Doctoral thesis abstract

Climate change and Mediterranean ecosystems: plant and soil responses to UV radiation and water availability before and after a perturbation

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Abstract

In the Mediterranean basin, reductions in cloud cover as a consequence of climate change is expected to enhance solar UV levels (UV-A and UV-B) and to decrease precipitation amount over the coming years, especially during summer months. In addition, more frequent and intense wildfires are also expected due to drier and warmer conditions. At plant level, the potential effects of higher UV doses and diminished water availability on the biochemical, morphological, physiological and growth traits could alter the regeneration ability of Mediterranean resprouter species after a disturbance. In this sense, variations in the resprouting success of plant species in response to UV and water levels could have implications on the resilience of shrubland ecosystems, a common Mediterranean-type terrestrial community. The role of UV radiation in the functioning of Mediterranean shrublands, particularly in C and N pools of plants and soils, remains still unclear, with null information about the possible interactive effects between UV radiation and precipitation and/or fire. Because of that, the present study aimed to contribute to the elucidation of the effects that projected changes in UV radiation and precipitation could have on Mediterranean resprouter species and shrubland ecosystems in the near future, taking also into account how aerial plant biomass removal due to a disturbance (such as a fire) could modulate these effects.

In this context, the specific objectives pursued in this thesis were: 1) to examine the effects of enhanced UV radiation (UV-A and UV-B) and diminished water supply, before and after a disturbance implying aerial plant biomass removal, on the leaf content of phenols and antioxidants, leaf morphology and physiology, plant growth, root reserves and resprouting capacity of two common Mediter-

Figure 8.1: Pictures of the two experiments performed during this thesis: an outdoor experiment involving UV supplementation combined with two levels of irrigation conducted using seedlings of two resprouter species (photo abova); and a field experiment in a natural shrub community where the levels of UV and water availability reaching the ecosystem were modified (photo below).

ranean resprouter species; and 2) to investigate the role of UV radiation (UV-A and UV-B) in C and N pools of the soil and dominant plant species of a Mediterranean shrubland before and after a fire, and whether this role can be altered by the expected reduction in precipitation. To achieve objective 1, an outdoor experiment involving UV supplementation combined with two levels of irrigation was conducted (Fig. 1) using seedlings of *Arbutus unedo* and *Quercus suber*, two sclerophyllous resprouter species, whose aerial biomass was removed during the study period. Several parameters associated to leaf biochemistry, morphology and physiology, plant biomass, root biochemistry and resprouting success were measured in seedlings and resprouts. To accomplish objective 2, a field experiment was conducted in a natural Mediterranean shrub community, where the levels of UV and water availability reaching the ecosystem were modified (Figure 8.1). At the middle of the study period, all the vegetation was burned simulating a natural fire. In addition to plant and litter cover, different parameters related to C and N pools were measured in the soil, and in the litter and leaves of *A. unedo* and *Phillyrea angustifolia*, two of the resprouter species dominant in this shrubland community.

As main results, responses of *A. unedo* seedlings to enhanced UV, especially UV-B, were mainly addressed to the reinforcement of the antioxidant machinery through increases in the levels of quercetins, ascorbate and glutathione coupled with an upregulation of catalase activities. In contrast, *Q. suber* seedlings augmented UV-screening to face UV-B enhancement via accumulation of kaempferols. This species was also sensitive to enhanced UV-A, but, in this case, the response implied morphological adjustments to harden the leaves (smaller leaves with greater leaf mass per area (LMA)) coupled with a proportionally greater carbon allocation to roots (lower leaf to root biomass ratio). Concerning water supply, *A. unedo* appears to counteract water constraints by a stimulated antioxidant activity, as in response to enhanced UV-B, while the main response in *Q. suber* was a reduction in biomass allocation to leaves in relation to roots and to total biomass, likely as a strategy to minimize water loss by transpiration and increase water absorption by roots. The protective strategies displayed by both species were apparently efficient, since no reductions in root reserves or in resprouting success were found. However, after the loss of the aerial biomass, the sensitivity of resprouts to UV or water levels was notably different in relation to that of seedlings, being higher in *A. unedo* but lower in *Q. suber* resprouts. At ecosystem level, UV-A and UV-B exposure had opposite effects on C and N pools, being these

effects often exacerbated by reduced levels of precipitation. During the pre-fire period, UV-A exposure increased soil moisture, respiration and □-glucosidase activity, suggesting increased soil biological activity and C turn-over. The additional presence of UV-B increased C concentration in *P. angustifolia* leaves and decreased soil respiration, pH and □-glucosidase activity, pointing to a lower soil microorganism activity probably slowing down C and N cycling. Under reduced rainfall, UV-B exposure also enhanced δ^{15}N values in leaves and litter of *A. unedo*, suggesting higher nitrification and N losses by leaching in the soil. Most of the effects were only found before the fire, indicating a homogenizing influence of this perturbation.

To sum up, over the coming decades, changes induced by enhanced UV doses and diminished precipitation levels on C and N dynamics in Mediterranean shrublands would be in part driven by opposite effects of UV-A and UV-B on soil processes, being modulated by water availability and plant species-specific responses to these factors, which would differ before and after a disturbance (fire, clear-cut, grazing).

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