

AGENDA 3i9

Portuguese research and innovation agenda for cork oak and cork

1st edition
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2015

2nd edition
December
2021



INTRODUCTION

Based on the fact that:

- The current cork industry is based mainly on the added value of natural cork and champagne cork stoppers, used by the bottled wine sector, and on a portfolio of complementary products that allow the various segments of this consumer market to be satisfied;
- Although the wine sector is the main user of cork products, the industry is not limited to this segment and there are a number of complementary segments that make use of the by-products of the natural cork and champagne cork stopper industry, recycled material and virgin cork;
- Cork is a renewable, recyclable and biodegradable, unique raw material. Through this raw material, the European Union is the world leader in the production of wine closures, probably one of the few cases in which a natural product maintains its leadership of the market;
- The cork oak and cork forest, which sustain the cork industry, are agroforestry systems occupying an area of around 2.1 million hectares in the Mediterranean region, mainly in Southern Europe (Portugal, Spain);
- The cork oak, *Quercus suber*, is of particular importance in Portugal because it is the basis of a high added-value production sector that is decisive in territorial planning, in levelling out socio-economic asymmetries and also in preserving the environment;
- Cork oak forests are stable, rich and complex ecosystems that are dependent on human management, constituting multifunctional systems of land use, characteristic of Mediterranean regions with traditionally low productivity agriculture that produce natural non-food and food products in a balanced way;
- Cork oak forests are an effective barrier against desertification, which affects large areas in the Mediterranean region, and play a key role in several ecological processes such as soil conservation, regulation of the water cycle and carbon sequestration. They are also highly suitable as shelter, nesting and feeding grounds for various species of fauna, some with protection status.

This is a sector with unique characteristics for Portugal which, despite being a driver of economic and social development and a guarantee of environmental stability, has some weaknesses due to its geographical concentration in the Mediterranean basin and its small overall size.

It is in the face of this enormous challenge and set of opportunities that the production of cork, in quantity and quality, and the preservation of the cork oak and cork oak forest ecosystems are becoming increasingly important in the sector.

The Competence Centre for Cork Oak Tree and Cork (CCSC) was created in this context, as established in the constitution Protocol, and aims, among other objectives, to prepare a Portuguese Research Agenda for the Cork Oak and Cork Sector.

The Portuguese Research and Innovation Agenda in Cork Oak and Cork – Agenda 3i9 – is the result of work carried out within the scope of the Competence Centre for Cork Oak Tree and Cork (CCSC) with the primary aim of improving the conditions for the functioning of the relationship between the various agents involved in research and innovation in Portugal, reaching consensus on priorities, identifying available means and resources, establishing goals and seeking results that will enable progress to be made in consolidating a more representative, more resilient, more equitable and more sustainable cork sector.

The acronym "3i9 Agenda" aims to reflect the time frame of intervention – the short-term corresponding to a 9-year production cycle, the medium term corresponding to 3 production cycles of 9 years, and the interconnection of three primordial components – research, innovation and interaction between lines of action.

The cork oak and cork industry, in the format we know, led by the natural cork stopper sector and leveraged by a multifunctional cork oak forest, is a clear and unequivocal example of the concept of sustainability, the basis of the circular economy which is beginning to emerge as the only safe path for current and future generations.

The specific characteristics of this sector, geographically confined to the Western Mediterranean and with a preponderance of production and industry located in Portugal, pose a special challenge and an additional responsibility to our country and to the sector as a catalyst and locomotive in terms of the market, production and obviously research and innovation.

The aim of the 3i9 Agenda is: more and better cork, greater resilience of Portuguese cork oak forests and their productive continuity, in an investment in research and innovation projected over a time frame of three production cycles.

The Agenda was built on the basis of a participative process of listening to the CCSC partners, in meetings of the 27 members of the CCSC General Council and in thematic sectoral meetings in which 81 researchers and technicians from the 27 entities participated.

The 3i9 Agenda is based on a set of supporting, facilitating actions that enhance synergies between agents and improve the sharing of resources.

Support actions	Objective	Long/medium-term
Cork oak forest diagnostic inventory	Adequately and timely profiling of the current reality of the cork oak forest in productive and sanitary terms	<p>Carrying out a diagnostic inventory of cork oak forests. The selection of the areas to be inventoried will be based on the information from the 2005 National Forest Inventory (IFN, 2005), with the collection of field data on plots established on a complementary grid of photosites, at a distance of 2 x 2km (supported by the grid of photosites) that will be monitored in its entirety in the first year and thereafter annually only on the plots being harvested.</p> <p>These plots will be separated from the IFN sampling plots, thus allowing for a duplication of the amount of existing information on cork oak forests, in the case of future data provision by the IFN, and also for greater data regularity.</p>
Network of permanent plots for research and monitoring	<p>Ensuring continuous and long-term monitoring</p> <p>Enhancing working partnerships between research teams</p>	<p>Creation of a national monitoring system that integrates the IFN cork oak plots, the permanent plots of the experimental devices of higher education and research institutions and the permanent demonstration plots of the Forestry Producers' Organisations.</p> <p>The plots will be organised according to the type of data collected and, after spatial analysis, an information collection system will be proposed that is representative and equivalent for all the national cork oak production areas.</p> <p>Creation of space-based rapid diagnostic and warning systems.</p>
Map the potential suitability for cork oak	Knowing the expansion potential of the species and its current suitability	Portuguese Map for Cork Oak Allocation Potential.
Extension protocols	Ensuring that research results are decoded and disseminated to end users	Developing protocols/extension sheets with consolidated knowledge, including scientific basis, method/model of implementation and a cost-benefit analysis.
Data warehouse and metadata library	Ensuring that basic research data and project results are preserved, enabling their present and future access	<p>Creation of a platform to store data and metadata of the experimental units existing in Portugal.</p> <p>Creation of a Geographic Information System with the location of all experimental units (temporary and permanent plots and trials) and corresponding metadata that summarise the type of information collected.</p> <p>Creation of a legal system of contracting with institutions/researchers to enable secure data storage, as well as sharing it with the scientific community and Forest producer Organisations that allows, in a win-win logic, the integrated use of this data at national level.</p>

The construction process of the Agenda, which took place over the past year and culminated in sectoral meetings held during the month of July, made it possible to identify a set of priority research actions in various scientific fields. These actions integrate the structuring lines of five functional plans, but require urgent implementation due to their economic impact on the productive and industrial sector.

Structuring lines	Urgent actions/results
Nutrition and Fertilisation	Diagnostic methods for nutrient deficiencies and fertilisation recommendations
Pests and diseases	Methods for diagnosis, minimisation and control of biotic agents: <ul style="list-style-type: none"> • Flathead oak borer (<i>Coroebus undatus</i>) • <i>Diplodia corticola</i>
Promoting Regeneration, Stand Management and Optimising Production	Forestry options: <ul style="list-style-type: none"> • grazing models and regeneration promotion • production optimisation models • methods for anticipating first production
Characterisation of functional quality	Methods for the early assessment of cork quality in young trees
Harvesting and post-harvesting technologies	Methods and equipment for qualitative and quantitative streamlining of cork harvesting and complementary harvesting operations

The 3i9 Agenda was built on the basis of five nationwide functional plans:

1. National Improvement Plan
2. National Productivity Improvement Plan
3. National Defence Plan against Biotic Agents
4. National Cork Quality Plan
5. National Territorial Action Plan

Each of the functional plans contemplates:

- General objective
- Structuring lines
- Concrete actions
- Short-term (ST) and medium-term (MT) expected results

This compartmentalisation, arising from a practicable organisational model, is built on the certainty of the multiple interactions between structuring lines and functional plans and of the need for interdisciplinarity.



1

NATIONAL PLAN FOR CORK OAK GENETIC IMPROVEMENT

Objective → To produce quality cork from individual trees adapted to biotic and abiotic stress

The National Improvement Plan includes 3 structuring and complementary lines that will allow the proposed objective to be reached:

Structuring Lines	Actions	ST Results (9 years)	MT Results (3x9 years)
Improvement Population Management and Classical Selection	<p>Monitoring of the Improvement Population</p> <p>Propagation Population Development through seed and vegetative propagation</p> <p>Assessment of the adaptability of the cork oak and genetic control: of growth, adaptive characteristics and cork quality at young ages</p> <p>Base Population Management</p>	Production of Quality Forest Reproductive Material (FRM)	Regional/functional allocation of quality FRM genotype prospecting for genetic conservation purposes
Genome and Functional Analysis	<p>Cork Oak Genome Sequencing</p> <p>Transcriptomics</p> <p>GWAS (Genome wide association studies)</p> <p>Functional analysis of the impact of combined stress</p> <p>Integrative analysis of results to identify potential markers of cork production/quality and resilience to stresses</p>	Cork Oak Genetic Map	<p>Molecular markers of cork production and quality</p> <p>Phenotype prediction models as a function of genotype</p>
Bases for Genomic Selection	<p>Genotyping of young plants</p> <p>Association of genetic markers with cork quality</p> <p>Phenotyping and genotyping with a battery of high-density molecular markers</p>		

2

NATIONAL PRODUCTIVITY IMPROVEMENT PLAN

Objective → To produce quality cork from individual trees better adapted to biotic and abiotic stresses, in more resilient stands, in the knowledge of the key variables that influence the relevant physiological processes and under different management models

The National Productivity Improvement Plan comprises 3 structuring and complementary lines that will allow the proposed objective to be achieved:

Structuring Lines	Actions	ST Results (9 years)	MT Results (3x9 years)
Nutrition and Fertilisation	<p>Assessment of the nutritional state of mature stands</p> <p>Fertilisation of mature stands</p> <p>Fertilisation in the establishment of new stands</p>	<p>Foliar concentration reference values</p> <p>Fertilisation recommendations</p>	<p>Fertilisation recommendations</p>
Promoting Regeneration, Stand Management and Optimising Production	<p>Cork oak site index assessment</p> <p>Production system typologies definition</p>	<p>Density optimisation models</p> <p>Production optimisation models</p> <p>Management recommendations: density, understory management, promotion of regeneration</p> <p>Methods to bring forward production</p>	<p>Management recommendations: density, understory management, harvesting intensity and periodicity</p>
Stressed production systems	<p>Diagnosis of stress situations</p> <p>Ecophysiological monitoring: Soil-plant-atmosphere indicators – intensive stress assessment</p>	<p>Remote sensing techniques and field validation – mapping stress areas</p> <p>Management recommendations adapted to stress situations</p>	<p>Management recommendations adapted to stress situations, namely climate change</p>

3

NATIONAL DEFENCE PLAN AGAINST PESTS AND DISEASES

Objective → To predict, diagnose and control biotic agents – pests and diseases

The National Plan for the Defence against Pests and Diseases has 6 complementary structuring lines that will enable the proposed objective to be achieved, and which will be made compatible with the initiatives arising from the ICNF's Operational Plan for Forest Health:

Structuring Lines	Actions	ST Results (9 years)	MT Results (3x9 years)
Pests			
Flathead oak borer (<i>Coroebus undatus</i>)	Epidemiological studies Ecology of the species Predictive attack model Biotechnical control methods Resistance-inducing mechanisms	Procedures Manual Control measures	
Oak pinhole borer	Ecology of the species Population dynamics Biotechnical and chemical control methods Resistance-inducing mechanisms	Procedures Manual Control measures	
Cork oak defoliating pests	Predictive attack models Biotechnical control methods Resistance-inducing mechanisms	Procedures Manual Control measures Warning Network	
Diseases			
<i>Diplodia corticola</i>	Infection mechanisms in the host Mechanisms of pathogenicity/virulence Dispersal mechanisms Development of control measures	Procedures Manual Control measures	Production of more tolerant individuals
Phytophthora	Standardisation of disease development stages Study of the molecular mechanisms (genetic and biochemical) of interaction between oomycetes and the host Sanitary control in nurseries Biocontrol measures Selection of more tolerant individuals	Standardisation of disease development stages Molecular mechanisms of interaction between host and pathogen Infection risk map Management recommendations	Production of more tolerant cork oak individuals
Fungi associated with oak pinhole borer	Study of the fungus/host relationship Mechanisms of pathogenicity	Procedures Manual Control measures	Production of more tolerant individuals

4

NATIONAL CORK QUALITY PLAN

Objective → To ensure raw materials in ideal conditions for the industry, from a mechanical and sensory point of view, and streamline methods and procedures for harvesting and post-harvesting

The National Cork Quality Plan includes 4 structuring and complementary lines that will allow the proposed objective to be reached:

Structuring Lines	Actions	ST Results (9 years)	MT Results (3x9 years)
Harvest and post-harvest technologies	Prototype of mechanical cork harvesting – V 2.0 Streamlining of operations Quantitative and sensory parameterisation	Extraction machine Operations manual Metrology regulations	
Characterisation of industrial quality	Variation in cell structure and chemical composition of cork Modelling the main properties of cork Defects in cork with technological impact on the raw material	Fault detection systems	
Characterisation of functional quality	Cork quality throughout the tree's production cycle Prediction of reproduction cork characteristics from the virgin cork		Prediction model for the characteristics of reproduction cork
Adding value to raw materials	Extractive components Chemistry of structural components for biorefinery Behaviour of cork with other materials in composites Valorization of non-suberous components	New products	New products

5

NATIONAL TERRITORIAL ACTION PLAN

Objective → To assess the role of biophysical and location contexts on the productive potential of cork oak forests, the provision of ecosystem services and integrated rural development

The National Territorial Action Plan comprises 3 structuring and complementary lines that will allow the proposed objective to be achieved:

Structuring Lines	Actions	ST Results (9 years)	MT Results (3x9 years)
Biophysical and Location Contexts	<p>Geobotanical, structural and cultural typologies of cork oak forest</p> <p>Climate change scenarios</p>	<p>Cork oak suitability scenarios</p> <p>Management recommendations for mitigation and adaptation to climate change</p>	<p>Management recommendations for mitigation and adaptation to climate change</p>
Provision of Ecosystem services	<p>Scope of services</p> <p>Quantification, valuation, valorisation and mapping</p>	<p>Field protocols</p> <p>Valuation mapping</p> <p>Remuneration models</p>	
The role of the cork oak forest in rural development	<p>Identification of social and economic dimensions and variables and their indicators</p> <p>Characterisation of the cork oak forest typologies based on socio-economic indicators</p> <p>Building and prioritising prospective scenarios</p> <p>Social cost-benefit analysis per scenario</p>	<p>Quantification of the contribution of the cork oak forest to the degree of socio-economic development of the "cork oak forest areas"</p> <p>Estimate of the costs associated with the realisation of the prospective scenarios</p> <p>Recommendations for funding programmes</p>	<p>Funding programmes:</p> <ul style="list-style-type: none"> · Agri-environment · Forest-environment

FINAL REMARKS AND CONCLUSIONS

With the validation of this document in a plenary meeting of the General Council of the Competence Centre for Cork Oak Tree and Cork, the first level of objectives of the CCSC has been reached, and the foundations are defined, in accordance with the protocol of formalisation of the Centre and the commitment assumed by the Portuguese State, to prioritise access to Community funds.

It also opens up a new level that will allow:

- To enhance multidisciplinary teams that promote and implement strategies to meet the challenges of this Agenda;
- To ensure the necessary funds for its operation.

The 3i9 Agenda must obviously not be static, but rather should be dynamic and subject to periodic reassessment at the end of each three-year period in order to redefine its direction and strategy. The groups formed within the scope of the sectorial meetings will be maintained and enhanced, with six-monthly meetings planned to monitor the implementation of the Research and Innovation Agenda for the Cork Oak and Cork – Agenda 3i9.

Coruche, 11 September 2015

ADDENDUM 2021

This addendum constitutes the Agenda 3i9 1st revision, after the first 5 years of implementation. It aims to systematize the main completed projects and their relationship with the priorities established in the Portuguese Research and Innovation Agenda for cork oak and cork.

Support Action	2021 Status
Cork oak forest diagnostic	<p>Cork oak diagnostic inventory has not yet been carried out</p> <p>ICNF promoted a phytosanitary inventory between 2019 and 2021</p> <p>In remote sensing diagnostic systems:</p> <ul style="list-style-type: none">· Several published articles (ISA/UÉvora) on the use of remote sensing tools to monitor the status of the cork oak forests· the GEOSUBER operational group will provide a platform for monitoring dead trees and trees with vitality loss, to be used at the farm level
Network of permanent plots for research and monitoring	<p>CCSC project included the compilation of these plots in a GIS viewer with information about the plots and the responsible researchers and entities.</p>

Map the potential suitability for cork oak	<p>CCSC project developed an APP based on the existing scientific publication (Paulo, J., 2015)</p> <p>Published article in Silva Lusitana “Carta interpretativa do solo do mioceno da charneca do ribatejo” that includes the anhydrous cork weight as an indicator of cork oak potential suitability (Neves, N., 2020)</p> <p>Article published in the European journal of forest research “Quantile regression for modelling the impact of climate in cork growth quantiles in Portugal” (Paulo, J., 2021)</p>
Extension protocols	<p>Protocols between research entities and potential extension agents were not formalized</p> <p>Elaboration of technical datasheets in progress in the Operational Groups dedicated to the cork oak; international projects PRODEHESA, H2020 INCREDIBLE, LIFE Montado ADAPT; the CCSC project produced 8 fact sheets based on scientific publications.</p>

Structuring lines	2021 Status
Nutrition and Fertilisation	GO NUTRISUBER concluded and published the cork oak foliar reference values and the fertilization recommendations
Pests and diseases	<p>GO UNDERCORK in progress, but with probable impact on the diagnostic component and not yet on the control</p> <p>GO PLATISOR, ongoing with preventive and combat solutions</p> <p>PRODEHESA project published management recommendations in cork oak forests and nurseries to prevent and combat Phytophthora</p>
Promoting Regeneration, Stand Management and Optimising Production	<p>GO OAK REGENERATION in progress</p> <p>GO REGACORK in progress</p> <p>Extension factsheet prepared at FILCORK on optimization models for cork production, based on scientific publication</p>
Improvement Population Management and Classical Selection	<p>Published results of the existing cork oak provenance test in Monte Fava (ISA scientific articles)</p> <p>A project dedicated to the improvement of the cork oak in operation 7.8.5 of the PDR2020 has been approved and is currently in progress</p>
Harvest and post-harvest technologies	<p>Cork palletizer development and field tested (Corticeira Amorim) – 2020 and 2021 extractions</p> <p>Cork stripping machine tested in extractions from 2019 to 2021</p> <p>Pneumatic equipment to open and release the cork from the trunk, tested in the 2021 extraction</p>
Biophysical and Location Contexts	Results to be published in Life Montado ADAPT; GO Geosuber e PRODEHESA projects
Provision of Ecosystem services	Published in the ECOPOL project, the quantification and valuation of 3 ecosystem services of the cork oak forest
The role of the cork oak forest in rural development	<p>Several articles published by the University of Évora</p> <p>Report published by the CCSC</p>



**CENTRO DE COMPETÊNCIAS
DO SOBREIRO e DA CORTIÇA**

ccsobreirocortica@gmail.com

