crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

OFA
Olive, Fruit and Citrus Crops

Conservare, Caratterizzare e Valorizzare: le collezioni del CREA per rispondere alle nuove sfide dell'agricoltura

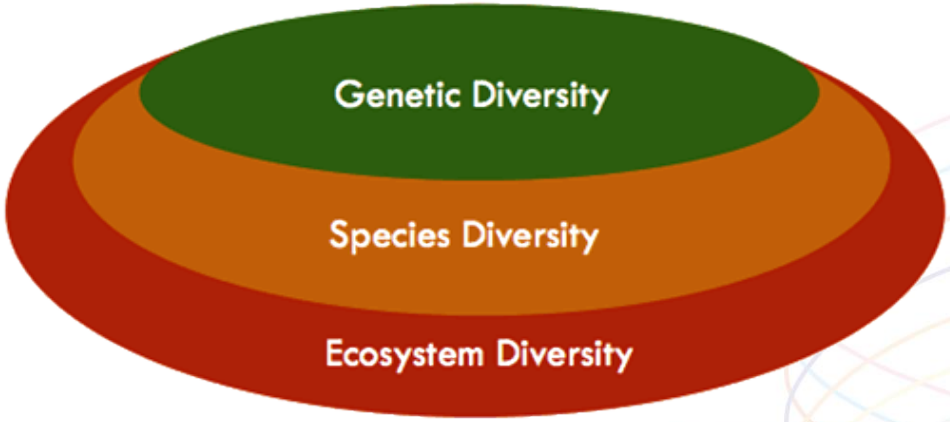
https://www.crea.gov.it/en/home

Ignazio Verde ignazio.verde@crea.gov.it

Biodiversità vs Agrobiodiversità

Genetic Diversity

Diversity of genes within a species



Levels of organization of the concept of biodiversity

Ecosystem Diversity

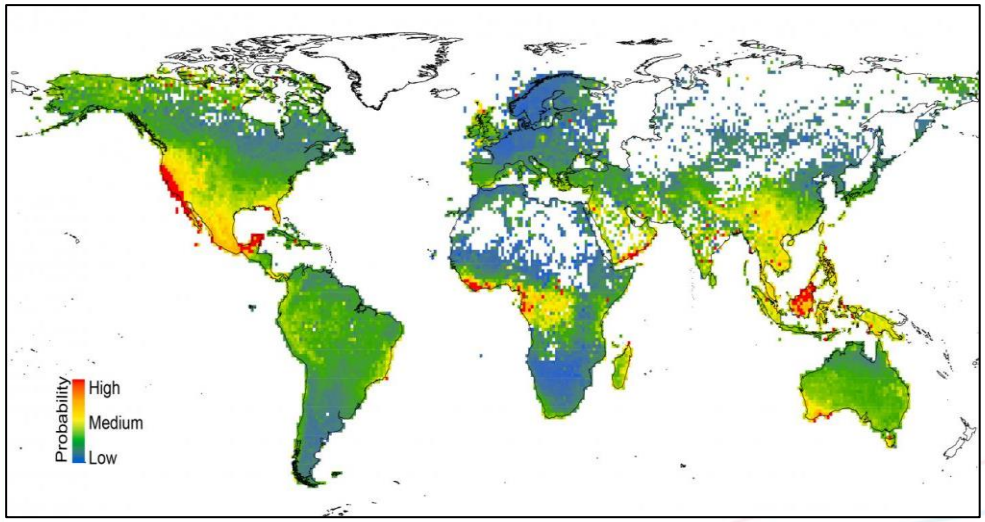
Diversity of a habitat in a given unit area

Species Diversity

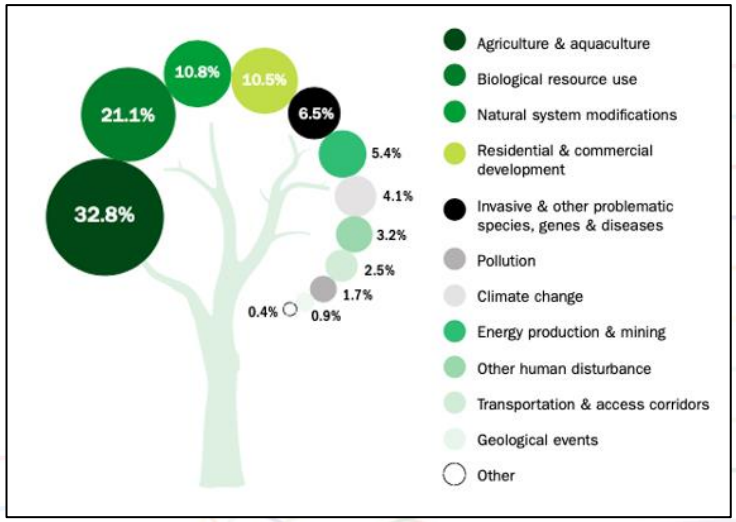
Diversity among species in an ecosystem

Agrobiodiversità: **Diversità genetica** delle specie coltivate e parenti affini (Crop Wild Relatives, CWR)

Perdita di Biodiversità globale



Worldwide distribution of plant species at risk of extinction

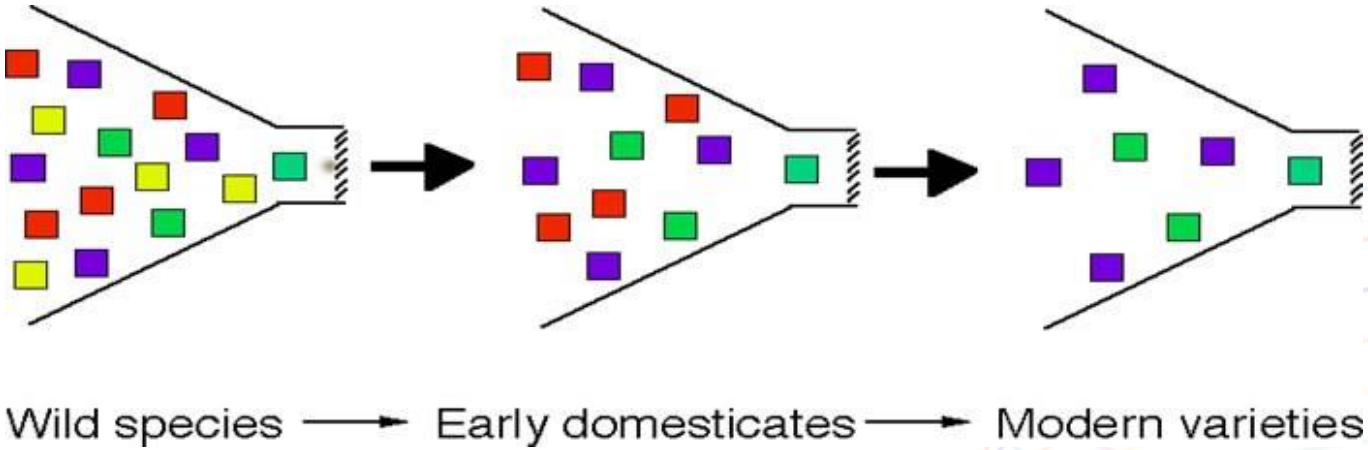


Main causes of plant extinction (1)

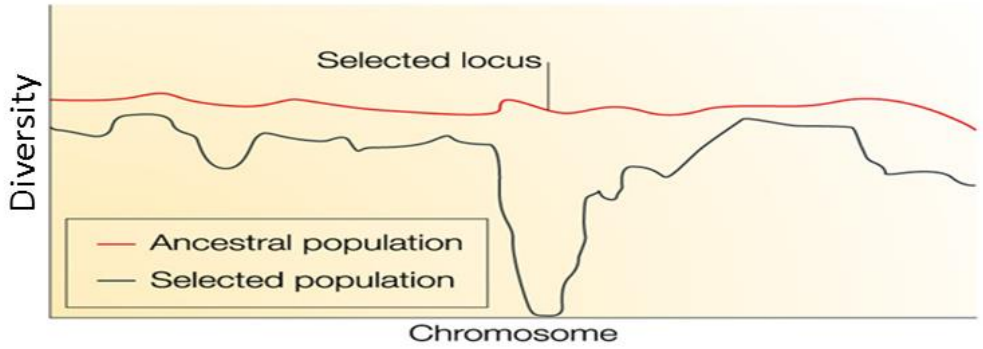
- **Around 40% of plant species are at risk of extinction globally.**
- **This figure fluctuates between 10%-45% for crop wild relatives, and reaches 60% for some groups (cycads, epiphytes, orchids)**

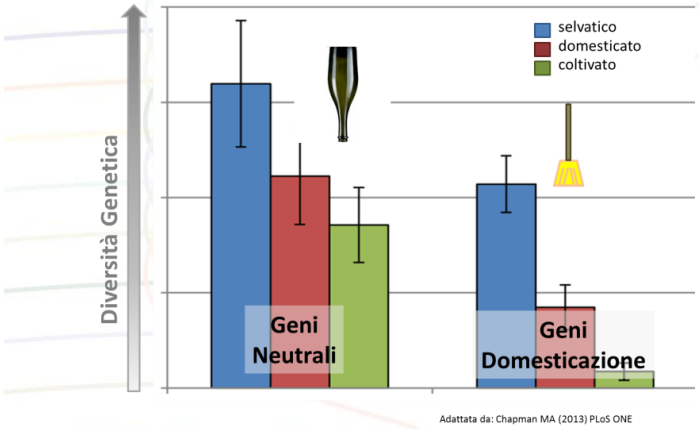
(1) Kew Gardens «State of the World's Plants and Fungi»

Perdita di diversità genetica a causa di selezione e breeding



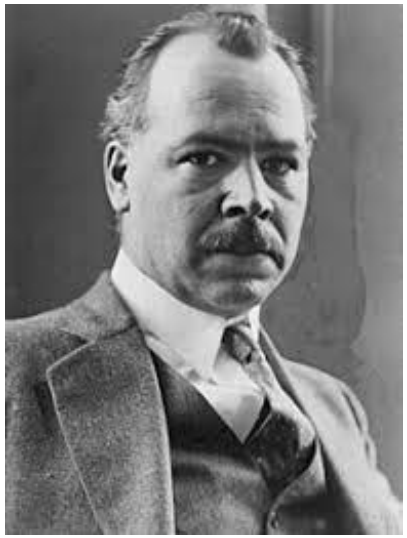
Erosione Genetica: la FAO stima che il 75% della diversità genetica delle specie coltivate sia stata persa durante i processi di selezione



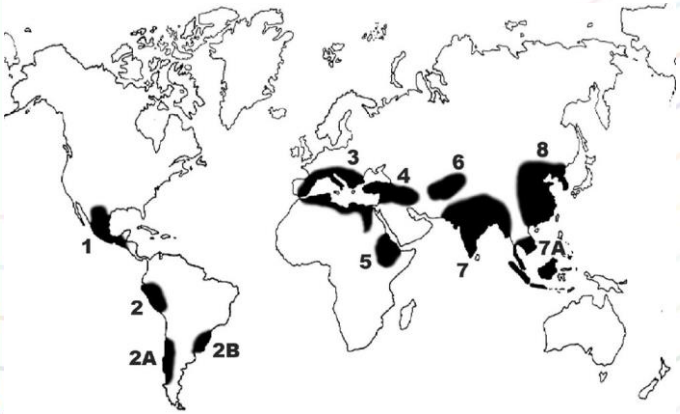


Nikolaj Ivanovič Vavilov 1887-1943

Le spedizioni di Vavilov alla ricerca dei semi



Tratto da: A cena con Darwin, Jonathan Silvertown

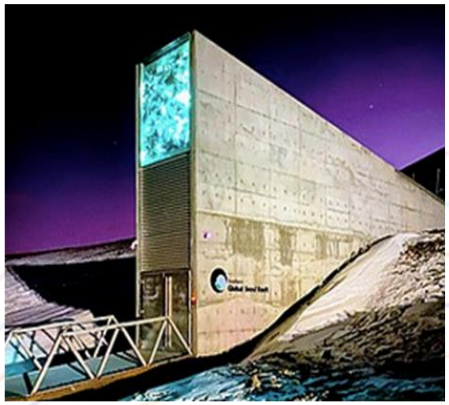


Centri di diversificazione di Vavilov. (1) Messico-Guatemala, (2) Peru-Ecuador-Bolivia, (2A) Cile meridionale, (2B) Brasile meridionale, (3) Mediterraneo, (4) Medio Oriente, (5) Etiopia, (6) Asia centrale, (7) India-Birmania, (7A) Indocina, (8) Cina e Corea.[2]

Prevenire la perdita di agrobiodiversità

In situ- on farm conservation

Ex situ conservation (Genebanks)



Seed vaults (the last resort)

Documentation & access

Safety

- Around 4 M of plant accessions are conserved in worldwide genebanks (1), of which around 2 M in Europe (2)
- The European accessions are spread over 400 different institutions, with dishomogenous management standards
- International regulations, and phytosanitary hurdles prevent the effective exchange of materials
- Active in situ / on-farm population conservation is very limited and does not meet proposed standards (3)
- 1.3 M of accessions are conserved at the Svalbard Global Seed Vault (4)

(1) https://www.genesys-pgr.org/
(2) https://eurisco.ipk-gatersleben.de/apex/eurisco_ws/r/eurisco/home
(3) http://www.fao.org/agriculture/seed/sow2/en/
(4) https://www.croptrust.org/work/svalbard-global-seed-vault/

Il Trattato FAO e il Programma RGV-FAO

Nel 2004 l'Italia ratifica il **Trattato Internazionale sulle Risorse Fitogenetiche per l'Alimentazione e l'Agricoltura (ITPGRFA)**, legge 101/2004, e istituisce un programma pluriennale, finanziato dal MASAF, con lo scopo di attuare e implementare l'articolo. 5 del Trattato stesso. Il programma è attualmente al 7 ciclo triennale.

The International Treaty ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Consiglio Nazionale delle Ricerche — IBBR (Bari) IBE (Follonica) IPSP (Cuneo)

CREA-OFA (Roma)

Rete Semi Rurali (Scandicci)

RGV/FAO
TRIENNIUM 2023-2025

National Programme for Conservation, Characterisation, Use and Valorisation of Plant Genetic Resources for Food and Agriculture

Specie e accessioni conservate e scambiate dal CREA

COLTURE	SPECIE (CROP)	CROP WILD RELATIVES	N. Accessioni mantenute
Cereali	24	33	17.006
Fruttiferi (Inclusi Olivo, Citrus e Vite e piccoli frutti)	70	108	11.719
Ortive	30	9	521
Colture Industriali (inclusi legumi	19	6	1.950
Ornamentali	197	-	974
Specie Medicinali e aromatiche	6	-	9
Colture Foraggere	70	-	7.643
Specie Forestali e da legno	2	-	733
TOTALE	**418**	**156**	**40.555**

CONSERVAZIONE

Numero di accessioni **scambiate dal** CREA dal **2004** al **2023**

Crop Group	N. of Accessions Transferred to			N. of Accessions Introduced from		
	Italy	Abroad	Total	Italy	Abroad	Total
Cereal crops	258	189	447	167	198	365
Fruit crops (including nuts, berries, citrus, olive and grape)	851	92	943	877	142	1019
Vegetable crops	87	0	87	80	152	232
Forage crops	30	50	80	71	98	169
Industrial crops (including grain legumes)	142	53	195	145	774	919
Medicinal and aromatic plants	63	10	73	13	9	22
Ornamental crops	19	1	20	11	0	11
Forest and woody crops	190	137	327	19	29	48
TOTAL	1640	532	2172	1383	1402	2785

Vaccino et al. Agronomy 2024

CONSERVAZIONE *EX SITU*: PERCHÈ?

CONSERVAZIONE

FUTURE CHALLENGES

- Climate change and new pathogens
- Population increase
- Environmental and biodiversity protection

- Identification of causal genes for important agronomic traits (as biotic and abiotic stresses) and developing of associted Molecular Markers.
- Breeding of improved cultivars using both classical and New Genomic Techiniques (NGT).

GENETIC CHARACTERIZATION

Molecular Markers:

- **SSR**: multiallelic, alto potere discriminante, bassa automazione
- **SNP**: biallelic, basso potere discriminante, alta automazione, high-throughput

COMMON PROBLEMS ON GERMPLASM COLLECTIONS

HOMONYMY: two or more genotypes that should be unique but are genetically diverse.

SYNONOMY: two or more genotypes that should be diverse but are genetically identical.

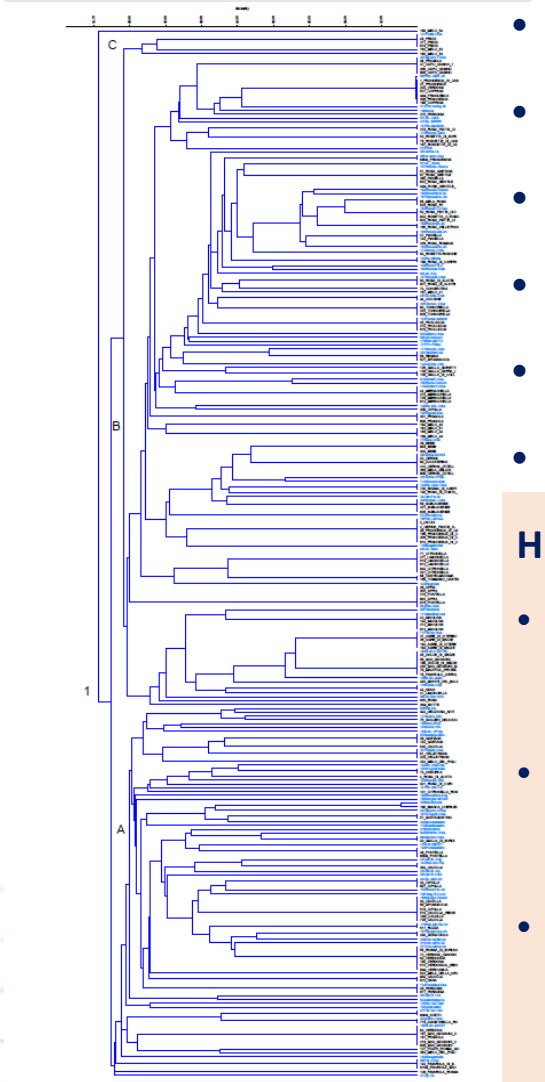
LABELLING ERRORS: incorrect identification of the genotypes at the time of introduction in the collection.

GENETIC DIVERSITY: estimation of heterozogosity, number of alleles, nucleotide diversity, population structure, identification of genes (GWAS)

Curatori banche di germoplasma
SSR (10-20), SNP (100)

Ricercatori,
SNP > 10.000

GENETIC CHARACTERIZATION



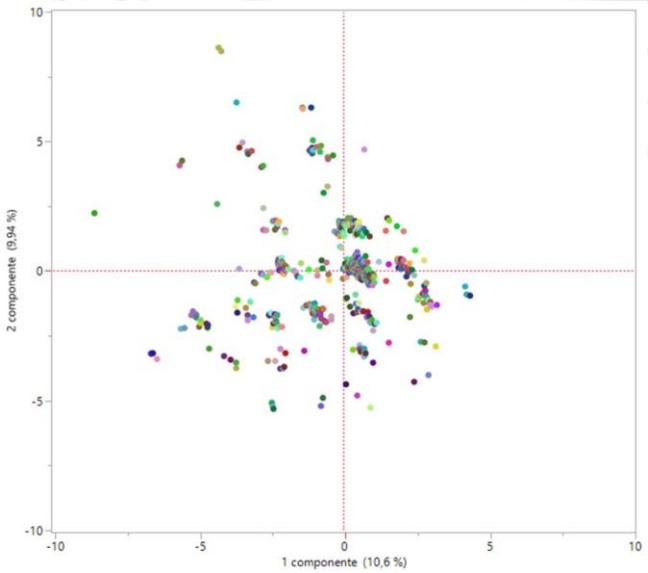
Simple Sequence Repeat Markers:

- **Cherry** 350 genotypes by 17 SSR markers
- **Apricot** 350 genotypes by 10 SSR markers
- **Plum** 100 genotypes by 13 SSR markers
- **Peach** 970 genotypes by 14 SSR markers
- **Pistacia** 40 genotypes by 13 SSR markers
- **Pear** 280 genotypes by 7 SSR markers

DONE

High Throughput (SNP markers)

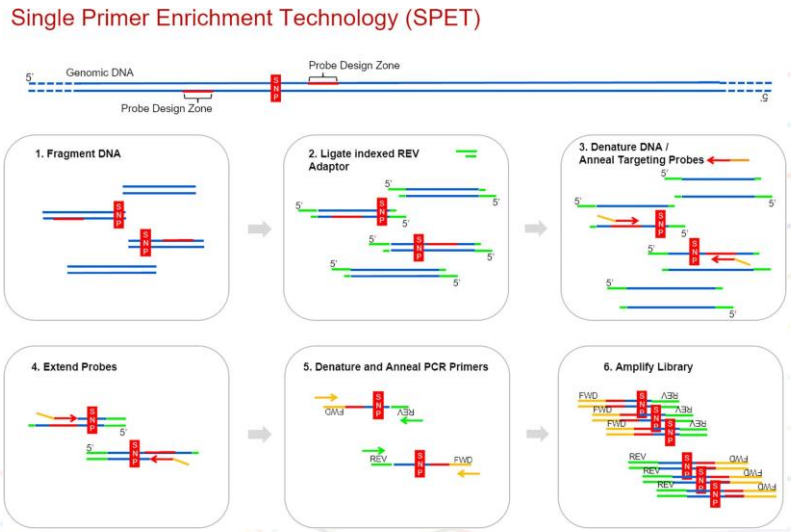
- **Peach** 400 genotypes by 9.000 SNPs (SNP Array)
- **Apple** 200 genotypes by 10.000 SNPs (SNP Array)
- **Apricot** 144 genotypes by 25.000 SNPs (Single Primer Enrichment Technology, SPET)



GENETIC CHARACTERIZATION

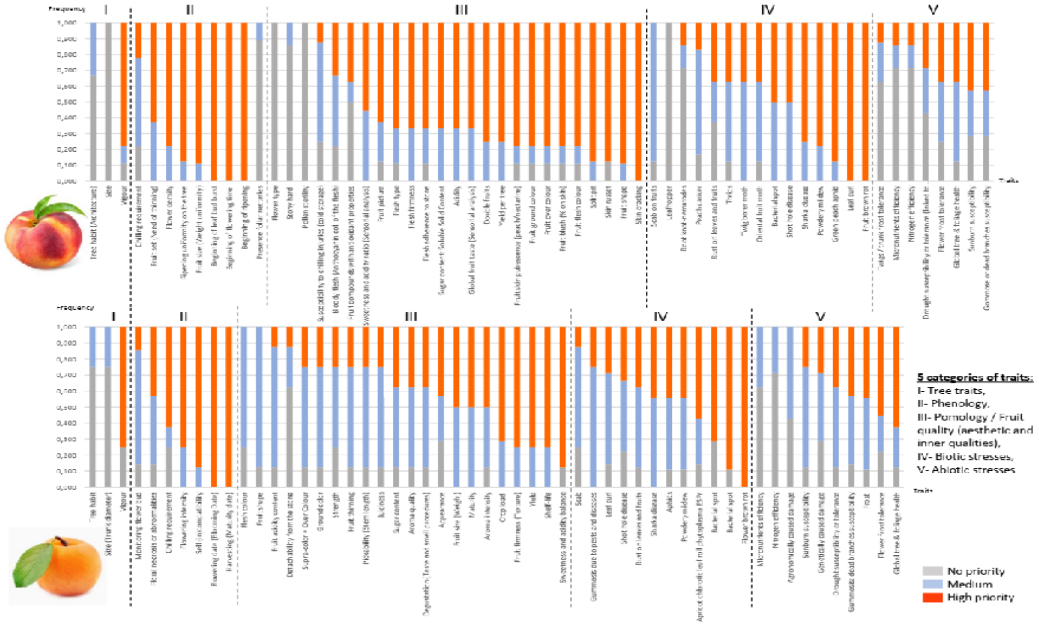
High Throughput (SNP markers)

- **Almond** 160 genotypes by 60.000 SNPs (AxiomTM 60K SNP Array for Almond)
- **Cherry** 700 genotypes by GBS approach



PHENOTYPIC CHARACTERIZATION

International Standards (ECPGR, FAO, Agreed Ontologies)



Field data collection

- Peach
- Apricot
- Plum
- Cherry
- Kiwi fruit
- Apple

DONE

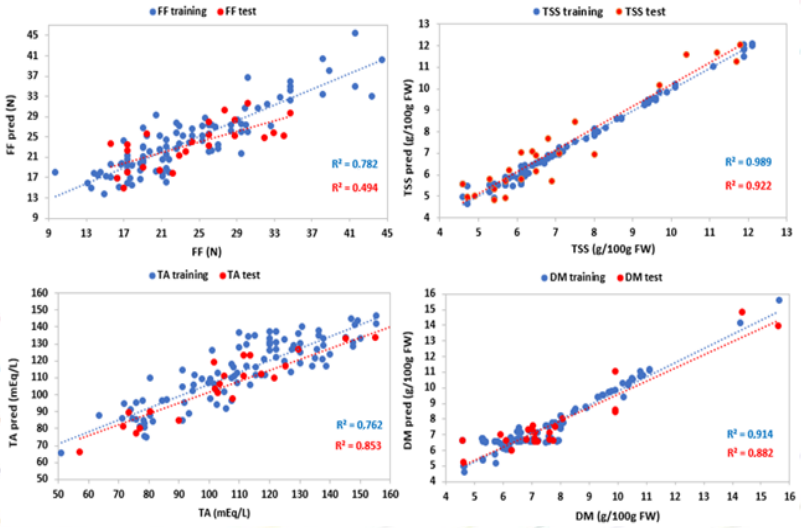
Lab Analysis (SSC, Sugar content, Firmness,…..)

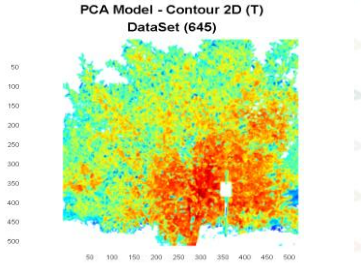
- Peach
- Apricot
- Cherry
- Kiwi fruit

PHENOTYPIC CHARACTERIZATION

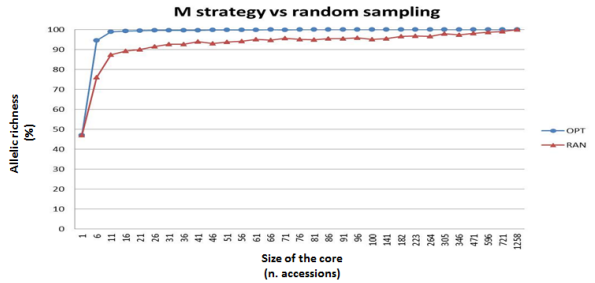
High Throughput and Digital Phenotyping (PHENOMICS)

- Spectral and Hyperspectral cameras
- Thermal cameras
- Drones
- Robots
- Sensors
- Model construction (non distruptive analyses)

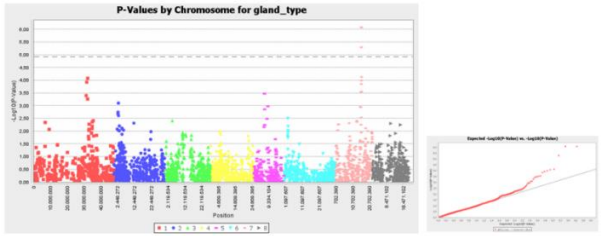


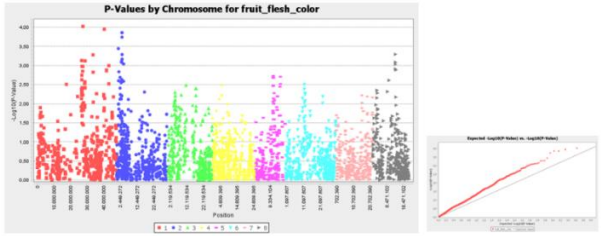


Peach Reference Population (PeachRefPop)



Validation through GWAS





VALORIZZAZIONE

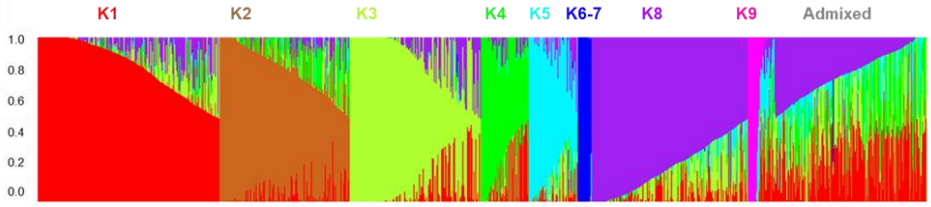
- **~1200** accessions genotyped with **9,000 SNPs**
- **4** European peach national germplasm collections: Italy (2), France and Spain
- A core collection of **69** accessions selected
- Ref-set (**PeachRefPop**) di **150** accessions validated with genetic diversity analyses and GWAS
- The **PeachRefPop** was **replicated in 5 locations** (Italy, Spain, and Greece) and is currently used to study GxE interactions in GWAS with the aim to find genetic factors involved in adaptation to climate changes as well as in the resistance to pests and diseases

Cirilli et al. 2020 Plant Phys doi: 10.1104/pp.19.01412

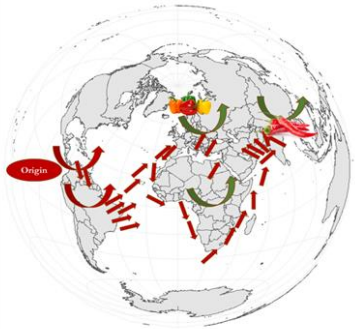
Pepper 10,000 genebank accessions

VALORIZZAZIONE

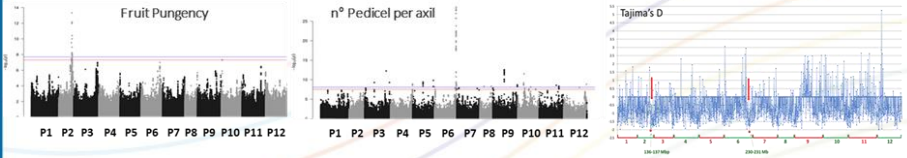
Genomic diversity



Routes of expansion and evolution



GWAS, candidate genes and selective sweeps



- Pepper germplasm from main **International Genebanks** and Research Institutions
- Over **10,000** accessions of 14 *Capsicum* species representing **130** countries
- Genotyping by sequencing yielding ~ **27000** SNPs
- Estimation of level of duplication among genebanks and putative misclassification of the accessions (1618) (16.2%)
- **Novel centres of diversification** identified in **Eastern Europe** and **South-Southeast Asia**
- Routes of evolution from the centre of origin highlight **west–east routes of expansion**, shedding light on role of Africa forming a natural link between the Americas and the Eurasian pepper complements
- The exploration of **phenomic data** in GWAS allowed to identify **new candidate genes** as well as **selective sweeps** for **key traits** under selection

Tripodi et al 2021 PNAS doi.org/10.1073/pnas.2104315118

Riso - Resistenza/tolleranza a patogeni, parassiti e insetti

Brusone – *P. oryzae*

VALORIZZAZIONE

1- Screening del germoplasma e mappaggio

311 accessioni

76 tropical *japonica*
224 temperate *japonica*
8 indica
2 aromatic
1 *aus*

2 stagioni di crescita

2 condizioni

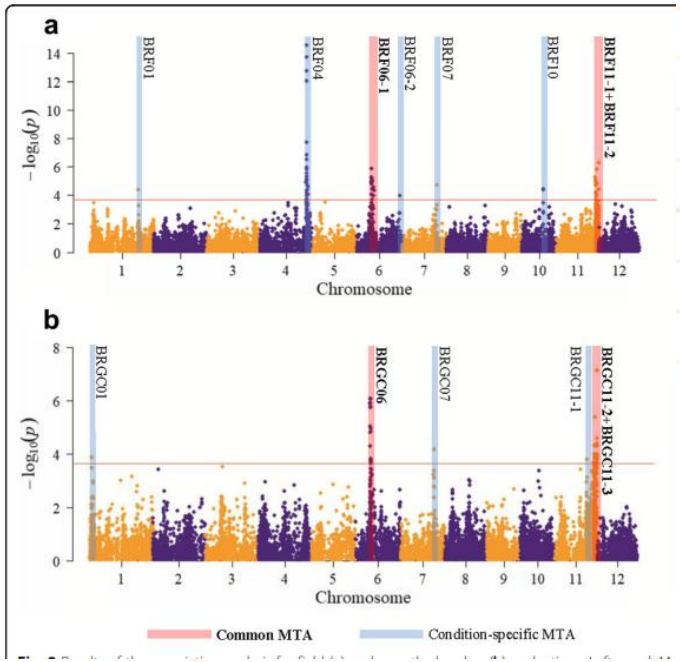
Pieno campo
Camera di crescita

Analisi DNA

37.423 SNPs

ANALISI DI ASSOCIAZIONE GWAS

- 14 associazioni significative (3 nuove)
- 11 accessioni ad elevato livello di R in entrambe le condizioni



Rice

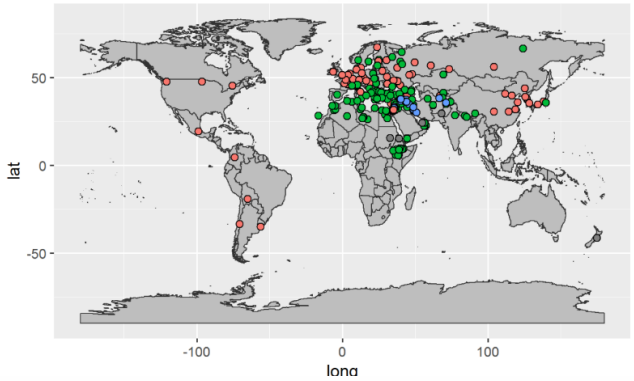
ORIGINAL ARTICLE Open Access

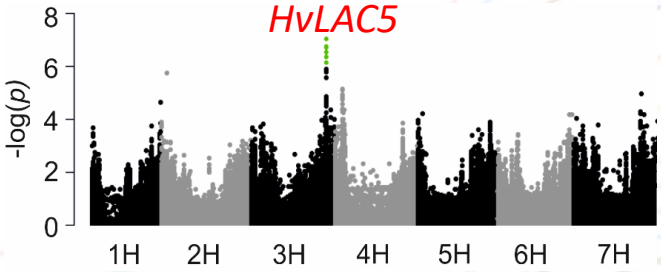
Genome wide association studies for *japonica* rice resistance to blast in field and controlled conditions

La collezione WHEALBI in orzo

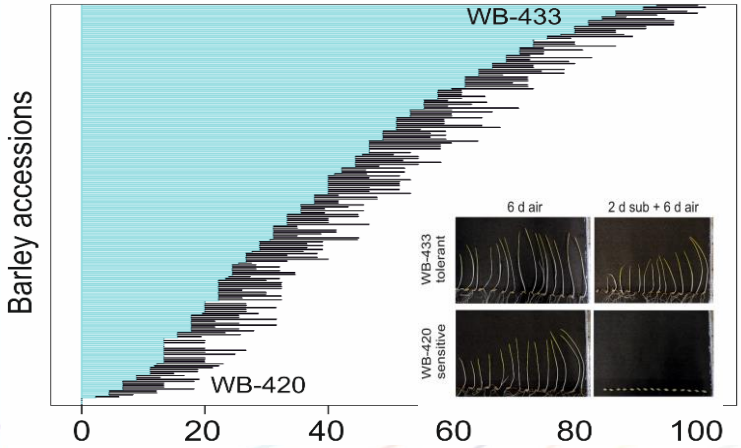
VALORIZZAZIONE

- ca. **450 accessioni** di orzo di diversa origine; include ecotipi locali, varietà antiche e moderne e accessioni di *Hordeum spontaneum*, il progenitore selvatico dell'orzo coltivato
- **>1 Million SNPs** derivanti dal sequenziamento dell'esoma
- GWAS ad alta risoluzione

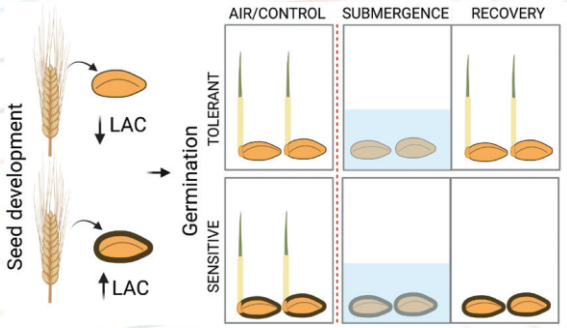




1 locus, *HvLAC5, controlla la germinabilità del seme in condizioni di stress anossico*



% semi germinate in condizione di stress / semi germinate in assenza di stress



- Minore permeabilità del seme
- Scarsa diffusione di O_2 → Ipossia
- Attivazione network ABA → dormienza secondaria

Gómez-Álvarez et al. JXB 2023

Piante TEA (NGT) in avanzata fase di valutazione

VALORIZZAZIONE

Piante in valutazione in **ambiente controllato**

- ✓ Melo cisgenico resistente alla ticchiolatura (CREA OFA - FEM)
- ✓ Melo editato per il gene della resistenza al fuoco batterico (CREA OFA - UNIBO)
- ✓ Pero cisgenico per il gene della resistenza al fuoco batterico (CREA OFA – UNIBO)
- ✓ Kiwi editato per il gene che controlla la resistenza alla batteriosi (CREA GB - CREA OFA)
- ✓ Pompelmo editato per il gene che determina una ridotta dimensione del seme (CREA OFA)
- ✓ Pompelmo rosa cisgenico per il gene per l'accumulo di antociani (CREA OFA)
- ✓ Frumento duro editato per i geni della dimensione del seme (CREA CI)
- ✓ Riso editato per un gene che espande le radici in profondità (CREA CI)
- ✓ Pomodoro editato nei geni che controllano l'accumulo di antiossidanti e metaboliti secondari (CREA OF)
- ✓ Basilico editato per il gene di resistenza a peronospora (CREA OF)
- ✓ Melanzane con ridotto accumulo di acido clorogenico che non imbruniscono (CREA GB)

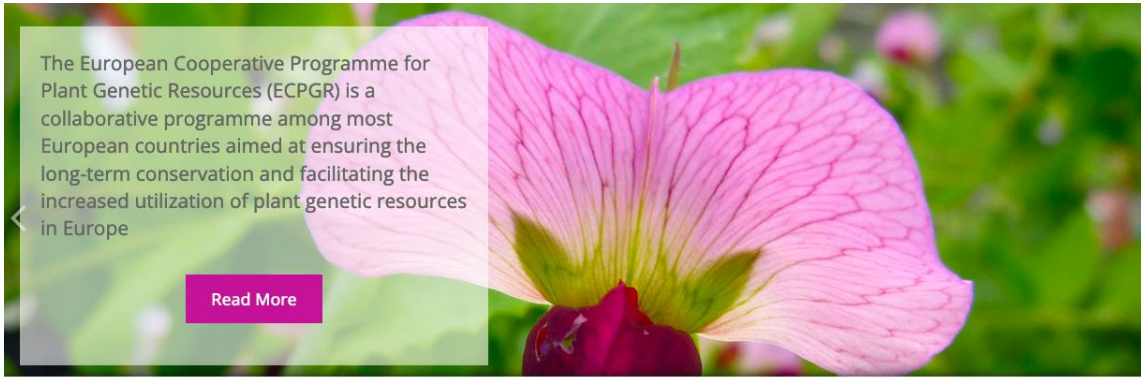
Piante TEA (NGT) in avanzata fase di valutazione

VALORIZZAZIONE

Piante in attesa dell'autorizzazione per le Prove di campo

- Piante di pomodoro in grado di inibire lo sviluppo delle orobanche (notifica già presentata in attesa di risposta) CREA OF
- Piante di arancio dolce arricchite in sostanze antiossidanti (antociani + licopene). (Notifica in fase di preparazione) CREA OFA
- Piante di vite resistenti alla peronospora. (Notifica in fase di preparazione) CREA VE
- Piante di melanzane senza semi. (Notifica in fase di preparazione) CREA GB

The international arena



European Cooperative Programme for Plant Genetic Resources
ECP/GR

eurisco
Finding seeds for the future

The **European Search Catalogue for Plant Genetic Resources** (EURISCO) provides passport and phenotypic data on >**2 million accessions** of crop plants and their wild relatives, preserved *ex situ* by about **400 institutes** from **43 member countries**.

>**10 EU-funded projects** have generated novel genetic resources and associated knowledge and methods on important crop plant families (Cereals, Solanaceae, Legumes, Rosaceae).

TRADITOM
AGENT
FORGENIUS
G2P-SOL
INCREASE
Farmer's Pride
Breeding Value
HARNESSTOM
InnOBreed
GEN4OLIVE

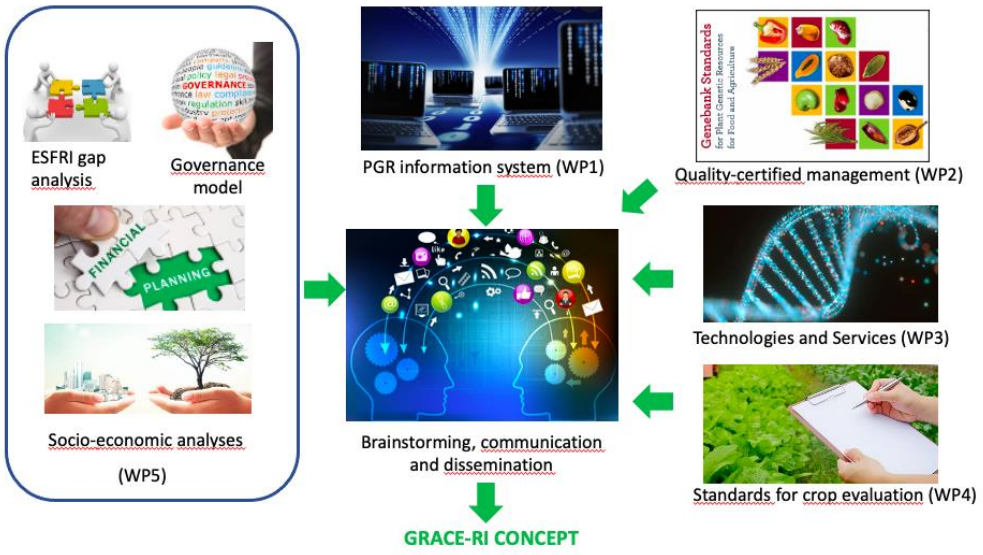
The PRO-GRACE project

Topic: Research infrastructure concept development (HORIZON-INFRA-2022-DEV-01-01)
Duration: 1st January 2023 – 30 June 2025
Funding: 2.85 M€ EU + 0.37 Assoc. partners
Coordinator: Giovanni Giuliano, ENEA; giovanni.giuliano@enea.it
Website: www.grace-ri.eu

Promoting a Plant Genetic Resource Community for Europe (PRO-GRACE)

PRO-GRACE
PROMOTING A PLANT GENETIC RESOURCE COMMUNITY FOR EUROPE

WP n.	WP title
WP1	Inventory and information system
WP2	Quality-certified ex situ and in situ management
WP3	Technologies and scientific services
WP4	Evaluation and valorisation
WP5	RI concept, social and regulatory aspects, governance and financial plan
WP6	Communication, dissemination, exploitation and training
WP7	Scientific coordination and management



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THANKS FOR YOUR ATTENTION

Il gruppo RGV FAO

ENEA
AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

Il dott. Giovanni Giuliano, ENEA

Il dott. Vincenzo Montalbano MASAF