RELATIONSHIP BETWEEN THERMAL SHOCK AND GERMINATION IN FIVE MEDITERRANEAN SHRUBS

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Abstract

The germination responses of 5 fire-prone shrub species: *Erica umbellata*, *E. australis* and *Calluna vulgaris* (Ericaceae), *Halimium umbellatum* (Cistaceae) and *Genistella tridentata* (Fabaceae) in relation to variable light and temperature regimes was determined. Heat treatments consisted of 5 levels of temperature from 50ºC to 200ºC and three exposure times: 1, 5 and 10 minutes.

The seeds of *Halimium umbellatum* and *Genistella tridentate* were the first to start to germinate, whilst those of *Erica umbellata* did not germinate throughout the study period. Germination in the dark only affects the seeds of *Calluna vulgaris*, with the germination percentage falling significantly in comparison with the seeds subjected to a dark/light photoperiod. As regards the effect of the temperature on seed viability, the Ericaceae are not significantly affected by the high temperatures, whilst *Halimium umbellatum* has maximum germination when its seeds are subjected to 100 °C for 5 minutes. The greatest germinative response of *Genistella tridentata* seeds is at 75°C for 10 minutes. Species belonging to the same plant community can have different responses to the heat allowing them to occupy the different niches created by the heterogeneity of fire.

Introduction

Fire is one of the most frequently occurring disturbance factors in vegetation in the Mediterranean basin (Trabaud 1987, Moreno & Oechel 1992); this frequency has made the effect of fires on vegetation in Mediterranean climate areas very important and can even determine the floristic composition of various plant communities. Thus, for example, shrub communities in Mediterranean climate areas are adapted to periodic fires and, in some instances, depend on them to maintain optimum functioning and structure (Luis Calabuig *et al* 1987). This type of plant community can be monospecific or have great species richness; generally community composition post-fire is similar to that existing before it (Naveh 1975, Trabaud 1987, Casal *et al* 1990). Heathland stands out as the dominant shrub formation, usually being the community with the highest diversity of woody species (Luis Calabuig *et al* 1987). These species can regenerate by vegetative resprouts, but there are a few others which regenerate solely from seeds (Tarrega *et al* 1992, Martinez Sánchez *et al* 1996). This

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type of behaviour has been considered an example of adaptation to the periodic presence of fire in some plant species (Keeley 1991, Keeley & Bond 1997).

Studies on heathland regeneration have been carried out throughout the world, Mediterranean Basin (Ojeda *et al* 1996, Valbuena & Trabaud 2001), California (Carrington & Keeley 1999) and Bretagne (Clement & Touffet 1990). Studies have been made of the effect of temperature on seed germination by Thanos *et al* (1992) on different species of the genus *Halimium*, by Bruggink (1993) on *Calluna vulgaris* and *Erica tetralix* and Baskin & Baskin (1998) have reviewed different studies on the subject.

The aim of the present study was to determine the germination response of different woody species seeds, the most common ones in the heathland of the north west Iberian Peninsula, when they are subjected to high temperatures simulating the passage of fire.

Three Ericaceae (*Erica australis* subsp. *aragonensis, Erica umbellata* and *Calluna vulgaris*), one Cistaceae (*Halimium umbellatum*) and one Fabaceae (*Genistella tridentata*) were chosen for this. Some of these species regenerate after fire by resprouting, for example *Erica australis,* others by seed, like *Calluna vulgaris, Erica umbellata* and *Halimium umbellatum,* and others use both mechanisms indistinctly, like *Genistella tridentata.*

Materials and methods

The seeds were collected in a shrubland, the result of intensive farming being abandoned and of frequent fires. It is situated in the farming area of Tierra de León in the municipal district of Valdefresno, León province (Spain) (UTM co-ordinates: 30TTN994281) at an altitude of 970 m on a gentle slope. The study area has a Subhumid Mediterranean climate, Central European tendency, with long, severe cold winters (Rivas Martínez 1987). It has a mean annual temperature between 8 and 13°C; with mean maximum temperature between 2 and 9°C and mean minimum temperature between –4 and –1°C in the coldest month. Annual precipitations normally exceed 650 mm, with a more or less long and intense rainfall season between autumn and spring and a dry summer period (26mm) lasting at least two months.

The typical relief of the area is formed by valleys orientated from North to South and the transition zone between the mountains and meseta. According to the classification of the Seventh American Approximation (Ministerio de Agricultura, Pesca y Alimentación 1984), the soil in the area is included in the order Inceptisol, suborder úmbrico, great group haplumbrepts. They are transition soils, not too recent in young areas, which are generally found in humid climates.

The most dominant species found in the area with the highest cover values are: *Quercus pyrenaica, Erica australis, Erica umbellata, Calluna vulgaris, Cistus laurifolius, Cytisus scoparius, Genistella tridentata, Halimium lasianthum* subsp. *alyssoides, Halimium umbellatum, Tuberaria globulariifolia, Aira caryophyllea* and *Avenula marginata.*

Seeds were collected in July and August, coinciding with the dispersion period of these species, *Erica umbellata*, *E. australis* and *Calluna vulgaris* (Ericaceae), *Halimium umbellatum* (Cistaceae) and *Genistella tridentata* (Fabaceae). Fruits were collected from different plant branches and from different individuals throughout the area. Immediately after collection the fruits were dried so that the seeds could then be isolated. The seeds obtained from the fruits were stored in paper bags before being used.

Five temperatures were selected: 50°C, 75°C, 100°C, 150°C and 200°C. The seeds were heated for 1, 5 and 10 minutes (mean wildfire conditions) in a hot air chamber. These treatments were chosen by considering the potential conditions to be found among soil seeds when a fire occurs (Valbuena 1995). Two batches of seeds that were not subjected to thermal shock were used as a control. One was subjected to a light/dark photoperiod, similar to that of the treated seeds, and the other was left in darkness to test the effect of light on seed germination.

Immediately after treatment the seeds were sown in Petri dishes, 8.5 cm in diameter, on four layers of filter paper saturated with demineralized water. There were 5 replicates of 20 seeds for each treatment. The same number of replicates were used for light and dark.

The dishes were placed in a controlled environment cabinet at a temperature of 20°C ± 1°C with photoperiods of 15 hours' light and 9 hours' dark. A temperature of 20°C was used, as in other germination studies which varied between 20°C and 23°C (Whittaker & Gimingham 1962, Trabaud & Oustric 1989).

Fungus attacks were avoided by using a fungicide (Benlate).

The seeds were examined every week. A seed was considered to have geminated when the radicle could be seen with the naked eye (Booj & Ramakryshnan 1982, Vigna *et al.* 1983). The experiment was continued in this way for 19 weeks.

The results of germination were analyzed using an analysis of variance comparing the germination response to the different treatments. The Scheffe test (1959) was used to detect any significant differences (α=0.05) in the comparison between the pairs of treatments.

Results

Figure 1 contains the germinative response of the different species: the untreated seeds, both those placed in darkness to germinate and those set to do so in a photoperiod, and those seeds subjected to different temperatures for different periods.

It can be observed that *Calluna vulgaris* has high germination percentages in untreated seeds. The seeds of this species are harmed when germination develops in darkness: germination percentages decreased and the differences were statistically significant ($p<0.001$). In contrast, the treatments at high temperatures favoured germination. Although they do not reach statistically significant differences, germination maximum was found at 100°C for 5 minutes. This increase in germination was observed until the seeds were subjected to 150°C for 10 minutes, when it started to decrease until no germination was observed at 200°C for 10 minutes.

As regards *Erica australis* the germination percentages are low, not exceeding 10% germination in any case. The control seeds set to germinate in a light/dark photoperiod have lower percentages than those placed in darkness, though no statistically significant differences were recorded. Very similar results were obtained with all the treatments.

No germination was obtained in *Erica umbellata*, independently of the treatment carried out.

Genistella tridentata is a species which responds to a disturbance like fire by resprouting or by seed germination. It responds in the same way when its seeds were set to germinate in the dark as when they were subjected to a photoperiod, but it was observed that high temperatures favoured germination. The germination maximum was at 75°C for 10 min-

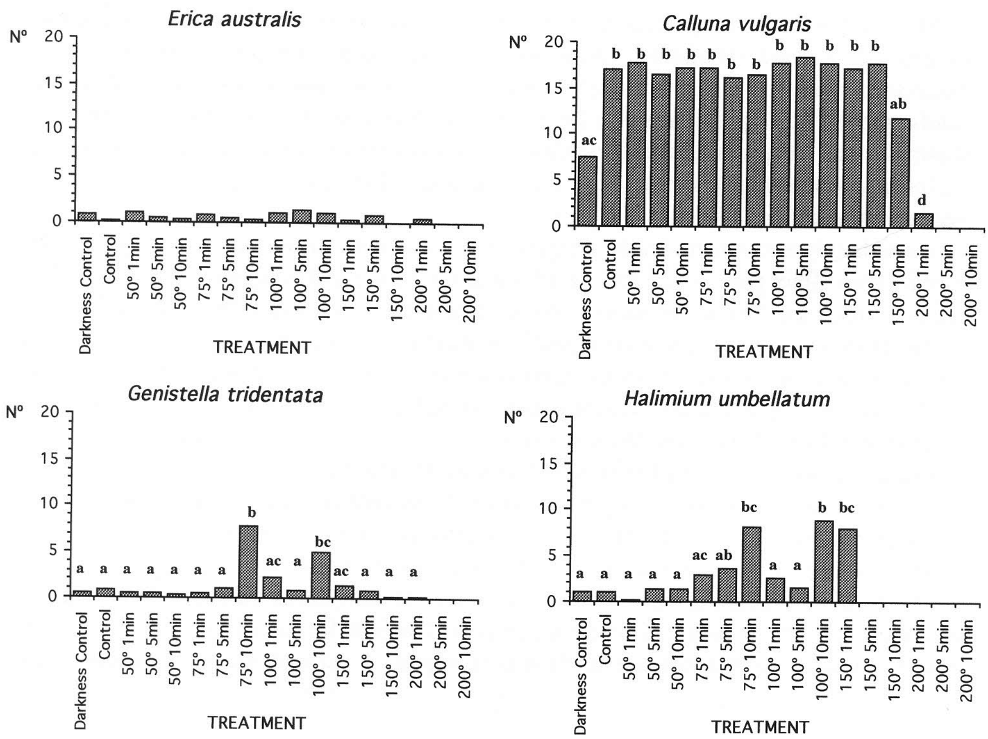

Fig. 1. Germinative response of the studied species. Mean values per dish (maximum 20 seeds). Different letters indicate statistical differences by Scheffe test.

utes with statistically significant differences when compared to the control ($p < 0.0001$). There was no germination at temperatures of 200ºC.

Halimium umbellatum is an obligate seeder species after a disturbance such as fire. Its germination was not affected when its seeds were set to germinate in the dark. The germination maximum was at 100°C for 10 minutes. Similar results were found at 75°C for 10 minutes, but when the temperature is increased to 150°C and the exposure times was 5 minutes, no germination was observed. This is the species the most rapidly harmed by high temperatures.

Discussion

As can be stated in the results obtained, the untreated seeds placed in the dark throughout the study period in general do not respond differently to those subjected to a light-dark photoperiod; only a fall in *Calluna vulgaris* seed germination is observed. This behaviour has also been observed in other populations of this species by different researchers, for example in populations of the NW Iberian Peninsula (González 1993) or in *Calluna* populations in the Netherlands (Bruggink 1993).

The only species which does not germinate throughout the study period is *Erica umbellata.* This contrasts with the results obtained in the field where a large number of seedlings appears after a disturbance such as fire (Fernández Abascal, unpublished data) and results obtained in populations in the NW Iberian Peninsula by González (1993), in which germinations were observed in the control, and the highest germination percentages were recorded when the seeds were subjected to temperatures of 110°C.

As regards the effect of temperature on seed germination, no clear relationship has been found between the adaptive response to fire, resprout or germination, and the effect of the high temperature on seed germination. Thus, for example, the seeds of *Erica australis*, a typical resprouter, are not positively affected by the rise in temperature. Even temperatures of 200°C and exposure times of 5 and 10 minutes cause non-germination. *Calluna vulgaris*, a typical seeder species, responds in a varied manner depending on the populations; in the tests carried out high germination percentages are observed in the control as well as the seeds subjected to high temperatures with no statistically significant differences between them. However, in NW Spain González (1993) recorded the maximum germination percentages at 110°C. In any case the germination percentages are lower in *Erica australis* than in *Calluna vulgaris.*

Seed germination of *Genistella tridentata*, a species mainly using resprouting as its response to disturbances, although it sometimes also uses seed germination, is favoured when they are subjected to high temperatures. The highest results are obtained at 75°C. The germination maximum of *Halimium umbellatum*, a typical seeder in the communities studied, is at 110°C, but suffers more rapidly at high temperatures, dying at 150°C for 5 minutes.

Germination stimulation by thermal shock is also common in Californian chaparral and South African fynbos species where a disturbance like fire occurs frequently (Keeley & Bond 1997). Species belonging to the same plant community can have different responses to heat allowing them to occupy the different niches created by the heterogeneity of fire.

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