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Seed isotopic analysis as a tool to understand ecological processes influencing plant development and physiology: the case study of Quercus rotundifolia Lam. in a desertification gradient in Mediterranean areas

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Plant responses to climate change highly depend on the temporal variability in precipitation events and on plant specific strategies, such as drought tolerance and resilience. Within the different plant organs, seeds have become an important research tool in the past years to study plant development and nutrients allocation. Key features of seeds such as the tendency to accumulate and store nutrient compounds open many possibilities to explore isotope analysis (13C, 15N and 18O), with many outcomes in fields from ecology to food traceability. The application of light stable isotopes to plant materials have been used to study both physiological (i.e. photosynthesis and stomatal conductance), nutrients uptake and metabolism (origin of nitrogen and symbiotic associations) as well as many ecological processes, which will produce a distinctive isotope fingerprint on the plant tissues. Thus, the isotopic composition of certain bio and geo-elements of seeds, yielding relevant information on plant ecophysiology, are able to relate the plant functioning with local climatic conditions (e.g., temperature and precipitation). The application of isotope analysis in this way can be used as a proxy to understand complex environmental degradation processes such as land degradation in drylands resulting from various factors including climatic variations and human activities.

In this study acorns of Quercus ilex plants were sampled during 2012-2013 in a region of southern Portugal, according to (i) soil land-use; (ii) aridity and desertification indexes. The approach developed combined plant seed analysis (seed morphology and compounds quantification) with isotope ratio mass spectrometry (δ13C, δ15N and δ18O) as a "tool" to study changes in plant ecophysiology over time and space. Seeds allow studies at specific temporal scale (development period) which varies according to its biology and depends on the climatic conditions where the plant is grown (i.e, seed's biomass integrate climate variations information of several months). The results indicate a clear relationship between seed morphology and both temperature and precipitation as well a significant correlation between δ15N and precipitation, which indicate an influence of major climatic variables on seed carbon allocation and nitrogen uptake. These results may also contribute to future mitigation programmes in degraded areas where there are systematic problems with plant regeneration and ultimately to learn about the application of stable isotopes approaches in dryland ecosystems.