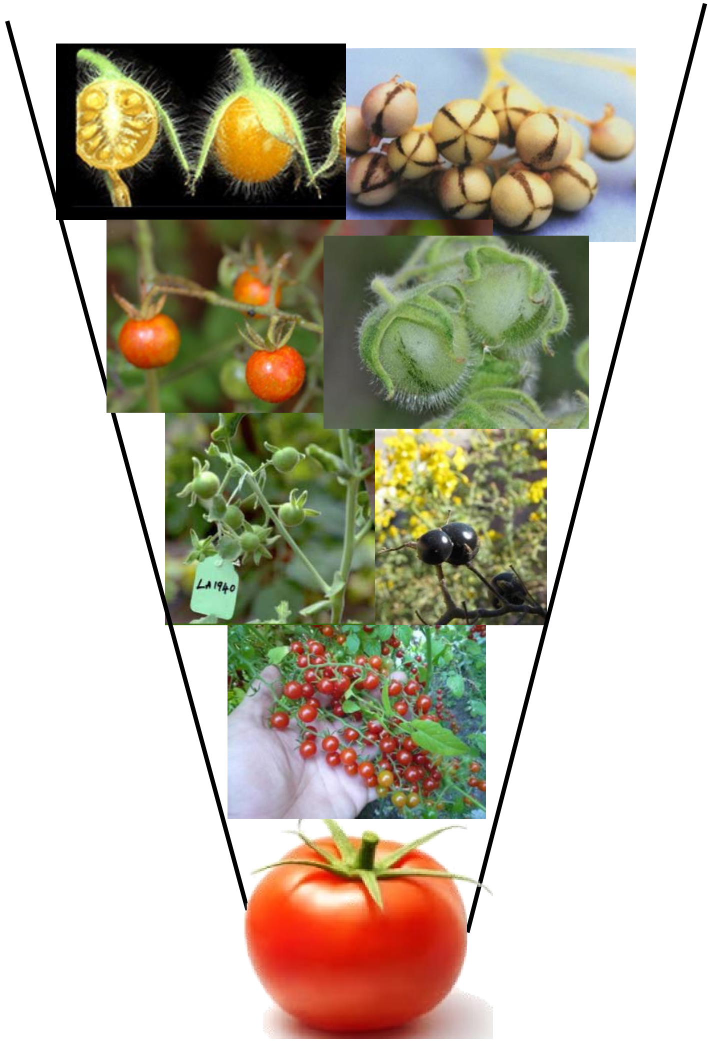
Exploitation of tomato wild relatives: crossability barriers



An example of use of genetic resources in breeding: Tomato

Modern tomato incorporates many wild genes

Disease	Pathogen	Gene of resistance	Source
Fungi			
Verticillium wilt	*Verticillium dahliae*	*Ve*	*S. pimpinellifolium*
Fusarium wilt	*Fusarium oxysporum* f. sp. *lycopersici*		
	--pathotype 0	*I*	*S. pimpinellifolium*
	--pathotype 1	*I-2*	*S. pipimnellifolium*
	--pathotype 2	*I-3*	*S. pennelli*
Alternaria stem canker	*Alternaria alternata* f. sp. *lycopersici*	*Asc*	*S. lycopersicum*
Grey leaf spot	*Stemphyllium* spp.	*Sm*	*S. pimpinellifolium*
Leaf mould	*Fulvia fulva* (*Cladosporium fulvum*)	*Cf* (1 to 24)	*S. pimpinellifolium* *S. lycopersicoides* *S. habrochaites* *S. peruvianmum*
Powdery mildew	*Leveillula taurica*	*Lv*	*S. chilense*
	Oidium neolycopersici	*Ol-1* *Ol-2*	*S. habrochaites* *S. lycopersicum*
Late blight	*Phytophthora infestans*	*Ph-1* *Ph-2* *Ph-3*	*S. pimpinellifolium* *S. pimpinellifolium* *S. pimpinellifolium*



Fusarium crown and root rot	*Fusarium oxysporum* f.sp. *radicis lycopersici*	*Frl*	*S. peruvianum*
Corky root	*Pyrenochaeta lycopersici*	*Pyl*	*S. peruvianum*
Viruses			
Tomato mosaic virus	Tomato mosaic virus (ToMV)	*Tm-1* *Tm-2* *Tm-2²*	*S. hirsutum* *S. peruvianum* *S. peruvianum*
Tomato spotted wilt virus	Tomato spotted wilt virus (TSWV)	*Sw-5*	*S. peruvianum*
Tomato yellow leaf curl virus	Tomato yellow leaf curl virus (TYLCV)	*Tylc* *Ty-1* *Ty-2*	*S. pimpinellifolium* *S. chilense* *S. habrochaites*
Tomato leaf curl virus	Tomato leaf curl virus (TLCV)	*Tlc*	*S. pimpinellifolium*
Alfalfa mosaic virus	Alfalfa mosaic virus (AMV)	*Am*	*L. hirsutum* f. *glabratum*
Potato virus Y	Potato virus Y (PVY)	*pot-1*	*S. habrochaites*
Bacteria			
Bacterial speck	*Pseudomonas syringae* pv. *tomato*	*Pto*	*S. pimpinellifolium*
Bacterial spot	*Xanthomonas campestris* pv. *vesicatoria*	*Bs-4*	*S. pennellii*
Nematodes			
Root-knot nematode	*Meloidogyne incognita, M. arenaria*	*Mi, Mi-1, Mi-3, Mi-9*	*S. peruvianum*
Potato cyst	*Globodera*	*Hero*	*S. pimpinellifolium*

Breeding and pre-breeding

An example of use of genetic resources in breeding: Tomato

Tomato breeding: creating variation and selecting the best combinations

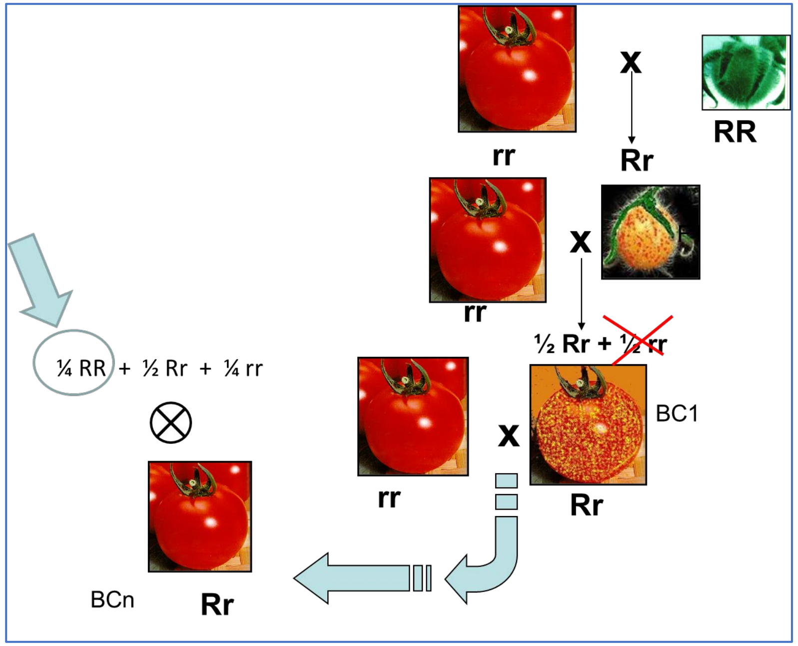
Artificial hybridization

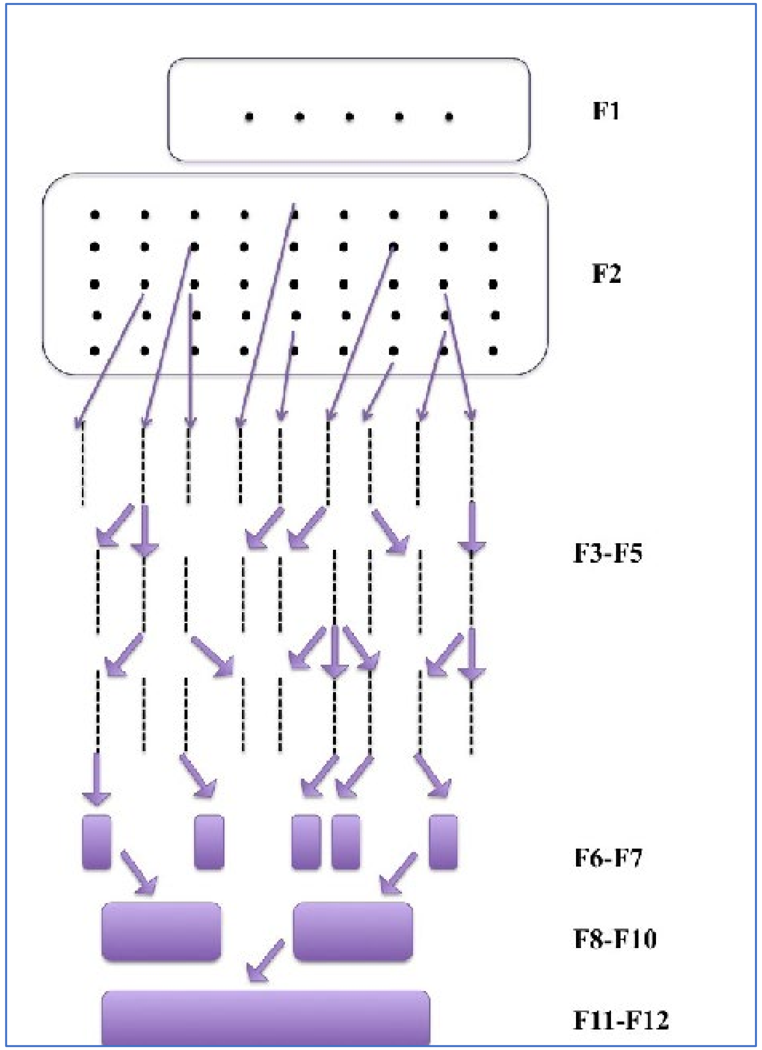
Pedigree selection

Recurrent selection

Hybrid development

Backcross





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PROMOTING A PLANT GENETIC RESOURCE COMMUNITY FOR EUROPE

An example of use of genetic resources in breeding: Tomato

Current goals of tomato breeding:

Yield

Adaptation to different growing systems

Resistance to diseases

Quality

Abiotic stresses: climatic change, incresing temperatures, salinity, drought

Enhancing traditional varieties

Increase diversity

Diversity

Yield

Disease resistance

Jointless pedicel

Joint pedicel

An example of use of genetic resources in breeding: Tomato

The new era in the use of genetic resources

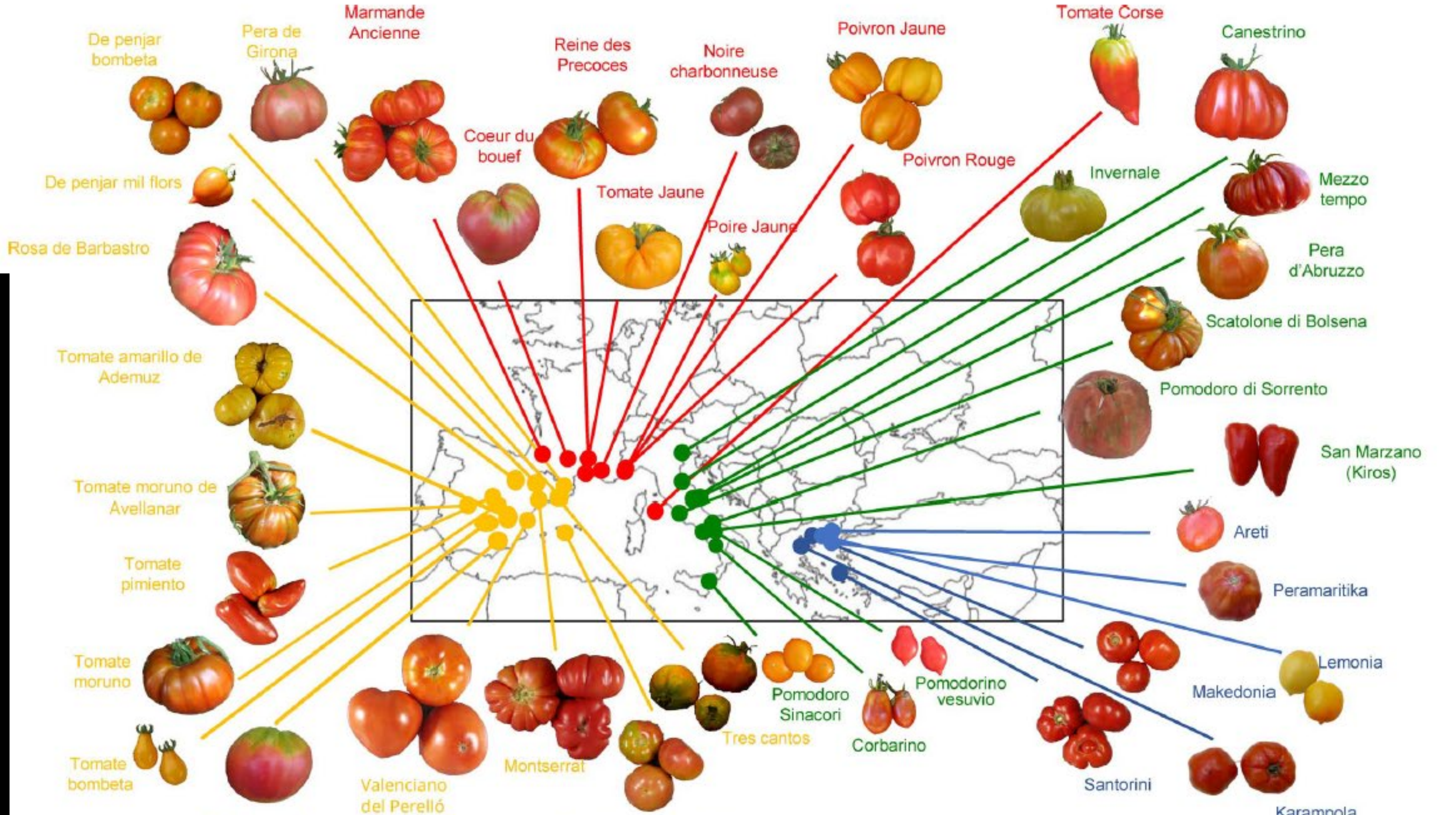
Massive high throughput phenotyping and genotyping

New QTL, genes and alleles discovery

Gene editing

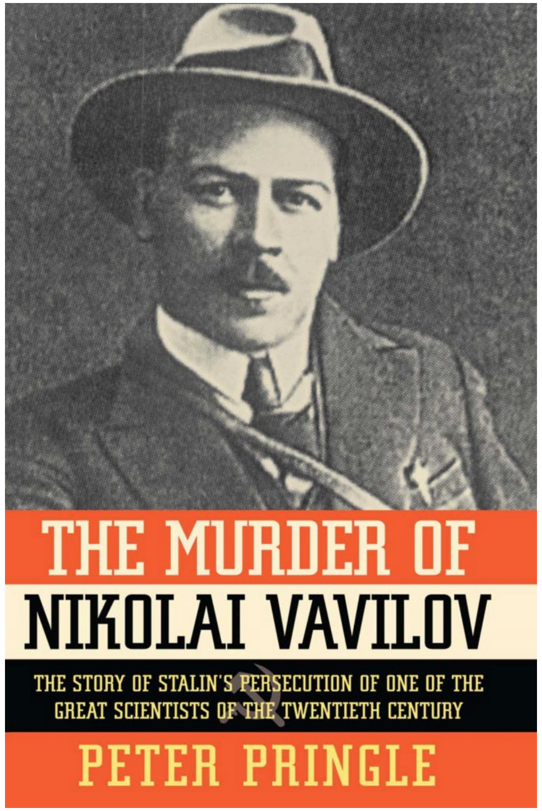
Gene editing

Phenotyping, genotyping, QTL discovery



Pre-breeding

Pre-breeding consists in the use of exotic (typically wild) materials for the development of élite materials that can be readily incorportated by breeders in their pre-breeding pipelines.



Nikolái Vavilov was a Pioneer in advocating for pre-breeding: “He wanted to use the new science of genetics to breed varieties that would grow where none had survived before. The key was a treasure trove of genes he was sure he could find in the unknown and wild types“ (Pringle, 2008)”

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Breeding and pre-breeding

Pre-breeding

In the face of climate change, pre-breeding is becoming increasily important to address the new challenges.

European Crop Protection

Northern Europe may begin to experience a more Mediterranean climate while the south may become too hot and arid for many of the current crops. Farmers will have to grow different crops and will face pressure from different pests. On average, due to a warming climate, one new pest is appearing in Spain from north Africa every 10 months.

Pre-breeding

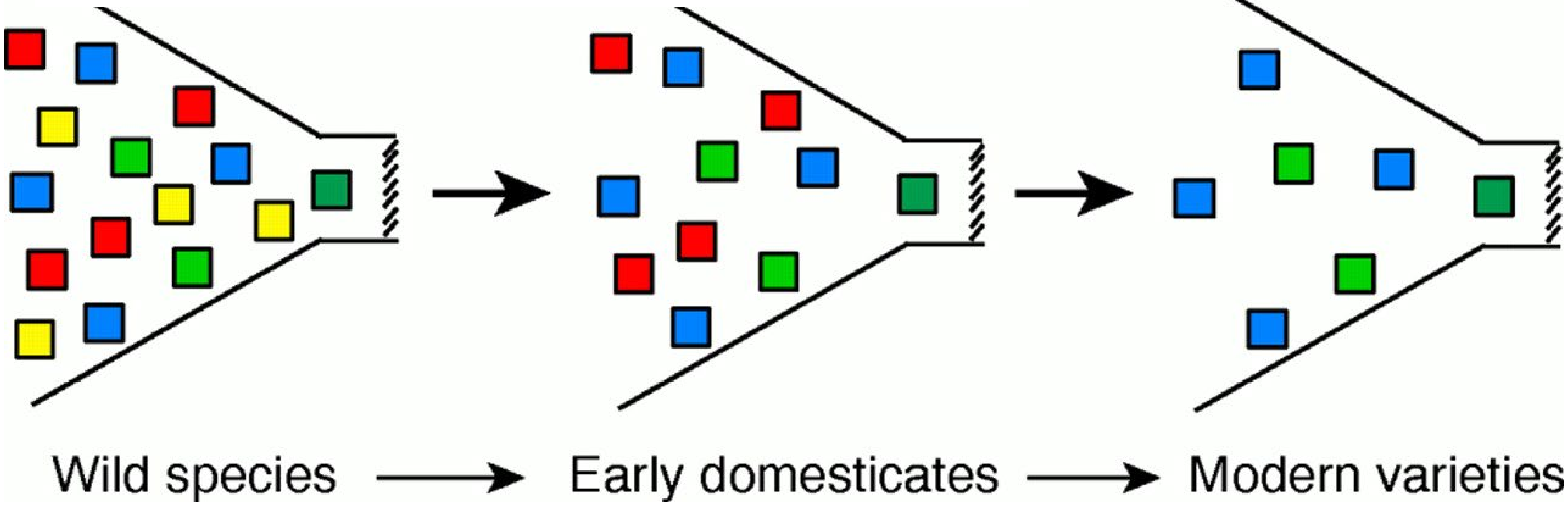
A new paradigm: tapping 'the wild' for adapting the crops to climate change

ARTICLE

Seed Banks and Molecular Maps: Unlocking Genetic Potential from the Wild

Steven D. Tanksley and Susan R. McCouch

Science 22 Aug 1997:
Vol. 277, Issue 5329, pp. 1063-1066
DOI: 10.1126/science.277.5329.1063



Multitude of stressing environments

Adaptation to modifed environments

Environments highly modified to avoid stress

Pre-breeding

A new paradigm: tapping 'the wild' for adapting the crops to climate change

Many wild species are tolerant to stress

Solanum chilense (tomato CWR)

Solanum incanum (eggplant CWR)

Oryza rufipogon (rice CWR)

Breeding and pre-breeding

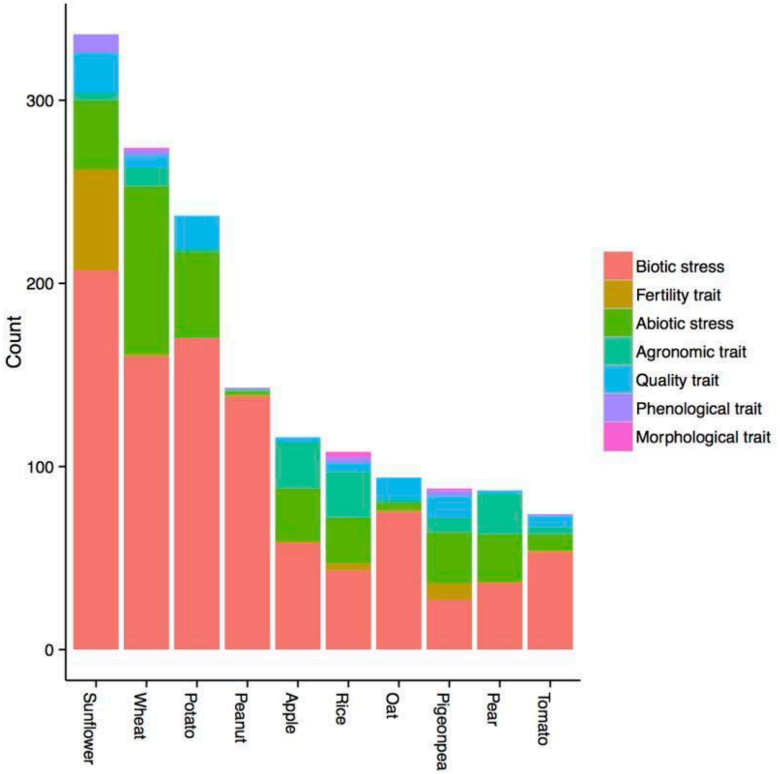
<u>Pre-breeding</u>

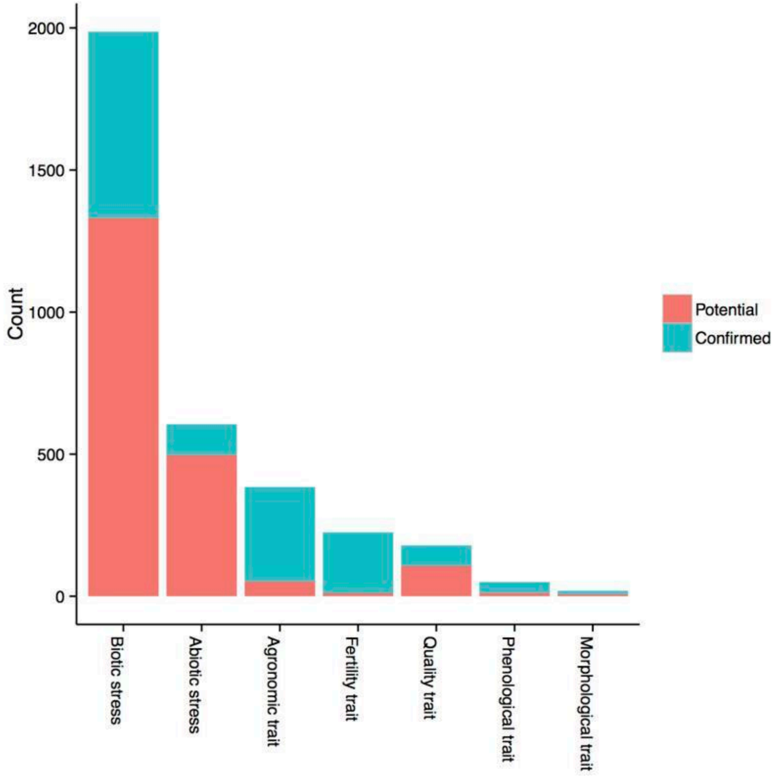
A new paradigm: tapping 'the wild' for adapting the crops to climate change

Past and Future Use of Wild Relatives in Crop Breeding

Hannes Dempewolf,* Gregory Baute, Justin Anderson, Benjamin Kilian, Chelsea Smith, and Luigi Guarino

The most widespread CWR use has been and remains in the development of disease and pest resistance





Breeding and pre-breeding

Pre-breeding

A new paradigm: tapping 'the wild' for adapting the crops to climate change

-Conventional approach: Use one wild relative for a specific trait

-New approach: **Introgressiomics**

"Mass scale systematic development of multiple plant materials and populations carrying introgressions of genomes from (mostly wild) crop relatives into the genetic background of crops that may allow developing new generations of cultivars with dramatically improved properties, in particular adaptation to climate change"

Introgressiomics: a new approach for using crop wild relatives in breeding for adaptation to climate change

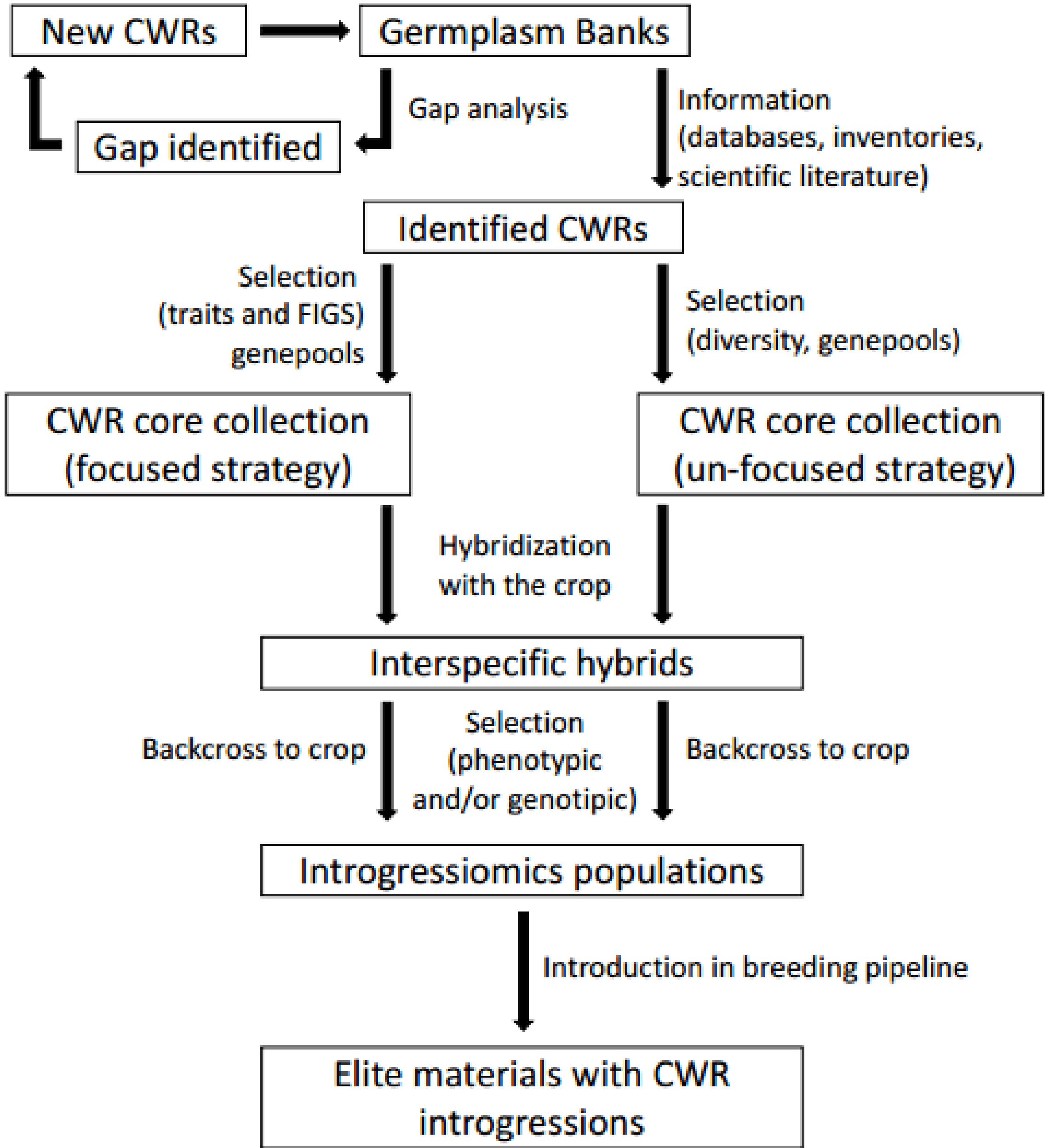
Jaime Prohens · Pietro Gramazio · Mariola Plazas · Hannes Dempewolf · Benjamin Kilian · María J. Díez · Ana Fita · Francisco J. Herraiz · Adrián Rodríguez-Burruezo · Salvador Soler · Sandra Knapp · Santiago Vilanova

Breeding and pre-breeding

Pre-breeding

What defines introgressiomics?

-Scale
-Integrated use of disciplines: germplasm, genomics, wide hybridization, selection, phenotyping,…
-Élite material ready for breeders



Breeding and pre-breeding

Pre-breeding

Steps for introgressiomics

1) Identifying the target wild species:

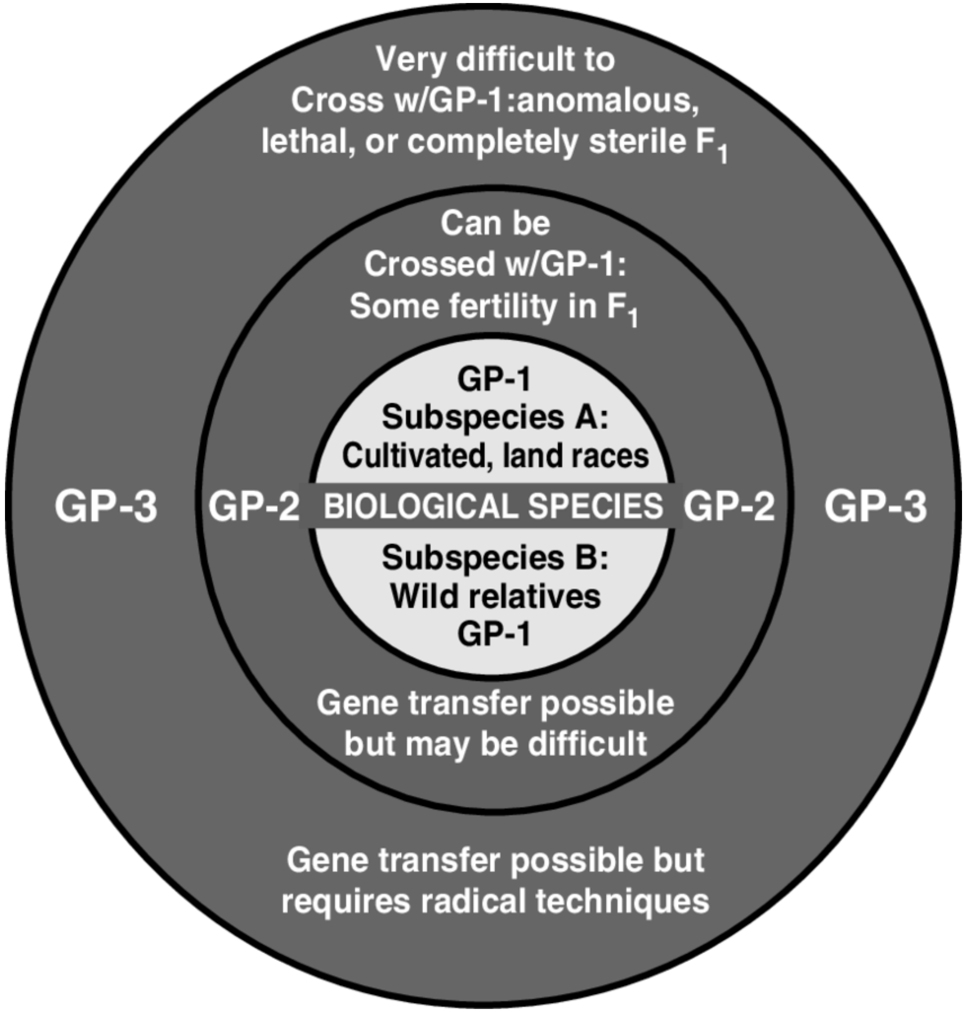
-Primary, secondary and tertiary genepools

Based on diversity:

-Genetic
-Phenotypic
-Evaluation
-Environments
-Origins
-Genepools

Some identification strategies:

-FIGS (Focused Identification of Germplasm Strategy)
-Nested core collections



Genepool concept (Harlan and de Wet, 1971)

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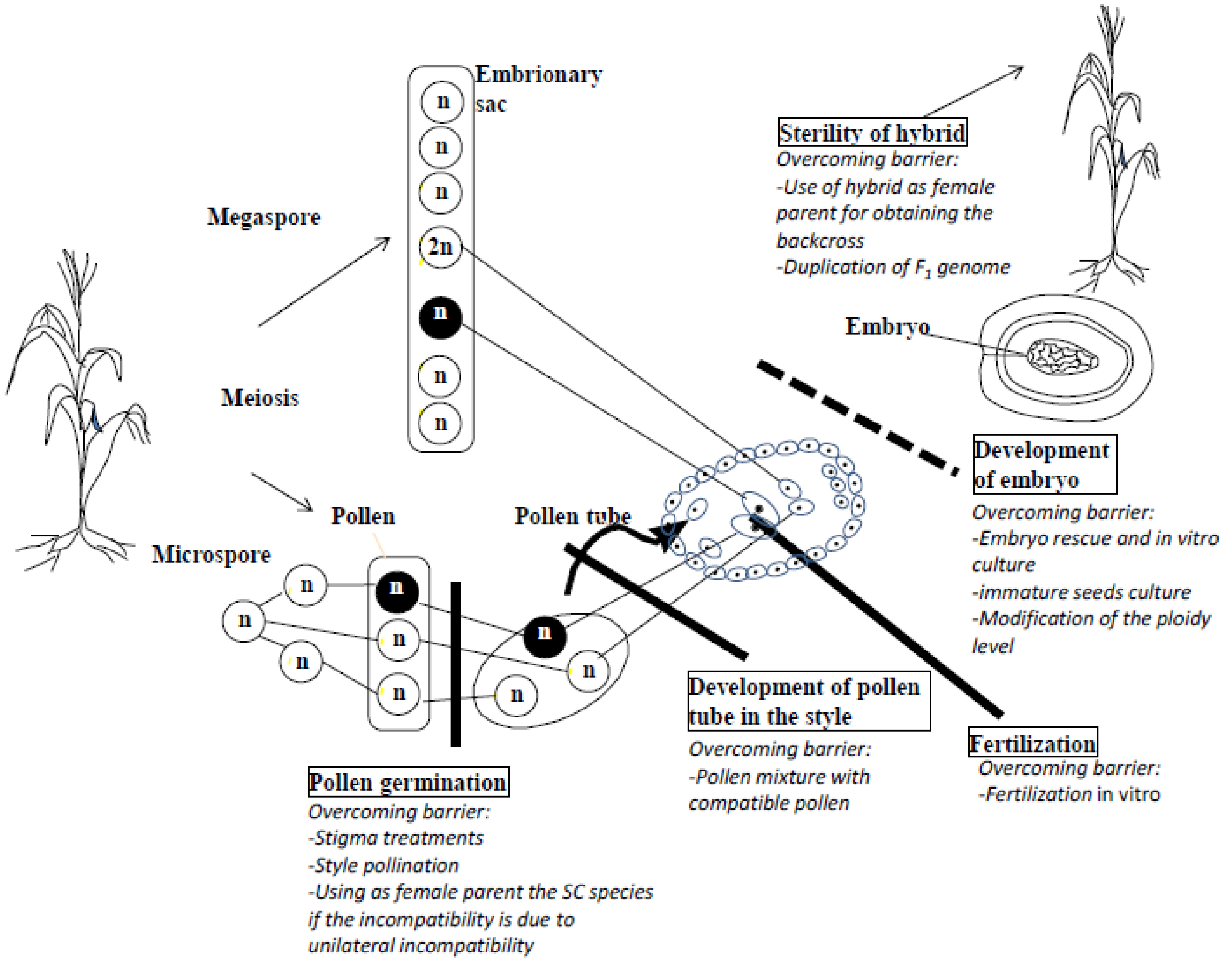
Pre-breeding

Steps for introgressiomics

2) Interspecific hybridization:

-Barriers to hybridization (pre-zygotic, post-zygotic)

-Techniques to overcome the interspecific hybridization



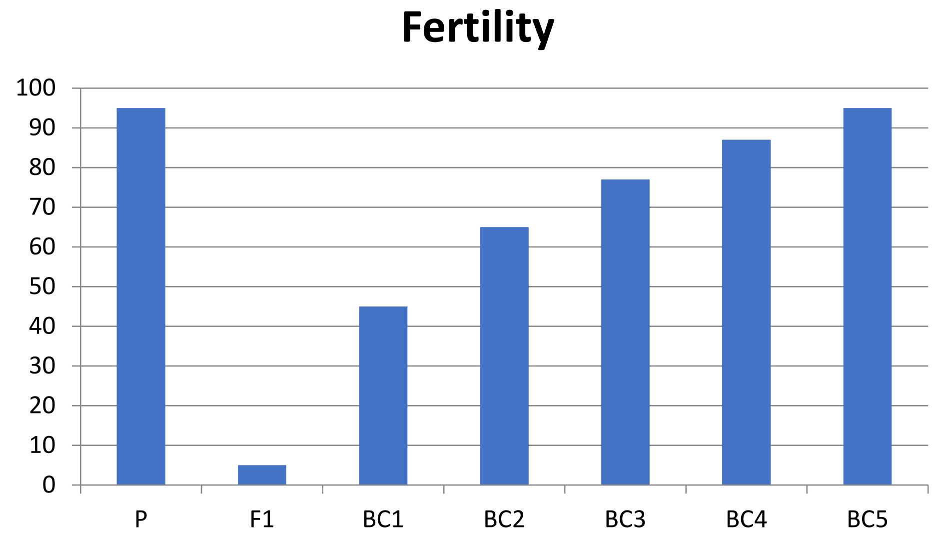
Breeding and pre-breeding

Pre-breeding

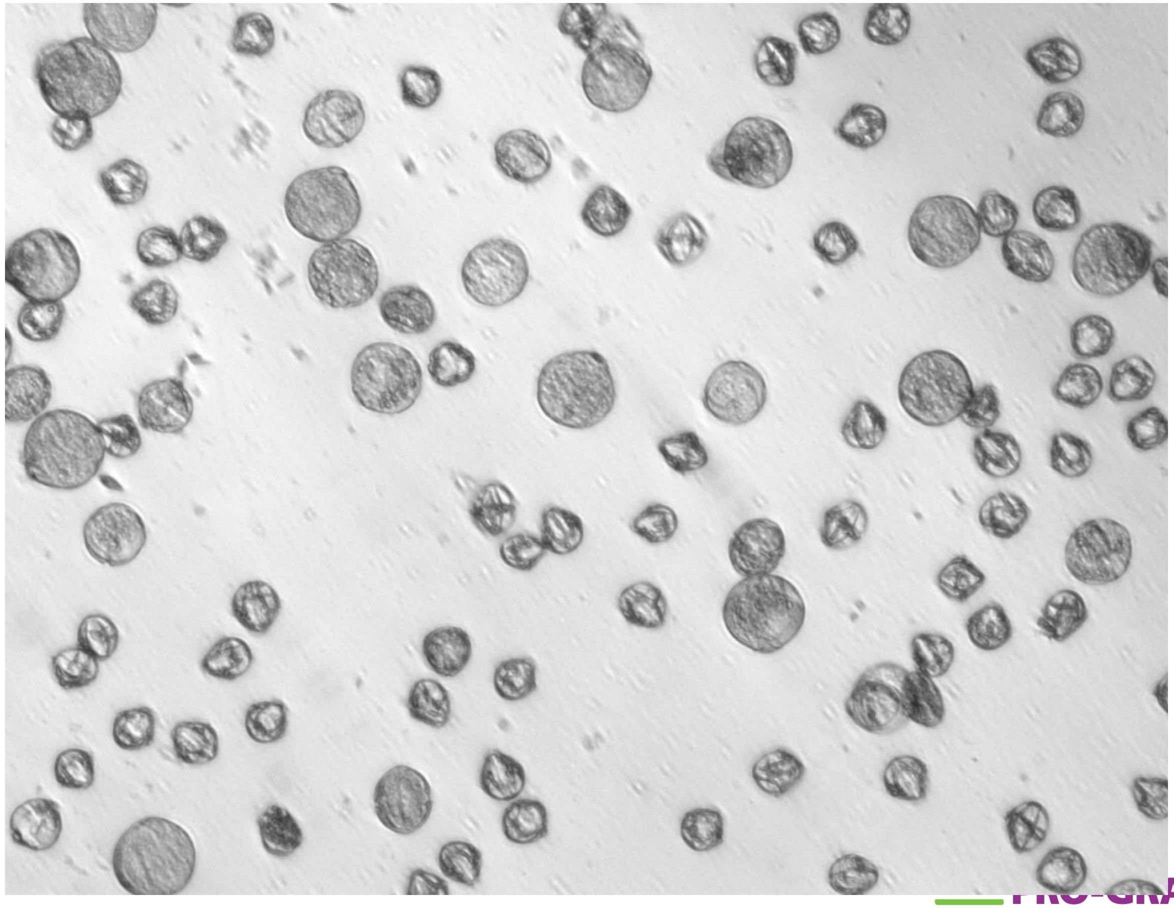
Steps for introgressiomics

3) Hybrids fertility:
-Different number of chromosomes
-Irregular pairing during meiosis

-Use hybrid as maternal parent
-Genome duplication to restore fertility



Interspecific hybrid *S. melongena* x *S. anguivi*



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Breeding and pre-breeding

Pre-breeding

Steps for introgressiomics

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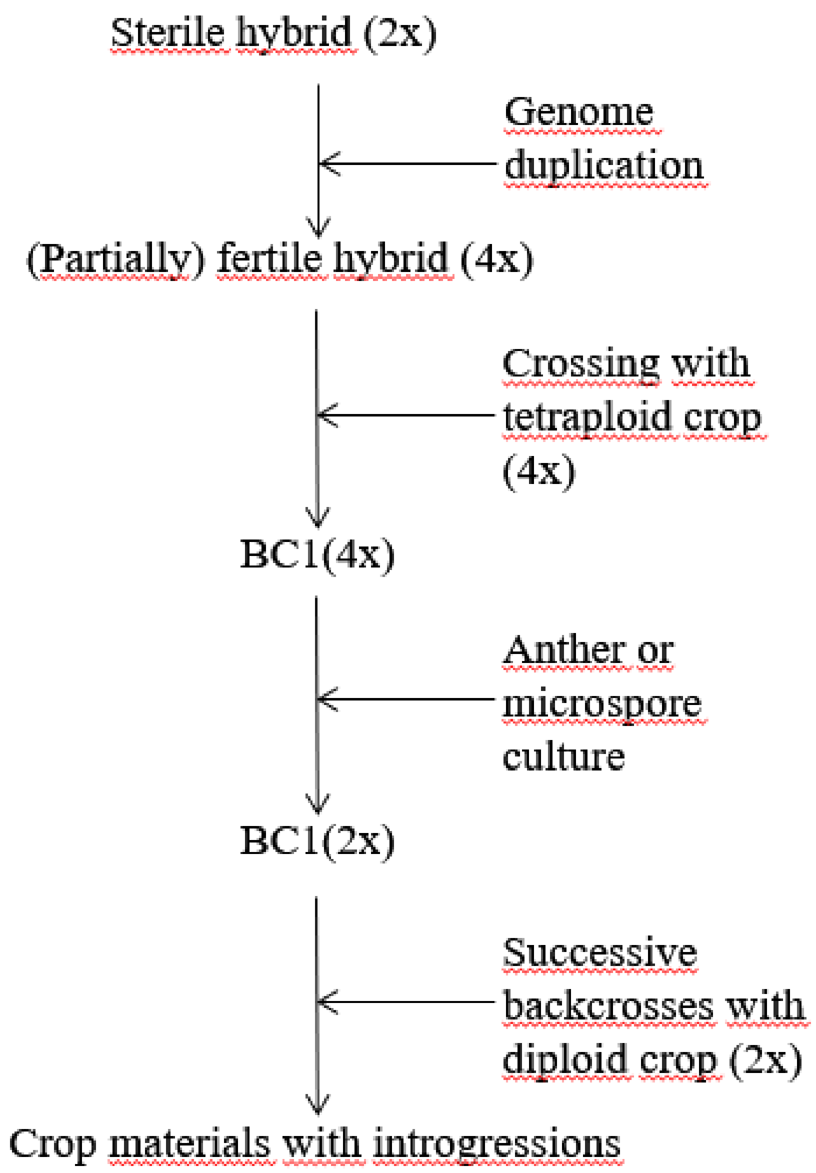


Pre-breeding

Steps for introgressiomics

4) Backcrossing
-Usually fertility is restored during the backcross process
-Some parts may not present recombination (linkage drag)

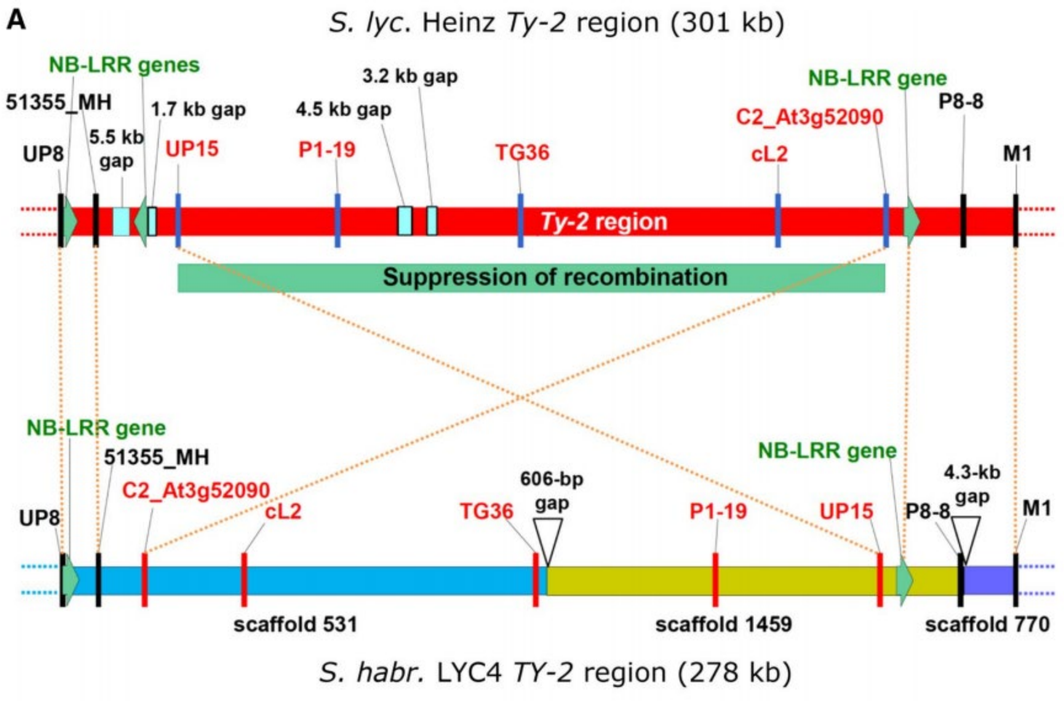
-Marker assisted selection

Theor Appl Genet (2015) 128:1987–1997
DOI 10.1007/s00122-015-2561-6

ORIGINAL ARTICLE

Detection of an inversion in the *Ty-2* region between *S. lycopersicum* and *S. habrochaites* by a combination of de novo genome assembly and BAC cloning

Anne-Marie A. Wolters[1] · Myluska Caro[1] · Shufang Dong[2] · Richard Finkers[1] · Jianchang Gao[2] · Richard G. F. Visser[1] · Xiaoxuan Wang[2] · Yongchen Du[2] · Yuling Bai[1]

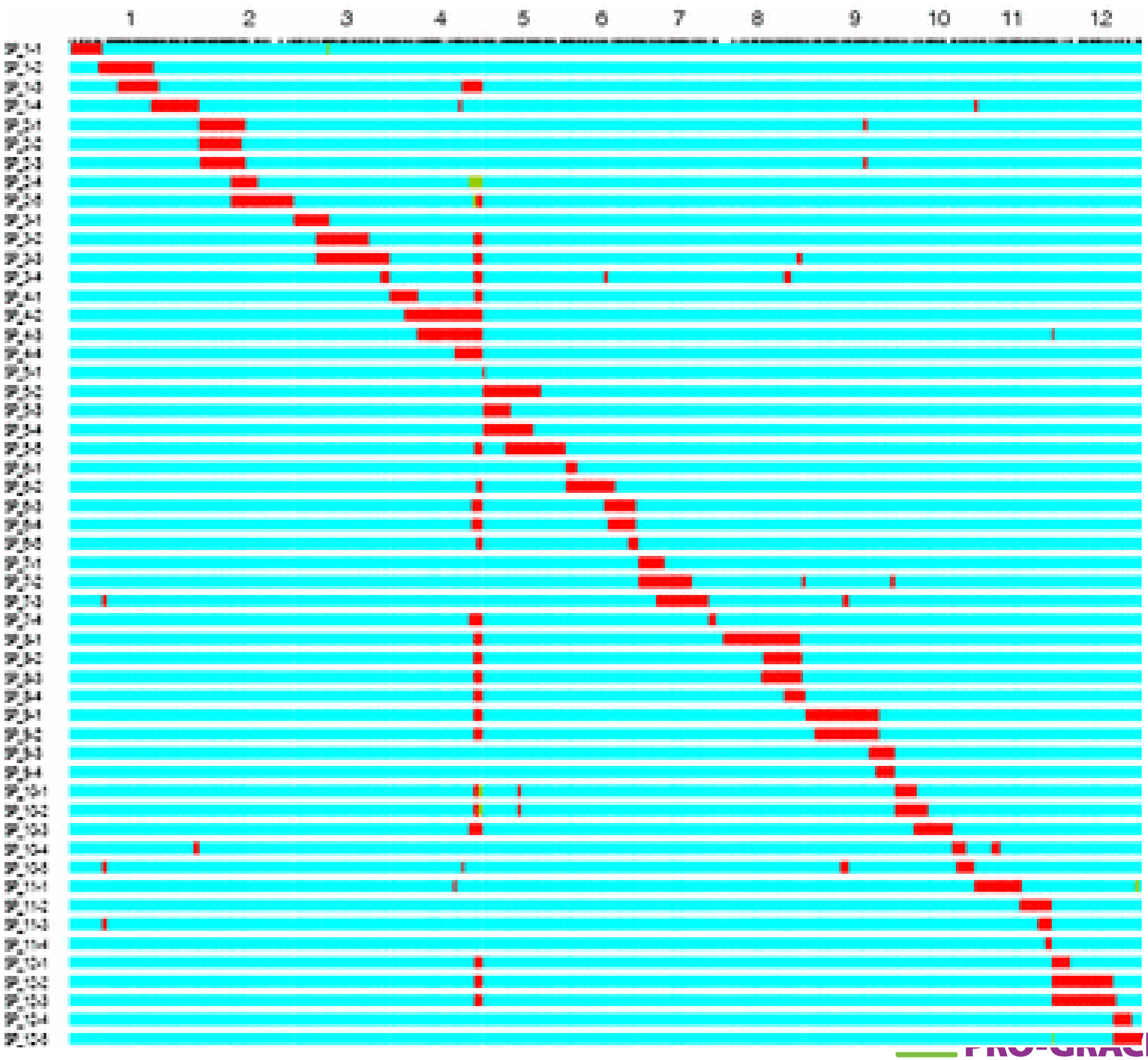


Breeding and pre-breeding

Pre-breeding

Steps for introgressiomics

5) Development of introgression materials
-Advanced backcrosses
-Introgression lines collections:



Barrantes W. et al. 2014. Highly efficient genomics-assisted development of a library of introgression lines of *Solanum pimpinellifolium*." *Mol. Breed.* 34:1817-1831.

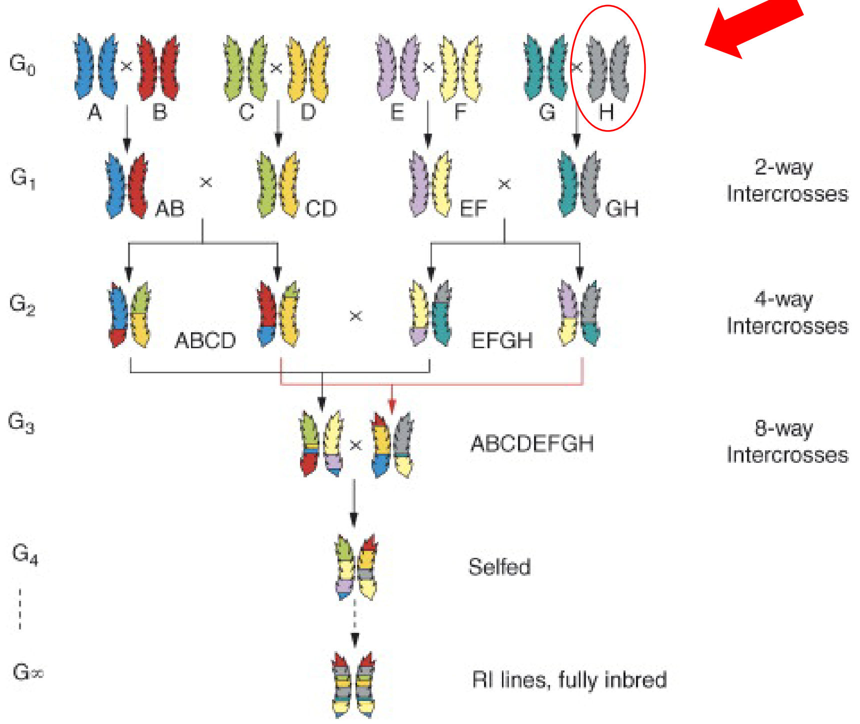
Breeding and pre-breeding

Pre-breeding

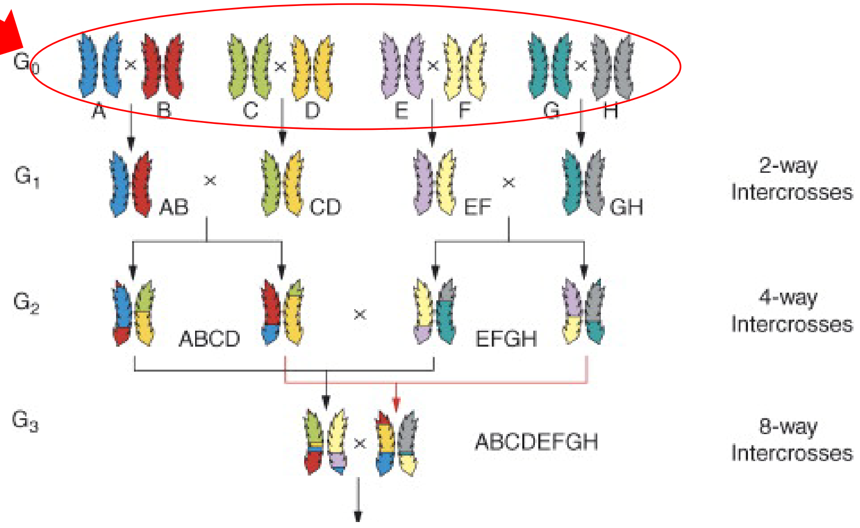
Steps for introgressiomics

5) Development of introgression materials
-Multi-parent populations:

CWR/s



12.5% wild genome



100% wild genome from 8 CWRs

Successive backcrosses to cultivated (single seed descent)

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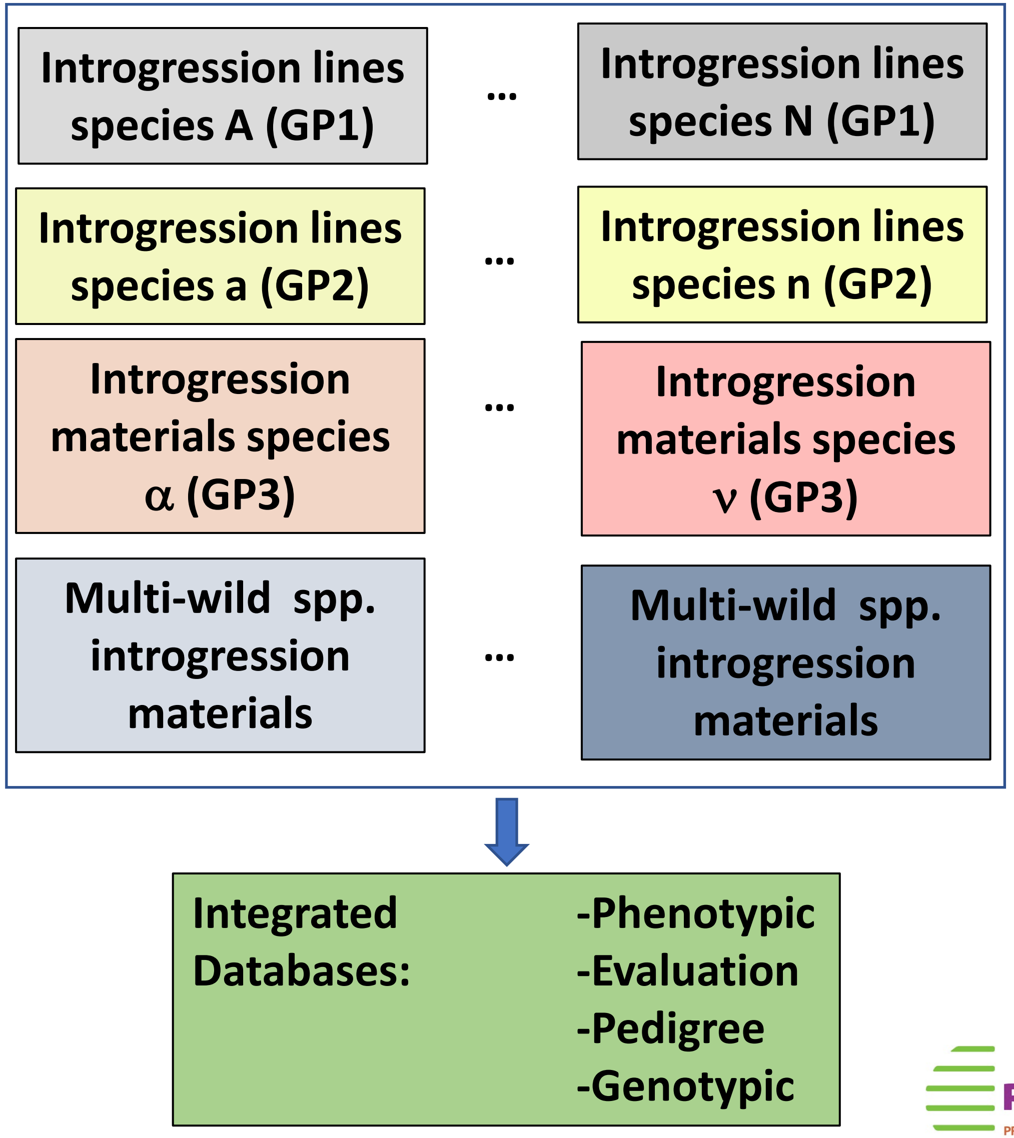
Breeding and pre-breeding

Pre-breeding

The ideal outcome

Developed pre-bred easily accessible materials with introgressions from multiple wild species included in repositories



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Breeding and pre-breeding

Pre-breeding: an example in eggplant

Four sets of introgression lines

S. incanum (GP2; 1.6 Mya)

Phenolics
Drought tolerance

S. insanum (GP1; 6 kya)

Wild ancestor of eggplant
Domestication traits

S. dasyphyllum (GP2; 3.4 Mya)

Spider mites tolerance
Phenolics

S. elaeagnifolium (GP3; 6.7 Mya)

Drought tolerance
Alkaloids

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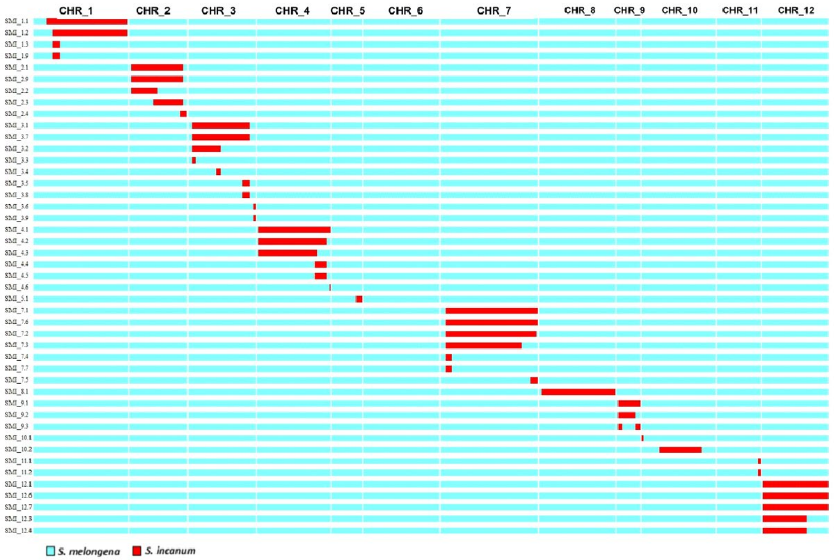
Breeding and pre-breeding

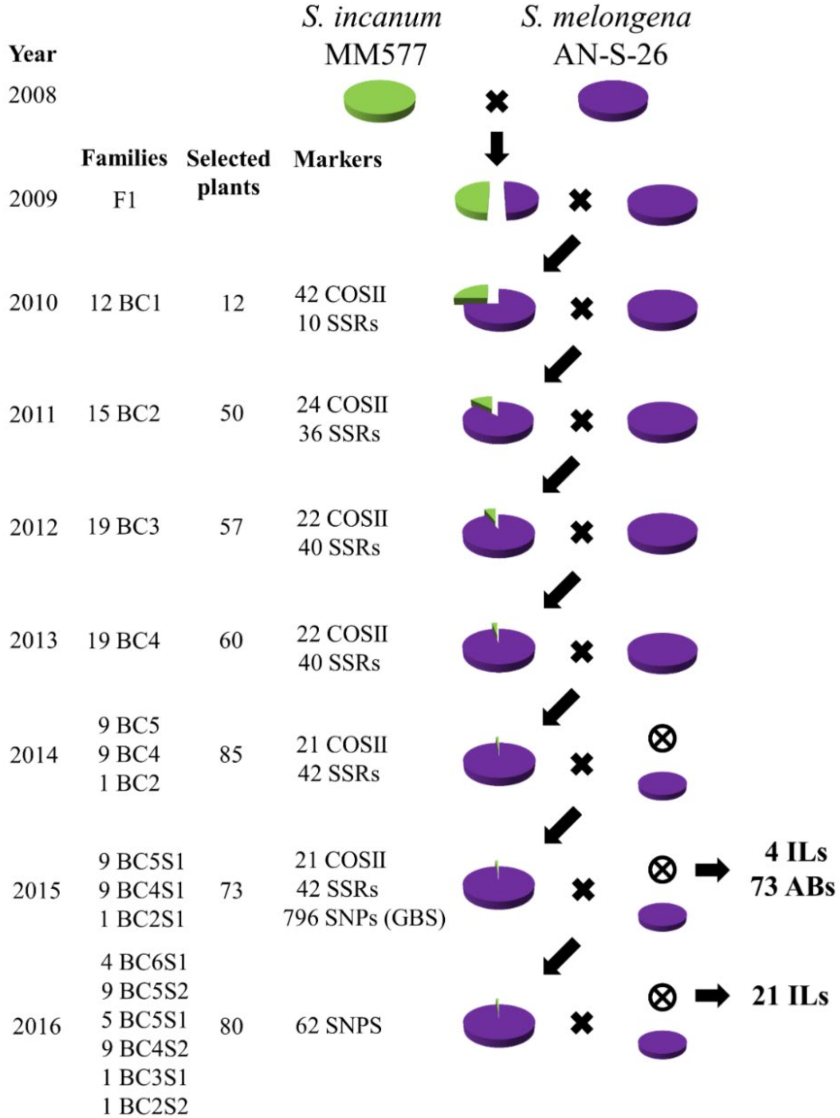
Pre-breeding: an example in eggplant

S. incanum MM577   *S. melongena* ANS26

51 ILs covering 71.4% of the genome



Four sets of introgression lines



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Breeding and pre-breeding

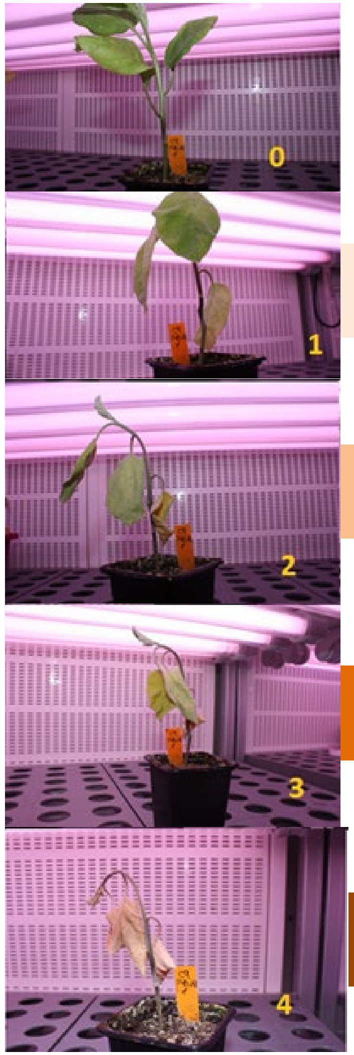
Pre-breeding: an example in eggplant

Several independent studies under different conditions

↓

QTL in chromosome 3

Spain (climatic chamber)



0

1

2

3

4

Sri Lanka (field)

Ivory Coast (field)

Breeding and pre-breeding

Pre-breeding: an example in eggplant

Solanum elaeagnifolium is highly drought tolerant

«Γερμανός»: Το φυτό-εισβολέας που εξαπλώνεται ταχύτατα -Πότε έφτασε στην Ελλάδα, τι απειλεί [εικόνες]

Breeding and pre-breeding

Pre-breeding: an example in eggplant

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«Γερμανός»: Το φυτό-εισβολέας που εξαπλώνεται ταχύτατα -Πότε έφτασε στην Ελλάδα, τι απειλεί [εικόνες]

Breeding and pre-breeding

Pre-breeding: an example in eggplant

20 BC1 plants

No genotyping
Backcross

17 BC2 families obtained

90 BC2 plants from 17 BC2 families

10,377 SNPs SPET

35 selected BC2 plants

Backcross

35 BC3 families obtained

89 BC3 plants from 35 BC3 families

10,377 SNPs SPET

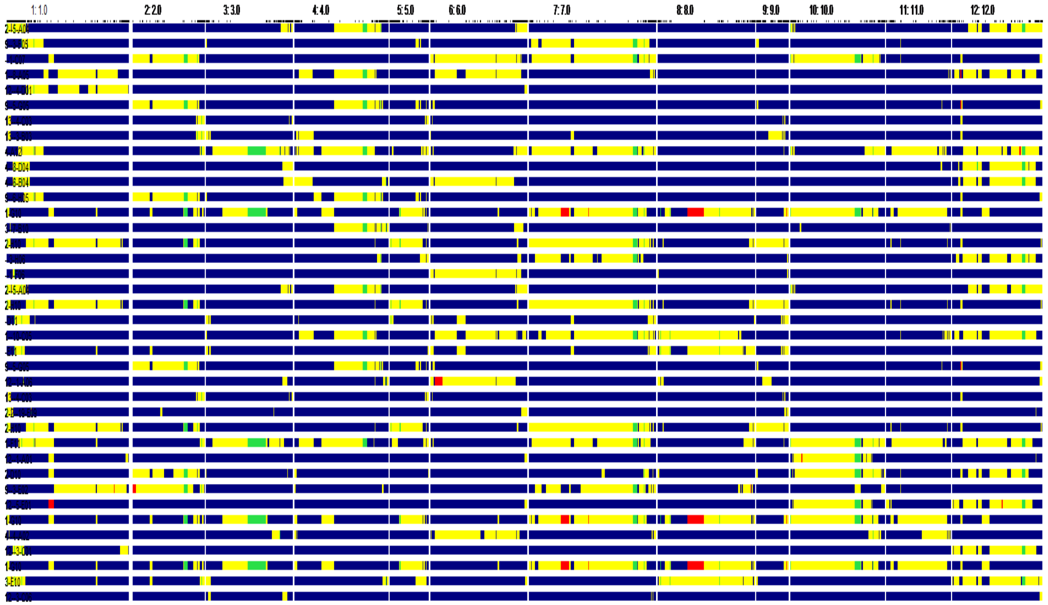
31 selected BC3 plants

Backcross & selfing

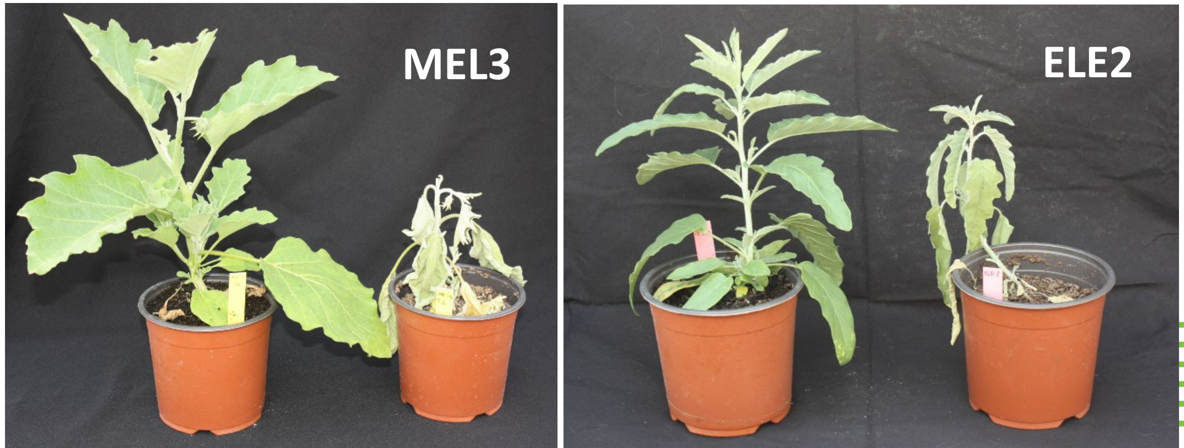
Obtaining BC4 (ongoing)

Introgression lines programme with *S. elaeagnifolium*

Selected BC3



Segregation for drought tolerance



Breeding and pre-breeding

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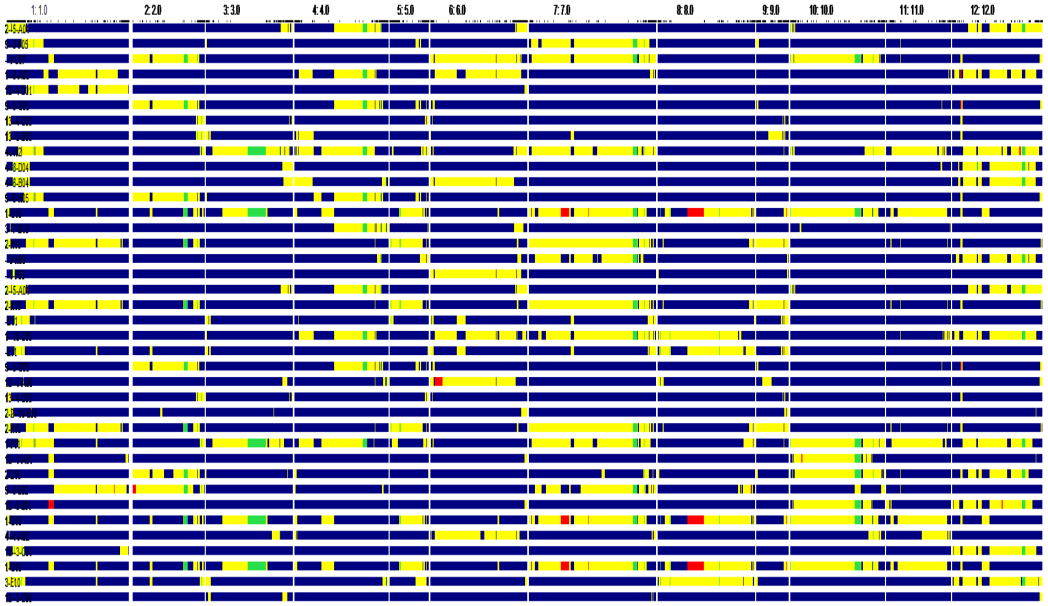
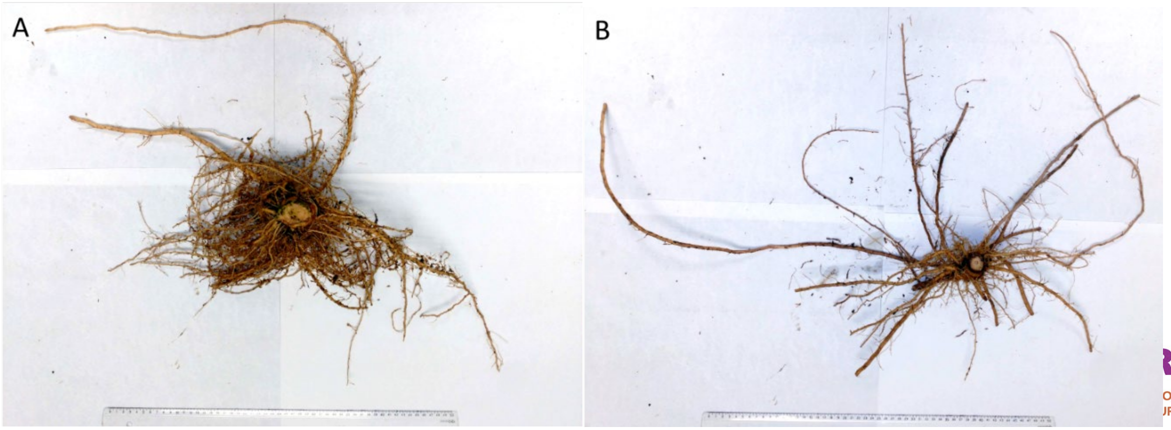
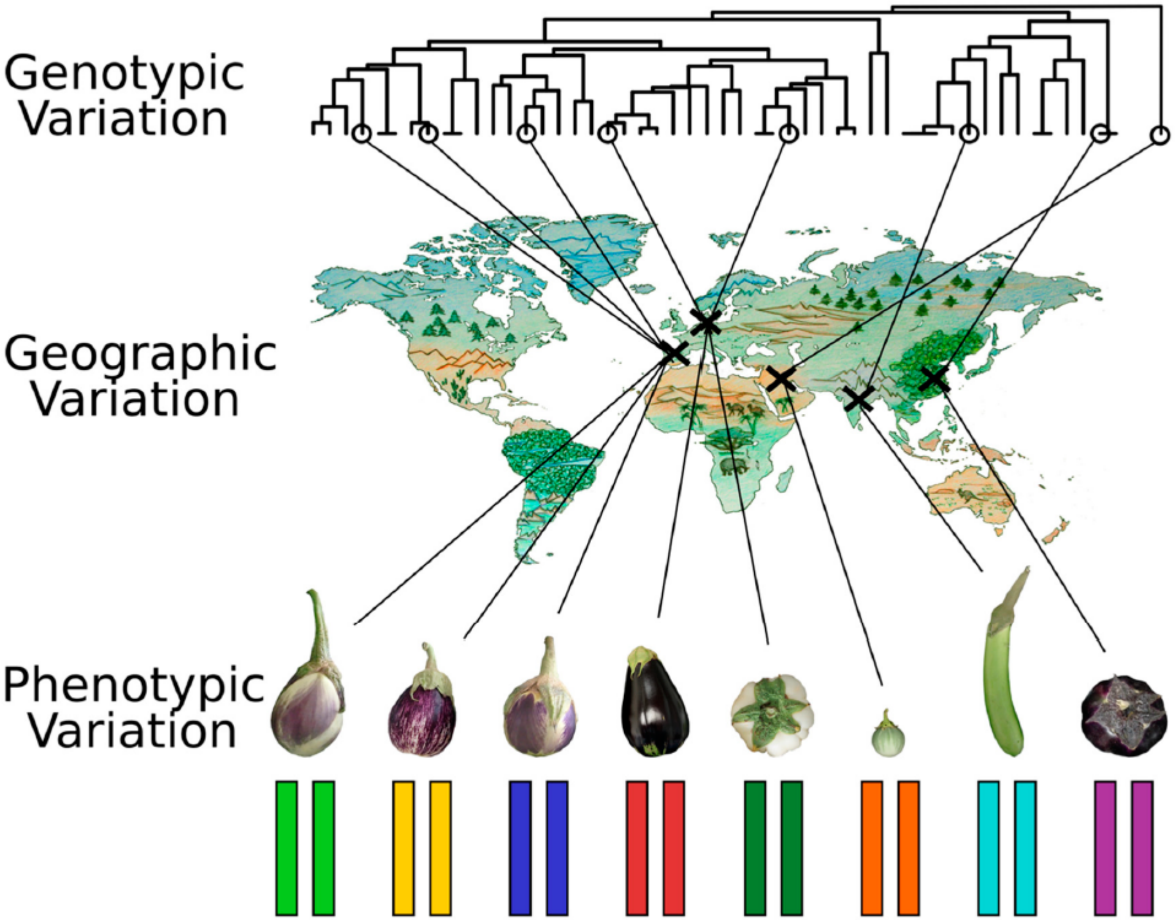


Segregation for root system



Pre-breeding: an example in eggplant

Selection of parents

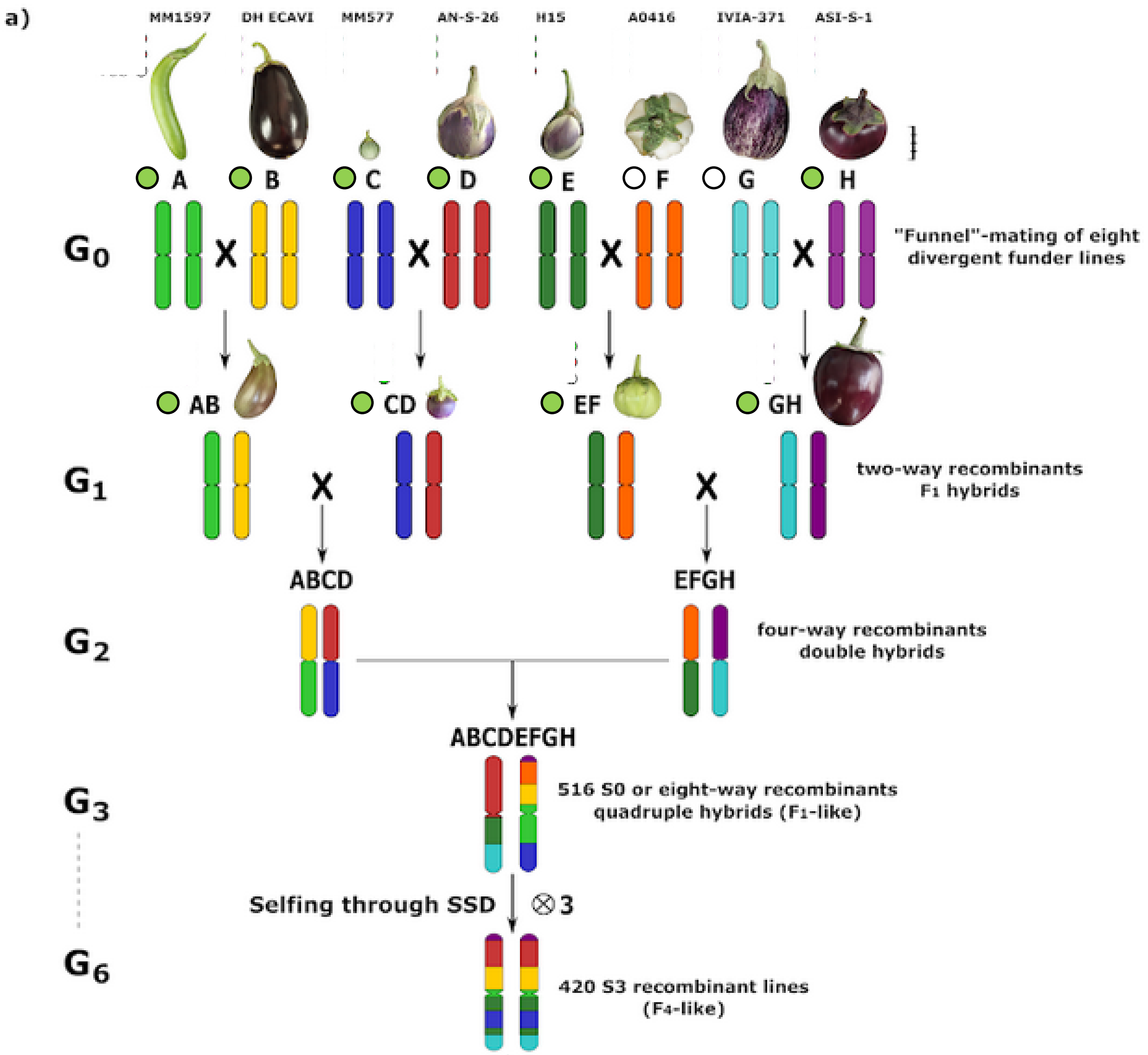


Breeding and pre-breeding

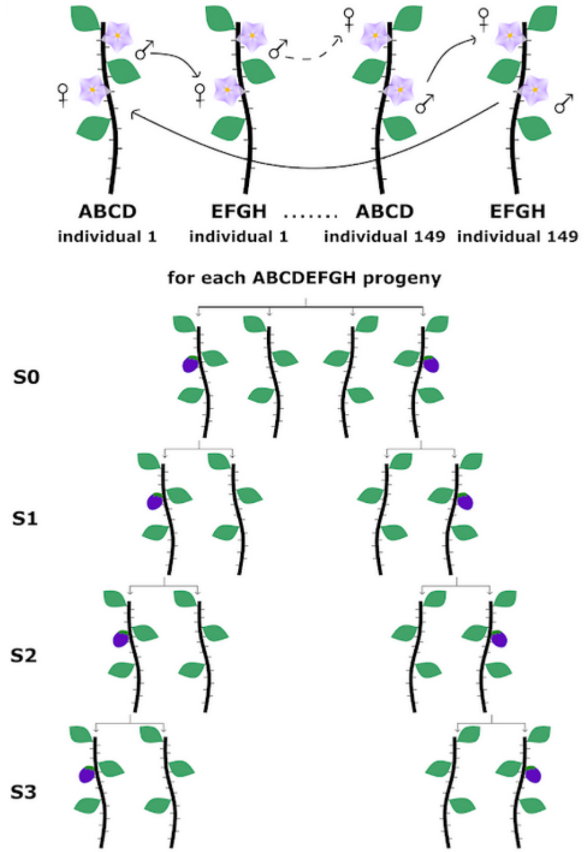
Pre-breeding: an example in eggplant

The eggplant MAGIC population

8-way "funnel" eggplant MAGIC population



Chain pollination scheme



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Pre-breeding: an example in eggplant

The eggplant MAGIC population

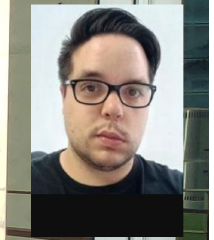
A wide diversity was observed in the MAGIC population, with new phenotypes

Breeding and pre-breeding

Breeding and pre-breeding: take home message

- Genetic resources are the raw material on which breeding is performed.
- Breeding has allowed dramatic improvements in major crops.
- Present and future breeding will rely on the extensive use of genetic resources, which requires high throughput phenotyping and genotyping of the available germplasm collections
- Pre-breeding can broaden the genetic base of crops, by incorporating genes from wild species to the genetic background of the crop, as well as the development of new genetic resources (introgression lines, recombinant lines).
- Introgression breeding is expected to play a major role in adaptation to climate change as well as in a new more sustainable agriculture
- Introgressiomics is a holistic approach that can make a major contribution to adapting our crops to climate change as well as to the development of new generations of resilient crops with new and improved properties.

Thanks for your attention



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