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Effects of water and a nutrient pulse supply on *Rosmarinus officinalis* growth, nutrient content and flowering in the field

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Abstract

Rosmarinus officinalis is a dominant shrub species of calcareous Mediterranean communities that has increased its presence in wide areas due to fire frequency increase and field abandonment. We aimed to study the capacity of adult shrubs to respond to nutrient pulses such as those produced by fires and human driven eutrophycation. In a 5 years old post-fire Mediterranean shrubland we conducted an experiment to investigate the effects of irrigation and N and P fertilisation on the growth, nutrient status and flowering effort of adult plants of the dominant shrub *R. officinalis* in a post-fire shrubland. The responses were monitored during the immediate 3 years after fertilisation. P fertilisation increased plant growth, produced a great increase in P aerial mineralomass and P concentration in leaf and stems and had a slight positive effect on flowering effort. Irrigation increased plant growth, but did not have significant effects on nutrient contents and flowering. The results show that adult individuals of the Mediterranean shrub *R. officinalis* have a notable capacity to positively respond in growth and in nutritional status to a sudden increase of the limiting nutrient, in this case P, and in a lesser extent, to an increase of water supply. These capacities may be important under the more unpredictable nutrient and water availability conditions expected for the near future; they will allow to take advantage of the pulses of higher nutrient and water availability in the middle of dry periods, thus increasing the community capacity to improve the nutrient retention in the ecosystem.

Keywords: Calcareous soil; Flowering; Irrigation; Growth; Mediterranean; Nitrogen; Nutrient content; Nutrient pulse; Phosphorus; *Rosmarinus officinalis*; Shrubland

1. Introduction

The summer drought is the most characteristic trait of Mediterranean ecosystems (Mooney and Parsons, 1973; Specht, 1979; Mooney, 1989), but the nutrients play an important role too (Kruger, 1979; Specht, 1979; Carreira et al., 1992). Water and nutrient availability are the main abiotic factors that drive the structure and relations in Mediterranean plant communities (Dunn et al., 1977; Rundel, 1982; Witkowski et al., 1990; Barbault and Doucet, 1993; Lebourgeois et al., 1997; Rodà et al., 1999). Mediterranean ecosystems

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are also characterised by recurrent fires (Trabaud, 1991). Frequent fires in wide areas of Mediterranean Basin may result in cumulative nutrient losses through volatilisation, smoke particles, windblown ashes, soil leaching and soil erosion (Tiedmann et al., 1978; Belillas and Rodà, 1993; Serrasolsas and Vallejo, 1999). However, fire increases N and P availability in the first moments after fire (Kutiel and Shaviv, 1989; Thomas et al., 1999; Gimeno-Garcia et al., 2000). The sudden increase in P availability frequently lasts only a short time due to the fact that such increase principally occurs in soluble P inorganic forms (Kutiel and Kutiel, 1989; Thomas et al., 1999), and therefore, the P losses after fire can also be high after fire (Soto et al., 1997). On the other hand, in the last decades, the great use of fertilisers and farm residues to increase agricultural yield and air pollution have increased the N and P inputs in those Mediterranean ecosystems (Peñuelas and Filella, 2001). The increase of atmospheric CO_2 concentration can also vary plant nutrient needs in these Mediterranean ecosystems (Peñuelas and Matamala, 1990; Peñuelas et al., 2001) and the climate change may affect nutrient availability (Sardans and Peñuelas, 2004). Thus, the increase of fire frequency, eutrophycation, and atmospheric and climatic changes favour a wide range of nutrient inputs and nutrient availability across the territory, that can trigger species substitution in some Mediterranean areas (Carreira et al., 1992). Henkin et al. (1994) observed that the cattle activity significantly increased the P availability in the soil top layers of some Mediterranean areas favouring the growth of herbs more than the growth of shrubs. In a Mediterranean area of Galilee a single application of P-fertiliser significantly retarded regeneration of shrub and produced a 3–5-fold increased in herbaceous biomass, suggesting a change in the typical Mediterranean succession toward a stable evergreen Mediterranean community (Henkin et al., 1998).

The capacity of response of the reproductive effort to nutrient fertilisation in Mediterranean environments has been previously tested and some positive effects have been observed, especially for N supply (McMaster et al., 1982; Herrera, 1992; Vilà and Terrades, 1995). The increased of nutrient availability with or without water availability changes can affect the reproductive effort of the dominant species of the Mediterranean shrublands and in this form affect the future composition of these communities.

Rosmarinus officinalis is a very widespread shrub in the Mediterranean basin that is dominant in the post-fire shrubland communities principally in calcareous soils. It is an obligate seed germinator with abundant flowering. Its sunlit character and its high reproductive effort allow it to colonise the bare landscape. Its presence on landscape has been progressively increased in the last decades in wide areas of north-western Mediterranean Basin likely as a consequence of increased fire frequency and field crops abandonment. Furthermore, this species is important in order to maintain the soil structure and fertility both in the first weeks after a fire event and in the first phases of community building that can last some years. The capacity to respond to different water and nutrient supply levels in the field is important not only for the growth and persistence of *R. officinalis* but for the capacity to maintain the nutrients in the ecosystem during the initial and middle phases of ecological succession. The capacity to improve the plant fitness (growth and reproduction effort) and mineralomasses increments of the adult shrub plants in response to nutrient pulses is determinant of the future productivity of the community and may be an important mechanism to guarantee the preservation of soil quality that permits the future establishment of Mediterranean tree species.

We conducted a study in a field post-fire calcareous shrubland dominated by adult plants of *R. officinalis* 5 year after the last fire to investigate the effect of a nutrient pulse and water availability on growth, nutrient contents and reproductive effort of adult *R. officinalis* plants in natural conditions. We aimed to gain knowledge on the extent up to which *R. officinalis* is able of responding to sudden nutrient inputs and under different levels of water supply, when plants have already reached their maturity.

2. Material and methods

2.1. Experimental plot

The experiment was conducted in a naturally regenerated post-fire shrubland that had been burnt three times in the past 20 years. The last fire occurred in summer 1985, 5 years before the experiment started. The study site was located on a hill top (slope