Intra-annual tree diameter increment and seasonal leaves nutrients in cork oak species under three understory management alternatives

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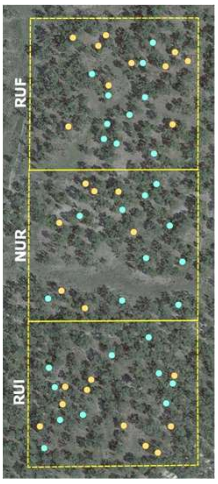
Background: In *montado*, anthropogenic interventions in the understory layer are a common management practice, that may potentially affect tree growth and regeneration, but also soil functions and nutrient availability.

How cork oak trees respond to distinct understory management alternatives ?

Overview: An experimental trial implemented on a pure uneven-aged cork oak stand, in Podzol soil, with the specific goal of comparing understory management alternatives, was monitored between 2003 and 2015. The stand understory layer is composed by spontaneous vegetation dominated by *Cistus salvifolius*, *Lavandulla peduncalata* and *Ulex airensis*. Cork samples from two distinct cork rotation cycles (2003 to 2012 or 2006 to 2015), taken at the beginning and end of the debarking period, were analyzed regarding cork ring width (Faias *et al.* 2018, Faias *et al.* 2019). Results suggest a different effect on cork annual growth depending on whether the operations are performed at the middle or at the beginning of the cork rotation cycle. Under the CorkNeighbors research project, this trial was continuously monitored and analyzed between 2016 and 2019 (Faias 2019).

Trial Description



Understory management alternatives (UMA):

- **NUR:** spontaneous understory vegetation maintenance (as control);
- **RUI:** understory removal with biomass incorporation into the soil;
- **RUF:** understory removal with simultaneous NP fertilization.

Along 2 years, 30 trees selected by UMA and YD (cork rotation cycle: **2012**, **2015**), were monitored, regarding the tree variables:

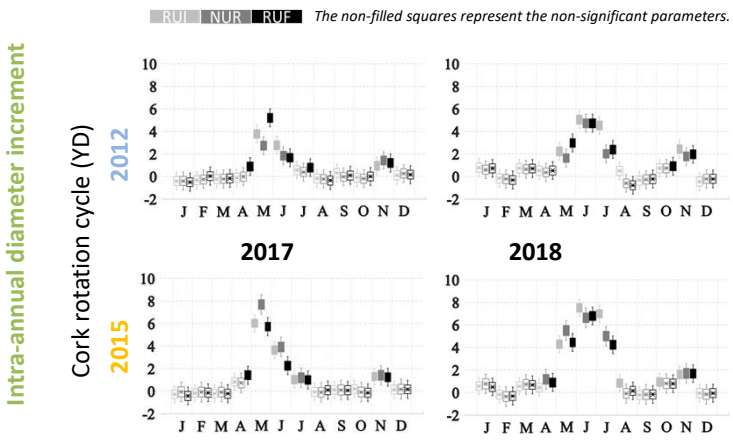
- Monthly diameter increment, with band dendrometers;
- Current-year leaves nutrient variability, samples taken in the end of spring, before the first rain and in the winter.

Methods: Two distinct approaches were defined considering both tree response variables:

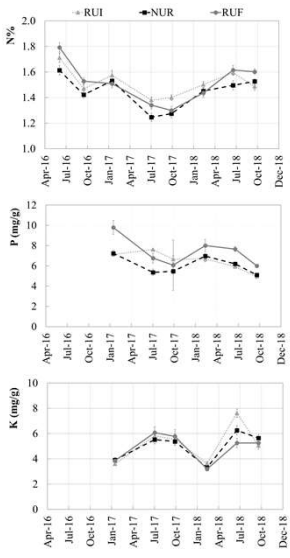
- Specific leaf area (SLA) and nutrient contents (NPK), comparison between UMA, were assessed with a ANOVA 3-factor: season, YD, UMA.
- A linear mixed model approach was applied for the monthly diameter increment data. The random effects considered trees inside plots, and the fixed effect focus in the interaction between: UMA, YD, measurement year (YM) and month.

$$y_{ijlm} = \mu + \beta_{i(j)} + \gamma_l + \tau_m + x_i + (x|\gamma|\tau)_{ijlm} + \varepsilon_{ijlm}$$

where y_{ijlm} is the diameter increment of tree i at plot j at measurement l (mm); μ is the general mean; $\beta_{i(j)}$ is a tree random effect within each plot; γ_m is a month fixed-effect; τ_n is a year fixed-effect; x is related to the cork debarking cycle and understory management variables (single or combined) and ε_{ijklm} is residual error.



The fixed effect parameters interval regarding 3 factors interaction (UMA|YD|YM), suggest an effect on RUF in the spring after NP fertilization, on the trees with older cork age (**2012**).



Leaves N, P, K mean content by UMA, along two consecutive years

Leaves seasonal variability

Results from ANOVA (p-value) for the leaves seasonal sampling regarding specific leaf area (SLA) and nutrients contents (N, P, K), where YD relates the cork cycle in 2012 or 2015 and Season is the time of taken the sample within the year.

Effect	SLA (cm^2/g)	N (%)	P (mg/g)	K (mg/g)
UMA	**0.0006**	**<0.0001**	**<0.0001**	0.2046
YD	**<0.0001**	**<0.0001**	0.0921	0.1030
Season	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
UMA|YD	0.8148	**0.0154**	**0.0174**	**0.0002**
UMA|Season	0.9987	**0.0069**	**<0.0001**	**0.0005**
YD|Season	**0.0324**	0.7409	0.9983	0.4855
UMA|YD|Season	0.9707	0.5434	0.9689	0.7972

The leaves P content was higher on RUF, in the two years after performing understory operations, while the leaves N content was higher in the second year.

References: Faias SP, 2019. Using neighbourhood vegetation information on cork oak growth and yield modelling. PhD thesis. Universidade Lisboa, Instituto Superior de Agronomia, Lisboa, Portugal, 119pp; Faias SP, Paulo JA, Firmino PN, Tomé M, 2019. Drivers for annual cork growth under two understory management alternatives on a Podzolic cork oak stand, Forests 10(2): 133, https://doi.org/10.3390/f10020133; Faias SP, Paulo JA, Palma JHN, Tomé M, 2018. Understory effect on tree and cork growth in cork oak woodlands. Forest Systems, 27(1), http://dx.doi.org/10.5424/fs/2018271-11967

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