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Chestnut orchards sustainability and resilience to climate change, a multidisciplinary approach through precision farming and breeding

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Abstract

Sustainability is the keyword for the future, particularly in food production systems considering the ongoing climate changes. In chestnut orchards, improving input efficiency and selecting cultivars more resistant to biotic and abiotic stresses are two interesting approaches, among many others, towards higher sustainability and resilience to climate changes.

The balanced development of the trees is important for their input conversion efficiency. Discover nondestructive methodologies to understand the morpho-functional state of trees will help avoiding their stress. The applicability of innovative methodologies such as ground proximal sensing (chlorophyll content and fluorescence, stomatal conductance) and remote sensing (aerial images in visible and near-infrared wavelengths), to assess the stress/vitality level of chestnut trees is under evaluation in full production orchards-.

Considering that water deficiency or excess can be a major source of plant stress, it is important to understand how to manage irrigation at its best, particularly under the current climatic situation. The irrigation needs of chestnut are under study on two years old trees, applying three different irrigation levels and monitoring vigour, chlorophyll physiology and stomatal conductance, to determine the most suitable volume and timing of irrigation for chestnut trees.

Agronomical characteristics of trees are important for their adaptability to orchard environment. The agronomical traits of a chestnut F1 progeny which consists of 130 eleven years-old trees, obtained from the cross Bouche de Bétizac (*Castanea sativa* x *C. crenata*) x Madonna (*C. sativa*) are under study. The study focused on vegetative (vigour, habitus, sucker emission, stamina typology), phenological (flowering and ripening time) and nut production traits (number of nuts/kg, , colour, shape, hairiness, stripes, number of embryos, pellicle intrusions, presence of pathogens and pests) in order to create a genetic linkage map and select interesting individuals for propagation and further study to introduce new cultivars. Understanding plant morpho-functional state and needs is important to efficiently manage chestnut orchards from an agronomic point of view, while knowing genes linked to useful agronomical traits can facilitate breeding process.

Keywords: Plant stress, Irrigation, Remote sensing, Genetics, Progeny

Methodology for phenoclimatic observations and modelling of chestnut varieties, and revitalizing chestnut growers' local knowledge in France, ROC-CHA project

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Abstract

The ROC-CHA project is a joint project of researchers co-led by the CNRS (National Center for Scientific Research) and the SNPC (National Union of Chestnut Producers) in France. Our partners include INRAE Bordeaux, and associations involved in the development of chestnut cultivation in France, RENOVA in Ariège, Epi de Mains in Lozère, Groupement Régional des Producteurs et Transformateurs de Châtaignes et Marrons de Corse (GRPTCMC) in Corsica, as well as individual expert chestnut growers in Ardèche, Lozère, Corsica and Ariège, Agricultural Chambers (Ardèche and Corsica). This project aims at establishing a network for observation and conservation of chestnut varieties at farm level and associated scientific and chestnut grower's local knowledge in France; with the main objectives that are to: 1) develop phenoclimatic observations and modelling of chestnut varieties within the context of climate change, and 2) consolidate local knowledge and know-how of chestnut growers through peer-to-peer exchanges within a network of reference sites. These sites which are on-farm living labs where we use a methodology developed by the "Observatoire des Saisons", a research and citizen knowledge platform in France, that we refined and adapted through a co-construction process, with some 20 chestnut growers to find a practical approach for developing comparative observation of major phenological stages of chestnut varieties development. The results presented in this paper are our methods for the follow-up of these phenological stages which are the budburst, initial opening of leaves, the flowering of first male flowers, the fruiting, and senescence, i.e., changes in leaf colouring and finally fallen leaves. All sites are associated to data loggers in order to obtain a database of temperatures, at the pace of one data per hour, 24 per day. We explain the approach that links researchers and chestnut growers, the observation processes, modelling and some preliminary results. We also present the experimental set up of peer-to-peer exchange of knowledge between chestnut growers, based on ethnoecological approaches for reconstructing fragmented local knowledge, the experimental setups that favour the emergence of almost lost

knowledge, and we present some results regarding how this type of knowledge enables a better characterizing of numerous local varieties of these four regions. In conclusion, we consider that both, observation of phenological stages, and revitalizing local understanding of characteristics of chestnut varieties, leads to a better understanding of how best to face climate change.

Keywords: Chestnut growers, phenoclimatic observation and modelling, co-constructed methodology, revitalizing local knowledge, Ardèche, Lozère, Corsica, Ariège.

Effects of osmoprotective compounds on freezing tolerance in chestnut *(Castanea sativa* L) leaves

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Abstract

The European Chesnut is an interesting productive alternative for farmers in Southern Chile. However, in recent year, climatic variability with the occurence of late spring and early summer frosts have caused severe damage to new shoots and leaves on youg trees, especially in the training phase in herbaceous tissues. Low temperature stress affects growth, productivity and triggers a series of morfological, physiological and biochemical changes in fruit trees. The experiment aimed to evaluate the effect of osmoprotective compounds on freezing tolerance in chesnut leaves. The trial was estabiliced in an orchard of Cittá di Castello 3 years- old trees in a leader training system. A randomized complete block experimental design was employed with 3 replication of 10 trees per treatments with planting distances between row of 8x7m (178 trees ha). The treatments were the folowing: control (T0), 50mg L¬ Salycilic acid (T1), 100 mg L ¹ salicylic acid (T2), 150 mg L¬ salicilyc acid (T3), 250 mg L¬ salycilic acid (T4), T(5), 50mg L¬ ascorbic acid (T6), 100 mg L ¬ ascorbic acid (T7), 150mg L ¬, ascorbic acid(T8),

250mg L⁻¹ ascorbic acid and (T9),3cc L ⁻¹ Stimplex. The treatment with 100mg L ⁻¹ of salicylic presented the highest content of polyphenols and the treated plants showed less cold damage. The highest chlorophyll (a+b) content was determined for the salicylic acid (100mg L⁻¹).

Keywords: Osmoprotective compounds, cheasnut, cold tolerance.

ClimCast. Predicting the behavior of Portuguese chestnut cultivars grafted on ColUTAD under different edafoclimatic conditions

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Abstract

Anthropogenic climate change (ACC) are anticipated to raise the Earth's average temperature by 1.8 to 6.0°C by 2080, while precipitation would fall by roughly 22% compared to the peak of the Industrial Revolution, besides other extreme climatic events like hot waves, long periods of Summer drought. In Portugal the hot waves of July leaded to a decrease on chestnut production of about 50% in 2022 compared to the record production of 43 841kt in 2019. ClimCast is the Portuguese chestnut network constituted by seven demonstration orchards (DO) replica, installed in 2018, covering the main producer regions. with the aim to performing studies with the main Portuguese cultivars under edafoclimatic contrasting conditions.

Demonstration Orchard (DO)	Coordinates (decimal degree)	Altitude (m a.s.l.)
Salgueiros - DO_{S-Vi}	41º54'12.73"N; 7º01'40.95"W,	1008
Parada - DO_{P-B}	41º38'12.53"N; 6º42'42.94"W	740
Lagoa - DO_{L-VPA}	41°31'52.32"N; 7°31'39.58"W	1050
Carrazedo Montenegro - DO_{CM-Va}	41º33'41.76N; 7º25'51.41''W	765
Penela da Beira - DO_{PB-P}	41º01'38"N; 7º26´38"W	885
Refoios do Lima - DO_{RL-PL}	41°47'35.85"N; 8°32'38.81"W	67
Porto da Espada - DO_{PE-M}	39°21'19.5"N 7°21'40.1"W	583

Here, there are presented first results obtained during July, on DO_{P-B} (T_{midday} = 32ºC), DO_{CM-Va} (T_{midday} = 30ºC), DO_{PB-P} (T_{midday} = 28ºC) and DO_{PE-M} (T_{midday} = 30ºC), on the Portuguese cultivars Judia, Longal and Martaínha; and Spanish cultivars Parede and Pilonga, both grafted on the hybrid rootstock ColUTAD.

Highest photosynthetic rates (A) were measured in DO_{CM-Va} and Do_{PE-M}, 11.2µmol $CO_2.m^{-2}.s^{-1}$ and 10.9µmol $CO_2.m^{-2}.s^{-1}$, respectively. Concerning midday stem water potential (ψ_{wmd}), they were -1.2MPa and -0.78MPa, respectively, indicating a buffer capacity of A concerning these ψ_{wmd} range values. The OJIP Test parameter, performance index (PI) were 6.3 and 4.5, respectively. The lowest A was determined in DO_{P-B} 6.9 µmol $CO_2.m^{-2}.s^{-1}$, ψ_{wmd} was -1.6 MPa (a value below the threshold level, -1.2 MPa) and PI = 5.1. In relation to tree growth, they presented 42.8mm, 55.3mm, 35.2mm and 44.5mm, for DO_{CM-V}, DO_{PE-M}, DO_{P-B} and for DO_{PB-P} which presented intermedium values. Relating to cultivars and the impact of ColUTAD on them, A was 33% (Judia), 29% (Longal), 22% (Martaínha), and 12% (Pilonga) higher than in ungrafted ColUTAD, while in what concerns Ψ_{wmd} was 15% (Judia), 9% (Longal and Martaínha) lower (more water availability) than ColUTAD, while Pilonga shown 6% higher. Relating to Parede cultivar, results were obtained only in DO_{CM-V}, being A=12.8µmol $CO_2.m^{-2}.s^{-1}$(58% higher than ColUTAD) Ψ_{wmd} =-1.1MPa (7.5% higher than ColUTAD) and PI=6.7.

These results demonstrate the impact of the edafoclimatic conditions on chestnut development, and the utility of the installation of Climcast network to deep the knowledge about local and cultivar potentialities.

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Keywords: ClimCast, climate changes, chestnut cultivars, ColUTAD, gas exchanges, water relations,

Principio del formulario

Effects of climatic conditions on parasitism of *D. kuriphilus* by native and introduced parasitoids at the western edge of the sweet chestnut distribution

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Abstract

Dryocosmus kuriphilus is an invasive cynipid native to China that is a serious pest of chestnut trees worldwide. It was detected for the first time in Europe in 2002, since then, it has spread rapidly throughout the territory, becoming a major pest, causing significant economic losses. The species was detected in Galicia (NW Spain) in 2014, and from the beginning the parasitoid *Torymus sinensis* was released in the area to control this species, although its establishment was not as rapid as indicated in other countries. *D. kuriphilus* also recruits natural enemies from native gall makers living in nearby oak forests in the invaded area. The aim of this study is to determine the effect of the climatic conditions on the establishment success of the introduced parasitoid compared to native parasitoids that also overwinter in the cynipid galls. The effect of the hibernation site, crown or soil, was also evaluated. Four climatic areas of Galicia were considered (coastal, inland, mountain and Mediterranean). The study was carried out in 48 localities (12 by climatic zone). At each point, 20 random galls were collected in the canopy and

20 in the soil after leaf drop. The galls were collected in April, shortly before the emergence of the adults. Once the galls were collected, they were incubated in individualized emergency chambers labeled according to their origin and were periodically monitored to count and identify emerging individuals. The results show strong differences between climatic zones for the introduced parasitoid, being the coastal zone the one with the worst results and the inland and mountain zone the best. However, there were no differences between climatic zones in the percentage of galls with native parasitoids, although species richness was also much lower in the coastal zone. In both cases, the number of overwintering parasitoids was three times higher in canopy galls than in ground galls. Parasitoid survival may be limited on galls that overwinter in the soil after leaf fall, probably due to the rainy winters and high moisture of this geographic area. This could be one of the causes of the delay in the establishment of the introduced parasitoid.

Keywords: Castanea spp., invasive species, Asian chestnut gall wasp, natural enemies, climate.

On-farm evaluation of 471 Chinese and hybrid chestnut grower selections in the Eastern US

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Abstract

Chestnut growers in the eastern USA generally favor seedlings over clonally propagated trees, due to limited commercial micropropagation of superior *Castanea mollissima* cultivars and reports of graft failure. Limitations to clonal orchards are likely to be resolved in the coming decades as chestnut research increases. Meanwhile, growers in the Eastern US continue to establish seedling orchards. Due to preference for seedlings from superior cultivars, the grafted research orchards at

the University of Missouri Horticulture and Agroforestry Research Center (HARC) became the main seed source for the eastern US chestnut nursery industry. Distribution of germplasm to hundreds of growers over the past two decades allowed the University of Missouri Center for Agroforestry to partner with these growers to conduct large-scale, decentralized evaluations of grower selections across diverse environments. In 2020, over 7,000 known offspring of bearing age from more than 20 half-sibling families of *C. mollissima* or complex hybrid cultivars from HARC research orchards were in cultivation throughout the eastern US. Interested growers identified 471 elite selections representing 12 US states, which were evaluated from 2020-2022 for 35 traits relevant to commercial production. Average kernel weights ranged from 3.0-25.8 g both years, and defects ranged from 0-80%. Over 40 preliminary selections were made based on 2-year data and thresholds for nut size (> 11 g), defect rate (< 10%), and visual assessment of crop load. Selections' weights ranged from 11.0-22.3 g in 2020 and 11.1-25.8 g in 2021, and all had < 10% defects, except for areas with severe chestnut anthracnose. In 2022, the top 10% of grower selections were conserved via grafting *ex situ* at HARC, along with relevant checks, in a trial with five replications. On-farm samples and HARC trials will continue to be evaluated, and the best-performing on-farm selections will serve as improved seed sources for future assessment.

Keywords:

Castanea mollissima, *Castanea* hybrids, chestnut, on-farm evaluation, participatory breeding, advanced selections

Estimation of carbon stock in young sweet chestnut forest and agroforest plantations

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Abstract

Removing CO2 from the atmosphere and storing carbon in soil and vegetation are important ecosystem services provided by sweet chestnut (*Castanea sativa* Mill.) plantations, both in forest and agroforest systems, for which producers may be paid under certain circumstances. Diversifying chestnut owner's revenues beyond timber or nut, turning storage of carbon into a passive income stream, could be an opportunity to make these areas more profitable. Estimates of the carbon sequestration for the species in Portugal are based on data from national inventory which do not distinguish between agroforest (orchards) and forest systems (within the latter, between coppice or high forest regime), or site quality. Considering that the capacity for carbon sequestration is strongly dependent on the cultural system, management and the quality of the site, the objective of this study is to evaluate and compare the carbon storage capacity in young stands of chestnut (up to 24 years old) in forest system (high forest and coppice regime) and agroforest, considering low, medium and superior site qualities. For this purpose, dendrometric data from combinations of local-inventory date selected from a universe of 18 permanent plots were considered, and also 4 coppice permanent plots, with different management systems, measured over time. Biomass equations referenced in the literature were selected to estimate biomass and after converted to carbon using the conversion factor of 48.4%. The estimated carbon sequestration or conservation: high forest 2.98 – 92.44 Mg C ha^{-1} in a time frame of 7-24 years, accumulation rate 0.43-3.85 Mg C ha^{-1} $year^{-1}$; coppice 71.04 – 117.47 Mg C ha^{-1} in a time frame of 7-24 years, accumulation rate 4.89-10.14 Mg C ha^{-1} $year^{-1}$; orchards 1.15– 40.85 Mg C ha^{-1} in a time frame of 7-24 years, accumulation rate 0.16-1.70 Mg C ha^{-1} $year^{-1}$. Coppice systems show the highest carbon storage capacity, followed by high forest and orchards. Site quality and management regimes significantly influence carbon storage capacity.

Keywords: ecosystem services, carbon storage, forestry, orchards, carbon sequestration, *Castanea sativa*