Universidad de Navarra

Hydraulic lift as a mechanism driving facilitation between species in mixed beech and oak temperate forests

Final Year Project

Bachelor´s degree in Biology

Botany Department, Faculty of Sciences

Academic Year 2018-2019

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Abstract

With temperature increments and greater water shortage forecasted as a consequence of climate change, temperate forests could be affected, especially in their southern distribution limit. Biotic processes, enhancing or aiding their stability, claim for attention. Hydraulic lift performed by adult oaks (*Quercus petraea* (Matt.), Liebl.) in a mixed broad-leaf European beech temperate forest (*Fagus sylvatica* L.) in northern Spain was studied to determine if this physiological process could account as a mechanism driving facilitation between species. Our initial hypothesis was that hydraulic lift could aid beech saplings development by making water more available on the surface. Hydraulic lift was therefore investigated by comparing three characteristics measured under beech and oak adult trees: 1) soil volumetric water content, 2) root development of beech saplings, and 3) mycorrhizal colonization of beech saplings. We expected to detect significant differences in soil moisture, root area and mycorrhization between samples gathered under beech and oak trees influence, which will indicate hydraulic lift presence and the importance of its role in this ecosystem. However, non-significant differences were found indicating that, so far and for the conditions held during the investigation, hydraulic lift does not account as an important factor for temperate forest maintenance in relation to beech sapling development.

Objective and Hypothesis

The aim of this research is to determine if there is a facilitation process between adult oaks and beech saplings that could be driven by the hydraulic lift performed by oaks. Therefore, the hypothesis is that water availability under adult oak would be higher than under adult beech due to the hydraulic lift oak trees perform. As a consequence, we expected:

1. Soil water content should be higher under oak than under beech adult individuals.

2. Beech saplings root development should be lower underneath oaks as water is already available.

3. Mycorrhizal root colonization and diversity should be higher under oaks enhanced by hydraulic lift.

Materials and methods

Experimental site

The study area is located in an unmanaged temperate mixed beech-oak acidophilus forest in Bertiz, northern Spain; within Bertiz National Park (43º10´N, 1º36´W) found in the western Pyrenees of Navarra (Spain). In greater detail, the study area is found in

the watershed known as ‘‘Suspiro’’, a bowl-shaped area of 132 hectares, east orientation and covered by almost constant tree canopy. The mean altitude of the study area is 370 m above sea level. The climate is humid-oceanic, with mean annual precipitation of 1600 mm, and temperatures ranging from 7.2ºC in January to 21.6ºC in July. Parent rock materials is predominantly schist, slate, and conglomerate (Gazol & Ibáñez, 2010). Bertiz is characterized for being a beech dominated temperate forest with some areas of well-developed mixed beech-oak forest, mainly in northern location; and others where oaks predominate, usually in the southern slopes. In order to fulfill our objective and, knowing that adult oaks must be present, the study was developed on the northern slope.

Study design

Even though our site was found within a temperate area where precipitations were abundant, we believed that this process (HL) could also be identified here based on Dawson’s work (1993). Nevertheless, seeking for dry periods which enabled to reproduce the drought conditions predicted for the future, precipitation accumulations were examined constantly through MeteoNavarra (http://meteo.navarra.es). The top 25 cm of the soil get easily saturated by rain fall water but a period of only 9 days is needed for it to dry-out (Dawson, 1993). After that time HL effects as fluctuations in soil water potential can be observed again. Other studies expose that within 6 days the lifted water can be detected in superficial layers (Zapater *et al.*, 2011). Thus, data collecting required a previous minimum 6-9 day period with none or as leas as possible levels of water accumulation. We considered minor precipitations those less than 10 mm.
Data were collected in two different days (11-Oct-2018 and 20-Nov-2018) to reproduce two different drought periods. October, right after summer water shortage, accounted for the long drought period and November represented the short one.
To determine the presence of HL and its role in the community three different variables under adult beech and oak individuals were measured:

i i. Volumetric water content of soil.

ii ii. Root development in beech saplings.

iii iii. Mycorrhizal colonization in beech saplings.

For both volumetric water content (VWC) and sapling root development, we selected 3 pairs of beech and oaks adults (considered to be adults if their treetops reached the canopy). A minimum distance between adults had to be respected so that the discrimination of whether beech saplings were under the effect of beech or oak was easy and clear. Adult individuals must have similar size, good physiologic state and share slope and orientation conditions. All six adult trees were georeferenced using a GPS device (Garmin Oregon 450) and their diameter at breast height (DBH) was also measured. Underneath each tree, 5 soil cores samples and 5 saplings were gathered attending to the following procedures.

Conclusion

The results of the study do not seem clear and are ambiguous, not meeting our expectancies in any level. Based on our data, VWC cannot be said to be higher under adult oaks than under beech trees or differential between drought conditions. Roots area

values are not significantly larger under beech adults as expected. Mycorrhizal colonization does not show any differential pattern depending on whether beech saplings grew under beech or oak adult trees. Nevertheless, this does not mean that HL does not exist. It could be present but masked by other factors as strong competitions. Also, the study design may have not been the optimum to detect HL presence.
Even though results are poorly conclusive, there are some highlights that could be used as a base for future studies. Competition relationships could be stronger and much more determinant in temperate environments causing HL to be more moderate. Other traits different to morphological ones like physiological traits (leaves water content) may be better to study HL and the velocity at which changes of morphological traits occur is still not known. Also, the higher presence of *Genea* mycorrhizal type under oaks could be important for the understanding of HL effect. In this way, further studies are recommended.

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