GEN4OLIVE

Layman's Report

GEN4OLIVE

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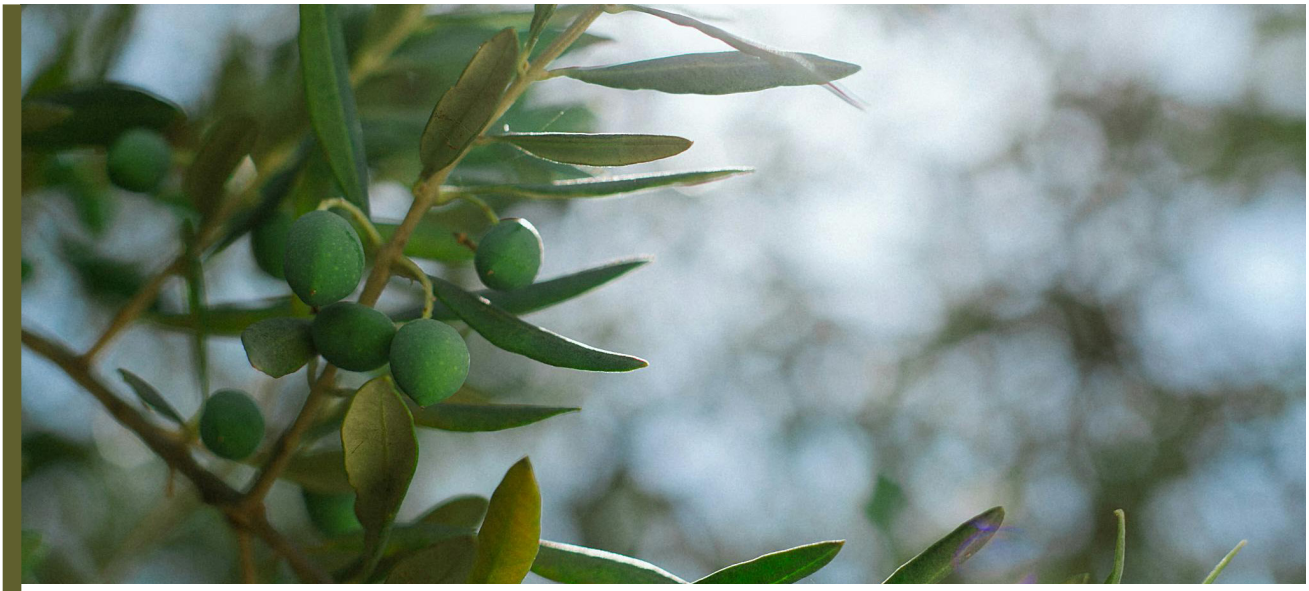
GEN4 OLIVE



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INTRODUCTION

Olive farming is a cornerstone of Mediterranean agriculture, with deep socio-economic and cultural significance. However, the sector faces numerous challenges, including climate change, emerging diseases, biodiversity loss and evolving onsumer demands. These issues threaten olive production, oil quality and long-term sustainability. To address these challenges, innovative solutions in breeding, technology, and sustainable practices are essential to secure the future of the olive sector.

To address these challenges, the GEN4OLIVE project was launched under the Horizon 2020 research and innovation program. The project aims to unlock the potential of olive genetic resources (GenRes), fostering breeding activities, digital innovations and industry engagement to future-proof the sector. By identifying, characterizing and enhancing genetic traits in wild, ancient and cultivated olive varieties, GEN4OLIVE is providing solutions that ensure the resilience and productivity of olive farming worldwide.

OBJECTIVES

1

Genetic Characterization

Extensive profiling of 600+ cultivated and wild olive genotypes to assess key agronomic traits such as drought tolerance, disease resistance, oil quality, and yield potential, enabling targeted breeding efforts.

2

Digital Resource Access

Creation of user-friendly digital platforms to ensure breeders, researchers, and farmers can easily access and utilize comprehensive genetic data for informed decision-making and cultivar selection.

3

AI-Driven Tools

Deployment of artificial intelligence and machine learning in mobile apps to automate cultivar identification and support early detection of diseases, improving field efficiency and responsiveness.

4

SME Innovation Support

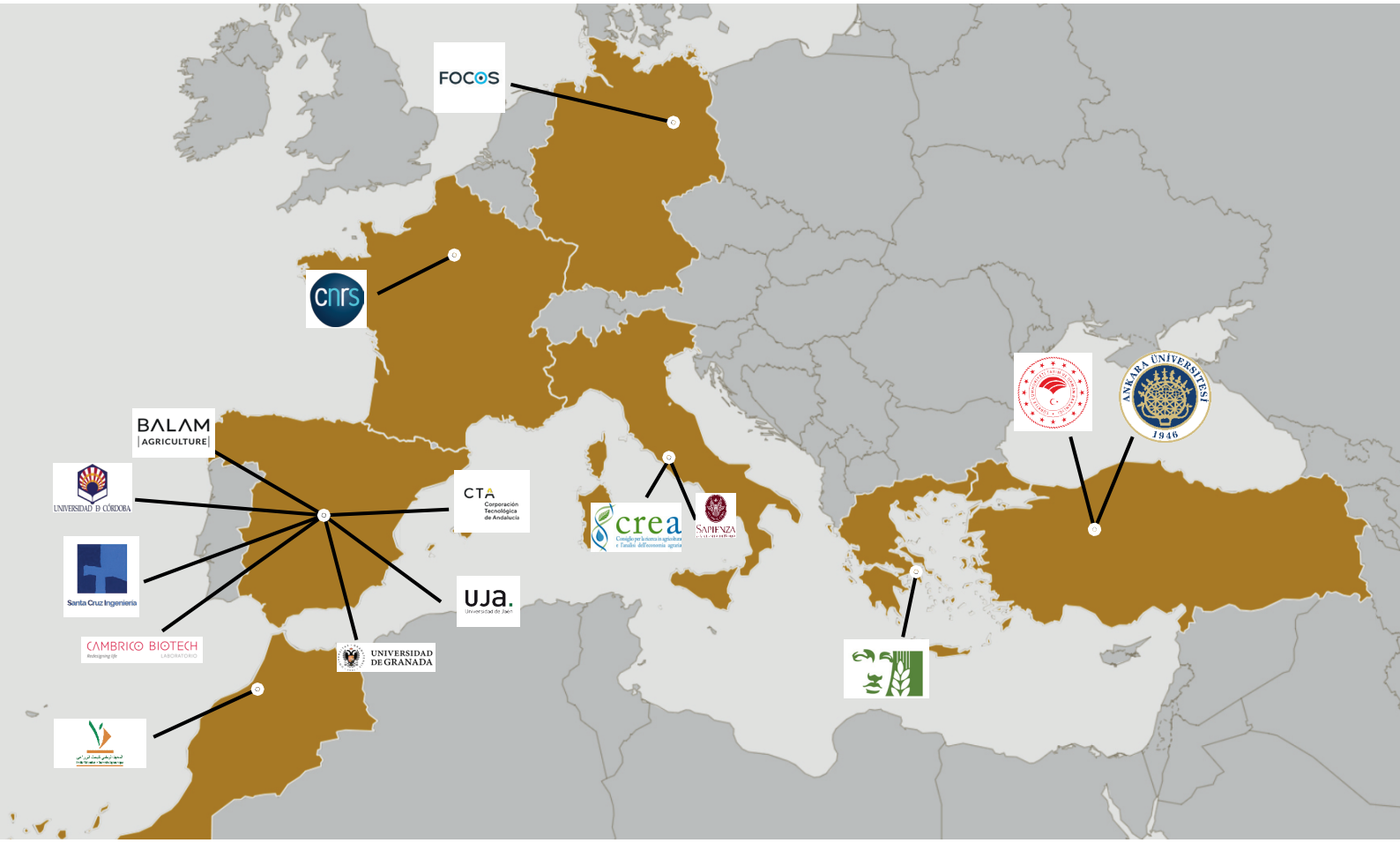
Two open calls successfully engaged SMEs and start-ups, resulting in 25 funded pre-breeding projects that enhance innovation and practical application of research outcomes in the olive sector.

5

Multi-Actor Collaboration

Promotion of strong synergies between research institutions, Germplasm Banks (GB), industry players, and policymakers to advance sustainable breeding practices and preserve olive genetic diversity.

PARTNERS



Universidad de Córdoba - ES

The UCO is one of the key agents involved in the World Olive Germplasm Bank of Cordoba and it is currently the largest olive germplasm bank. UCO holds the role of Project Coordinator and, as main responsible for the project, provides an academic multidisciplinary profile to the Consortium.

ELGO - Dimitra - EL

DEMETER holds the Greek Germplasm Bank. Responsible of the tasks related to climate change effects prediction and implementation of Genetic x Environment interaction studies.

Ministry of Agriculture and Forestry- TR

ORI is the responsible entity for the Turkish Germplasm Bank. Involved in activities such as the characterization and authentication of cultivars and varieties available in this GB.

Santa Cruz Ingeniería SL - ES

SCI is a company focused on agronomic management and R&D activities. They have applied their results from previous R&D projects and olive breeding, while carrying out cross-cutting activities related to communication, dissemination, exploitation and innovation management

Institut National de la Recherche Agronomique - MA

INRA, as the responsible entity of Morocco Germplasm Bank have worked in the characterization, authentication and cataloguing of domesticated, wild genotypes and selected ancient olive trees.

PARTNERS

Fundación Corporación Tecnológica de Andalucía - ES

CTA Is a regional public-private partnership, key companies to drive innovation in the private sector, linking it with academia and society.

Balam Agriculture SL - ES

BALAM is a leading olive breeding company, devoted to communication, dissemination and exploitation of project results, and in collecting end-users' needs and engaging them in the GEN4OLIVE activities.

Cambrico Biotech SL - ES

Placed in Sevilla (ES). Develops new technologies, products and services based on genomics and molecular biology.

Enosi Fytoriouxon Ellados - EL

Largest Greek association of propagating plant material. Some of their tasks include: a) collect the needs of nurseries and their contributions to the project; b) to carry out dissemination and communication

CREA - IT

CREA oversees the Italian Germplasm Bank, key role by characterizing cultivars from the Italian GB, identifying domesticated and wild genotypes, authenticating and cataloguing varieties.

Focos GBR Foodconsultingservices - DE

Strategy consultancy for the food industry. In charge of co-creation and capability-building activities.

Ankara University - TR

The main role of ANKU in the project is: a) the development of techniques to short the juvenile phase of olive plant and consequently to accelerate the breeding process

Universidad de Granada - ES

Through its Ecology Department is responsible of the characterization of wild olives and setting up core reference collections of wild material.

Universidad de Jaén - ES

Represented by the Ecology, Evolution and Conservation of Mediterranean Vegetation Research Group. Responsible of the characterisation of wild olives and setting up core reference collections of wild material

Universita degli Studi di Roma La Sapienza - IT

They will develop the interface where all the project findings will be digitalized for the end users and two applications for determining olive varieties and diseases through images.

Centre National de la Recherche Scientifique - FR

The Evolution and Biological Diversity and the Centre for Functional and Evolutionary Ecology will take part in roles as the establishment of a wild olive seed bank network.

ACTIVITIES AND RESULTS

WP 9,10&11

- Communication, dissemination and result exploitation.
- Project management and ethical issues.
- Ethics requirements.

Towards a dynamic olive breeding community

WP 7&8

- Co-creation and capacity building.
- Pre-breeding specific calls for SMEs involvement.

WP 6

Development of a user-friendly interference: database and apps.

WP 1

Definition of common protocols and consulting end-users' needs.
Establish links with other projects.

WP 2

Identification and characterization of wild olives and establishment of shared germplasm banks.

Prebreeding activities.

WP 3

Characterization of valuable olive domesticated and wild genotypes traits.

WP 4&5

Assessing the genetic control of valuable characters in olive and development of new techniques for speeding up breeding process.

Climate change effects: prediction and strategies to face them: Genetic x Environment.

GEN4 OLIVE

ACTIVITIES AND RESULTS

WP 1 Definition of common protocols and consulting end-users needs. Establish links with other projects

Standardization of protocols for olive characterization:

- Development of common methodologies for evaluating olive genotypes' tolerance to extreme environmental conditions (drought, frost, chilling requirements).
- Standarized protocols for disease susceptibility assessment, including Xylella fastidiosa, Verticillium wilt, Peacock Spot and Bactrocera oleae.
- Protocols for measuring fruit and oil yield, quality and agronomic traits like tree shape and blooming.

Collaboration with other projects and stakeholders:

- Collaboration is a key aspect, with strong connections to other projects, to integrate existing research and optimize resources.
- There is an urgent end-user needs for future olive breeding programs, engaging key stakeholders such as farmers, breeders and industry representatives.
- Meetings and surveys have helped defining breeding priorities, ensuring practical applications for the sector.

WP1 RESULTS

- Establishment of 27 common protocols for the evaluation of the olive cultivar characteristics covering 44 traits across 600 olives varieties.
- Networking and interaction with other projects and identification of end-user needs.

Drought resistance evaluation of olive varieties

WP 2&3 Characterization of olive genetic resources

Wide genetic sampling:

- Over 600 olive varieties studied across 5 Mediterranean countries.
- Wild olives preserved with seeds and cuttings from diverse regions.
- Ancient olive trees catalogued (41 Turkey, 25 Morocco, 183 Spain).

Climate resilience and disease resistance studies:

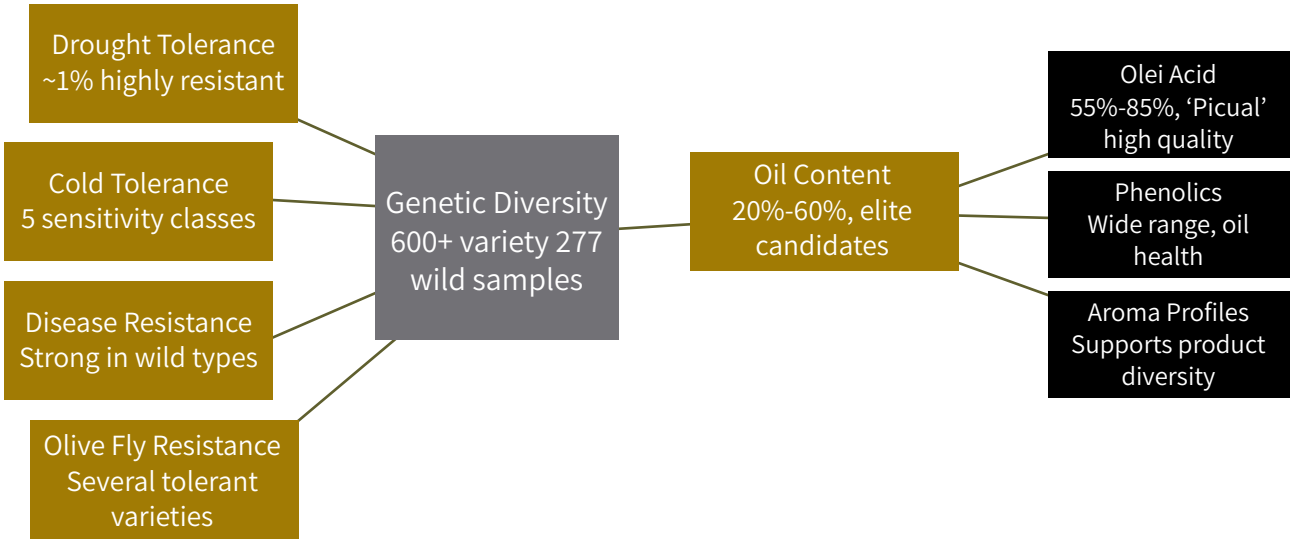
- Drought tolerance varies: only ~1% of varieties are very drought-resistant.
- Cold tolerance classified into 5 groups, helping identify hardy trees.
- Screening for diseases (*Verticillium wilt*, *Xylella*, fungal infections) ongoing, with some wild olives showing strong resistance.
- Olive fly pest resistance found in certain cultivars (e.g., Adramitini, Koutsourelia).

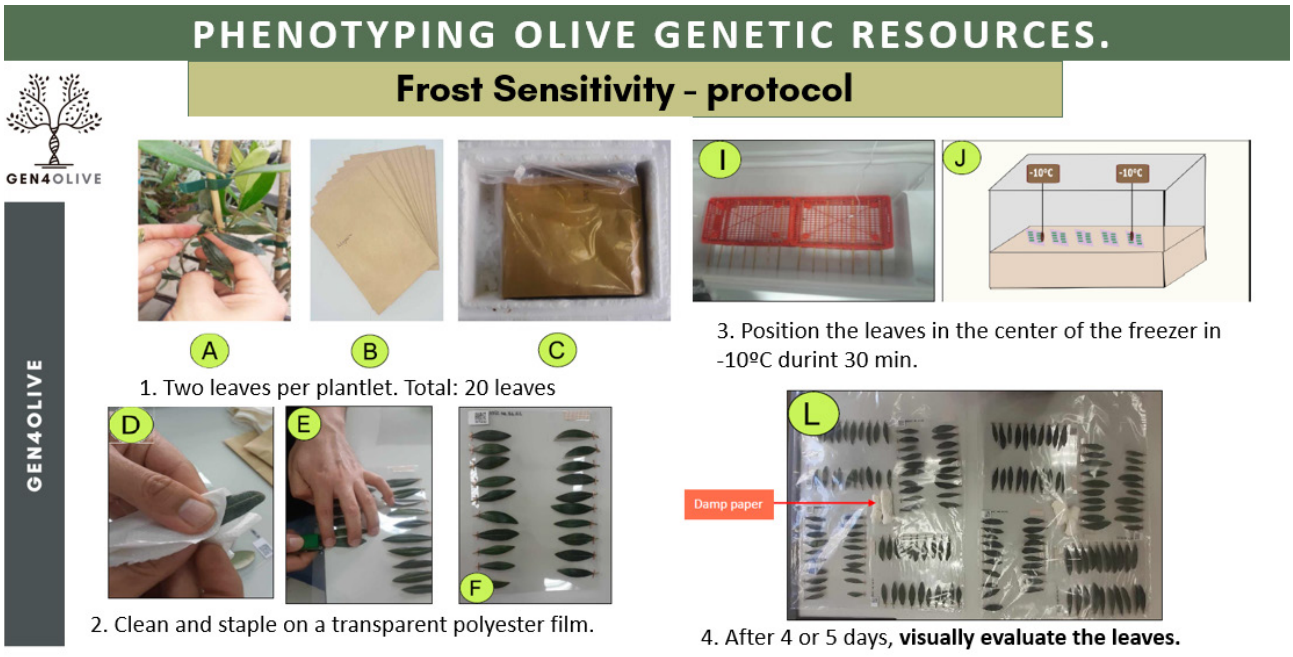
ACTIVITIES AND RESULTS

Oil quality and nutritional profiling:

- Chemical composition analyses were conducted on 444 olive oil samples.
- Oil content ranges 20% to 60% dry matter; some cultivars surpass 'Arbequina'.
- Oleic acid (healthy fat) varies widely, with 'Picual' as a top source.
- Phenolic compounds (linked to health benefits) vary greatly, separating cultivars into high and low groups.
- Diverse aroma profiles support differentiated olive oil products.

WP2&3 RESULTS





ACTIVITIES AND RESULTS

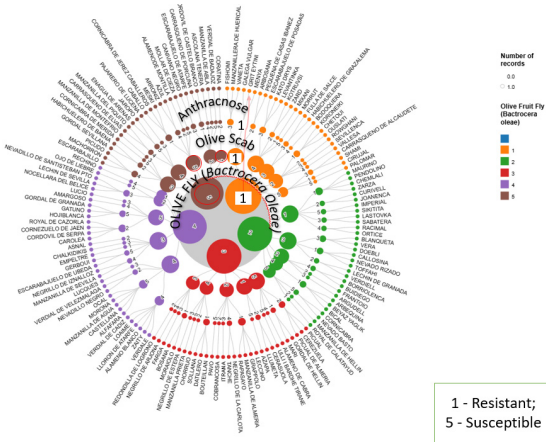
WP 4 Breeding for climate resilience and disease resistance

- Identifying genetic markers for stress and disease resistance.
- Using advanced breeding and phenotyping techniques to speed up cultivar improvement.
- Developing tools to shorten the juvenile phase in olive breeding.

WP4 RESULTS

TOPIC	WHAT WAS DONE/FOUND
Genetic markers	24 genes linked to disease resistance identified (e.g., for *Verticillium* & *Xylella*)
Genome sequencing	Sequenced resistant and susceptible varieties, found key genetic variants
Stress responses	Studied 14 varieties for drought, heat & cold tolerance; key stress hormones and genes identified
miRNA biomarkers	Developed miRNA tools (miR156, miR172, miR159) to predict and reduce juvenile phase duration; IP protection underway
Parental effects	Tested crosses between 'Sikitita' and 'Arbosana'; maternal parent may influence phenolic content
Speed breeding	Hybrid growth chambers with controlled environment; red LED light accelerated flowering to 27 months (vs 8–12 years normally)

"Hybrid-Fully Automatic Growth Chamber" (H-FAC), pilot chambers built in Izmir (Turkey)



Three level classification of the main pest and areal diseases of olive

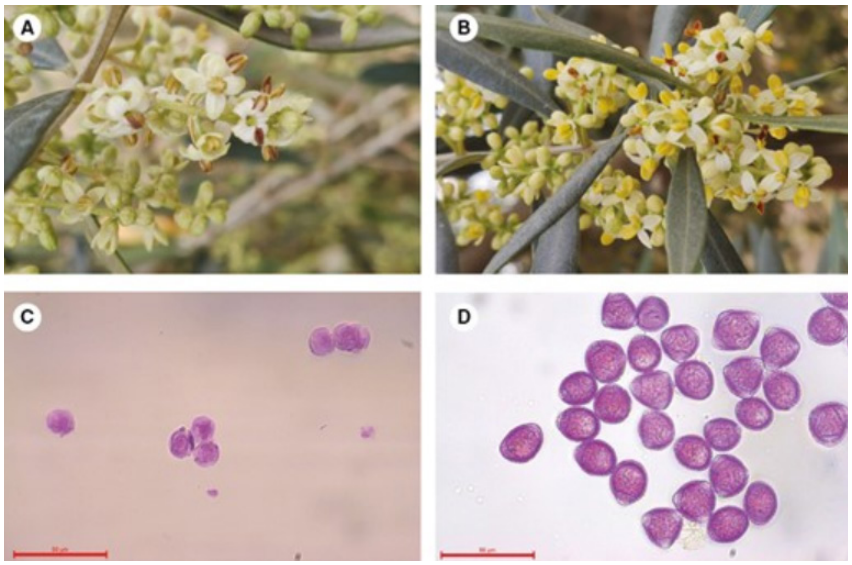
ACTIVITIES AND RESULTS

WP 5 Climate change effects prediction and strategies to face them: Genetic x Environment

- Evaluation and comparison of the phenology (budburst, flowering and ripening) of 30 varieties in five different GBs located in contrasting climate conditions.
- Breeding modelling: adaptive traits to different environments, diseases and climate change scenarios.

WP5 RESULTS

- Report about the E x G interaction of 30 olive varieties found in the five different GBs.
- Guidelines with suggestions and breeding strategies to face the present and future risks.
- Greece and Spain show early budburst and flowering, while Italy, Turkey, and Morocco have later budburst and flowering—except Morocco, which has early flowering.
- Climate change and temperature shifts may disrupt phenology, causing insufficient chilling or frost damage.
- Significant variability was found in pollen production among cultivars, ranging from over 65,000 pollen grains per anther to some varieties that produced no pollen.



Inflorescences and undeveloped pollen grains stained with fuchsin (scale bar = 50 µm) in the androsterile cultivar 'Vera' (A and C) and in the excellent pollen donor 'Arbequina' (B and D)

ACTIVITIES AND RESULTS

WP 6 AI & Digital tools for olive farming

Development of two mobile tools:

- Olive Cultivar Identification App: Uses AI-powered image recognition to classify olive varieties.
- Olive Disease Detection App: Employs machine learning to analyze symptoms and suggest early interventions.

Online database:

- Creation of an online genetic resource database, integrating genetic, agronomic and environmental data for easy access by researchers and industry stakeholders.

Machine Learning models:

- Advanced AI-based models have been trained on thousands of images and environmental data points to enhance prediction accuracy.
- The system continuously learns from new data, improving its detection capabilities over time.

WP6 RESULTS

- An AI-powered Olive Cultivar Recognizer to identify varieties from images.
- An advanced pest and disease detection tool using artificial intelligence.
- Multi-filter search options for tailored cultivar selection.
- Standardized data from five major Mediterranean Germplasm Banks.
- Available in eight languages for global accessibility.
- A comprehensive user manual to guide users through the tools.

Interactive Olive Database & AI Tools

WP 7 Pre-breeding activities specific calls for SMEs involvement

- Two Open Calls for SMEs and Startups:
  - First call: Funded 8 pre-breeding projects, focusing on genetic diversity, oil quality and pest resistance. Allocated budget: 700.000 €.
  - Second call: Funded 17 projects, integrating AI applications, genome sequencing and sustainability innovations. Allocated budget: 170.000 €.
- Establishment of knowledge-sharing platforms, fostering collaboration between industry players, policymakers and researchers.
- Encouraging technology transfer by facilitating connections between research institutions and agribusinesses interested in commercial applications.

ACTIVITIES AND RESULTS

WP7 RESULTS

1st CALL FOR PROPOSALS RESULTS

35 Proposals received	8 Projects approved (2 individual and 6 collaborative)
€ 700.000 Allocated budget	14 SMEs Receive grant (Spain, 7; Italy, 3; Greece, 2; Albania, 2)

Empowering SMEs to innovate and transform olive farming

2nd CALL FOR PROPOSALS RESULTS

27 Proposals received	17 Projects approved
€ 170.000 Allocated budget	12 SMEs Receive grant Spain: 7 · Italy: 1 Turkey: 1 · France: 1 Albania: 1 · Georgia: 1

Funded Projects

WP 8 Co-creation and Capacity Building

- Engage key stakeholders, accelerate pre-breeding, close knowledge
- gaps and build capacity in the olive sector.
  Co-creation panels in 5 countries (Spain, Italy, Greece, Turkey, Morocco)
- to gather input from farmers, breeders, and nurseries.
- Dynamization events for GEN4OLIVE open calls.
- GEN4OLIVE interface co-learning programme.
- External Expert Advisory Board feedback.
  Capacity building in genetic resources from wild olives.

Top 10 tips for olive breeders and farmers

Co-creation panel & Dynamisation event in Spain

Co-creation panel & Dynamisation event in Morocco

ACTIVITIES AND RESULTS

WP8 RESULTS

- Over 500 stakeholders engaged across five countries through co-creation activities.
- 305 participants from 4 continents trained to use GEN4OLIVE digital tools.
- 1,400 wild olive seeds and 436 genotypes collected and conserved.

Co-creation panel & Dynamisation event in Turkey

Co-creation panel & Dynamisation event in Greece

Pictures from co-creating activities

TESTIMONIALS

ELGO - DIMITRA
Georgios Koubouris
Final Symposium

FAO
Daniele Manzella
Final Symposium

University of Granada
Rafael Rubio, Andrés Barea
Final Symposium

University of Jaén
Ana M. Fernández
Final Symposium

University of Córdoba
Hristofor Miho
Final Symposium

CTA
Nathalie Chavrier
Final Symposium

University of Córdoba
Concepción Muñoz
Final Symposium

University of Sapienza
Luigi Mancini, Alicia K. Bidi,
Fabio de Gaspari
Final Symposium

CONCLUSIONS

1

Successful completion and significant achievements

GEN4OLIVE reached its planned objectives, marking the largest European investment in olive genetic improvement in decades. Substantial progress in the phenotyping, characterization and valorization of over 600 olive varieties, including cultivated, wild and ancient genotypes.

2

Enhanced genetic resource management

Fundamental contribution to the conservation and utilization of olive genetic resources by creating a freely accessible digital platform. This platform provides open access to detailed data on olive cultivars, supporting breeding, research and broader societal use.

3

Integration of advanced technologies

Innovative tools such as early molecular markers for marker-assisted selection (MAS), machine learning applications for disease and cultivar identification.

4

Broad phenotypic and genotypic characterization

The study of Genotype x Environment interactions revealed key insights on environmental impact on traits, enabling more precise breeding strategies.

CONCLUSIONS

5

Unprecedent Scientific Innovation

More than 25 standardized evaluation protocols were developed to ensure data comparability across germplasm banks and regions.

6

Long-term impact and sustainability

GEN4OLIVE's outputs are expected to enhance olive sector sustainability by reducing genetic erosion, diversifying cultivar use and improving resilience to climate change and pests.

7

Societal and economic benefits

The project's data and tools support a more sustainable, productive and innovative olive industry in the Mediterranean and beyond.

8

Future prospects

There is a clear intention to continue the project's momentum at the European level, pursuing further research and innovation in olive genetic resources. The project represents a model for combining scientific, digital and commercial approaches to agricultural improvement.

FUTURE DIRECTIONS

Expanding Genetic Resources and Data Analytics

The project aims to enhance its genetic resource database by incorporating new data layers and advanced analytics. These additions will improve the precision of cultivar characterization and optimize breeding strategies for sustainable olive production.

Advancing AI for Disease Detection

Ongoing research will refine AI-driven models for early disease detection in olive trees. Enhanced accuracy in identifying pathogens will help farmers take preventive measures, reducing crop losses and minimizing reliance on chemical treatments.

Strengthening Policy Support for Sustainable Breeding

Advocacy efforts will focus on integrating biotechnological advancements into EU agricultural policies. By promoting sustainable olive breeding programs, the project seeks to align genetic innovation with environmental and economic sustainability.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