Is the interaction between waterlogging and drought a worsening factor in oak (Quercus Petreae and Quercus robur) decline?

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Context & scientific issues

Climate change scenarios in Centre France in the coming decades predict an increase of rainfalls during winter and spring, and recurrent droughts during summer and autumn (http://www.drias-climat.fr/). The probable consequences for forests would be an increase of waterlogging during winter and spring followed by marked droughts during summer and autumn. Both events will presumably have a strong impact on oak decline, by limiting tree growth and/or inducing a deficit of carbon reserves that may limit future resistance to stress (e.g. winter frosts, insect damages, or diseases).

Specific objectives:

1. How does the water table affect root distribution growth?,
2. How does the summer soil extractable water content affect root growth?,
3. Is there an interaction between both (waterlogging and drought)?

Oak decline in Allier

Soil subjected to temporary ground water table

Material & methods

Study sites:
3 oak (*Q. robur* and *Q. petraea*) forests located in the county of Allier (Auvergne, Central France) (latitude 46ºN and longitude 3ºE).

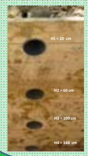
Forest sites studied

Measurements:
Many usual sensors were used in order to identify and quantify the key parameters of water stress in both oak species, such as:

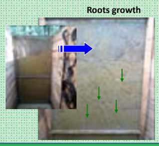
- Microclimate (light, rainfall, soil and air temperatures, air humidity),
- Soil water balance (volumetric soil water content measured by TDR, water table depth by piezometer),
- Tree transpiration (sap flux),
- Rroot growth (rhizotrons 2m deep), and
- Trunk growth by PépiPIAF

Microclimate

volumetric soil water content



Roots growth



Stem growth

Sap flux

Conclusions

-Microclimatic variables measured under tree cover were very similar among the three sites (Fig. 1).

-No root growth occurred during waterlogging period (from January to June) in the three sites (Fig. 2), because water excess led to hypoxia (oxygen deficiency) [1].

-After the water table decrease, root growth was observed in the three sites (Fig. 2), but rooting profiles (0-180 cm below ground) were variable in the course of time (Fig. 4), this fact is related to soil water content (Fig. 3). As the soil surface horizons desiccated, root growth and plant water uptake may preferentially occur in deeper horizons in order to attenuate the duration and intensity of water deficit [3]. These deep fine roots probably acted only during a short period (end of summer), when oxygen supply was sufficient, i.e., when water table fell. However, water deficit was stronger in one site, this fact may be due to its soil type, podzolic pseudogley, susceptible to dry out quickly and strongly in summer due to the coarser texture: the maximum water reserve is particularly low [2].

-We can conclude than the root growth has two main issues in a one-year cycle. One is the temporary ground water table which stops the growth of the new roots during the waterlogging period, and the second issue is a low soil water content that becomes the main water limit for well root growth in a drought period.

Results

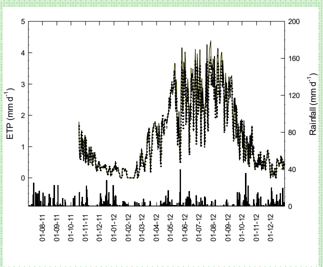


Fig.1 Daily rainfall (vertical bars) and mean daily evapotranspiration potential (ETP) in P1 (thin line), P2 (short dash line) and P3 (dotted line) plots during the experimental period.

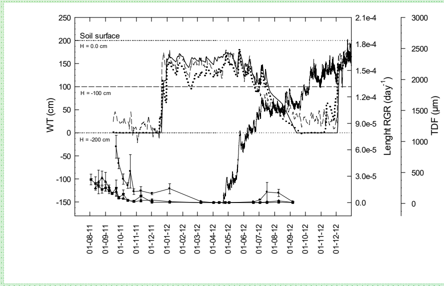


Fig. 2 Water table (WT) values for the soil profile in P1 (thin line), P2 (short dash line) and P3 (dotted line); length relative growth rate (Length RGR) values for the roots of oak trees in P1 (black squares), P2 (black triangles) and P3 (black circles); trunk diameter fluctuations (TDF) values for oak tree (thin line) in plots during the experimental period. Horizontal dotted lines indicate, from top to bottom, the soil surface (0 cm) and the deep soil (200 cm below ground), respectively.

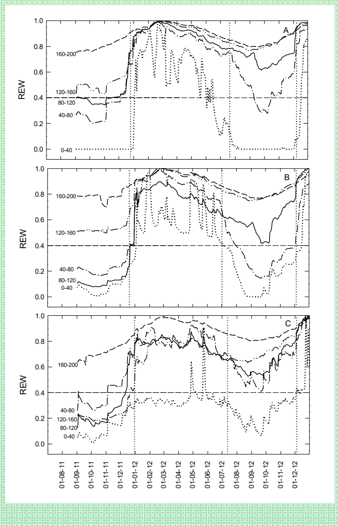


Fig. 3 Relative extractable water (REW: A, B and C) values for soil profile in REW0-40 (dotted line), REW40-80 (dash-dot line), REW80-120 (thin line), REW120-160 (dash-dot-dot line) and REW160-200 (short dash line) levels during the experimental period. Horizontal dotted line indicate, in the middle (0.4), stress index in the soil profile. The periods of time between vertical dotted lines from left to right represent phases I, II and III of the root growth caused by high WT level in the soil profile

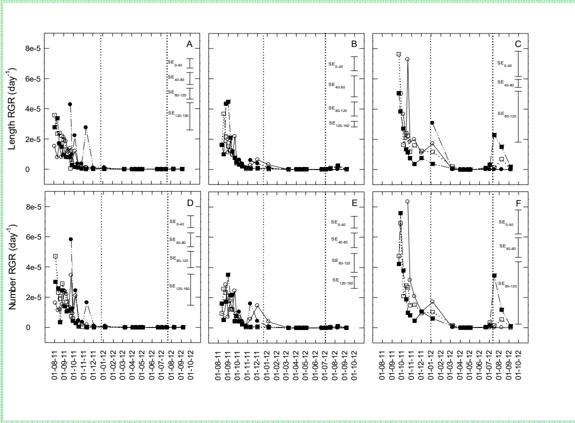


Fig. 4 Length and number relative growth rate (Length RGR: A, B and C; Number RGR: D, E and F) values for the roots of oak trees in RGR0-40 (white squares), RGR40-80 (black squares), RGR80-120 (white circles) and RGR120-160 (black circles) levels during the experimental period. The periods of time between vertical dotted lines from left to right represent phases I, II and III of the root growth caused by high WT level in the soil profile.

References:

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