



2nd International Meeting on
Mediterranean
Stone Pine for Agroforestry

Oeiras - PORTUGAL

BOOK OF ABSTRACTS



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ORGANISING INSTITUTIONS

FAO-CIHEAM Network on Nuts
IAMZ-CIHEAM
INIAV
ISA
UNAC
INIA
IUFRO RG 1.08.00 - Silviculture for production of edible fruits
FAO Silva Mediterranea

TIME SCHEDULE

WEDNESDAY, 18TH MAY 2016

09:00 REGISTRATION

09:45 OPENING SESSION

10:15 The FAO-CIHEAM Interregional Cooperative Research Network on Nuts

10:30 Session 1. MANAGEMENT OF STONE PINE FOR CONE PRODUCTION IN AGROFORESTRY

Keynote Speaker: **Margarida Tomé, ISA (Portugal)**

11:00 COFFEE BREAK

11:30 Spatial and temporal changes in the pine nut forest of Turkey: a case Study in Ayvalik Forest Planning Unit. **D. Mumcu Küçüker, KTU (Turkey)**

11:45 Effect of fertilization on the mineral composition of pine stone needle.
F. Calouro, INIAV (Portugal)

12:00 The needles as drivers of tree productivity: relationship with growth, vitality and cone production in *Pinus pinea*. **A. C. Correia, ISA (Portugal)**

12:15 Determination of effect of fertilizing on cone yield rate of stone pine (*Pinus pinea* L.) in Kozak province/Turkey. **M. Özçankaya, EFRI (Turkey)**

12:30 Trials on *Pinus pinea* and *Pinus halepensis* rootstocks from Tunisia and Spain.
M. Piqué, CTFC (Spain)

12:45 DISCUSSION

13:00 LUNCH

14:30 Session 2. GROWTH AND YIELD MODELLING

Keynote Speaker: **Rafael Calama, INIA (Spain)**

15:00 Development of a spatial tree growth model for stone pine – PINEAFITS.
J. Ribeiro, ICNF (Portugal)

15:15 Tree growth and gas exchange of stone pine (*Pinus pinea*) in northeastern Tunisia.
S. Fkiri, INRGREF (Tunisia)

15:30 Stone pine responses to the combined effects of drought stress and warming.
R. Lobo-do-Vale, ISA (Portugal)

15:45 Does management improve the photosynthetic capacity of stone pine (*Pinus pinea* L.) in northwest Tunisia? **T. Rzigui, Silvopastoral Institute /INRGREF (Tunisia)**

16:00 Evaluation of interannual growth prediction in *Pinus pinea* stands from multi-temporal UAV imagery datasets. **J. Guerra Hernández, ISA (Portugal)**

16:15 DISCUSSION

16:30 COFFEE BREAK

17:00 POSTER SESSION

THURSDAY, 19th MAY 2016

09:30 Session 3. GENETIC IMPROVEMENT, SELECTION AND BREEDING OF STONE PINE

Keynote Speaker: **Bruno Fady, INRA (France)**

10:00 Reproductive phenology of *Pinus pinea*. **T. Valdivieso, INIAV (Portugal)**

10:15 Establishment of clonal stone pine orchards as nut crop. **S. Mutke, INIA (Spain)**

10:30 *Pinus pinea* clonal orchards: contributions for genetic improvement. **C. Silva, AFPC (Portugal)**

10:45 COFFEE BREAK

11:15 Variability of kernel yield in Portuguese *Pinus pinea* L. stands from Provenance Region V
I. Carrasquinho, INIAV (Portugal)

11:30 DISCUSSION

11:50 Session 4. BIOTIC RISKS AND THEIR IMPACT ON STONE PINE PRODUCTS

Keynote Speaker: **Edmundo Sousa, INIAV (Portugal)**

12:20 Distribution of *Leptoglossus occidentalis* Heidemann (1910) in Turkey and its impact on stone pine forests. **S. Parlak, Bursa TU (Turkey)**

12:35 Genetic structure and invasion pathways of the Western Conifer Seed Bug, *Leptoglossus occidentalis*, in the Iberian Peninsula. **A. Farinha, ISA (Portugal)**

12:50 Pine nut damage on immature cones of *Pinus pinea* L: evidences for *Leptoglossus* causality.
R. Calama, INIA (Spain)

13:10 LUNCH

14:30 Seasonal damage on stone pine cones and seeds caused by feeding of *Leptoglossus occidentalis* (Hemiptera: Coreidae). **J. Pajares, U. Valladolid (Spain)**

14:45 Does forest management have an effect on cone pest damage? **P. Naves, INIAV (Portugal)**

15:00 DISCUSSION

15:20 Session 5. PINE NUT INDUSTRY AND MARKETS

Keynote Speaker: **Pedro Amorim, PineFlavour, Lda (Portugal)**

15:50 Local population's role in the collection and processing of stone cones in Rimel Forest (Bizerte, Tunisia). **S. Sebei, INRGREF (Tunisia)**

16:05 Value chain of stone pine forests in Lebanon: insights on good management practices.
E. Sattout, U. Balamand (Lebanon)

16:20 State of stone pine (*Pinus pinea*) forests in Turkey and their economic importance for rural development. **D. Mumcu Küçüker, Karadeniz T.U. (Turkey)**

16:35 COFFEE BREAK

17:05 Stone pine in Portugal: main policies and recent developments. **C. Ferreira, ICNF (Portugal)**

17:20 DISCUSSION

17:40 FAO *Silva Mediterranea* Working Group 2 on Non-Wood Forest Products Agenda

17:50 FAO/CIHEAM Stone pine subnetwork follow-up session

18:10 CLOSING SESSION

FRIDAY, 20th MAY 2016

08:30 FIELD TRIP Alcácer do Sal, Alentejo. *Departure from Praia Mar Hotel, return 17:30* Lisbon Airport

THE FAO-CIHEAM INTERREGIONAL COOPERATIVE RESEARCH NETWORK ON NUTS

Rovira M, Mutke S, López-Francos A

FAO-CIHEAM Research Nut Network on Nuts



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The Research Network on Nuts was established in 1990, after an expert consultation organized by FAO (REU, RNE and AGPS). Exchange of scientific information, joint applied research, exchange of germplasm, and establishment of links between researchers were identified as the main objectives. In 1996, FAO and CIHEAM agreed to cosponsor the Network. CIHEAM was already involved in fostering nut tree research activities.

The Network structure is based on a Coordination Centre (Coordinator and Secretary), supported by different Subnetworks (Working Groups) with the mission of fostering and coordinating specific activities. IRTA Mas de Bover has been the Coordination Centre from the start of the Network activities, in 1990. Today, the Network has 7 Subnetworks (6 tree crop species and 1 miscellaneous): Almond, Chestnut, Hazelnut, Pistachio, Stone Pine, Walnut, all of them having a Liaison Officer as Coordinator, and one miscellaneous, including Pecan, Genetic Resources and Economics, which is included in the general coordination. Two representatives, one from each supporting institution (FAO and CIHEAM) are also integrated in managing the Network.

The general activities of the FAO-CIHEAM Research Nut Network are proposed, discussed, agreed and planned in the Technical Consultations (participation of representatives of the member countries) and at the Coordination Board meetings (FAO and CIHEAM Officers, Network Coordinator and Subnetwork Liaison Officers).

The main activities carried out during the last 20 years have been: promotion of R&D activities; edition of proceedings, reports, and the NUCIS Newsletter; edition of inventories of germplasm and research lines; organization of meetings, workshops, and two international courses on “Nut Production and Economy”, and providing training grants for young researchers.

Within the network, stone pine (*Pinus pinea*) is particular. Being a conifer, its *pine nuts* are seeds, not true nuts; its cones, not seeds, are gathered, and until recently, they had been wild-collected, not orchard-cropped, without any defined cultivars. Only in the last 20 years have new specific plantations for cone production come into production, and first elite clones have been registered recently as basic materials for graft scion supply. In 2011, AgroPine2011 was held in Spain as First International Meeting on Mediterranean Stone Pine for Agroforestry, co-organised by our stone pine Subnetwork together with several institutions. The meeting brought together about forty experts, researchers, public and private forest managers, land owners, and representatives of pine nut processing enterprises, from Spain, Portugal, Tunisia, Turkey and Lebanon, with contributions also from France and Chile, reviewing the current state of the art in Mediterranean pine nut production in forests and orchards.

Welcome to AgroPine2016, the 2nd Meeting on Mediterranean Stone Pine for Agroforestry! The main objectives of this meeting are to connect the different researchers from the Mediterranean region, to update, share and transfer current knowledge and to foster further links between researchers, industrials and potential users of this species. We invite all of you to participate, discuss the challenges of the future, and propose ideas and activities to keep the Stone Pine Subnetwork alive.

Mercè Rovira, Nut Network Coordinator
Sven Mutke, Liaison Officer for Stone Pine
Antonio López-Francos, CIHEAM Representative



Keynote

**SESSION 1. MANAGEMENT OF STONE PINE FOR CONE PRODUCTION IN
AGROFORESTRY**

**MANAGEMENT OF STONE PINE FOR CONE PRODUCTION
- RESULTS FROM RECENT RESEARCH**

Margarida TOMÉ

Centro de Estudos Florestais, Instituto Superior de Agronomia, Universidade de Lisboa (Portugal)

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The importance of stone pine for the diversification of the landowners economy has increased in the last decades, leading to several studies towards the optimization of cone production. The maintenance of networks of permanent plots, thinning trials, intensively monitored trials with the manipulation of site factors and trials aiming to track the impact of pests and diseases are just a few examples.

Present stone pine silviculture is going through some intensification that includes grafting or even irrigation but the impact of such practices is still not completely understood.

In my talk I will review the recent research contributing to the understanding of stone pine growth and phenology establishing the link between the acquired knowledge and the optimization of cone production.



MARGARIDA TOMÉ is professor/researcher at ISA Lisbon.

Her present research interests relate to forest inventory and forest growth models with emphasis on the hybridization of empirical and process-based models and its application to sustainable forest management at different spatial levels. She has published more than 300 works, 25% in ISI journals. She has participated in the planning and data processing of most Portuguese National Forest Inventories.

Margarida has been the coordinator of IUFRO division IV "Forest assessment, modelling and management" [2006-2014], of the COST Action FP0603 *Forest models for research and decision support in sustainable forest management* and currently of the COST Action FP1203 *European non-wood forest products network*. She participated in EU- and nationally-funded research projects, namely coordinating ISA participation in FORSEE, EFORWOOD, AFORE, STARTREE and SIMWOOD.

Session 1. Management of stone pine for cone production in agroforestry

**SPATIAL AND TEMPORAL CHANGES OF PINE NUT FORESTS IN TURKEY:
A CASE STUDY IN AYVALIK FOREST PLANNING UNIT**

Mumcu Küçüker D, Baskent EZ

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Background. With the current trend towards ecosystem management in the Turkey forests over the last decades, timber and pine nuts are considered as main products from the stone pine forests. Stone pine woodlands in Turkey are approximately 89,028 ha and pine cone and nut production is about 3.501 tons/year and 280 tons/year, respectively. The forests covered by stone pine (*Pinus pinea*) also present other services and products such as hunting, sequestration of carbon, resin, bark or wood. The production and marketing of pine nut from stone pine in Turkey has grown dramatically over the last two decades.

The great social and economic importance of stone pine as non-wood forest production (NWFP) distinguishes it from other kind of pines. NWFP, provided by stone pine areas, generates employment and supplementary incomes for forest villagers who live in and near the forests and have low economic condition. The villagers prefer incomes from NWFP instead from timber in these areas, because pine nut production is more profitable than timber production.

Methods. Understanding of landscape dynamics as a historical legacy of disturbances is necessary for sustainable management of NWFP. In this study, spatial and temporal change in forest cover types in Ayvalık Forest Planning Unit, where pine nuts are very important as a NWFP, was analyzed by using GIS and FRAGSTATSTM. The analysis was done through forest cover type maps from 1989 and 2002.

Results. Results showed that there are marked changes in the temporal and spatial dynamics of land use and forest cover in the study area. Between 1989 and 2002, while there was an increase of 26.5% in total forested areas, there was an increase of 43.6% in stone pine areas. On the other hand, from the analysis of the changes in crown closure and trees development stages of the forest over the 13 years, we obtained an increase of total forest area and stone pine forest area with medium crown closures and with trees in a young stage of development.

Session 1. Management of stone pine for cone production in agroforestry

**EFFECT OF FERTILIZATION
ON THE MINERAL COMPOSITION OF PINE STONE NEEDLES**

Marcelo ME¹, Jordão P¹, Fontes L², Tomé M², Calouro F¹

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Background. The leaf composition of trees may reflect both the availability of nutrients in the soil and their ability to use these nutrients, whilst the soil analysis does not provide enough information about their nutritional needs. Therefore leaf analysis may be a suitable method to evaluate the nutritional status of forest stands.

Purpose. This study aims to assess the effect of some nutrients on the needles mineral composition of stone pine (*Pinus pinea* L.) one year after their application to the soil.

Methods. The field experiment was established on a stone pine planted in 2009, located in Ribatejo on a soil with acid reaction, medium levels of organic matter and extractable potassium, and low levels of extractable phosphorus, manganese, zinc, copper and boron. The experiment was arranged into completely randomized blocks with three replications, assigned to plots with eight trees. The experimental treatments were as follows: T1 - control (without fertilization); T2 - N; T3 - NP; T4 - NPK; T5 - NPK + limestone; T6 - NPK + MnZnCuB; T7 - NPK + MnZnCuB + limestone; T8 - NPK + B + limestone (N - 40 kg ha⁻¹; P - 87 kg ha⁻¹; K - 100 kg ha⁻¹; Mn - 4 kg ha⁻¹; Zn - 2 kg ha⁻¹; Cu - 1,5 kg ha⁻¹; B - 2 kg ha⁻¹; limestone - 8000 kg ha⁻¹ in 2008 plus dolomite limestone - 4340 kg ha⁻¹ in 2014). Needles composite samples were collected in each of the 24 plots of the experiment in March. The needles were taken from the top third of the crown, from the middle part of the fully expanded growths of the former year. ANOVA was performed in order to evaluate the effect of the experimental treatments on the mineral composition of the needles and differences among means were established through Duncan multiple range test ($\alpha=95\%$).

Results. Fertilization induced significant differences ($p \leq 0.05$) on the needle levels of nitrogen, phosphorus, sulphur, manganese, zinc and boron, whilst potassium, calcium, iron and copper were not affected. The application of phosphorus and boron increased the foliar levels of these nutrients. Manganese and zinc levels in needles were higher with their application without liming. The limestone induced lower levels of manganese and zinc, according with their lower availability when soil pH rises. The levels of extractable potassium in the soil may explain the absence of response to the application of this nutrient. Concerning nitrogen behaviour, the results are not very clear. However, the levels of soil organic matter may be responsible for the appropriate nitrogen levels in the needles. The study will continue for further years in order to confirm the obtained results.

Session 1. Management of stone pine for cone production in agroforestry

**THE NEEDLES AS DRIVERS OF TREE PRODUCTIVITY: RELATIONSHIP WITH
GROWTH, VITALITY AND CONE PRODUCTION IN *Pinus pinea***

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Background. Leaf area index (LAI) is an important ecophysiological parameter, closely related with canopy photosynthesis and transpiration and therefore with gross primary productivity of vegetation. It is defined as the amount of one-sided leaf area per unit ground surface area. It varies among years and seasons reflecting drought conditions and phenological events and is one of the key variables in process-base modelling.

Cone production in *Pinus pinea* trees is very sensitive to the manipulation of the leaf area during stand development. Tree thinning and pruning are required to allow canopy light exposure free from neighbourhood competition. These evidences support the hypothesis of a potential relationship between LAI measured at the tree and stand level and cone production.

Purpose. The objectives of this study were to improve the accuracy of the measurements of *Pinus pinea* LAI through: 1) the description of the specific leaf area (SLA, the ratio between the projected needle surface area and the correspondent weight, cm²/g DW) variation within the canopy, with needle age and inter-annually according with hydrological years, and 2) improve measurements of needle biomass and area at the tree level using allometric relationships.

Methods. Needle samples were collected from trees and stands of different age classes, from grafted and non-grafted trees, from contrasting ecological regions, in stands of different tree densities and subjected to fertilization and irrigation treatments. For the allometric relationships, we used a database of harvested trees collected in ecologically contrasting sites in Portugal.

Results. Differences in needles morphology were found according to the canopy light exposure levels and between needles ages. Light and water use efficiency was higher in the needles from top as compared with needles from the base of the crown, but water and nutrients addition increased overall canopy efficiency. At tree level, needles biomass was positively correlated with trees diameters, and especially with the sapwood water transport section. The combination of the allometric models with the SLA values allowed calculating stand LAI. Preliminary results show that cone production occurs for specific LAI intervals.

Conclusions. LAI monitoring in space and time may help the understanding of the processes involved in cone production, including the formation of flowers, mortality and growth. An additional advantage of LAI is the possibility to be measured using remote sensing tools (aerial photography or satellite image, for example) with great potential to be used as a tool to support modern forest management.

Session 1. Management of stone pine for cone production in agroforestry

**DETERMINATION OF EFFECT OF FERTILIZING ON CONE YIELD RATE OF
STONE PINE (*Pinus pinea* L.) IN KOZAK PROVINCE/ TURKEY**

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Purpose. This study was carried out between 2006 and 2011 to increase the cone productivity in a 25-year old stone pine stand in Karaveliler Village in Bergama/Kozak Basin, which is the most extensive growth area of stone pine in Turkey.

Methods. For this aim, different doses of 4 different commercial fertilizers were used in the study area. These fertilizers were ammonium sulfate (21 % N), triple super phosphate (42 % P₂O₅), potassium sulphate (50 % K₂O) and calcium nitrate (15.5 % N, 26.5 % CaO). During the two full growing periods of the cones, 6 different treatments including 5 different fertilizer applications and one control were applied. For every single treatment, 5 stone pine trees were randomly determined as repetitions. The effects of the fertilization on the harvested cone amounts and their total weights, cone, seed and kernel properties and tree heights, diameters, crowns and needles were determined in the study. Furthermore, changes in the soil productivity, nutrient contents of the cones and needles were investigated depending on the fertilization. Additionally, some other studies were carried out in order to determine whether there was a relationship between fertilization and cone pests.

Results. Fertilization were found effective on the cone amounts and total weights, seed amounts and weights, seed length and diameter, 1000-seed weight, filled seed percentages (%), amount and weight of kernel, and weight of 1000- kernel. Moreover, fertilizer applications were also effective on the tree diameters, needle lengths, soil productivity and the nutrient contents of the cones and needles. There were significant differences in the all parameters relative to the years.

Session 1. Management of stone pine for cone production in agroforestry

**GRAFTED STONE PINE PLANTATIONS FOR CONE PRODUCTION:
TRIALS ON *Pinus pinea* AND *Pinus halepensis* ROOTSTOCKS
FROM TUNISIA AND SPAIN**

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Background. Grafted *Pinus pinea* plantations for early and abundant fruit production are a good chance for restoring and promote Mediterranean areas; they can generate both economical (pine nut production) and ecological (soil protection) benefits. Moreover, grafting *P. pinea* on *P. halepensis* rootstocks can result in even more interesting outcomes because they can be used in degraded, dry and calcareous sites, which can hardly support any relevant forest production.

Methods. For this reason in the framework of a project supported by the Spanish Agency for International Development and Cooperation (AECID), implemented in Tunisia and Spain, we produced grafted plant using two types of stock (*P. pinea* and *P. halepensis*) from known provenances from Spain and Tunisia. During autumn-winter 2011-2012, field trials were established in both countries, in a range of different soil and climatic conditions, with the aim of studying the adaptation, development and cone production of the grafted plantations. In Spain and Tunisia, there are respectively five and six grafted field trials, using Spanish scion clones and eight stock provenances (four from Tunisia, four from Spain) of *P. pinea* and *P. halepensis*.

Results. In these plantations the basal tree diameter, total tree height, height until grafting point, graft diameter, success of grafting and cone production were measured. Factors influencing the grafting success, trees development and cone production were studied, namely stock species, stock provenance, initial stock size and slenderness, scion provenance, grafter's experience and field site conditions.



← Photo: Quinta da Regada

Keynote

SESSION 2. GROWTH AND YIELD MODELLING
WHICH MODELS DO WE NEED FOR *Pinus pinea* FORESTS?

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In the last 20 years, *Pinus pinea* has evolved from being a species with a scarce knowledge concerning growth and yield dynamics to be nowadays one of the best known species in the Mediterranean forests ecosystems. This widening of the scientific knowledge was the necessary basis for the extraordinary effort in constructing models to explain and predict the evolution and yield of stone pine forests. Currently there are available models for the species acting at different spatial, temporal and functional scales, with geographical validity in different countries and regions within countries. Classical empirical models for predicting growth and yield now coexist with climate-driven models, physiological based models predicting photosynthetic activity, models attempting to predict different dynamic processes, as natural regeneration or decay, or large scale process-based models. Apart from timber and fuelwood production, existing models for stone pine aim to simulate cone production, nut quality and content, and the provision of other ecosystem services, as CO₂ fixation. Temporal scale of different models ranges from the second to the multiannual scale, while spatial scales extents from the leaf to the region. Moreover, the modelling activity is going on, with new models and approaches being currently under construction.

However, despite the wide sample of modelling tools nowadays available, existing models seem somewhat not to be useful for answering many of the questions, demands and concerns that stone pine forest managers, forest owners, policy makers and industrials are facing. Our models are often criticized for being oversimplifications working far from the reality while, at the same time, they are claimed to show complex formulations where the demanded inputs are not easily available. Spatiotemporal scales usually do not match with those required by the users, and outputs from the models are far away from those expected. Meanwhile, some basic questions seem not to be adequately answered by our models. Topics such as: cone and timber production in the next decades; how to manage stone pine forests under an unpredictable climate; how to optimize cone production for a given stand; how to make a small property profitable; which is the expected impact of an extreme drought event; what to do with the mixed stands... and many others remain uncovered by our model predictions.

In this presentation we'll attempt to make a critical review of the current state of the art of modelling in Mediterranean stone pine forests, focusing on the stakeholders and end-users criticisms and point of views. Main deficiencies as well as potentialities of the currently existing models will be presented and discussed, suggestions for a correct use of the models will be given and proposals for improving current existing models will be presented. Finally, ideas aiming to define a proper design of the future models for *Pinus pinea* will be approached.



RAFAEL CALAMA, PhD in forestry, is researcher in the department for Silvicultur and Forest Management at INIA-CIFOR and invited professor of Forest Modelling at the Universidad de Valladolid.

Expert on forest modelling, silvicultural systems and non-wood forest production. His main line of research has focused on modelling the different processes associated with the dynamics of Mediterranean forests, ranging from classical growth & yield models to more specific models for processes as natural regeneration, fruiting, inter and intraspecific competition or physiological traits.

Most of his research activity has paid special attention to *Pinus pinea* forests, leading and participating into different national and international research programs focusing on the species.

Session 2. Growth and yield modelling

**DEVELOPMENT OF A SPATIAL TREE GROWTH MODEL
FOR STONE PINE – PINEAFITS**

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Background. Stone pine has been one of the most common species used in forestations in the last decades in the south of Portugal, which means not only changes in forest composition but also a significant change in the rural landscape structure. These changes require a new approach to forest management in the medium and long term in order to maintain the multifunctionality of these areas. Growth models enable to analyze different management strategies in order to attain economic efficiency, but until now few models have been developed for this species. In forestry, the most commonly used are stand models and distance-independent individual tree models.

Purpose. A distance-dependent individual tree model, named *PINEAFITS*, was developed. This type of model is more complex and more data demanding but provides more detailed information, which is relevant to forest planning and management of young stands.

Methods. The model was based on inventory data collected from permanent plots established in two public areas, the National Forest of Cabeção and the Contenda Community Forest. The stone pine stands where the study was carried out were planted 40 to 60 years ago by the Forest Service in areas with different geographical, soil and climatic characteristics. In each plot, the center was installed, and complete set of dendrometric parameters were collected, in 2006 and repeated in 2011, such as distance and stem coordinates and several tree characteristics. For model design and construction, a potential modifier concept was followed, constructing a potential model for dominant height growth for three site quality classes and building the modifier for diameter growth for each site quality class using spatial competition indices.

As large areas of the south of Portugal have low potential for the development of various forest species, this study also includes the analyses of the aesthetic and recreational values of different stands of stone pine in order to increase in the future the value of other components of these areas.

Session 2. Growth and yield modelling

**TREE GROWTH AND GAS EXCHANGE OF STONE PINE (*Pinus pinea*)
IN NORTHEASTERN TUNISIA**

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Background. Tunisia forests are characterized by a high presence of coniferous species. Stone pine and Aleppo pine together cover nearly 40% of all Tunisian forests and they occupy a prominent place in the priorities of forestry production. Introduction of Calabrian pine, *Pinus brutia*, in Tunisian arboreta has shown very encouraging results especially under humid and sub-humid climate.

Purpose. In an effort to guide the selection of reforestation species, the aim of our study was to compare tree growth and gas exchange of stone pine comparing with both species Aleppo pine and Calabrian pine planted in the same arboretum in order to compare acclimatization of its species under sub-humid bioclimate of Tunisia.

Methods. Dendrometric, dendrochronological and physiological approaches were used in this study. Species are located in experimental site (Djebel Abderrahmen) in the northeast of Tunisia (36°40'N, 8°57' W, 255 m). The site covered an area of 19.91 hectare and was established in 1966. It is characterized by a cold and sub humid climate. On November 2011, the height (h), diameter (DBH), dry matter and leaf area were measured and survival rate was calculated for each tree in the site. At least 3 trees with average DBH were selected for this study. Two cores were sampled from each tree (aged 47 years) at breast height 1.30 m. Then, Statistical parameters commonly used in dendrochronology were calculated from ring-width data. Gas exchange measurements were carried on the same trees during June which were used to characterize photosynthesis in response to intercellular CO₂ concentration (Ci) using a portable gas-exchange system LI-6400.

Results. Stone pine had the highest survival rate (86 %), height (12 m), diameter at breast height (28.3 cm) and specific leaf area SLA (2.9cm²/g⁻¹) and. The lowest values were recorded in Aleppo pine respectively (51 %, 8.3 m, 15.1 cm and 2.3 cm²/g⁻¹). The ring width data showed that stone pine had the best radial growth (2.79 mm) which is correlated to the lowest mean sensitivity (0.409). The CO₂ response curves of leaf net photosynthesis was used to directly calculate the main photosynthetic parameters, including the CO₂-saturated net photosynthetic rate (A_{sat}), stomatal limitation and carboxylation efficiency. At ambient CO₂, stone pine and Aleppo pine had the higher values of net photosynthetic rate successively (14.45 μmol m⁻² s⁻² and 15 μmol m⁻² s⁻²). Calabrian pine had the higher value of instantaneous water use efficiency (222 μmol mol⁻¹). Under high CO₂ conditions, no significant differences were observed between Aleppo pine and stone pine for A_{sat}. The relative stomatal limitation was highest in Calabrian pine (69.7 %). The present study shows that both stone pine and Calabrian pine had a large plasticity and interesting productivity under sub-humid bioclimatic conditions in Tunisia, while Aleppo pine showed that the favourable climate for development is the semi-arid. Our results are in accordance with previous studies by Khouja and Khorchani.

Conclusions. In conclusion, a significant finding of the study was that stone pine has the best growth during reconstructed climate and higher productivity and net photosynthesis performance. In contrast, Aleppo pine was able to acclimate physiologically to climate change (i.e. drought and CO₂ elevation). Calabrian pine improves a well species water use efficiency.

Session 2. Growth and yield modelling

**STONE PINE RESPONSES TO THE COMBINED EFFECTS
OF DROUGHT STRESS AND WARMING**

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Background. Projections for future climate show that temperature will increase substantially, and many areas currently affected by seasonal drought, Mediterranean region included, will become more arid. Rainfall variability is expected to increase as well, with more frequent and intense extreme events, like severe droughts or heat waves. Drought and increasing temperatures will decrease soil water and increase evaporative demand and water loss from plants.

Tree functional traits associated with carbon storage and water use can be linked to higher tree survival and recovery from disturbances imposed by climate change. However, the mechanisms underlying the effects of combined drought and temperature stresses on tree growth and survival are not fully understood.

Purpose. Here we present and discuss the mechanisms driving coupled carbon and water dynamics in stone pine affected by climate change.

Methods. Stone pine seedlings (18 month old) were submitted to combined drought stress and high temperatures in a factorial design with 2 levels of water availability (watered and no water addition, respectively W and D) and 2 levels of temperature (ambient and ambient+2°C, respectively A and +), corresponding to 4 treatments: WA, W+, DA, D+, from April to November 2014. Warming was provided by open top chambers. Two broadleaved species (cork oak and eucalypt) were also studied.

Leaf gas exchange (mainly leaf dark respiration and nocturnal stomatal conductance) and water potential were measured every two weeks. Growth was evaluated by 4 destructive harvests (before drought imposition, moderate drought stress, severe drought stress and after a recovery period) and the dry weight of leaves, stems and roots was determined. Fresh sub-samples were collected for non-structural carbohydrates determination (starch and soluble sugars) and wood anatomy assessment in 6 seedlings per treatment per harvest. Seedling mortality was monitored over the study period.

Results. The detrimental effects of water stress overlapped the beneficial effects of increased temperatures, by significantly decreasing growth, and, contrary to the broadleaf species, the stone pine responses were not straightforward. Drought stress was the main cause of seedling mortality, which was observed only when severe drought stress occurred (30%).

Conclusions. Results must be seen in a whole-plant perspective, linking sources to sinks. Stone pine responses can be compared to broadleaved species responses.

Session 2. Growth and yield modelling

**DOES MANAGEMENT IMPROVE THE PHOTOSYNTHETIC CAPACITY OF
STONE PINE (*Pinus pinea* L.) IN NORTHWEST TUNISIA?**

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Methods. The effects of tress density on morphological and physiological parameters were investigated in two sites of Mediterranean stone pine (*Pinus pinea* L.) stands in the north-western provinces of Tunisia. The first site has never been thinning but two thinning were applied in the second site. Light-response curve of leaf net carbon uptake, were used to estimate photosynthetic performance under the two silvicultural alternatives.

We hypothesized that the reduction of the stand density of trees will improve growth and will be positively correlated with photosynthetic capacity [characterized by light-saturated net photosynthetic rates (A_{max}), associated light compensation points (LCP), and apparent quantum yield (Φ)].

Results. The analysis of dendrometric parameters shows that the radial growth and the height are clearly highest in the site with lower trees density. However, unexpected results show that the photosynthetic capacity (A_{max}), LCP, Φ and stomatal conductance (g_s) were the lowest in this site. Same water use efficiency (WUE) was estimated at both sites. Also, our study illustrates the trade-off between light interception and light use efficiency. The light interception efficiency is higher in trees of the first site; however, this benefit comes at a cost of decreased efficiency of light use for growth.

Conclusion. Results indicate that practice of thinning can improve the tree growth by impacting light interception and CO₂ uptake performance.

Session 2. Growth and yield modelling

**EVALUATION OF INTERANNUAL GROWTH PREDICTION IN
Pinus pinea STANDS FROM MULTI-TEMPORAL UAV IMAGERY DATASETS**

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Background. Improved methods to monitor the growth and development of *Pinus pinea* plantations and to flexibly and non-destructively estimate yield of biomass on harvest are needed to facilitate forest management decisions.

Purpose. Evaluation of the use of unmanned aerial vehicle (UAV) imagery for multi-temporal forest height and crown growth assessment in a *Pinus pinea* L. plantation over a two-year period.

Methods. The objective was to evaluate the level of uncertainty in UAV-based growth estimates through time so that the optimal repeat interval necessary for statistically meaningful growth measurements could be evaluated. Unmanned aerial vehicles equipped with low-cost consumer grade cameras have potential to provide information on both structure (height and density) and to detect spatial variations in growth or estimate yield differences between different treatments. This research provides a pilot study of this capability, based on a trial of *Pinus pinea* plantation under different treatment in Portugal.



Keynote

SESSION 3. GENETIC IMPROVEMENT, SELECTION AND BREEDING OF STONE PINE

A BRIEF EVOLUTIONARY HISTORY OF *Pinus pinea* L

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Pinus pinea L., the Mediterranean stone pine, is a distinctive element of Mediterranean landscapes and forests. How did it come to be so is subject of much debate. The most striking feature of this widely distributed pine is its unusually low genetic diversity across its entire genome.

In my talk, I will review the most likely hypotheses that have led to low genetic diversity: biological features, phylogeny, Pleistocene climate changes and human impact. I will conclude with a few words on conservation and sustainable use of natural populations and their genetic resources.



BRUNO FADY, French Institute of Agronomic Research (INRA), Avignon.

Bruno is a geneticist with an ecology background and a 25-year experience in Mediterranean forest ecosystems. He holds a BSc degree in Plant physiology and cellular biology (Université Pierre et Marie Curie, Paris, France) and a PhD in Ecology (Aix-Marseille Université, France). Bruno Fady is a senior scientist and deputy director at the Ecology of Mediterranean Forests research laboratory (INRA-URFM) in Avignon, France.

He is interested in many fields related to forest genetics and ecology, from breeding to conservation, and has published over 80 articles and book chapters. Currently, he is focusing on how genetic diversity is structured at broad and fine geographic scales in relation to natural ecological factors and human impacts in Mediterranean tree species.

Bruno is also involved in activities at the crossroads between science, management and policy that aim at optimizing the conservation and sustainable use of forest genetic resources worldwide.

http://www6.paca.inra.fr/ecologie_des_forets_mediterraneennes

Session 3. Genetic Improvement, selection and breeding of stone pine

REPRODUCTIVE PHENOLOGY OF *Pinus pinea*

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Background. Stone pine (*Pinus pinea*) is one of the major species worldwide, assuming an extreme economic, cultural and environmental importance in the Mediterranean Basin. Pine nut production represents a valuable and profitable activity in producing countries (Spain, Portugal, Italy, Tunisia and Turkey) where pine nuts are traditionally marketed and consumed. In Portugal, 70% of the national production comes from Alentejo region, mainly in Alcácer do Sal, where edafoclimatic conditions are propitious to high productivity and quality, rendering high economy revenue from pine nut exploitation.

The stone pine has a peculiar reproductive cycle since it takes 26 months instead of 14 months since flowering to fecundation than the majority of other *Pinus*. *P. pinea* is a monoecious species and mainly anemophilous pollinated species where flowering occurs in spring, from late March to early June. In stone-pine female strobilus, from differentiation to fruit maturation takes approximately 4 years. Flower induction/differentiation occur in the first year, pollination occurs in the spring of the second year, fecundation at the late spring of the fourth year and fruit set at the autumn/winter of that same year.

Methods. During two consecutive years, reproductive phenology has been monitored in two plots, one located in Alcácer do Sal and another one in Coruche. In each plot, we randomly select 30 adult trees. Observations and images were acquired over two growing periods, from beginning of March 2012 to end of August 2013. The periodicity of the observations ranged between one and three weeks depending on the time of the year. Male phenology was described by 3 main phases and female phenology was described by 7 main phases.

Results. The evolution of male and female reproductive structures was macroscopically presented through a sequence of phenological stages.

Conclusions. The knowledge of reproductive phenology is important for relate production and productivity with climatic data or even in a major scale with climatic changes. Through plant phenological stages it is possible to assess damage that may be caused by insects that can damage reproductive structures that compromise the production.

Session 3. Genetic Improvement, selection and breeding of stone pine

ESTABLISHMENT OF CLONAL STONE PINE ORCHARDS AS NUT CROP

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Background. Given the global increase in plantations of Mediterranean stone pine, *Pinus pinea* L., for producing Mediterranean pine nuts, the production of grafted treelets is of major interest for allowing massive propagation of genetic improved material. Since early 20th century, stone pine area has expanded threefold from 0.31 to 0.96 million hectares in the Mediterranean area. Half of this increase has been done by private landowners in the last 20 years. Especially in Portugal and western Turkey, where maritime influence with annual rainfalls exceeding 500 mm favours cone productivity, the current expansion is already fourfold the original area, approaching 180,000 and 200,000 hectares, respectively. In Spain, stone pine expansion on farmland has been minor, due to less favourable climate that limits expectations.

Purpose In this context, the standardised use of grafted trees for establishing new plantations requires the implementation of a legal, technical and commercial framework for supplying certified forest reproductive materials (scions, grafted trees) under strict quality standards.

Methods. Grafted comparative common garden trials have evaluated candidate clone, obtained in Spain since the early 90ies from plus tree prospection in pine forests based on their superior cone yields. The analyses of growth and cone yield in the trials, as well as cone and seed characterisation, have allowed ranking for several hundred evaluated clones. But among the most productive clones, only 18 could be distinctively characterised by molecular markers (nuclear microsatellites); nevertheless clone identifiability is a mandatory requirement for inclusion of clones in National Register of basic materials for producing forest reproductive materials following Council Directive 1999/105/EC, Annex IV.

Results. In 2015, the Spanish Ministry for Agriculture, Food and Environment (MAGRAMA) has released and registered 15 elite clones, as result of more than twenty years of experimentation. The registered clones have shown to yield 9-31% more than average cone crops in the grafted trials.

Conclusions. The catalogue of elite clones as registered basic materials is a first step in the supply chain building. The next issue is the definition of commercial standards for planting stock (scions, rootstocks and grafted plants obtained in nursery), and the establishment of certified mother plant orchards for scions production, supplying planting stock for commercial plantations. The present communication resumes the experiences of the authors during the development of genetic improvement programmes for stone pine in Spain and presents the characterisation of the registered clones.

Session 3. Genetic Improvement, selection and breeding of stone pine

***Pinus pinea* CLONAL ORCHARDS:
CONTRIBUTIONS FOR GENETIC IMPROVEMENT**

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Background. In Portugal, *Pinus pinea* L. represents 6% (175 742 ha) of the national forest area and has increased 46% considering the last two national forest inventories. Expansion occurred primarily through plantations. The implementation of the grafting technique has become usual to anticipate and increase cone production. For commercial purposes, the first clonal orchards were installed by private owners' forest associations APFC and ANSUB at Coruche and Alcácer do Sal, respectively.

The establishment of Coruche clonal orchard started in 2004 by grafting in a three years old stone pine plantation (8 ha). The scions were obtained from 64 plus trees, phenotypically selected in the provenance region V for their high cone production. All data included in the present abstract belong to this clonal orchard/bank. From a total of 2 871 grafted trees only 1 501 succeeded. Since 2008, 11 permanent plots (43 trees) with grafted and non-grafted plants were maintained and monitored for cone production (number of cones and weight). For commercial purpose, between April and May each year since 2009, scions are randomly collected from each grafted tree without individual (clone) identification. Annually, also cone pine production has been continually registered.

Methods. In order to evaluate the cone and kernel yield per clone, in April 2015 the scion picking from 625 selected trees was interrupted at the Coruche clonal orchard. The criteria for these trees selection was: 10 ramets for each of 64 the clones, preferably from an area where most of the grafts were succeeded (only 8 of the 64 clones have less than 10 ramets).

Results. Individual cone production per ramet was registered. In the 2015/16 campaign, the cone production totaled 1 174 cones (281.75 kg). The total production per clone, considering the sum of the individual productions of the ramets sampled in each clone, varied between 2 to 67 cones and 0.25 to 22.2 kg cones.

Conclusions. The presented data is just a preliminary approach for the evaluation of each clone production from the Coruche clonal orchard. However this cone production does not express the total potential of each clone due to the previous scions picking in 2013 e 2014. This evaluation will be maintained in 2016-17 cone campaign, complemented by dendrometric evaluation for each tree. The first real cone production per clone will be only obtained in 2017-18 campaign.

Session 3. Genetic Improvement, selection and breeding of stone pine

**VARIABILITY OF KERNEL YIELD IN PORTUGUESE *Pinus pinea* L.
STANDS FROM PROVENANCE REGION V**

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Background. Mediterranean stone pine is an important forest species for its cone/kernel production. In Portugal, more than half of this cone/kernel production comes from the provenance region V (Alentejo). In a previous study, five different tree developmental stages were established, using data obtained in *Pinus pinea* permanent plots distributed in this provenance region. Considering biometric (diameter at breast height, crown diameter, crown area and height diameter ratio) and cone productivity (number of cones and cone crop weight) traits, each tree was classified in one of the following stage: juvenile (stage 1), dominant vegetative growth (stage 2), cone production phase I (stage 3), cone production phase II (stage 4) or cone production phase III (stage 5). New trees can also be assigned to a development stage using a discriminant function.

Until now, number of cones and cone crop weight has been used as a proxy for pine nut production and for selection of high productive trees. However, these variables are considered to be an indirect approach for the evaluation of kernel production. In fact, long reproductive cycle (three years), biotic and/or abiotic factors can affect seed/kernel production and thus bias the selection of these productive trees in a genetic improvement program.

Purpose. This study aims to include the kernel productivity variation to complement the characterization of the five development stages and to evaluate the previously identified best productive trees.

Methods. To perform this study, kernel production per cone in each tree was used. Data were obtained in three consecutive years, from 2004 to 2007, in *Pinus pinea* permanent plots within the provenance region V.



Keynote

SESSION 4. BIOTIC RISKS AND THEIR IMPACT ON STONE PINE PRODUCTS CONE PESTS OF STONE PINE IN THE MEDITERRANEAN BASIN

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In the Mediterranean Basin the stone pine is normally considered one of the most defended pines against pests. There are only a few species that can cause damages, such as defoliators (*Thaumetopoea pytiocampa* (Schiff.)) or bark beetles (*Tomicus* sp. and *Ips sexdentatus* (Boern.)). In punctual situations these insects can weaken or even cause mortality, but the main concern is due to the insects that feed on cones and seeds, like *Pissodes validirostris* Gyll (Coleoptera: Curculionidae), *Dyorictria mendacella* Staudinger (Lepidoptera: Pyralidae) and *Leptoglossus occidentalis* Heidemann (Hemiptera: Coreidae) in consequence of its economic impact. The first two species are endemic from the Mediterranean basin, while the third is an invasive species originate from America.

During seed development, the trees invest substantial resources to be used during embryogenesis. Therefore, seeds provide a concentrated source of carbohydrates, fat and proteins and low water content, compared to young needles. Species like *P. validirostris* and *D. mendacella* burrow through and feed on seed-bearing structures or cones, while *L. occidentalis* suck out the contents of seeds or seed-bearing structures as well as needles, flowers or shoots and twigs. At the same time these specialized insects have developed diverse ecological strategies to complete their biological cycle. For example, *P. validirostris* completes its immature stages inside the cones, while *D. mendacella* larvae leave the cone to pupate in the soil, and *L. occidentalis* completes its development always outside the cones.

Additionally to direct consumption, insect attacks can cause fruit abortion or facilitate introduction of pathogens, such as the transmission of the fungus *Diplodia sapinea* (Fr.) Fuckel by the sap-sucking insect *L. occidentalis*. Impacts of cone pests are related to reductions in the seeds production and productivity at the economic level and to reforestation and afforestation programs at the ecological level. However in stone pine forests, phenology and seed production can be highly irregular in both space and time, affecting directly the population dynamics of these pests.

In this presentation, we summarize the current knowledge on the most important cone pests in the Mediterranean Basin, emphasizing: (i) the biological and ecological mechanisms involved in the establishment and the spread of these species, (ii) the damages associated and, (iii) the strategies available for the integrated management with the objective of controlling their populations.



EDMUNDO SOUSA, researcher at INIAV since 1984. In the field of Agricultural Sciences, he dedicates his activity in the forestry sector with particular emphasis on Forest Entomology, particularly in the areas:

- Tree - Insect - Fungus - Nematode Interactions
- Bioecology of forest insects
- Resistance mechanisms of trees to insect attack Effect of climate changes on tree - Insects interactions
- Temporal and spatial progression of forest pests.

He also dedicated his activity to the knowledge and assessment of the mechanisms involved in the decline of the Portuguese forest.

In the area of Forest Entomology, he has worked on insect fauna of pine, chestnut, eucalyptus and cork oak, particularly: evaluation of plant health status of forest stands, identification and prospection, biological behaviour and monitoring of pests. He develops insect studies particularly on xylophagous that act as vectors of other organisms such as the *Platypus cylindrus* and *Monochamus galloprovincialis* or sap sucking insects like *Leptoglossus occidentalis*.

Session 4. Biotic risks and their impact on stone pine products

**DISTRIBUTION OF *Leptoglossus occidentalis* HEIDEMANN (1910) IN TURKEY
AND ITS IMPACT ON STONE PINE FORESTS**

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Background. Although *Leptoglossus occidentalis* has been reported first time in 2009 in Turkey, lack of productivity in stone pine due to conelet loss and empty seeds had started already in 2005. Despite many studies carried out about causes of conelet loss and unproductivity, after 5-6 years it could only be understood that *Leptoglossus occidentalis* Heidemann, (1910) is responsible. Behind the reasons of this delay in identification are that life cycle of the insect is passed mostly in crown part of the tree and leaving no physical sign of sucking damage on cones.

In 2015, a study found a lot of conelet loss in Kalenema Creek, Trabzon, which is most northern distribution of stone pine in Turkey. In 2015 afterwards, insects have been observed in Bursa and entered even houses, in the last November on Uludağ Mountain about altitude 1,750 m. Adults and nymphs have been found abundantly in the surveys, reporting the insect as excessively found wherever stone pine distributed.

Methods. After finding bugs on a few spot in Izmir, detailed studies have been started to find exact distribution. Without any discrimination either planted or natural or any altitude or any aspect, cones have been collected from 32 localities which are distributed all around Turkey. Weight and size of cones have been measured and seeds extracted by drying at 55 °C in climate cabinet, then damages on seeds by *Leptoglossus occidentalis* and unshelled seed yield were determined.

Session 4. Biotic risks and their impact on stone pine products

**GENETIC STRUCTURE AND INVASION PATHWAYS OF THE WESTERN CONIFER
SEED BUG, *Leptoglossus occidentalis*, IN THE IBERIAN PENINSULA**

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Background. *Leptoglossus occidentalis*, a cone and seed insect pest native from North America has already been considered a significant pest in several European countries since its first appearance in Italy in 1999. In Spain and Portugal it was recorded for the first time in 2003 and 2010, respectively, and its impact on Stone Pine (*Pinus pinea*) is a major concern. The Iberian Peninsula contains 85% of the global distribution of stone pine stands being the pine nut production an important economic and social activity.

Purpose. Before trying to develop control measures to this insect pest it is paramount to clarify its population dynamics. Therefore, our aims were to (a) characterize the genetic structure, diversity and (b) invasion pathways of *L. occidentalis* populations in the Iberian Peninsula.

Methods. Samples of *L. occidentalis*, adults or nymphs, were collected at thirteen sites widely distributed within the Iberian Peninsula. A multi-marker strategy with mtDNA and microsatellites was used. Highly polymorphic genetic markers like microsatellites are suitable to analyse population's structures and elucidate invasion routes even at a small-scale resolution of space and time.

A fragment of the mitochondrial cytochrome b gene (Cytb) was amplified for 48 specimens which corresponded to at least three individuals per population. Regarding microsatellites, a total of 224 specimens were genotyped at 11 microsatellites markers, developed previously by Lesieur and team.

Results. The mitochondrial cytochrome b gene (Cytb) data revealed that all haplotypes previously found in European populations were also present in the Iberian Peninsula although presenting different relative haplotypes frequencies. The absence of new haplotypes could mean that there were no new introductions in the Peninsula in the last years but only an expansion of the European populations however this idea has yet to be confirmed. Microsatellites results are still being analysed and we hope they can help clarify both the population's structure and the invasion pathways of this pest in this Peninsula.

Session 4. Biotic risks and their impact on stone pine products

**PINE NUT DAMAGE ON IMMATURE CONES OF *Pinus pinea* L:
EVIDENCES FOR *Leptoglossus* CAUSALITY**

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Background. Severe decrease in stone pine nut yield (ratio between weight of shelled nuts and weight of green cones) has been observed in the recent years across the Mediterranean basin. This dramatic reduction is related with an increment in the rate of damaged pine nuts, which reach a value up to 60% in some regions, compared with historical values of 15-20%. While the exotic bug *Leptoglossus occidentalis* has been proposed as the main cause of this reduction, evidences of this causal agent are still lacking.

Purpose. (i) Description of the damage on pine nuts caused by artificial feeding of *Leptoglossus occidentalis* using immature cones of *Pinus pinea* (ii) comparison of damages observed at laboratory with the evolution of damage observed at field conditions across the cone maturation season.

Methods. Immature two years-old cones were collected in pure stone pine forests in Valladolid every two weeks from mid-May to the end of October. A subsample of these cones was used to artificially feed a colony of *Leptoglossus* maintained in controlled laboratory conditions. After a 4-days period of exposition to the bug the cones were opened, pine nuts extracted, counted and classified according to the observed level of damage. Pine nuts were compared with those from a non-exposed sample, in order to evaluate the real effect of the bug over immature cones and nuts. The damage on pine nuts observed on laboratory was thereafter visually compared with the damage observed at field conditions.

Results. The immatures cones collected before mid-July which were exposed to the action of *Leptoglossus* showed rates of pine nut damage reaching 100%, whereas in non-exposed control cones this value was close to zero. From mid-July on, the rate of damaged pine nuts at field conditions increased up to values over 80% even in the control, matching with the period of maximum activity of *Leptoglossus*. Due to this, on these dates, it is difficult to discriminate among pine nuts damaged at field or afterwards at laboratory. Visual comparisons among pine nuts positively damaged by *Leptoglossus* and observed damages at field reveal several similitudes.

Conclusion. The results strongly support the implication of *Leptoglossus occidentalis* in the observed decrease on pine nut yield, as well as give insight into the temporal process of evolution of pine nut damage.

Session 4. Biotic risks and their impact on stone pine products

**SEASONAL DAMAGE ON STONE PINE CONES AND SEEDS CAUSED
BY FEEDING OF *Leptoglossus occidentalis* (HEMIPTERA: COREIDAE)**

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Background. Western conifer seed bug, *Leptoglossus occidentalis*, is a cone pest known to cause severe reductions in seed production in its native range in North America. This insect has been introduced and spread all over Europe. Its spread within the Mediterranean region has been coincidental with notable reductions in cone production and yield in stone pine, which raised great concern among forest owners and pine nuts producers.

Methods. Several experiments were carried out in a clonal orchard of *Pinus pinea* located in Tordesillas (Valladolid, Spain) during 2015 and 2016. Pairs of two virgin F1 females, reared in laboratory from wild parents, were caged for two weeks in pine braches, each bearing one 2nd or 3rd year cone. Different treatments, consisting in 4 different caging occasions, from late April to late July (3rd year cones) or late August (2nd year), were set in 15 trees (blocks) in a complete randomized block design. Exposed cones and caged cones without bugs were also included as control treatments. Similarly, 1st year conelets were caged with two 2nd/3rd instar nymphs for a week in early July and late August. Cones were checked weekly and let to develop once the treatment has ceased. Mature cones were collected in December and were weighted and dried in laboratory. Seeds were extracted, weighted and opened and possible damages were characterized as one of three types.

Results. Preliminary results show that *L. occidentalis* had a very severe impact on the cones of all ages. All 1st year conelets receiving feeding during early July died, as did all 2nd years cones that had bugs during spring or first half of summer. A seasonal effect on cone mortality, seed abortion and seed damage types was observed.

Session 4. Biotic risks and their impact on stone pine products

DOES FOREST MANAGEMENT HAVE AN EFFECT ON CONE PEST DAMAGE?

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Background. In recent years, there has been an increase on the incidence of pests and diseases affecting the cones of Stone Pine, *Pinus pinea*, in Portugal, resulting in a decreasing tendency for both production and productivity. Nevertheless, there is a significant variation between locations on the incidence and damages caused by these biotic agents, and even in the same estate there are differences between forest plots which are difficult to explain. Forest management has been associated with these contrasting patterns, although this has not been proven yet in Portugal.

Methods. In this study we tried to assess the impact of a few selected management techniques on the impact caused by forest pests on the cone production and productivity. For the evaluation of damages and factors involved experimental plots were implemented in the Herdade do Zambujal (Sado river estuary, Portugal) during 2012-2013. Six plots under different management treatments were defined, consisting of fertilization (three plots), irrigation and chemical treatment for defoliators (one plot) and soil tilt by grazing and tillage (two plots). In all the plots the cones of the pines were exhaustively collected from a single tree (in 2012) and from six trees (in 2013), for subsequent evaluation under laboratory conditions. The sanitary condition of the cones was evaluated along with biometric parameters of both cones and seeds.

Results. Both the total number of cones and the incidence of damage by biotic agents differed among plots. Three pests and one disease were identified associated with cone damage and affecting its production and productivity, namely: *Pissodes validirostris* (Coleoptera), *Dioryctria mendacella* (Lepidoptera), *Leptoglossus occidentalis* (Hemiptera) and *Diplodia pinea* (fungal disease). Some of the analysed parameters significantly differed among treatments, namely the number and weight of the viable seeds, the weight of the healthy pinions and the number of empty pinions per cone, although other factors such as tree density, height, canopy volume, bark thickness and trunk diameter varied among plots, and also need to be taken into consideration.

Conclusions. Overall, results suggest that some of the studied management techniques may reduce the damages caused by pests and diseases, and can be used to limit the impact of these biotic agents on cone production and productivity.



Keynote

SESSION 5. PINE NUT INDUSTRY AND MARKETS

PINE NUTS: BEGINNING TO END PROCESS

FROM FACTORY TILL FINAL CONSUMER

Pedro Miguel EVARISTO AMORIM

PineFlavour, Lda, Portugal

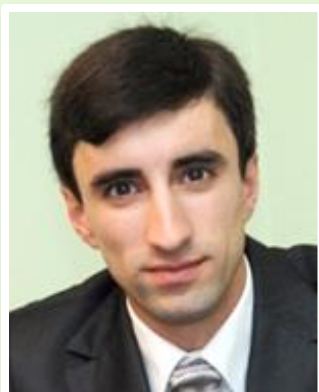
Pine nuts industrial process can be managed differently according to the methodologies or approach you may choose. Such methodology can be indexed to different approaches, depending on the way you open your pine cones (either by natural maturation process or by means of mechanic instruments), the way you crack the pine nut shell (crashing it or by projection pressure) and lately case you adopt or not washing and shinning processes to the finish good (the white pine nuts).

When you come across the decision to which industrial process fits your needs, you are taken to put together variants like what is your available capital to invest, what is the production capacity you may desire and what are your target markets, either local or export (all the three are linked and must be balanced). Furthermore, its extremely important, if not mandatory, to think since the beginning, how can you avoid the human error (means automation maximization balanced with your capital for investment and risk balancing) and the waste percentage (as this two factors will have direct impact on your margins).

Over the past twelve years, nuts species generally have seen their production grow as well as its exportation and world wide consumption. Contributing for these figures we may point out factors as health benefits linked to nuts consumption which is now recognized as very benefic and furthermore is affordable.

Pine nuts itself is not among the product with the greatest grow indicator, but its still a great business opportunity, specially in markets with big dimension (USA, Germany, China, Russia), as well as in markets with the highest consumption per capita (Spain, Australia, Israel).

Nevertheless, it is extremely important to recognize and understand that there are still a lot of investigation to be done in the several areas part of the Pine nut process (from A to Z) in order to keep the marked grow, make it stable and more important, make this attractive business even more viable.



PEDRO AMORIM has a master's degree in Civil Engineering by IST (Instituto Superior Técnico). Throughout his career he gained enough experience to take on the leading role in major projects, in key areas such as budget control, timeframe, safety at work and human resources, materials and equipments management.

In the past few years, he specialized in the implementation and monitoring of ISO 9001 and 50001, crucial standards to ensure effective management in terms of production quality and energy management.

In 2014, together with his partners, Pedro created PineFlavour, a company dedicated to pine nuts processing that uses highly advanced technology, respecting ecological and sustainability principles.

Sessions 5. Pine nut industry and markets

**LOCAL POPULATION'S ROLE IN THE COLLECTION AND PROCESSING
OF STONE CONES IN RIMEL FOREST (BIZERTE, TUNISIA)**

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Background. Rimel forest is the oldest reforestation with stone pine in Tunisia, its objective was fixing the dunes. Rising prices at the global scale and on the domestic market oriented local population to collect stone pine cones. The forest people who live nearby stone pine stands engaged in harvesting the cones as a business.

Results. The use of this non-timber forest product was the subject of public tenders and use rights obtained from the forest service. The contractors could not collect ripe cones. The few gains from the cones harvested before maturity attracted many of actors. Harvesting is done by specialized trees climbers. Their average capacity collection of cones is 500 kg per day. With a selling price in the field for cones about 0.750 DT/kg their turnover per day is 30-40 DT. The capacity of cone crusher is 500 kg/day. These operations are performed by family labour or women workers paid apiece 15 DT/t cones and 5DT/kg extracts seeds, corresponding to remuneration for cone crushing 7.5 DT/day and for the extraction of seeds 15 DT/day.

Session 5. Pine nut industry and markets

**VALUE CHAIN OF STONE PINE FORESTS IN LEBANON:
INSIGHTS ON GOOD MANAGEMENT PRACTICES**

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Background. In Lebanon, stone pine (*Pinus pinea* L.) forests occupy 9.5% of the total forest cover (12,755 ha) with 5,400 ha of productive area. Productive forests are located in the districts of Aley, Jezzine, Chouf and El Metn. They are distributed on state owned, communal, municipal and private lands. Lebanese stone pine forests are sources of pine kernels; they are renowned as the *white gold* among the forests keepers and managers. The annual revenue reached up to US\$ 52.5 million in 2005.

Purpose. The objectives of this study are to assess the socio-economic state and the governance of stone pine forests in Lebanon based on the cost benefit and to provide insights on their good management practices

Methods. Focus groups meetings and rapid appraisals were organized with the forestland tenants, users and keepers. Additional outcomes of the study are [1] the value chain of stone pine forests with positive and negative externalities resulting from the existing governance and management practices and [2] good management model stemming from Analytical Hierarchy Process (AHP) applied to forests.

Results. The forest tenants are around 400 in number. They are either temporary or long-term tenants of the forestlands. The workforce is mainly composed of foreigners because of the low costs of management practices as well as harvesting and processing of cones. Estimates of the total annual production between 2010 and 2015 reveal a discrepancy in the average local production as well as the economic values. During the same period, the average local market price increased from US\$ 20 to 80. The total annual production was estimated at between 1,200 and 1,500 tons with a total annual value of US\$ 16.5 to 25.8 million between 2003 and 2005. During that same period, the annual production was estimated at 2,600 tons with approximate revenue of US\$ 52.5 million. In 2010, this value decreased to 840 tons at US\$ 33.5 million revenue.

Conclusions. On one hand, the market has been affected by the import of pine kernels from Turkey which price is less than half of the local production. On the other hand, forest production is decreasing because of prevailing practices in their management coupled with the production cycle of trees affected by biotic and abiotic conditions of the sites. In the last few years, these forests have been subject to the Western conifer seed bug (WCSB) (*Leptoglossus occidentalis*) observed across the entire Mediterranean basin. The WCSB has affected the tenancy of stone pine forestlands.

Session 5. Management of stone pine for cone production in Agroforestry

**STATE OF STONE PINE (*Pinus pinea*) FORESTS IN TURKEY
AND THEIR ECONOMIC IMPORTANCE FOR RURAL DEVELOPMENT**

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Background. Stone pine is one of the most characteristic tree species in the Mediterranean, specially, because of the ancient use of its edible seeds. In Turkey, stone pine (*Pinus pinea*) is the most valued pine species because of the multifunctional management. Multi-objective management of stone pine forest focuses on timber and pine nut, as the main products, as well as other beneficial values such as soil protection, recreational use and biodiversity.

From all these ecosystem services and products, nut production is currently the most profitable one for the owners of stone pine forests and villagers. Pine nut production in the stone pine areas promotes rural development by providing employment and supplementary income for forest villagers. Stone pine forests can play an economic role in increasing income level of forest villagers thanks to its primary and secondary products. In Turkey, incomes coming from pine nut production are around about three times greater than incomes coming from timber production.

Turkey is one of the largest producers and exporters of pine nut in the world. The great economic and social importance of stone pine (*Pinus pinea*) forests cause to increase the plantation areas in Turkey. Based on legal pine kernel production for 2000-2010 data, total annual production of pine cone in Turkey increased from 1500 to 6000 tons and estimated pine nut production changed from 120 to 500 tons.

Methods. In this study, all stone pine areas of Turkey have been examined in terms of natural and plantation areas, age and developing conditions. In addition, based on amount of villagers, annual pine nut exportation and income from international trade statistics and annual trade income per villagers from pine nut have been estimated. In this way, contribution of stone pine forests in Turkey on rural development and strategic importance of Turkey in global pine nut market is obtained.

Session 5. Pine nut industry and markets

STONE PINE IN PORTUGAL: MAIN POLICIES AND RECENT DEVELOPMENTS

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Background. Main national forest policies in Portugal targeted at *Pinus pinea* and pine nut sector are presented. *Pinus pinea* has a high importance for certain regions in Portugal. It is a species that is used to protect and restore degraded soils, while providing habitat for many species. Its economic value is also very relevant, mainly for pine nut production, but also for wood, resin and biomass, providing a good financial return for forest owners. Exports of pine nuts largely cover imports (over 15 million euros in 2015) and prices of pine cone and nuts have been increasing over the past decade.

Methods. The diversity of functions performed by stone pine stands had a consequence on the priority given to it in public afforestation programs, with resulted in an increase of 46% of the area of this species, between 1995 and 2010.

A center of competences that gather entities interested in stone pine and pine nut production, research, industry, as well as the public authorities, is now looking at problems affecting stone pine and pine nuts in order to improve knowledge and build synergies to solve them – pests and diseases are main concerns, as well as nutrition, silvicultural models and species improvement.

Results. A new legal regime for the harvest, transport, storage, processing, import and export of pine cones was recently established. This law regulates a set of procedures, including the registration of economic operators and the mandatory prior notice of the activities carried out in the whole economic circuit (from the cone harvesting to the cone processing) in an information system (SiP). The most recent data obtained in this system will be presented and discussed.





Poster Session 1. Management of stone pine for cone production in agroforestry

PORTUGUESE STONE PINE SILVICULTURAL SYSTEMS FOR CONE PRODUCTION

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Purpose. This study presents guidelines for a stone pine silvicultural system in order to optimize the production of cone and kernel per hectare in various development stages of the stand, characterizing the influence of cultural treatments such as thinning and pruning on cone production per hectare and on pinion nut and kernel yield and production per hectare. Also is presented the second version of an Excel tool that uses these rules, the PineOptim1.

Methods. Data was mainly collected in 77 permanent plots established in 2004 and 2005 in a stone pine provenance region with higher cone production in Portugal. The plots were installed in stands of different ages and under different conditions of competition, corresponding to pure or mixed stands of stone pine with cork oak and/ or holm oak and / or maritime pine. The inventory of the plots was repeated in 2011 and 2015/16. Cone production in most plots was measured between 2004/05 and 2007/08, and between 2013/14 and 2015/16.

Results. The plots with higher cone production were those that, in general, had reduced competition between the trees, being a key condition good exposure of the canopy to light and free of intraspecific and interspecific competition. However, it seems to be a tendency for increased cone production in mixed stands with cork oak and lower cone production in stands with maritime pine.

Conclusions. The data collected so far suggests that forest system for stone pine have to be adapted according to the conditions of climate and soil. Future research should focus on maintaining and expanding the network of permanent plots in stone pine in order to obtain long-cone production series and geographically distributed and the study of possible synergies with other species, including the cork oak, a nature multiple use.

Poster Session 1. Management of stone pine for cone production in Agroforestry

**DO WE NEED NEW SILVICULTURE MODELS FOR STONE PINE STANDS TO
ENHANCE BIODIVERSITY AND RESILIENCE AGAINST INSECT PESTS?**

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Background. Until a few decades ago, a large part of the woodlands where stone pine prevails were favorable for biodiversity and wildlife, thus providing scenic landscapes. Some of the best examples can still be found in the region of Alcácer do Sal, Portugal, and in Southern Andalusia, Spain. Many of these forests are not managed in an intensive way, being uneven aged in general, rather open and with glades of fractal size, mixed with cork oak in many areas, and with a rich floristic understory which include *Juniperus navicularis*, *Laurus nobilis*, *Myrica faya* or *Q. coccifera*. Although timber is the main target in many of these stands, such as the ones at the National Forest of Valverde (Alcácer do Sal region), in the remaining areas, and chiefly in mixed stands with cork oak, pine cones for extracting their edible pine nuts are a very important yield, besides cork, sheep and game hunting returns. In such areas, problems concerning biodiversity and pests damage do not seem to be relevant, and the sustainability of the stone pine ecosystems appears to be ensured in the long term.

However, since the 90's of the XX century, new plantations of stone pine have been taking place in Portugal, with its total area increasing in more than 55,000 ha from 1995 to 2010, mostly consisting of pure and even-aged stands. Furthermore, settlement of stone pine orchards, grounded on genetic selection and grafting for pine nut production, exclusively, have been gaining increasing interest in recent years. As well as intensive agriculture systems are continuously facing pest damage and control problems arise - where chemical pesticides usage is losing terrain -, the pure and dense young stone pine stands suffer from similar problems – e.g. severe outbreaks of pine processionary moth (*Thaumetopoea pityocampa*) or western conifer seed bug (*Leptoglossus occidentalis*), affecting pine nut yield. This is a risk that faces all intensive, dense, and monoculture crops or plantations in general. Looking for profits is proper, but the excessive artificiality of biological systems is usually paid in the medium and long term.

Purpose. Considering the above concerns, we present and discuss here the need of new and sustainable silviculture models for the forthcoming stone pine plantations and a posteriori management measures aiming at the biophysical rehabilitation of the structural vegetation of the already installed even aged stands, in order to enhance its biodiversity and the natural resilience to insect pest damages. Furthermore, short term measures are also suggested for the existing stone pine woodlands targeting to keep insect pests populations at harmless levels.

Methods. Selection of stone pinewoods case studies: extant woodlands before the Community Support Framework (CSF) 1986 vs. plantations after the CFS 1986 will be analyzed.

Results and Conclusions. The majority of stone pine plantations established in Portugal after the late 80's of the 20th century seems to be successful, but the stands have in general a very simple vegetation structure, not only regarding the tree layer but also the understory, and therefore also simplified animal assemblages. Outbreaks of pine processionary moth in younger pure stone pine stands seem rather common. Some ideas on planning and management of stone pine forests regarding their ecological and economical sustainability are revisited here, since almost all have been highlight as long as for thirty or forty years.

Poster Session 1. Management of stone pine for cone production in agroforestry

**OVERVIEW: THE PAST AND THE FUTURE RESEARCH
ABOUT STONE PINE (*Pinus pinea* L.) IN THE AEGEAN REGION**

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Natural and planted area of *Pinus pinea* L. cover 195,000 ha in Turkey, 72% located in the Aegean Region. The most important pine nut production areas, especially Kozak and Koçarlı Provinces, are territorially within the responsibility of our Ege Forestry Research Institute, located near Izmir.

Several projects about stone pine had been carried out in EFRI in the past, for example socio-economic studies, effects of biotic factors and nutrients on conelet losses, provenance trials, or about effect of fertilizing on cone yield. There are ongoing projects about the effect of different pruning treatments on cone production; construction of stem value tables; integrated crop management programs.

Some project about phenology, pollination biology and climatology, *Leptoglossus occidentalis* infestation and fungal seed pathogens, and Integrated Pest management (IPM) against biotic and abiotic factors has been developed in cooperation with different faculties of Ege University Izmir.

In this communication, all studies – finished, ongoing and planned for the near future – are briefly introduced, and their results and impact are discussed, underlining the ecologic, economic and social relevance of stone pine for our region.

Poster Session 1. Management of stone pine for cone production in agroforestry

**ADAPTIVE MULTIFUNCTIONAL MANAGEMENT AND VULNERABILITY OF
Pinus pinea STANDS UNDER A GLOBAL CHANGE SCENARIO**

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Background. During millions of years, forests have experimented numerous and intensive climatic changes, which they have been capable to overcome through variation in their distribution, specific composition and structure. However, the current climate change occurs in a global change scenario, where forests suffer a high human pressure. For instance, Mediterranean forests, located in a transitional climatic zone, are especially sensitive. Thus, it is important to manage the change to reduce the negative impact on the ecosystems services (ES) provided by forests.

Purpose. With this purpose in mind, we present the project RTA2013-00011-C02-01 “Adaptive multifunctional management and vulnerability of *Pinus pinea* stands under a global change scenario”, financed by the Spanish National Research Programme. Its main objective is to define the adaptive multifunctional management of *Pinus pinea* stands in Spain, based in a better knowledge of the species vulnerability and the sustainability of its management, using different representative regional case studies, different management alternatives and climate and socioeconomic scenarios.

Methods. Current sustainable forest management (SFM) is compared with the proposed adaptive management through different field experiments. The valuation and comparison of the management alternatives is done through indicators of SFM, including the provision of ES (timber production, non-timber products, carbon sequestration). Improved models for the assessment and projection of ES for each forest system, management alternative and scenarios as well as novel planning and decision support tools are developed.

Results. The results will allow comparing different alternative managements and defining the optimal forest management for each scenario and forest system. The scientific knowledge acquired on the management of these stands should be transferred to the stakeholders for their active interaction.

Discussion. Thus, the project assess the effect of global change in *Pinus pinea* stands by: vulnerability of the stands under climate change and related human activities, and adaption to minimize the negative impacts of global change in the forest systems and in their functions. Adding the need to transfer the results, we get three parts (vulnerability, adaptive management and transfer of results) which are not independent, interacting among them. The project is coordinated between INIA-CIFOR, the University of Huelva and the SME Föra Forest Technologies (for the transfer of the results).

Poster Session 1. Management of stone pine for cone production in agroforestry

**SHORT-TERM EFFECT OF TREE THINNING ON THE REGROWTH OF
POST-FIRE *Pinus halepensis* MILL.**

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Background. Wildfires have increased worldwide, mainly in Mediterranean forests, mostly due to climate change and abandoned rural areas. Mediterranean woody species are known to regenerate directly and abundantly after a fire. Therefore, post-fire regeneration should be managed as soon as possible in order to reduce fire hazard with the possibility of installing an agroforestry system.

Purpose. The objective of this study was to investigate the growth response of *Pinus halepensis* Mill. at tree-level and accumulated biomass at stand-level in 15-year-old post-fire regenerations subject to different thinning intensities (no thinning, strong thinning: 1200 remaining trees/ha, and very strong thinning: 600 trees/ha).

Methods. The experiment was set up at three separate sites (Mariola, initial density of 290,000 trees/ha; Bocarient, 170,000 trees/ha, and Albaida 100,000 trees/ha) located in the Valencia region in Spain, with three years of monitoring growth, relative change (rc =Absolute Growth Change divided by the initial value, before tree thinning) as well as the Relative Growth Change (RGC) of both tree height (H) and diameter at the base (D), as well as live crown ratio (LCR).

Results. All growth variables were significantly influenced by thinning, the site and the interaction between these two factors. The mean $rc\ H$ (also RGC) in both Albaida and Bocarient was the highest for the very strong thinning, and the lowest for the no thinning treatment, with an intermediate value for the strong thinning; whereas for Mariola the opposite tendency was observed. The unthinned treatment had the lowest mean $rc\ D$ (also RGC), whereas the two thinning treatments had about the same $rc\ D$ (also RGC) only for Albaida and Mariola. LCR was the lowest for the unthinned treatment and about the same for the two other thinning treatments for Albaida and Bocarient. The accumulated dry biomass at stand-level was higher for the strong thinning than for the very strong thinning (before treatment 10,316 kg/m² vs. 4,135 kg/m²).

Conclusions. The effect of thinning on tree growth (expressed in terms of RGC and rc) in post-fire regenerations can be detected even in the short term, and very strong thinning tends to improve growth.

Poster Session 1. Management of stone pine for cone production in agroforestry

STONE PINE THINNING TRIAL IN THE CENTRAL REGION OF PORTUGAL

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Background. Stone pine (*Pinus pinea* L.) is an important species in Portugal and, according to the last national forest inventory, is the 5th species in area occupying 173,716 ha of pure and dominant stands that correspond to 6% of the total forestland. Since 1985, the Community Support Framework defined the initial densities for stone pine evenaged stands. For stands where the main product is pine kernels, the minimum planting densities ranged between 200 and 800 trees/ha. However, in Portugal, there are no trials that show the effect of density in the production of pine cone and existing knowledge is based on data from permanent plots installed in stands with different densities and ages.

Purpose. In order to support the definition of stone pine even-aged silvicultural models, a thinning trial was installed and the relation between density and stand and mean tree variables was analysed.

Methods. Under the FFP/2006.09001077.5 project coordinated by INIAV, a thinning trial was installed in the Escaroupim National Forest in October 2007, in a pure evenaged stand planted in March 1992 (spacing 4x4). Systematic thinning were applied in two blocks and four treatments per block: moderate thinning (spacing 4x8, 313 trees/ha), heavy thinning (spacing 8x12, 104 trees/ha), operational thinning (spacing 8x8, 156 trees/ha, and control (spacing 4x4, 625 trees/ha). The plots, with 5,000 m² of area, were thinned in autumn 2007 and all remaining trees were pruned. Inventories were carried out in 2007, 2010, and 2013 (at respective age 16, 18, and 21 years), measuring diameter at breast height of all trees, total tree height of a tree sample including dominant trees, and crown radius in a tree sample. In 2007, due to the high stand density and the fact that the trees had never been pruned, inventory was carried out only after thinning. In a tree sample, dbh and the corresponding stump diameter were measured and an equation was fitted and used to estimate dbh of felled trees before thinning. Also in 2007, some of the thinned trees were used to obtain biomass fractions. Cones will be harvested in the 2016/17 campaign, in order to quantify the effect of thinning in cone production.

Results. Effects of thinning in the development of per hectare stand variables (basal area, total volume and biomass) and the mean tree (diameter and volume) were evident since 2010. Basal area, stand volume and total biomass growth, between 2007 (after thinning) and 2013, were higher in the control plots (with a high number of trees) and smaller in the heavy thinning plots. But quadratic mean dbh and mean tree volume growth were higher in the heavy thinning plots when compared with the other treatments.

Poster Session 2. Growth and yield modelling

**MATURE *Pinus halepensis* MILL. SPRING PHENOLOGY
IN BEJA FORESTS (NORTH OF TUNISIA)**

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Background. Aleppo pine is the main forest species in Tunisia known by its multi-uses purposes.

Purpose. Within the present research work, we are interested on the phonological variability of the species in Beja forest area.

Methods. For this, eight natural forest sites within Beja district were selected to follow the species phenology during the spring season. Forest sites are located in two bioclimatic forest zones (subhumid and upper semi arid) where we followed foliage and growth development, vegetative buds and flowering achievement related to climate, geography, site characteristics and tree size measurements. During the experimental design dominant tree and average tree per site and per bioclimatic zone were sampled.

Results. Mature Aleppo pine needles thickness and width of the average tree were significantly important in the upper semi arid than needles in the subhumid forest areas. Similar results were also recorded for the average tree developing needles but in this case, needles sampled from subhumid zone have significant higher length, fresh and dry weight in addition to higher surface area than developing needles in the upper semi arid forest area. Characteristics of developing needles of the dominant tree are better in the subhumid than in the upper semi arid zone. Floral or vegetative buds traits are significantly better in the subhumid for both sampled size trees.

Conclusions. Similarly, it was deduced that blooming and species phenology are influenced by environmental conditions and tree's size within forests. Findings are significant but require further contributions in time and space.

Poster Session 2. Growth and yield modelling

IMPACT OF ENVIRONMENTAL FACTORS ON ALEPPO PINE PHENOLOGY IN CENTRAL TUNISIA FORESTS

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Background. The main forest tree species in central Tunisia (Siliana and Kairouan) is Aleppo pine with more than 94% covering area. This species have important benefits of goods and services mainly for rural populations.

Purpose. The present study is interested on Aleppo pine phenological variability in central Tunisia forests located in two different bioclimatic zones (upper and middle semi-arid zone).

Methods. An overall of 785 Aleppo pine trees sampled from eight natural forest sites within Siliana and Kairouan districts were measured and selected to follow the species phenology. During this research work we followed foliage and its growth development, vegetative buds and flowering achievement related to environmental factors. Phenological variables were only measured for the dominant and the average Aleppo tree for each stand per bioclimatic zone.

Results. Mature Aleppo pine needles traits (length, thickness, width, weight and surface area) of the dominant tree were significantly better in the middle semi-arid stand than in the upper semi-arid forest areas. However, results recorded for developing needles sampled from both trees types (dominant tree or average tree) showed that needles measurements were significantly better in the upper semi-arid forest zone than in the middle semi-arid area. Buds emergency traits recorded were considerably better in the middle semi-arid than in the upper semi-arid forest zone.

Conclusions. It was deduced that species phenology is influenced by ecological factors and tree characteristics. These deductions are considerable and call for promoting extra coming contributions for better understanding the species growth and yield.

Poster Session 2. Growth and yield modelling

**CONSTRUCTION OF NEW SITE INDEX CURVES
FOR THE SPATIAL TREE GROWTH MODEL *PINEAFITS*:
A HOLISTIC STUDY APPROACH WITH STEM ANALYSIS**

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Background. Stone Pine (*Pinus pinea* L. 1753) is a typical species of the Mediterranean areas, whose studies about growth dynamics and production are still less developed. Forest production of a specific stand is estimated starting from the study of single-tree growth dynamics, or a stand as a whole. Stem forms may vary whether in the same species or even in the single tree, depending on the station, silvicultural prescriptions and genetic constitution. Stem analysis represents an interesting alternative to estimate tree growth in a fast and precise way, allowing predicting tree evolution and, on a wider range, producing analysis on the future production of the stand.

Purpose. Starting from the collected data with this methodology, this work aimed to assess the growing trend of the stand, by developing a statistical model fitted to it.

Methods. Several growth equations have been tested.

Results. Monomolecular function was the best capable of fitting the collected data trend for the creation of Site Index Curves. Gompertz function was applied for the diameter growth model. Furthermore, outputs from the stem analysis (conveniently treated and combined with other instruments) are available to provide a useful decision support tool for forest management and stand ecology analysis.

Conclusions. Obtained results, adequately compared with previous studies provide a solid analysis tool and will serve for the further development of the spatial tree growth simulator *Pineafits*. The development of a new Site Index function and a diameter increment model for the National Forest of Cabeção serves as a new tool to better understand the dynamics of the stand in question and to aid the decision-making process in future forest management activities. Moreover, stem analysis methodology was proved to be a very efficient and precise approach to assess and study individual-tree growth, allowing us to confirm and expand our knowledge about stand dynamics and tree response to silvicultural interventions. Perspectives for this study are to be found in the next inventory, when a new data set at stand level will be available, allowing new considerations and a more accurate study on the population dynamics: competition, mortality, succession and regeneration. Finally, the improvement and implementation of the individual-tree growth simulator *Pineafits* is the next step to work on.

Poster Session 2. Growth and yield modelling

**DROUGHT EFFECT ON XYLEM VULNERABILITY TO CAVITATION
AND HYDRAULIC TRAITS IN *Pinus halepensis* MILL.**

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Background. Rapid transpiration during drought increases water tension in the xylem and the risk of cavitation in the conducting units of trees and water transport dysfunction. Low vulnerability of xylem to cavitation may account for resistance to drought and explain some species distribution patterns. Resistance to drought-induced cavitation is an intrinsic property of the conductive elements, and is usually characterized by the xylem water potential causing 50% loss of hydraulic conductivity (P_{50}), a proxy of vulnerability to cavitation.

Pinus halepensis Mill. is widely distributed in the Mediterranean region, and different provenances introduced in south-east France displayed different survival rates, supposedly associated with different drought resistance levels.

Methods. We compared P_{50} values of branches of the same age of *P. halepensis* sampled in a common garden where several provenances were planted and from the Font-Blanche forest where it occurs naturally as a result of recolonization. The planted provenances were chosen for their different aptitudes to survive to drought conditions.

Results. Difference of response of the shoots were found regarding vulnerability to drought, with mean xylem tension for P_{50} ranging from -5.6 MPa to -4.4 MPa with a better xylem resistance displayed by pines from the natural forest site and by one of the provenance having a low survival rate in plantation.

Conclusions. This suggests that vulnerability to cavitation may not be the driving factor of resistance to drought for that species. Those results will be discussed in the light of other morphological traits associated with water conduction and water loss (namely specific conductivity and leaf specific conductivity). Short-term and long term effect of drought on these hydraulic traits will be analysed based on additional measurements made on trees from the Fontblanche forest, that were subjected or not to an artificial 30% rainfall decrease and from forest sites in south east France along a rainfall gradient.

Poster Session 2. Growth and yield modelling

**IMPACT OF CLIMATE CHANGE ON THE
ECOPHYSIOLOGICAL PARAMETERS OF STONE PINE IN TUNISIA**

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Background. Climate change resulting from increased concentrations of atmospheric carbon dioxide (CO₂) is expected to result in warmer temperatures and changed precipitation regimes during this century. These changes will increase summer evapotranspiration and increase the frequency and severity of droughts. The extent of these effects will depend on the magnitude of climate change, the abilities of individual trees to acclimate, and for tree populations to adapt in situ, or to migrate to suitable habitats.

Stone pine (*Pinus pinea* L.) is one of the most important forest tree species in the Tunisian reforestation programme. *Pinus pinea* has been successfully introduced into North Africa mostly Tunisia. Drought stress is one of the major abiotic stresses in agroforestry worldwide.

Purpose. This study was carried out to investigate the effect of drought stress on ecophysiological processes between different tree diameters.

Methods. The experiment was carried out in the field of Souiniet, located NW of Tunisia in the region of Jendouba (35°54', 8°48', 492 m a.s.l.). Measurements were conducted during the dry season. Photosynthetic rate (AN), stomatal conductance (gs), intercellular CO₂ concentration (Ci) and transpiration rate (E) were measured using a portable photosynthesis system (LI-6400XT, Licor, Inc., Lincoln, NE, USA). Parameters were measured with saturating light (1,400 $\mu\text{mol m}^{-2} \text{s}^{-1}$ provided by an external light source), 400 $\mu\text{mol CO}_2 \text{ mol}^{-1}$ and 25 °C (average leaf temperature during measurements) of leaf block temperature.

Results. We noticed that stone pine supports the environmental stresses. Photosynthesis, transpiration, and intrinsic leaf WUE increased with the diameter of tree.

Poster Session 2. Growth and yield modelling

STONE PINE BIOMASS ALLOMETRIC EQUATIONS ANALYSIS FOR THE MEDITERRANEAN AREA

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Background. Forest carbon stocks evaluation is based on estimates of forest biomass, usually by applying biomass equations to forest inventories. Studies regarding forest biomass in stone pine species have been performed on the Mediterranean basin, namely Italy, Spain and Portugal.

Purpose. The aim of this study was to analyze the aboveground biomass estimated with the allometric equations published in each of these countries, assessing the behaviour of regional specific biomass equation applied to data from another region.

Methods. A dataset of 250 trees was gathered with the tree biomass obtained by destructive sampling undertaken in several regions representing the stone pine species distribution area in these countries. Aboveground biomass of each tree was expressed as the sum their tree components: stem (wood + bark), branches and needles. Stand age (t), stand density (N) and basal area (G) were only available for the plots from Italy and Portugal. The overall objective was to perform a residual analysis by applying the different country models to the dataset, using two approaches to estimate aboveground biomass: (1) with general equations, (2) with a system of compatible biomass equations per tree component (needles, branches, stem).

Results. Although the tree dimension range may differ along countries/regions, the relationship between aboveground biomass and tree diameter shows the same correlation pattern. This may suggest an allometric uniformity between trees from different ecological regions and management. Regarding the biomass allocation by component, for the some tree dimension, some differences were found between the countries/regions that may be due to a geographical adaptation. When applying the general equations of the considered countries to estimate aboveground biomass, we observed that the estimates were more biased for trees with diameters higher than 40 cm.

Conclusion. The inclusion of total tree height as an additional explanatory variable to tree diameter, improved the accuracy of the model, with a significant decrease in the residual sum of squares.

Poster Session 2. Growth and yield modelling

UMBRELLA PINE ABOVE GROUND BIOMASS ESTIMATION WITH HIGH RESOLUTION SATELLITE IMAGES

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Background. Above ground biomass is frequently estimated with forest inventory plot data with an extrapolation method for the per unit area evaluations. This procedure is labour demanding and costly. On the other hand, the estimation per unit area is based on the forest inventory sampling design and intensity for the defined error threshold.

Methods. In this study, above-ground biomass functions, whose independent variable was the crown horizontal projection, were developed. Multi-resolution segmentation method and object oriented classification, based on high resolution satellite images, were used to obtain the area of tree crown horizontal projection for umbrella pine (*Pinus pinea*). In the study area a set of inventory plots were measured and with existing allometric functions for this species above ground biomass per tree and per plot were calculated. The data sets were used to fit linear functions both for individual plot and their cumulative values.

Results. A good performance of the models was achieved. Errors of 10% and 5% were attained for crown horizontal projection areas of 10,000 m² and 15,000 m², respectively. Considering the mean value of crown horizontal projection per plot (4,565 m²ha⁻¹) which corresponds to a mean ground area of 7,124.9 m², errors smaller than 10% and 5% are obtained for stand areas greater than 1.4 ha and 2.1 ha, respectively.

Conclusions. The obtained functions have the advantage of estimating above-ground biomass for all the area not requiring forest inventory.

Poster Session 3. Genetic Improvement, selection and breeding of stone pine

**COMPARATIVE STUDY OF PHENOLIC COMPOUNDS AND
ANTIOXIDANT ACTIVITY OF NORTH AFRICA MARITIME PINES**

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Background. Maritime pine (*Pinus pinaster* Aiton) is a highly valuable coniferous species broadly distributed in the western Mediterranean Basin reaching the High Atlas and Tunisian in North Africa.

Methods. This study was conceived about the phenolic compounds of methanolic extracts and antioxidant activity of essential oil in two North Africa maritime pines varieties (var. *maghrebiana* and var. *renoui*), introduced at Souiniet arboretum of Tunisia. The antioxidant activity was evaluated by the 2,2-diphenyl-picrylhydrazyl (DPPH). The total phenolic, flavonoids and tannins concentrations of tested extract were determined using spectrophotometric methods.

Results. Significant differences were founded between the two varieties. We showed that var. *maghrebiana* from Maroco presented higher polyphenol (28, 87 EAG/g), flavonoid (4, 86 CU/g) and tannin (28 CAT/g) contents than Var. *renoui* from Tunisian. In addition, var. *magrebiana* showed the best antioxidant activity.

Conclusion. Var. *maghrebiana* extract will be a good selection as natural source of antioxidants in future reforestation in North Africa.

Poster Session 3. Session Genetic Improvement, selection and breeding of stone pine

**EFFECT OF ENVIRONMENTAL CONDITIONS ON CHEMICAL POLYMORPHISM
AND BIOLOGICAL ACTIVITIES AMONG
Pinus halepensis PROVENANCES GROWN OF TUNISIA**

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Background. *Pinus halepensis* Mill. is used in traditional Tunisian medicine and as condiments. In traditional Tunisian cuisine, pine nuts of this specie, commonly called “zgougou”, are ground for a paste.

Methods. In the present study, two extracts were prepared from seeds of this species, collected at two sites, Béja, some 90 km west of the capital Tunis, and Siliana, 80 km south, for comparing their chemical profiles.

Results. A significant qualitative and quantitative variation of the composition and biological activities according to the studied localities was revealed. Quantitative estimation of total phenol, flavonoid and tannins content by a colorimetric assay showed that the methanolic extracts from Siliana has a strong content in total phenols (0.584±0,1 mg/g) compared with the extract from Béja (0.5039±0.01 mg/g).

Assessment in vitro antioxidant activity using a 2,2-diphenyl-picrylhydrazyl (DPPH) showed that the methanol extracts of pine nuts from Siliana exhibited good antioxidant activity (0.08 mg/ml) compared of those from Béja (0.1 mg/ml). From the correlation analysis, significant correlations were observed between the total phenols or flavonoid or tannins contents in methanol extracts and antioxidant activity. In addition, methanolic extracts exhibited antimicrobial activity.

Conclusions. The methanolic extract of Tunisia *Pinus halepensis* could be considered as a source of potential antioxidants and will promote the reasonable usage of these plants in food technology and processing as well as for medical use. In addition to cultivation and climatic conditions at origin, variation of phytochemical profiles and biological activities might be related in a part to genetic factors. Selection of the optimal environmental conditions and the best genotypes for the industrial exploitation of the studied species needs further investigations.

Poster Session 3. Genetic Improvement, selection and breeding of stone pine

**ECOPHYSIOLOGICAL RESPONSE OF EIGHT PROVENANCES
IN A PROVENANCE TRIAL OF *Pinus pinea* L. IN TORDESILLAS (VALLADOLID)**

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Background. *Pinus pinea* is a widespread Mediterranean species with a high adaptive plasticity to the unpredictable Mediterranean environment that, however, shows an exceptional low diversity and differentiation in different traits. Although the response of the provenances to different resources availability is moderate, the species shows an ecological grouping of the provenances along a latitudinal gradient and an inland-coastal gradient. Regional climatic change scenario projections expect that the Mediterranean region will be especially vulnerable to climate change. Among the measurements to reduce vulnerability to climate change provenance selection is proposed.

Purpose. The aim of this study was to compare environmental and physiological traits throughout a year on eight *Pinus pinea* provenances of an international provenance trial in Tordesillas (Valladolid) to know the adaptative behavior to the environmental conditions of the site.

Methods. Soil moisture (%), specific leaf area ($\text{m}^2 \text{kg}^{-1}$), needle water potential (MPa), dimensionless chlorophyll fluorescence related parameters – maximum quantum efficiency of PSII photochemistry (F_v/F_m), quantum efficiency of PSII (PSII) and electron transport rate (ETR) – and gas exchange parameters – photosynthetic rate (A , $\mu\text{mol m}^{-2} \text{s}^{-1}$), transpiration rate (E , $\text{mmol.m}^{-2} \text{s}^{-1}$) and stomatal conductance of CO_2 (g_s , $\text{mmol m}^{-2} \text{s}^{-1}$) – were measured once a month in 4 trees per provenance during one year.

Results: The ranges of values of the variables were as follows: $0.1 < \text{soil moisture (\%)} < 11.5$, $2.07 < \text{specific leaf area (\text{m}^2 \text{kg}^{-1})} < 25.09$, $(-1.8) < \text{needle water potential (MPa)} < (-0.2)$, $0.63 < F_v/F_m < 0.91$, $0.49 < \text{PSII} < 0.84$, $3.4 < \text{ETR} < 53.95$, $0.004 < A < 4.74$ ($\mu\text{mol.m}^{-2}.\text{s}^{-1}$), $0.004 < E$ ($\text{mmol.m}^{-2}.\text{s}^{-1}$) < 0.62 and $0 < g_s$ ($\text{mmol.m}^{-2}.\text{s}^{-1}$) < 0.27 .

The results show that the different provenances have a similar behaviour in physiology except in May 2015, which was extremely dry (3.02 ± 0.23 %). In this month, significant differences between provenances in soil moisture, specific leaf area and gas exchange parameters (A , E and g_s) were found.

Conclusions. It is interesting to note that the differences between provenances were related to unexpected low soil water availability in May, when trees are actively growing. Our results confirm the low differentiation between provenances.

Poster Session 4. Biotic risks and their impact on stone pine products

***Pinus pinea* VOLATILES, BEFORE AND AFTER INOCULATION
WITH THE PINEWOOD NEMATODE, *Bursaphelenchus xylophilus***

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Background. The pinewood nematode (PWN), *Bursaphelenchus xylophilus*, is the causal agent of pine wilt disease, a serious threat to global forest populations of conifers, especially *Pinus* spp. In Portugal the PWN was detected for the first time in 1999 in *Pinus pinaster*, associated with the insect vector, *Monochamus galloprovincialis*. Portuguese pine forests are dominated by *P. pinaster* and *P. pinea* L. but only the first species is currently associated with PWN infection. *P. pinea*, which commonly co-occurs in the infested zone, has shown no symptoms and has been classified as moderately resistant to the PWN. Limonene, the most abundant terpene from *P. pinea* volatiles, has been reported as toxicant and as an oviposition deterrent for several pine-infesting insects.

Purpose. Aiming to obtain further information on the constitutive and nematode inoculation induced plant volatiles, a time-course study of the volatile profile of 2-year-old *P. pinea* was performed for 7 weeks after inoculation with the PWN.

Methods. 2,000 PWN (mixed stages) from a virulent Portuguese isolate were inoculated into superficial incision wounds in the uppermost branch of each individual. Volatiles from whole plant healthy controls (H), mechanically wounded controls (MW) and PWN inoculated (IN) individuals, were isolated by hydrodistillation and analysed by GC and GC-MS. Additionally, the volatiles from the inoculation areas (INa) and uninoculated wounded areas (MWa), and the main volatile enantiomers from H, MW and IN individuals, were also evaluated. The essential oils (EOs) from H individuals were characterized by chemical consistency and the dominance of limonene (52-61%).

Results. Cluster analysis revealed no substantial differences in the EO composition that would allow establishing a distinction between H, MW and IN individuals. The monoterpene hydrocarbon enantiomeric composition analysis also did not show major variations between H, MW and IN individuals. However, volatiles isolated from the INa and MWa revealed an increase in diterpene resinic acids comparatively to the monoterpene hydrocarbon rich volatile profile from whole plants. Diterpenoid resin acids are also of importance in wound sealing, some being considered insecticidal or fungicidal and its role in PWN infection should be further investigated.

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Poster Session 4. Biotic risks and their impact on stone pine products

**IMPACT OF THE DRY CONE SYNDROME
ON KERNEL YIELD FROM STONE PINE CONES**

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Background. The economic relevance of Mediterranean stone pine, *Pinus pinea* L., is based on the harvest of its cones for extracting the edible Mediterranean pine nuts kernels. But recently, a severe loss of kernel-per-cone yield has been reported by processing industries for stone pine cones collected in all main producing countries, from Portugal to Lebanon: When cracking apparently sane cones, up to half of the seeds have been found to be empty. Additionally, cone pickers have also been observing a high percentage of small, unripe conelets aborted in the crowns, a loss that reduces the final number of harvested cones. The recent coincidence of both phenomena has coined the common name *Dry Cone Syndrome (DCS)*, suggesting a possible common agent. Awareness has grown about the emergence of *DCS* all over the Mediterranean range of stone pine only in the last four years, after first alarms from Italy ten years ago. *DCS*, if persisting, is regarded as a serious threat for commercial pine nut harvesting, an activity essential for the economic sustainability of Mediterranean pine forests and plantations and for the cone processing industry in Europe, with a market of several hundred million euros annually.

Methods. In 2014, a first survey of cone processing industries produced a short dataset, which has been updated and enlarged, in order to assess the impact of *DCS* on the pine nut sector.

Results. Available time series of seed per cone yield data from cone processors are analysed and discussed. Average pine nut per cone weight yield has dropped in the last years from stable 17±3% to less than 12% since, kernel per cone weight yield from 4±0.5% to less than 3 (1.5-3.0)%. The reason in an increase in percentage of empty or damaged seeds from values less than 10% up to 34-50%.

Conclusions. The observed damages, conelets abortion as well as seed abortion, empty or only partially filled seeds that reduce the kernel-per-cone-weight yield, are plainly compatible with kinds of damages in other conifer species attributed to the introduced invasive seed-feeding bug *Leptoglossus occidentalis*. The prevalent causality of *Leptoglossus* as main biotic agent, however, or possible implications of increasing draughts or phenological shifts due to climatic change, must be elucidated by ongoing research by groups such as the Laboratory for Forest Zoology at INRA Orleans, INIA-CIFOR Madrid, the U. Valladolid, as well as Portuguese groups at ISA (U. Lisbon) and INIAV, or the EFRI Izmir in Turkey, among others.

Poster Session 4. Biotic risks and their impact on stone pine products

**SEX PHEROMONE OF THE CONE MOTH *Dioryctria mendacella* (STGR) AND
DEVELOPMENT OF OPERATIVE LURES**

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Background. The cone moth *Dioryctria mendacella* is a known stone pine pest, attacking cones of all ages and causing reduction of cone production all over the Mediterranean. Life traits of this species make particularly difficult the knowledge on its biological cycle and monitoring of its population dynamics.

Purpose. Studies to identify the female sexual pheromone of this species a operation lure were carried out aimed to develop a operational lure for monitoring.

Methods. Wild individuals were collected as late overwintering larvae and allowed to pupate. Pheromone glands of virgin female moths were extruded and excised into hexane and extracted.

Pheromone extracts were analyzed by gas chromatography (GC), GC coupled to mass spectrometry (GC-MS) and GC coupled to electroantennographic (EAG) recording from the antenna of a male *D. mendacella* moth. Field trapping tests of synthetic candidates were carried out in Valladolid province. Pheromone dispensers were polyethylene vials or rubber septa and traps were sticky delta traps, replicated seven times.

Results. The Cone moth pheromone is composed of at least two compounds, a dienyl acetate and a polyunsaturated hydrocarbon. The former elicits a strong EAG response from males while no response could be recorded to the latter. In field trapping tests, both compounds were individually unattractive to males, but blends of the two compounds were highly attractive. Several ratios, emission rates and purities of blends of these two compounds were tested.

Conclusions. A lure based on the blend, suitable for operational monitoring than can be used in cone moth management programs, was finally determined.

Poster Session 4. Biotic risks and their impact on stone pine products

***Leptoglossus occidentalis* DAMAGES
ON STONE PINE FEMALE REPRODUCTIVE STRUCTURES**

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Background. Stone pine (*Pinus pinea*) is one of the most important forest species in Portuguese forest context, generating economic benefits to the entities exploiting the species, particularly in fruit production (pine nuts). The detection of *Leptoglossus occidentalis* in Portugal since 2010 seems to be related with a significant decrease in production and productivity of pine cones, nevertheless the difficulty to detect and quantify its damages. This Hemiptera is a sucking insect that feeds on developing seeds of various conifer species by inserting its stylet between the cone scales and reach the developing ovules.

Results. Measurements of *L. occidentalis* stylet and body length, in the five nymphal stages and adults, and female reproductive structures, since flowering to the beginning of shell formation, show that its biological cycle is dependent and coincident with stone pine reproductive phenology. The distances between the ovules and cones surface were measured on the 1st, 2nd and 3rd spring cones, indicating that all development stages of *L. occidentalis* are capable of damaging the ovules, except the 1st instar on the 3rd spring cones.

In the 2nd spring cones, damages were observed in the channel formed by the junction of the scales and it was also possible to observe cellular damages in the developing ovules.

Conclusions. Through these histological observations it was possible to detect damages and by their characteristics, they could be associated with *L. occidentalis* feeding. The stylet length and distance between the ovules and cones surface are determinant factors to allow insect feeding.

Poster Session 5. Pine nut industry and markets

NUTRITIONAL VALUE OF *Pinus pinea* PINE NUT

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Background. Pine nuts are the edible seeds of pines, family *Pinaceae*, genus *Pinus*. More than 100 different species exist worldwide, but, according to Food and Agriculture Organization (FAO) only 29 species of *Pinus* found in Asia, Europe, Near East and North America produce edible nuts.

Pinus pinea L. (Mediterranean stone pine) is one of the ten *Pinus* species native to the Mediterranean basin with high economic relevance in Spain, Portugal, Italy, Tunisia and Turkey, for its economically important kernel production and gastronomic quality. In Portugal, pine nut production is centered in the region of Alentejo, mainly in Alcácer do Sal, where edaphoclimatic conditions are propitious to high productivity and quality.

Recently, there has been a growing worldwide market for pine nuts, especially in the USA, promoted by evidence that nut consumption has favorable effects on blood lipids and hence can reduce the risk of coronary heart disease and sudden cardiac death, as well as beneficial effects on other cardiovascular risks factors and vascular reactivity. These salutary effects are attributed to the fatty acids (FA) profile of nuts, which has a predominant content of total unsaturated FA. In addition to the positive implications for cardiovascular health, *P. pinea* pine nuts are characterized by an exceptional high nutritional and energetic value, as it is rich in proteins (32%), fats (45%), fatty acids, vitamins and minerals, especially potassium, phosphorus, zinc, iron and manganese. The chemical composition data of Portuguese pine nuts, performed on 27 populations from different provenance region, was very consistent with the corresponding results for all Mediterranean *P. pinea* populations reported so far.

Last years, as local production is not sufficient to compete with the high demand of pine nuts around the world, Mediterranean pine nut production and commercialization have been compromised by the unfaithful competition generated by Asiatic pine nut, mostly *Pinus koraiensis*, *P. sibirica* and *P. gerardiana*, of inferior quality that reaches the local markets at lower prices.

In order to promote and protect the *Pinus pinea* pine nuts produced in the region of Alcácer do Sal, an application for registration as protected designation of origin (PDO) has been submitted to the Portuguese authority, where it is now under evaluation. This EU scheme protects product names from misuse and imitation and, through information concerning the specific character of the product, supported in labeling and awareness and promotion campaigns, ensure an informed purchasing decision, helping the producers and the consumers.

Poster Session 5. Pine nut industry and markets

THE INDUSTRIAL APPLICATIONS OF *Pinus pinea* RESIN

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Background. *Pinus pinea* supports well not intensive and significant dryness, but requires an annual average temperatures above 10-11°C, thrives at annual rainfall between 400-800 mm, corresponding to situations of severe drought, particularly in summer. It prefers sandy and fresh soils, but adapts well to other types, including calcareous soils.

In Portugal, it occupies an area of 175,742 ha, with 38.3% in the region NUT III Alentejo Litoral, and its main direct economic value are pine nuts.

The increase of area in 46% of the total area in the last 15 years in Portugal shows the importance of this forest especie. With a slow growth and a low value of its wood, compared to *Pinus pinaster*, and on other hand with resin not in use, it is the commercial value of the pine nuts that interested in the region.

Purpose. Today the status has changed. We give importance to the resin so we explain in more detail, the applications of turpentine and rosin.

Methods. Resulting from distillation of *Pinus pinea* resin and chromatographic analysis of its turpentine and rosin, it's possible to know what its main components, then we given the most important applications that enhance this resin.

Results. Stone pine resin has distinct properties from others resins, namely in lower viscosity, higher spontaneous crystallization and lower content of monoterpenes, but higher percentage of limonene, which makes its application in chemical industry interesting.

Conclusions. The present contribution highlights applications of stone pine resin in industry.

Poster Session 5. Pine nut industry and markets

CONTRIBUTIONS TO EVALUATE DESIGN INVESTMENT IN PORTUGUESE AGRO-FOOD INDUSTRY

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Background. The variety of Portuguese products found in the Mediterranean diet has the potential to meet the demand observed for local and national products which origin is a synonymous of quality, reliability and environment friend. However, to trust you need to know. To know that behind these products there is a history, a tradition, a way of being. There are people in love with what they do, committed to improving the quality and food safety of agricultural products. Who most often choose to produce indigenous species which make them the guardians of the biodiversity of a region, biodiversity that shapes the landscape and offers the resources required to differentiate and generate wealth for the local economy.

Design, due to its skills, can realize which are the company's systemic features in order to identify value, add value and communicate value and from there develop partnerships, complement the offering, disclose the nutritional properties, the good they do to one's health, contributing not only to improve the quality of life in the community but also to boost the local economy through the implementation of street markets or markets for farmers. Design can develop communication, making convenient and secure the access and mobility to markets in order to provide a warm and participating moment. And finally it can develop educational activities to sensitize children and young people for health benefits in eating the products of the season and also to the importance of the fruit's life cycle to the region's biodiversity. But above all it can create closeness and trust through a narrative that shows the products' route to reach the final consumer, developing an offer that will not be easily replaced by money. Because nowadays a sustainable company, even an agricultural one, means less and less a product's offering and increasingly an immaterial offering that associates experiences, quality and wellness.

But in the fact if the agro-food industry small/medium-sized enterprises (SMEs) cannot measure design's cost/benefit, it will be difficult to understand design as an investment which adds value to business.

Purpose. The purpose of this research is to draw the SMEs attention for the importance of management design, by evaluating the return on investment in design in this sector.

Methods. We evaluate the return on investment design in a sample of this sector in Portugal.

Results. With these results, we have created a model so that SMEs can evaluate the investment in design.

SEMINAR PROCEEDINGS

The Seminar Proceedings, including the text of the keynote lectures, oral presentations and posters accepted by the Scientific Committee will be published in the CIHEAM journal *Options Méditerranéennes Serie A*. Articles may be written in English or French, with a maximum length of 8 pages in format 17x24 cm.

Deadline for the manuscript reception by email (agropine2016@gmail.com) will be June 30, 2016, for publication after a peer-review process.

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