CITAB
Centre for the Research and Technology of Agro-Environmental and Biological Sciences

Newsletter

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Welcome to CITAB

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The scope of CITAB's research is focused on agro-food and forestry systems using the production-chain approach as a whole.

CITAB's newsletter is published 3 times a year and is available in either print or electronic format which can be sent via email or downloaded from our website http://www.citab.utad.pt

This newsletter aims to divulge CITAB's scientific activities.

To receive this newsletter by email, write to **citab@utad.pt**

CITAB comprises a multidisciplinary team with expertise ranging from fundamental sciences such as biology and chemistry to agronomists, forestry engineers and ecologists. CITAB also benefits from input from scientific experts in mathematics, physics and several engineering disciplines. CITAB is clearly an innovative research unit, including other areas of expertise and promoting multi-disciplinary approaches to research projects in order to derive new solutions, maximize resources and bring higher added value to the development and upgrading of agricultural and forestry production chains. CITAB actively collaborates with key Stakeholders in the agro-food and forestry industries and natural resource management.

CITAB was recently reorganized into 3 Research Areas:

Sustainable Agro-food Chains (SAC), **Ecointegrity** (EI) and **Biosystems Engineering** (BE), which are focused on 6 key projects, that are described in greater detail in the contents of this newsletter:

- SAC
  - **Agronomy, climate change & environmental studies**
  - **Added-value plant products & co-products**
- EI
  - **Biodiversity in aquatic ecosystems and biotechnology**
  - **Disturbance of agro-forested ecosystems**
- BE
  - **Wood mechanical and quality evaluation**
  - **Image-based systems**

Since one of the major objectives is CITAB's internationalization, we are now issuing a Newsletter on a regular basis for our research and industry contacts and also for key global institutes. This first issue aims to promote CITAB on an international scale, highlighting the research Unit's scope and actions. We expect to reach a large percentage of the scientific community and attract the interest of our colleagues for future collaboration.

CITAB appreciates your attention and looks forward to future contacts.

In this edition

Biosystems engineering

The Biosystems Engineering (BE) group is composed of 38 investigators with expertise on engineering sciences, namely biomaterials, digital image processing, image-based systems, bioenergy, signal processing, data communications and biotelemetry. The BE group's principal aim is the design and development of engineering technologies applied to agri-forestry systems, environment and life contributing towards sustainable development and better quality of life.

BE's research is focused in two main projects:

Wood mechanics and quality evaluation

This project aims to:

a) develop a materials science approach to wood mechanics, from the micro to macro levels, which is fundamental for promoting wood as a soundly characterized engineering material;

b) improve bioenergetic conversion technology of agricultural and forest materials and wastes.

Detailed tasks are described hereafter.

Mechanical behaviour of wood

(José Xavier, jmcx@utad.com)

New mechanical tests are proposed for characterising the mechanical properties of wood species and spatial variation within the stem at both macro and meso (growth ring) scales. This type of test will allow several mechanical properties to be assessed using a single test configuration by generating complex and heterogeneous strain fields. These kinematic fields can be measured by full-field optical techniques. Suitable identification methods will then be used to determine the material parameter set. The full-field measurements will also allow the evaluation of the spatial variation of wood mechanical properties. This will represent vital data for quantifying wood quality (grading) resulting in more efficient utilisation for end-user needs and applications.

Fracture behaviour of wood

(Nuno Dourado, ndourado@utad.pt)

The growing trend towards forest conservation coupled with the need to keep production costs at competitive levels necessitates the intelligent use of wood in structural applications. Fracture Mechanics failure based criteria are better than conventional strength of materials criteria and non-linear fracture mechanics can be used for more general and accurate analysis of crack initiation and propagation in wood structures (Fig. 1). The overall objectives are: (a) the development of identification methods of wood fracture properties under pure mode I, II and III and (b) the development of appropriate failure criteria for use by wood structural application designers.

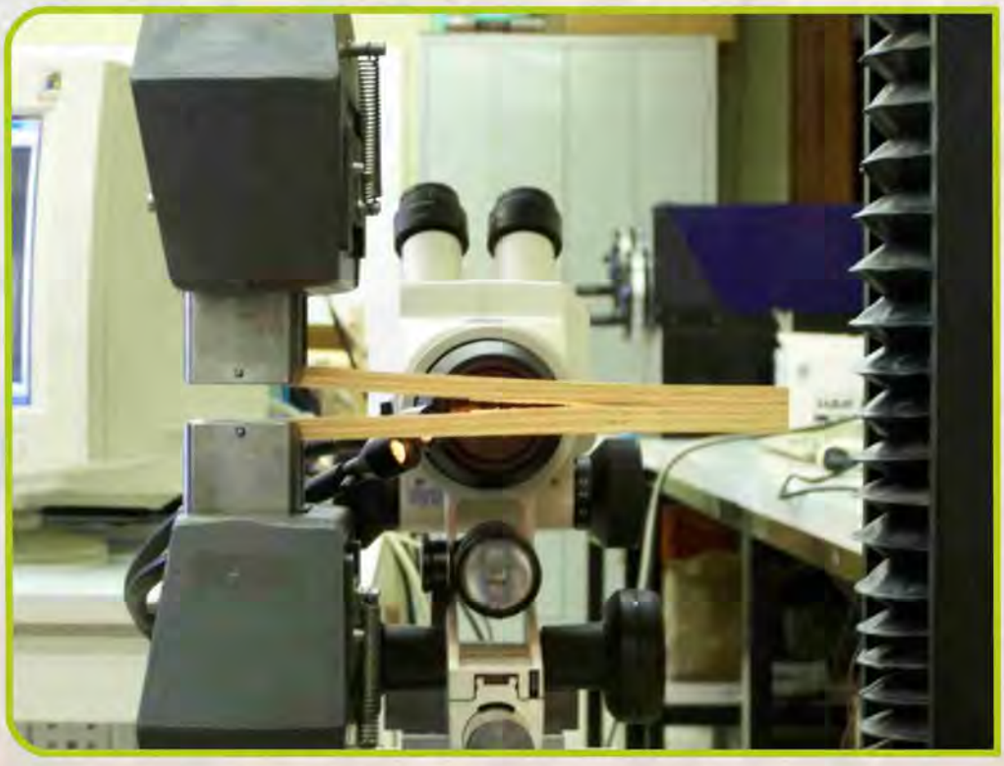

Figure 1 - Double cantilever beam fracture test.

Evaluating wood mechanical properties and quality

Advanced experimental and computational methods have been developed to characterise the mechanical and fracture behaviour of wood, from the micro to macro levels, based on full-field optical methods and digital image processing techniques. An effort has been also devoted to the wood structure-properties relationship, in order to model the variability of wood properties.

Numerical and experimental study of bonded wood joints (José Morais, jmorais@utad.pt)

Adhesive technologies in wooden construction offer several advantages over solid-sawn wood, allowing a more efficient exploitation of forest resources. It also permits engineers to design lighter, more innovative structures that offer better performance. This task will carry out comprehensive numerical and experimental research on the identification of cohesive laws for adhesively-bonded wood joints, under pure modes I and II and mixed mode I/II loading. The key feature of the work will be the use of different techniques and measurements to assess cohesive law. Besides the global mechanical response of specimens (loading–displacement curve), we intend to measure the near crack tip strains with digital image correlation technique and optical fibre Bragg sensors (FBGs).

Study of effects of moisture and physical aging on thermosetting polymers mechanical behaviour

(José Morais, jmorais@utad.pt)

The increased use of polymer adhesives in wooden construction requires experimental data and theoretical models to predict their long-term behaviour. The main objectives of the present task are (a) to develop an experimental methodology to characterize the physical effects of moisture sorption on the mechanical behaviour of thermosetting polymers, (b) to provide a reliable a data base to test theoretical models, and (c) to integrate moisture effects into the constitutive equations. Developed experimental methodology will use different techniques and measurements to assess the molecular mechanisms of moisture/polymer interaction.

Mechanical behaviour of wood bolted joints

(Nuno Dourado, ndourado@utad.pt)

A critical issue in timber engineering is the design of joints, such as bolted joints. The design of bolted joints is based on the empirical model of Johanson, included in the European design code for timber structures (Eurocode 5). In order to improve the overall competitiveness of wood as a structural material it is crucial to develop better design methodologies for bolted joints with well defined mechanical properties. This task will establish a new design methodology for bolted wood joints based on a materials science approach using wood mechanics and modern structural mechanical methods. Virtual testing of joints using advanced finite element modelling (non-linear constitutive modelling and non-linear fracture mechanics will be carried out. Results work will permit the evaluation of the accuracy of the Eurocode 5 leading to the formulation of a new design procedure for the everyday design practice.

Biomechanics: Hip dysplasia (HD) is a multi-genetic pathology, detrimental to the quality of life of affected canines. Functional evaluation can be assessed using kinetic and kinematic analyses, which are promising validated evaluation techniques. The "Serra da Estrela" dog breed is used as research model, since it suffers a high incidence of the pathology. For kinetic analysis, both animals affected and unaffected by HD are selected and moved through a walkway with two synchronized 1m RS scan pressure plates. For kinematic analysis, retro-reflective infra-red markers are placed on the dogs' skin over their main hind joints. Using 6 cameras, the "Optitrack" motion capture system is used to record their 3D position. Results will help to develop complementary and alternative methods for HD screening and to improve individual and population welfare.

Technological applications in vine: Image processing, signal and telemetry systems will be used to evaluate vine conduction system. Evaluation involves several parameters; currently the team is developing new technologies for two of these parameters, namely non-destructive methods to estimate leaf area and a new method for estimating vine strength. The team is also assessing a potential method for evaluating grape quality, in particular grape maturation and wine quality. The team provides support to commercial vineyards by providing computer software applications, technical publications and promoting workshops (an Interactive CD entitled "Support for the Wine-Grower" has been produced), "Web Application for Identification Ampelographic of Varieties", and "Application to support the Wine Tasting".

Biosystems engineering

Bioenergy from agriculture and forest materials

(Nuno Moreira, nam@utad.pt)

Bioenergy is regarded as a key option for mitigating greenhouse gas emissions and substituting fossil fuels. Bioenergy is an atypical energy source due to its diversity and inter-linkages with many other technological and policy areas. Bio-resource such as agricultural and forest materials have high potential for energy. Physical, thermochemistry and biological conversion processes of bio-resources allow their transformation into solid, liquid or gas to produce heat or electricity. This task will define conversion technologies that offer the maximum yield ratio of forest and agriculture material. Specific objectives are: (1) to specify available agricultural materials; (2) to specify available forestry materials; (3) to identify the best conversion technologies based upon forestry and agricultural material characteristics.

Waste materials methanisation

(Nuno Moreira, nam@utad.pt)

Biomethane, a renewable natural gas produced via waste recovery, meets many of the specifications for natural gas. It can be transported by existing infrastructures, replacing all natural gas applications. Biomethane has immense potential in reducing energy dependence, greenhouse gas emissions and as an alternative fuel for vehicles. There is no market for biomethane in Portugal or any legislation regulating its introduction into the same network as natural gas or its price. This task deals with the entire methanisation process (digestion, gasification, cleaning and purification systems) and establish the principles for the development of a biomethane market in Portugal.

Image-based systems

This project aims to:

a) design and develop computer vision and image processing based systems as a potential technique for the guidance or control of agricultural and food processes with manifold applications;

b) design and develop visual inspection systems for evaluation and measurement in agro-forestry, environment and biology applications.

Improved methodologies for image based classification using computational intelligence techniques

(Pedro Melo Pinto, pmelo@utad.pt)

Computational intelligence is a very active area of research that has been successfully applied in many different areas. It has been used in agro-forestry for studying soil and water problems related to crop growth management, design, analysis and control of food processing, and decision support in precision farming. However, there are still many unresolved problems in these areas, namely in classification, resulting from the complexity of the problems themselves and the huge amount of data usually involved.

This task will incorporate and develop the use of computational intelligence in computer vision and existing image processing classification methodologies, for agricultural, forestry,

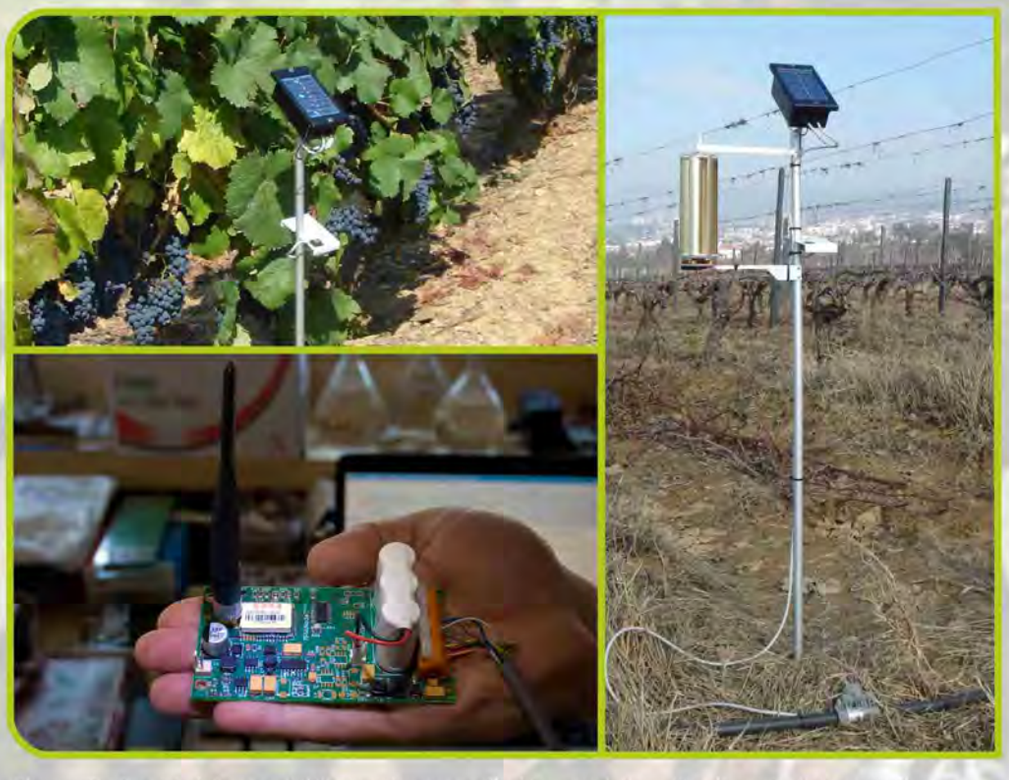

Figure 2 - Smart data acquisition systems applied to precision viticulture to improve disease prediction models. Energy to suffice power needs is harvested from environment.

Smart acquisition systems within precision viticulture practices: Helping plant physiologists and viticulturalists

(Raul Morais, rmorais@utad.pt)

Wireless sensor networks deployed in vineyards, powered from energy harvested from environment, such as sun, wind and water flow from irrigation pipes (Fig. 2), are currently being used to acquire climate data to improve disease prediction models and other comprehensive studies that includes remote sensing of the environment and physiological parameters monitoring, like humidity, temperature and luminosity, that determine the fungi diseases development inside the canopy of grapevines. It is possible in this way to have a better knowledge about the real time situation according to the phenology of the vineyards.

environmental and biological systems. This will develop approaches that take advantage of the flexibility provided by soft computing to deal with the complex problems posed by image based systems.

Development of image based methods applied to bio-materials micro-structure characterization leading to a shape descriptor (through image based parameterization) of wood micro-structure

(Pedro Melo Pinto, pmelo@utad.pt)

Cell shape descriptors obtained through image-based methodologies are a recent development in micro-structure characterization. With the help of classification pre-processing algorithms, the estimation of the cell shape description (as well of the estimation of the general micro-structure morphological characteristics) will provide valuable information allowing significant progress in wood mechanical characterization studies.

Application of local hyperspectral imaging techniques to grape quality analysis

(Armando Soares, asoares@utad.pt)

Hyperspectral reflectance measurements of individual grapes are used for grape chemical analysis. Measurements are carried out with the camera placed a few centimeters from the grapes (Fig. 3). The main objective of this task is non-destructive measurement of pH, sugar content and anthocyanin content for precision maturation control. The models that transform spectral measurements into chemical parameter values are based on neural networks. These advanced machine learning algorithms model non-linear data and are highly resilient to input data variability, such at those found on natural products. The non-linearity of the model is relevant because the correspondence between spectral and chemical parameters is non-linear when data include grapes from different years and regions. Hyperspectral imaging will significantly reduce analysis time compared to conventional laboratory analysis.

Application of local hyperspectral imaging techniques to wood quality evaluation

(Armando Soares, asoares@utad.pt)

Hyperspectral imaging techniques will be applied to the measurement of wood properties such as density and moisture content. Mathematical models will be developed using machine learning approaches to transform the spectra measured into the wood parameter values.

This work is innovative due to the use of hyperspectral cameras that are able to capture light with wavelengths between the 400 and 1000 nm. The measurement of wood properties with high spatial resolution, will allow separating measurements in early and late wood. It is also an innovation the hyperspectral imaging of wood from a Mediterranean species of pine tree, *Pinus Pinaster*.

Hyperspectral imaging is a relatively recent technique. It is growing in importance in applications such as atmospheric and environmental monitoring, mineralogy, food quality control, precision agriculture, and forest products analysis. Hyperspectral imaging allows measuring the percentage of incident light that is reflected by a certain material for thousands of different light wavelengths. With this information it is possible to build a reflectance spectrum. Its shape depends on the material chemical and physical composition and varies between materials. The analysis of the reflectance spectra with learning methodologies such as neural networks allows the non-destructive identification, discrimination and characterization of materials. Our attention has been focused on grape quality analysis and wood characterization where non-destructive material analysis is advantageous when compared to conventional techniques.

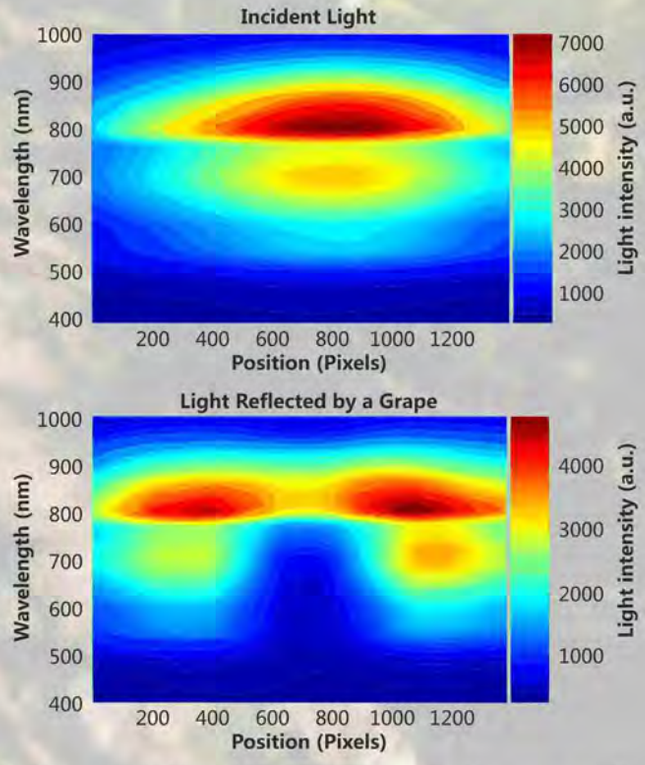

Figure 3 - Hyperspectral imaging techniques applied to grape quality analysis

Development of computed assisted imaging techniques, based on kinematic and kinetic data capture on biological models

(Ronaldo Gabriel, rgabriel@utad.pt)

Hip dysplasia (HD) is a disease that may affect dogs' quality of life. The Estrela Mountain Dog is used as research model, due to the high incidence of the pathology in the breed. For kinematic analysis, retro-reflective infra-red markers are placed on the dogs' skin over their backquarters joints.

Through biomechanical and environmental analysis of pedestrian trails, we intend to develop a predictive equation of the risk of foot and ankle sprains during the walk, based on the assessment of related parameters, the sample and the environment. This model will help to assess the level of difficulty of the pedestrian trails and constitutes an important aid in defining the intensity, duration, frequency and progression of this kind of activity, according to clinical conditions of pedestrian trail users and environmental conditions.

Application of digital image correlation techniques to wood quality evaluation

(Armando Soares, asoares@utad.pt)

This task will study the most advanced DIC techniques and, based on state-of-the-art knowledge, will attempt to make improvements to DIC. The task will focus is on the development of methods with subpixel precision that do not require the creation of artificial random speckle patterns to work, i.e., the new methods must be capable of analyzing unprocessed wood surface patterns. Methods to be developed must be resilient to changes in sample illumination and must be computationally simple in order to allow rapid calculations. A novel approach will be explored for DIC, namely the possibility of using machine learning techniques to create new DIC algorithms

Application of optimization methodologies to image based surface inspection in agro-forestry systems (Norberto Gonçalves, njg@utad.pt)

In heterogeneous surfaces such as agro-forestry systems, image processing is one of the best methods for extracting quality features through patterns. Despite considerable progress in this area, image processing tools and techniques have intrinsically complex and it is necessary to employ the right parameters in a specific situation. We aim to apply known and modified Evolutionary Algorithms to optimise systems parameters and increase their efficiency and the automatic adjustment to specific agro-forestry systems.

Development of device-independent image visualization techniques and data transmission issues (Carlos Serôdio, cserodio@utad.pt)

Modern wireless data communications technologies have high data rates and reliability. However due to factors such as the mobility of the nodes, the number of wireless nodes, distance between the base and the station, interferences, coverage area, link price, etc, the available bandwidth is affected.
Image adaptation is necessary in order to the reliable transmission of digital images over a transmission channel with low bandwidth (when compared with the amount of information to be sent). This adaptation must be done considering the final application.

Figure 4 - Ecological Monitoring in mountain systems affected by the installation of wind farms. The resulting datasets are the base of the StDM models construction.

Simulating the Ecological Status of Changed Ecosystems

A new Stochastic Dynamic Methodology (StDM) has been developed as a mechanistic understanding of the holistic ecological processes, by using appropriate statistical and dynamic modeling techniques. The StDM was successfully tested in several types of ecosystems, such as in changing traditional agricultural scenarios, in mountain systems affected by anthropogenic perturbations and in some of the environments commonly encountered in water-quality modelling: streams/watersheds, estuaries and reservoirs.

The Eco-integrity (EI) group is composed of 37 investigators with expertise covering areas in environmental sciences, particularly ecology, forestry, agronomy and biology.

The main aim of the EI group is to monitor, protect and restore natural resources, at various scales of observation, in aquatic and terrestrial ecosystems.

EI Group research is focused in two projects:

Biodiversity in aquatic ecosystems and biotechnology

This projects aims to:

a) create appropriate tools for capturing and predicting the dynamics, structure and function of terrestrial and aquatic ecosystems affected by human disturbance;

b) develop and promote typologically appropriate management plans, based on the ecological assessment of different components of the natural community.

Detailed tasks are described hereafter:

Studies on climate variability and extreme events on the dynamics of running waters and regulated rivers

(Rui Cortes, rcortes@utad.pt)

The effect of climate change on streams and rivers is far reaching but still quite poorly studied, especially on the Iberian Peninsula. The flow regime of Iberian streams is heavily influenced by changing phases of the North Atlantic Oscillation (NAO). Climate change will affect the structure, function, monitoring of lotic systems and associated ecotones such as riparian galleries (Fig. 5). All of these factors will result in fundamental changes in the provision of ecosystem services (provisioning, regulating supporting, cultural) and the sustainable monitoring and management of aquatic resources, the responsibility of key stakeholders that consult CITAB. We will continue to add to our large scale spatio-temporal data sets covering the northwest and centre of Portugal, combining biological indicators of catchment condition, landscape change and climate change from over the last few decades. We will assess interaction with anthropogenic effects at different spatial scales. Biological indicators will comprise not only elements of the aquatic community but indicators of the wider riverine environment (e.g. riparian galleries). We will use techniques such as remote sensing and GIS coupled with multivariate analysis and the application of neural systems.

Northern Portugal reservoirs provoke profound changes in aquatic ecosystem structure, function and connectivity as well as methane emissions. We will work in collaboration with stakeholders and use long term data bases available to characterize regulated rivers, detect and quantify the myriad of changes they provoke and propose mitigation measures.

Effect of water contamination in fish populations

(António Fontaínhas Fernandes, fontain@utad.pt)

Biomarker techniques allow quick and predictable associations to be established between obtained results and particular stressor agents, providing valuable information on the effect of different sources of water contamination. The results of biomarker

Wild Ecosystems

Habitat changes, especially concerning riparian vegetation produce important impacts on freshwater communities and on the ecological functioning of the aquatic ecosystem, from nutrient input to the entire food chain. Defining appropriate indices to characterize river habitats and hydromorphological changes and their interaction to the aquatic biota is an important research area in this group.

Figure 5 - The Sabor River - The last wild river in the Europe.

techniques can be used in the integrated assessment of aquatic ecosystems, complementing information provided by bioindicators.

The objective of this task is to evaluate and validate multiple biochemical markers of exposure (biotransformation enzymes and oxidative stress) in the dominant fish populations from the river sites under study and evaluate the impact of water contamination these species health using responses from the subcellular level (genotoxicity), tissue to organ level (histopathological).

This task will be carried out considering the degree and type of contamination/pollution at selected sampling points among those chosen for aquatic bioindicators. This study may be supplemented with some laboratory exposure experiments for specific contaminants/pollutants in model fish species.

EU directive compliant River rehabilitation

(Rui Cortes, rcortes@utad.pt)

Natural river ecosystems are highly complex. However, most river systems are highly altered as a result of anthropogenic activity, reducing ecosystem services, biodiversity, natural resilience and resistance as well as provoking alterations in structure and function. The connectivity (longitudinal, lateral vertical) of many river systems has been highly compromised by hard engineering (flood defence, dams) affecting catchment processes.

River restoration initiatives aim to bring back lost ecosystems services (provisioning, regulating supporting, cultural), recover biological and chemical processes and restore connectivity, functionality, diversity and resilience.

Temporally, restoration initiatives must embrace past, present, and future scenarios (including the effect of climate change). Spatially, they must take into account longitudinal, lateral, and vertical connectivity and the hierarchical organization of these systems, from the basin down to microhabitat. We will use new hydrodynamic models and bioengineering techniques to promote the restoration of aquatic habitats and riparian vegetation, to stabilize river banks and to improve biodiversity (mainly fish populations) across river typologies (Fig. 6).

Dynamic and spatially dynamic modelling to predict ecological indicators

(João Cabral, jcabral@utad.pt)

Climate change, human activity and shifts in socioeconomic activity lead to changes in land use in catchments and in patterns and types of point source and diffuse runoff.

Stochastic Dynamic Methodology (StDM), a sequential modelling process, developed to predict the ecological status of changed ecosystems will be applied to both terrestrial and aquatic ecosystems to explain past and present states, and to predict future ecosystem state. StDM has already been successfully tested in several types of ecosystems (Fig. 4), such as in changing traditional agricultural scenarios, terrestrial ecosystems and in some of the environments commonly encountered in water-quality modelling (streams/watersheds, estuaries and reservoirs). The ultimate goal is to produce simulation models that permit the

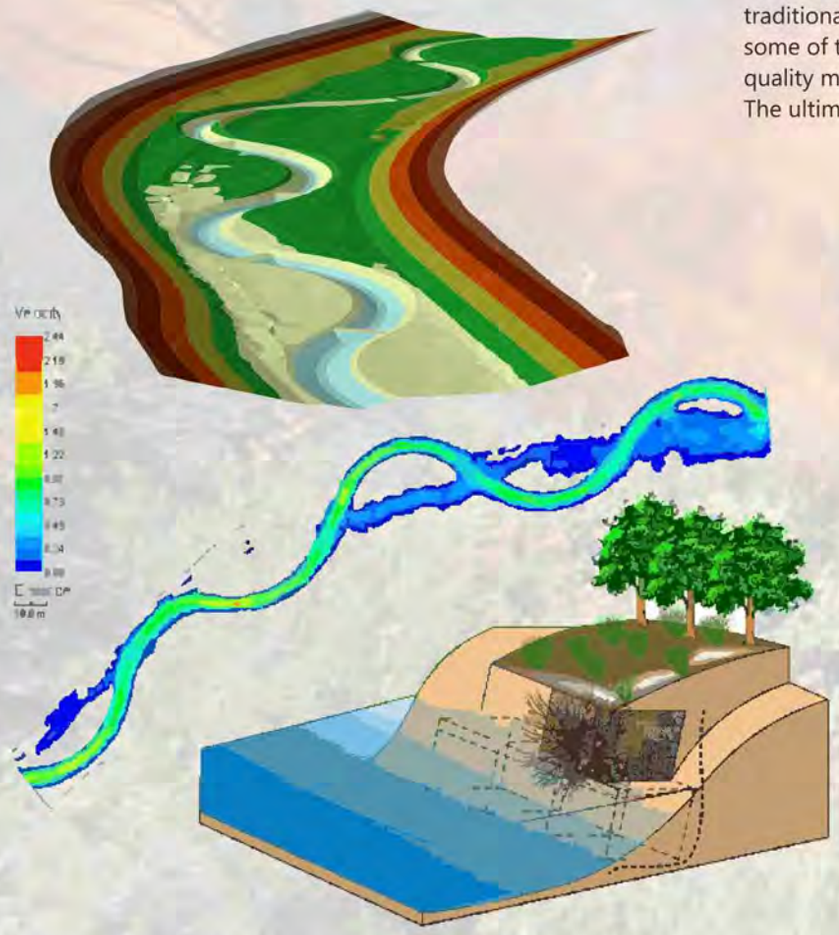

Figure 6 - The images show a simulation of the flow after defining the introduction of submerged weirs and meandering, and also illustrates one of the structures (vegetated gabion) to stabilize the banks.

Integrated rehabilitation of a Mediterranean River

The improvement of endangered fish species in Odelouca R. (Algarve) was one of the targets considered by local authorities after the construction of a dam for water supply. To preserve the biodiversity it was necessary to define the ecological flows using hydraulic models and to take into account their spawning requirements and the habitat for adults.

In order to decrease the visual impact and to increase the physical heterogeneity it were combined different soil engineering techniques according to the instability along the segment. Besides, the visual mitigation of the artificial structures was achieved by using live stakes of native vegetation or joint planting in the rock rip raps and gabions.

creation of landscape patterns from ecosystem changes, whose patterns are the basis of spatially explicit ecological models. This approach will develop more global techniques in this research area by creating rapid interfaces with Geographic Information Systems, which are more easily understood by decision-makers, environmental managers and stakeholders such as ARH-N for defining management models of aquatic resources and ecosystems (both natural and artificial). StDM will be complemented by agent-based modelling approaches (ABM), for predicting the response of ecological indicators to anthropogenic changes, aiding investigation associated with functional biodiversity and in conservation ecology.

Application of microorganisms in biotechnology and in nutrient cycling

(Rui Bezerra, bezerra@utad.pt)

Microorganisms are widely distributed across almost all ecosystem types and are high adaptable to unfavourable abiotic conditions. This ability may be used to break down xenobiotic and more recalcitrant compounds, which can be found in ecosystems as result of human use and disturbances. Several studies have aimed to find autochthonous bacteria, yeasts and fungi from polluted sources for use in bioremediation processes. Agro-industry generates several sub-products, such as residual waters with high polluting potential from olive oil processing industries and wine production. The group is currently selecting microorganisms to use in bioremediation processes, namely the treatment of agro-industrial residual waters.

Disturbance of forest and agro-forested ecosystems

This project aims to:

a) characterize the spatial and temporal patterns and regimes of disturbance and;

b) develop management-oriented guidelines towards mitigation and adaptation to disturbance.

Detailed tasks are described hereafter.

The role of vegetation (fuel) in the Portuguese fire regime (Paulo Fernandes, pfern@utad.pt)

Wildland fire regimes are determined by a complex interplay between ignitions, weather/climate, topography and vegetation (fuel). The relative role and influence of these factors is poorly understood in many ecosystems, including the Mediterranean Basin, and is the subject on ongoing debate. Fuel treatments (Fig. 7) are often proposed to control the extent and severity of wildfires, but quantification of their effectiveness remains elusive. We will analyze the Portuguese fire regime, using the Forest Service atlas of fire perimeters (1975-2008) and GIS tools, in order to describe and quantify if and to what extent fuel age (i.e. time since last fire, a surrogate for fuel characteristics) controls the fire regime. Our analysis will be focused on fire frequency, burn probability and surface burned, and will integrate the influences of weather conditions and human pressure. Regional variability will be considered in terms of ecoregions.

Promoting fire-resilient forest stands and landscapes: Research on wildland fires at CITAB addresses three major questions: how vegetation burns, how vegetation responds to fire, and how to decrease vulnerability to fire and increase ecosystem resilience to fire. The effects of weather and vegetation on the fire regime are examined at larger spatial and temporal scales. The effects of fire on different forest types are assessed and compared, and the structure of fire-resilient forests is described. The results obtained provide the much needed qualitative and quantitative guidance to forest management decisions, from species selection for afforestation to fuel treatments (e.g. through prescribed burning).

Figure 7 - Prescribed underburning in a *Pinus pinaster* stand to decrease fuel accumulation and fire hazard.

Trends, temporal, spatial and spatio-temporal clustering of fires in Portugal

(Mário Pereira, gpereira@utad.pt)

Fires are important disturbance factors in natural ecosystems and agro-forestry systems (forests, woodlands, shrublands). Natural and/or human caused fires can be considered as mere agents of disturbance, interrupting the long term succession or as a contributing factor to ecosystem degradation. Many factors contribute to temporal and spatial variability of fire occurrence and development. We analyze temporal (trends and spatial correlation of variables relating forest fire events in the Portuguese Forest Service fire database (1980-2009) using geostatistical methods and look for spatial, temporal and/or spatio-temporal clustering of point-database for past fire events and to foresee the continuity of current and the development of new clusters in the future.

The role of the pine processionay moth on the biomass increment of pine trees

(Paula Seixas Arnaldo, parnaldo@utad.pt)

Dendrometric measurements will be made on trees with different degrees of insect infestation. Previous analysis will comprise counting the number of insect eggs on the crown of pine trees, the number of larval nests (nests will be measured and exposition registered) and the degree of defoliation. Finally, biomass models will be applied to compare trees biomass increase after processionary moth attack.

The conservation of the blue alcon butterfly in the Alvão Natural Park

(Paula Seixas Arnaldo, parnaldo@utad.pt)

In Portugal, *Maculinea alcon* is the only representative of its genus and a rare resident butterfly. It is classified as a vulnerable species needing urgent conservation measures. The insect inhabits hay meadows, wet heaths and fens and has a univoltine life cycle. After eclosion *Maculinea alcon* larva feed for three or four weeks on G. pneumonanthe. In the fourth instar, larvae leave the host plant and wait on soil to be adopted by Myrmica ants. The larvae secrete allomones mimicking the ant larvae and thus are taken into the ant nests where they are feed by the ant workers and eat ant larvae.

The availability of host plant and host-ant species determines the quality of potential habitats. Thus, the first goal of this task is to assess the status of *Maculinea alcon* in the Park by (1) estimating densities of the larval host plant *G. pneumonanthe*, (2) searching for the host ant species and (3) estimating population sizes of *Maculinea alcon* based upon egg numbers and mark-recapture of butterfly adults.

Figure 8 - Pollen from Lada variety catkins is used to pollinate Judia female flowers, in order to improve agronomical characteristics of the main Portuguese variety.

The RefCast Project

Portugal is one of the world main chestnut producers and Trás-os-Montes the most important Portuguese region representing almost 85% of total nut production. CITAB research team is involved in the characterization and improvement of the main native varieties, concerning fruit and local edaphoclimatic adaptation. Leaf, flower and fruit morpho-anatomy, controlled pollinations, nut chemical composition and gas exchanges are team expertises.

Group is also involved in the coordination of a consortium composed by 25 partners with the aim to prepare a national plan, called RefCast, to reinforce chestnut culture.

Sustainable agro-food chains

The Sustainable Agro-food Chains (SAC) group is a multidisciplinary team, with 69 investigators with expertise range from fundamental sciences such as biology and chemistry to agronomy, forestry engineering and ecology.

The main goal of SAC is the development of effective and pragmatic strategies to optimize sustainable food production

SAC research is organized into two projects.

Agronomy, climate change & environmental studies (ACES)

This projects aims to:

a) develop suitable adaptation and mitigation measures in the agricultural sector in relation to environmental and climate changes, based on plant studies and numerical atmospheric modelling.

b) evaluate and reduce environmental impacts resulting from cultural production and other human activities related to farmland.

Related tasks are described hereafter.

Climate variability mechanisms

(Solange Leite, solange@utad.pt; João Santos, jsantos@utad.pt)

The non-linearity and multiplicity of the interactions among the different components of the Climate System make the study of climate variability extremely complex. The isolation of underlying mechanisms is fundamental in environmental research. The study of these mechanisms frequently implies an analysis on a global scale, or at least over a large geographical area and across several vertical levels. Factors include studies on precipitation and temperature variability, their corresponding extremes and also their relationship with large-scale atmospheric patterns. Our targets are: i) to assess temperature and precipitation variability in Europe and their respective large-scale forcing; ii) analyse climate extremes and investigate their onset, development and decay (e.g. flood, drought, heat waves); iii) study of rainfall variability in Portugal and its connection to the atmospheric circulation, specifically aimed at mitigating the vulnerability of the country to water availability.

Atmospheric modelling and environmental impacts

(Solange Leite, solange@utad.pt; João Santos, jsantos@utad.pt)

Atmospheric modelling is a key tool for assessing environmental impacts due to climate variability and likely future changes (Fig. 11). Physical, mathematical, statistical and empirical models can be developed in order to relate a set of climate variables with an almost unlimited number of environmental, social and economical variables. This research area will be conducted by multidisciplinary teams to integrate the different scientific expertises relevant to the different model parameters. A successful model yields obvious applications with great practical usefulness and enables the assessment of future scenarios. Particular attention will be devoted to the modulation of the productivity of several agro-forestry species with relevance to the portuguese economy, especially in the area of Trás-os-Montes e Alto Douro e.g. vineyards, olive trees, cork-trees, chestnut trees and pine trees.

Climate change impacts in plant physiology

Leaf gas exchange is nowadays an important tool to evaluate the physiological behaviour of plants in a context of climate change. This non-invasive and expedite methodology has been fundamental for physiological tasks of this team, such as in the following projects: Effects of elevated CO_2 and interacting environmental variables on grapevines grown under Mediterranean field conditions; Cover cropping: the decisive strategy for the sustainable management of the rain-fed olive orchards; Short-term climate change mitigation strategies for Mediterranean vineyards.

Figure 9 - Measurement of CO_2 assimilation by plants in the field.

Sustainable agro-food chains

Biodiversity: selection, characterization and conservation of plant resources

(Ana Paula Silva, asilva@utad.pt; José Gomes Laranjo, jlaranjo@utad.pt)

The recovery and valorisation of locally endangered germplasm, in traditional productive areas of the Mediterranean basin, to create a core collection of crop species is essential. In order to share and spread information on these genetic resources, the final aim is to set up a web based inventory linked with the major thematic international databases. The data will also be used to promote a wider application of traditional knowledge and agricultural practices and raise stakeholder awareness on the values of conserving biodiversity from the biological, economic and socio-cultural perspectives e.g. improving sustainable nut production in Portugal and assessment of the variability in chestnuts and other nut landraces for their industrial uses (Fig. 8).

Increasing functional biodiversity in olive groves and vineyards

(Laura Torres, ltorres@utad.pt)

Olive groves and vineyards are agro-ecosystems with high ecological potential and are very promising candidates for improving associations between agriculture and environment. The aim of this task is to evaluate the possibilities for practical improvements to protect against natural enemies in olive and vineyard agro-ecosystems via conservation biological control methods. The focus of these habitat manipulations involves the evaluation of native plant species for provision of essential food sources (e.g. nectar, pollen, honeydew, alternate host/prey), to natural enemies, thus enhancing their survival, fecundity, longevity and behaviour thereby increasing their effectiveness (Fig. 12). Native Portuguese plants will be used, benefitting wildlife conservation, biodiversity and landscape values. If subsets of native plants prove effective at enhancing natural enemies, farmers may have an economic reason for preserving and restoring remnant habitats or for re-creating similar communities on their farms.

Environmental impact effects on plant composition

(Berta Gonçalves, bertag@utad.pt; Jorge Ventura, jventura@utad.pt)

This task is focused on plant ecophysiology, namely the effect of different abiotic stresses such as water, light and elevated CO_2 levels on economically-important crops e.g. cherry, chestnut, hazelnut, olive, grapes and medicinal and aromatic plants. Light modulation exerts an effects at leaf (morphological, anatomical, chemical and physiological characteristics) and whole-plant levels (shoot architecture and biomass allocation patterns). High light levels lead to increased foliar accumulation of non-structural carbohydrates whereas light limitation leads to more carbon being diverted to plant defense e.g. secondary metabolites such as phenolics. Total phenols in plants can also be increased under low water conditions with associated oxidative stress. Therefore,

Figure 10 - Portuguese and International fruits, vegetables, herbs, teas, and medicinal plants: composition, health effects and co-products.

Secondary metabolites: Health effects and"Greening" sustainable agriculture, involves two parallel research themes:
a) measuring phytochemicals and key bioactivities (antimicrobial, antioxidant and anticancer) during cultivation and post-harvest (fresh and processed) of plant foods to improve food production and processing i.e. optimal health effects. This includes new research on mushroom metabolites and multi-purpose crop species e.g. Moringa oleifera;
b) the "Green" research involves collaborations with agro-food companies to develop pragmatic methods for processing their residues into added-value co-products e.g. biopesticides and nutraceuticals.

moderate water and light stress can stimulate the biosynthesis of secondary metabolites. From a horticultural point of view, good management and adoption of suitable practices relating to light and water could result in more efficient fruit production with high levels of antioxidants that enhance the quality of these products.

Trace gas emissions from agricultural systems under climate change scenarios

(Henrique Trindade, htrindad@utad.pt)

This task is focused on the evaluation of greenhouse gases emitted from crops under ambient and elevated temperature and CO_2 concentrations, providing data on CH_4, N_2O, NOx and NH_3 emissions from rice paddies in Mediterranean conditions and establishing associations between gas emissions and cropping practices, soil type, climatic parameters, and N cycle key-processes, like nitrification.

Design and improvement of cropping practices and mitigation measures

(Carlos Correia, ccorreia@utad.pt; José M. Pereira, moutinho@utad.pt)

This task aims to increase yield, quality and sustainability of selected crops (namely cherry, chestnut, grapevine, olive and medicinal and aromatic plants) in Mediterranean environment by improving adequate plant responses to environmental factors (water, light, heat, salinity, heavy metals stresses and viral and fungal diseases). We also intend to study new adaptation/mitigation cultural strategies in the context of climate change scenarios. These experiments use methodologies that investigate simultaneously plant physiology behaviour, yield and quality components (Fig. 9). The knowledge obtained in these studies will be of great use to farmers in the near future and for national and regional crops production sector.

Mitigation of animal manure and agro-food wastes impacts

(Henrique Trindade, htrindad@utad.pt; Rosário Anjos, ranjos@utad.pt)

A multidisciplinary and integrated (Life Cycling Assessment) approach will be used to improve and test land application methods and the effect on gaseous emissions of new manure treatment products and bio-fertilizers. We will assess the crop nutrient and soil quality value of new manure treatment products and bio-fertilizers. Studies will include the environmental consequences associated with the addition of phytochemical-rich plant materials to soils and subsequent effects of "green manures" on controlling soil non-pathogenic microorganism populations associated with fundamental plant and soil processes related to the C and N cycles, and also bacterial and fungal pathogens and nematodes responsible for plant diseases (Fig. 15).

The University of Minho SAC sub-group

The main goals of the UM-SAC sub-group are to identify and determine the role of bioactive plant metabolites, namely phenolic lipidic and terpenic compounds, in particular those related with environmental stresse, and study their biosynthesis and production in plants and in in vitro systems. Some studies are carried out in the sense to understand the molecular mechanisms underlying the metabolites production, their transport and accumulation at the sub-cellular, cellular, tissue, and organ levels. As products, the metabolites are studied in the sense of increase their added-value, either as extracts (phenolics, lipids, essential oils), fractions or isolated compounds, by determining their bioactivities and thereby their potential health benefits for humans, envisaging their uses as nutraceuticals and/or medicines, or their potential environmental benefits envisaging their uses as biological control agents (BCAs). The studies are also extended to co-products from agro-food wastes and thereby, some contribution is given to increase their add-value in parallel with the environmental bioremediation.

Climate and crop production

The role played by Climatology on many applied fields has been increasing in the last decades, mainly due to the new challenges imposed by both natural and human-driven climate change on the different environmental and socio-economic systems. In particular, multi-disciplinary approaches are required to properly assess climate change impacts on crop production, such as on grapevine yield.

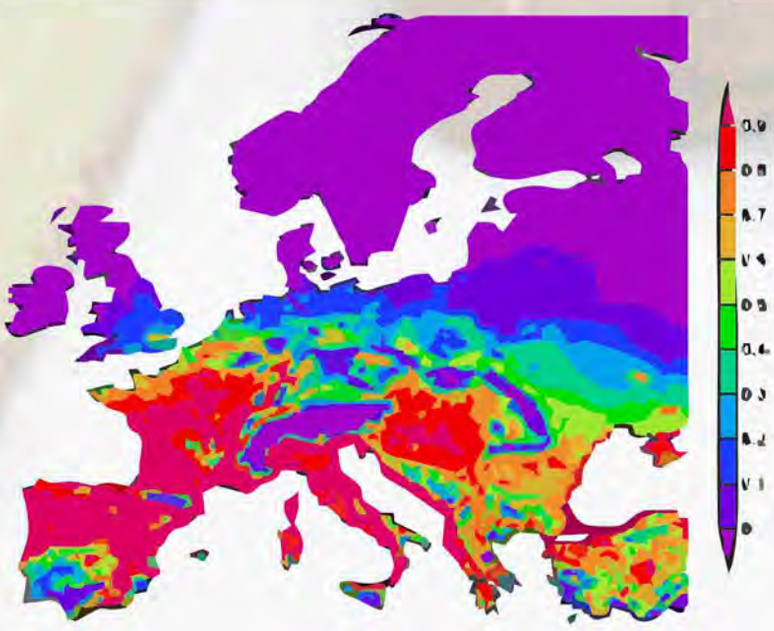

Figure 11 -Grapevine bioclimatic index for Europe and for the A1B-IPCC scenario (2010-2039) based on the COSMO-CLM atmospheric model.

Sustainable agro-food chains

Added-value plant products & co-products (APPC)

This project aims to:

a) find pragmatic, effective and sustainable solutions for "greening the food chain";

b) optimize human and animal health with emphasis on Mediterranean crops, Medicinal and Aromatic Plants (MAP) and other economically-important plants;

c) develop strategies for using agro-food/forestry wastes and application of plant cell cultures to generate added-value products and co-products.

Related tasks are described hereafter.

Composition and health effects studies of Portuguese and international foods

(Richard Bennett, rnbennett@utad.pt; Amélia Silva, amsilva@utad.pt)

This will continue to be an important research area, involving stakeholders and researchers from ACES and APPC areas, pooling expertise and facilities in different types of analyses (phytochemicals, vitamins, nutrients, and human cell models). Fundamental composition data is important for use as markers of stress, quality and eventually the potential health effects of the foods being investigated. This task links to key research within ACES and APPC and there are also collaborative projects with the Animal Nutrition group of UTAD (Fig. 10).

Added value co-products derived from Portuguese agro-food wastes

(Richard Bennett, rnbennett@utad.pt)

This rapidly developing research area is an important and major focus for APPC and involve researchers from ACES and other research centers/researchers in UTAD and agro-food and forestry stakeholders. This task is divided into the following sub-areas:

Phytochemical biopesticides and "Green Manures"

This is an active and developing area of research. We aim to identify effective natural products (phytochemicals and secondary metabolites from non-plant organisms) that can be used in the food chain to control economically important pathogens, food pests and also diseases of animals and humans e.g. pesticide resistant bacterial and fungal pathogens of crops and antibiotic resistant bacteria in animals and humans.

Functional food compounds from agro-food wastes

Agro-food wastes have great potential as sources of functional food ingredients including phytochemicals, dietary fibre and important nutrients (e.g. vitamins) and minerals.

Pragmatic and effective processing of agro-food wastes

An important issue in food production is the generation and subsequent disposal of wastes (solid and liquid). There is great potential to develop low-cost processing and extraction methods for many of these materials, generating added-value co-products and simultaneously reducing/eliminating negative environmental and health impacts.

Figure 12 - Natural vegetation provide essential nutrients to pest´s natural enemies, thus enhancing biological control in agro-ecosystems.

Enhancing functional biodiversity in olive groves and vineyards

This research, focusing in two emblematic crops from Mediterranean region, intends to contribute to the promotion of an habitat management strategy. This involves the establishment of communities of native flowering plants which will broaden the potential benefits of the ecosystems, either as promoting biological control of pests, function as a storage of carbon, and giving an added value to landscape through the visual and aesthetical improvement. Achieving an increase in the farm functional biodiversity it is expected an added economical benefit for the farmers which are more likely to adopt the proposed strategies.

Bioproducts & Biotechnology

(Manuel Ferreira, manuel.fernandes.ferreira@gmail.com)

This task is divided into the following sub-areas:

MAP-Tech & MAP-Products

The core of this research focuses on three axes: phytochemistry, bioactivities and biotechnology of medicinal and aromatic plants (MAP) e.g. the study of essential oils and phenolic compounds of plant species from the *Lamiaceae* and *Guttiferae* families.

Plant functional metabolites and plant genetic engineering

We aim to identify and determine the role of bioactive metabolites in plants related with biotic stress and to study their biosynthesis and production. The potential human health benefits of plant secondary metabolites, produced in response to plant-pathogen interactions and abiotic stresses, with antioxidant, neuroprotective, anticancer and antidiabetic activities. Also, we intend to genetically manipulate plants to produce pharmaceutically useful compounds.

Plant cultures physiology and biochemistry

The aim of this sub-task is to study and characterize in vitro plant cultures of economically-important species at the developmental, physiological and biochemical levels. Changes associated with dynamic processes, such as growth and differentiation, and responses to stress conditions for the development of in vitro-based bioplatforms to evaluate biological effects of extracts and specific compounds on plant development and physiology.

Figure 14 - **Beneficial microorganisms**

Experiments were undertaken to select mycorrhizal fungi and bacterial antagonists of soil-borne plant pathogens to be used as biofertilizants and biological control agents aiming to reduce the agronomic dependence on chemicals and energy inputs. These studies are undergone, in vitro and in vivo, mainly in Pseudomonas, Bacillus and actinobacteria strains isolated from various sources, based on disease suppressive mechanisms exhibited, as well on their persistence in the root environment and effects on plant growth.

Evaluation and reduction of environmental impacts from agriculture

This research focuses on:

a) developing strategies for minimizing negative environmental impacts from animal and crop production, namely from organic and mineral amendments used in agriculture, and;

b) emission of gaseous compounds with greenhouse effect (GHG) from crops and forestry under different scenarios (e.g. stress conditions or climate change)

Figure 13 - Screening of bacterial antagonistic activity against phytopathogenic fungi.

Figure 15 - Measurement of gas fluxes (CO_2, CH_4 e N_2O) from soils amended with organic residues.

CITAB Research organogram

The CITAB was formed in late 2007 from the merger of 3 existing Units (Centro de Estudos Tecnológicos, do Ambiente e da Vida (CETAV), Centro de Ciência e Engenharia Agrícola (CECEA) and Centro de Estudos em Gestão de Ecossistemas (CEGE)) based at the University of Trás-os-Montes e Alto Douro (UTAD). Selection of CITAB members was based on high quality criteria concerning scientific production.

Following the policy of attracting members out of UTAD, we count active members and collaborators from national and international institutions. CITAB is one of the research Units in Portugal, financed by the Portuguese Foundation for Science and Technology (FCT), after an international peer evaluation classified as "VERY GOOD".

CITAB Location and Contacts

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