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Research note

Effect of heat on seed germination of *Pinus sylvestris* and *Pinus nigra* ssp. *pallasiana*

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Abstract. The present note presents and explains the results of a study dealing with the germination of seeds subjected to heat. Seeds of Scots pine (*Pinus sylvestris* L.) and Anatolian black pine (*Pinus nigra* ssp. *pallasiana*) were exposed to a range of temperatures (70, 90, 110, 130, and 150°C) for different exposure times (1 and 5 min). Germination rates were similar for all treatments and control at 1 min exposure for Anatolian black pine seeds, and almost no germination took place for all treatments at 5 min exposure. Similar results were obtained for Scots pine seeds, with the exception of a sharp decrease in the number of seeds germinated above 110°C. The effect of increasing the exposure time to 5 min was immediate, and no germination took place above 90°C. Results obtained indicate that seeds of the two species do not necessarily need fire for successful regeneration, but fires may have a positive effect on the germination by removing crown cover, thereby providing more light for the seeds deposited to the ground.

Additional keywords: Anatolian black pine; fire; heat treatment; Scots pine; seed germination.

Introduction

Fire has been shown to be an important disturbance agent for successful germination of many plant species, and is an integral part of many forest ecosystems (Cooper 1961; Trabaud 1989; Pausas *et al*. 2004). Many plant species require high temperatures for a period of time for successful germination (Keeley *et al.* 1981). Regeneration of some species is stimulated by light (Orlandini and Malcoste 1972; Toole 1973; Bell *et al*. 1993), and recovery in others seems to be favored by fire (Thanos and Marcou 1991; Trabaud and Campant 1991). Some other species require heat for seed liberation (Alonso *et al*. 1992) and dormancy rupture (Thanos *et al*. 1989; Bell *et al*. 1993; Keith 1996). However, temperatures above 120°C for more than a few minutes have a decreasing effect on germination (Valbuena and Tarrega 1998) and are usually lethal for seeds of most species (Stone and Juhren 1953; Keely *et al.* 1985; Auld and O'Connell 1991; Habrouk *et al*. 1999).

Anatolian black pine (*Pinus nigra* ssp. *Pallasiana*) and Scots pine (*Pinus sylvestris* L.) are two of the most common conifers in Turkey, covering 2 204 381 ha and 738 192 ha, respectively. Pure stands of both species, especially of the black pine, are mostly found in fire prone areas and usually originated from high-intensity fires. Both species have non-serotinous cones and both are reported to establish well on site after fire. Thus, it is of crucial importance to know whether the seeds of the two species are affected by the temperature increase during wild and prescribed fires. The purpose of this paper is to analyse the germination rate of the seeds of these species when heated to different temperatures, for different exposure times.

Material and methods

The seeds used in the present study were obtained from the Forest Tree Seed and Breeding Center in Ankara, the capital city of Turkey. Scots pine seeds were originally obtained from Gümüshane (45°19′48″N and 39°16′00″E) from a 133-year-old stand, 1950 m above sea level. Black pine seeds were obtained from Kizilcahamam-Soguksu (40°19′48″N and 40°20′27″E) from a 78-year-old stand, 1500 m above sea level. Seeds were stored at 4°C in a fridge for 1 year, until the experiments were conducted.

Heat treatments were applied to seeds in an oven preheated to five different temperatures (70, 90, 110, 130, and 150°C) for different periods of time (1 and 5 min) to analyse germination response. These temperatures were chosen to simulate the effects of fire (Stone and Juhren 1953; Keely *et al.* 1985; Neyisci and Cengiz 1985; Tarrega *et al*. 1992; Bradstock and Auld 1995; Keith 1997; Kenny 2000; Nunez and Calvo 2000). The number of seeds subjected to heat in each treatment was 100 (25 seeds × 4 replicates) and another 100 were used as a control.

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The seeds were placed on Whatman 1 filter paper on sterilized river sand immediately after each treatment. Germination was carried out in a germinator under constant conditions at 25°C with a 12 h light : 12 h dark cycle. Seeds were checked 2–3 times per week for seed germination. Seeds were considered to have germinated when radicles emerged 1 mm out of the tegument (Côme 1970), and were then removed.

The germination data were statistically analysed using ANOVA to test the differences among the treatments and

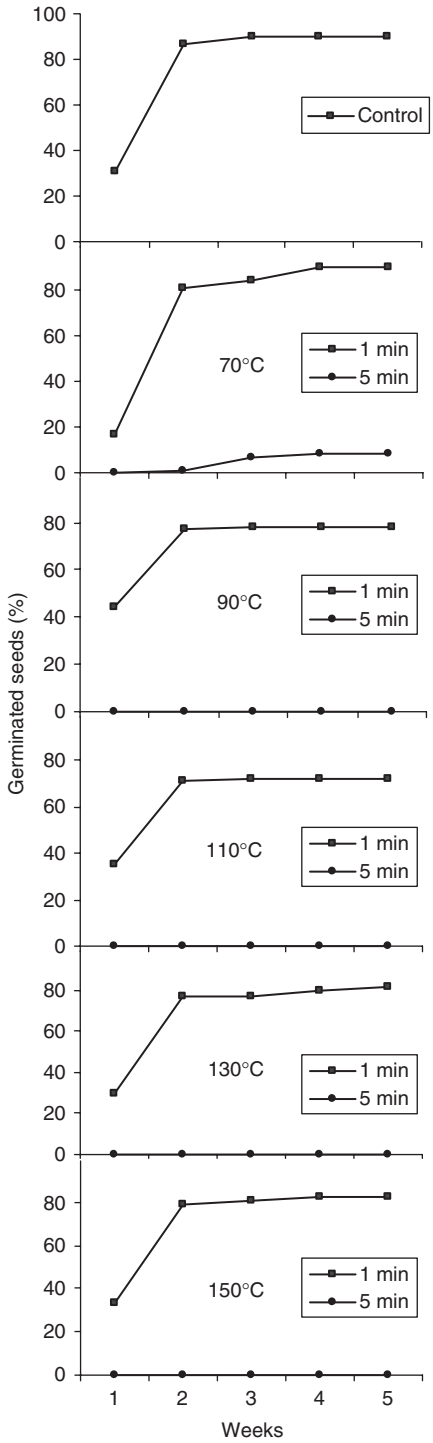


Fig. 1. Effects of temperature and exposure time on Anatolian black pine germination.

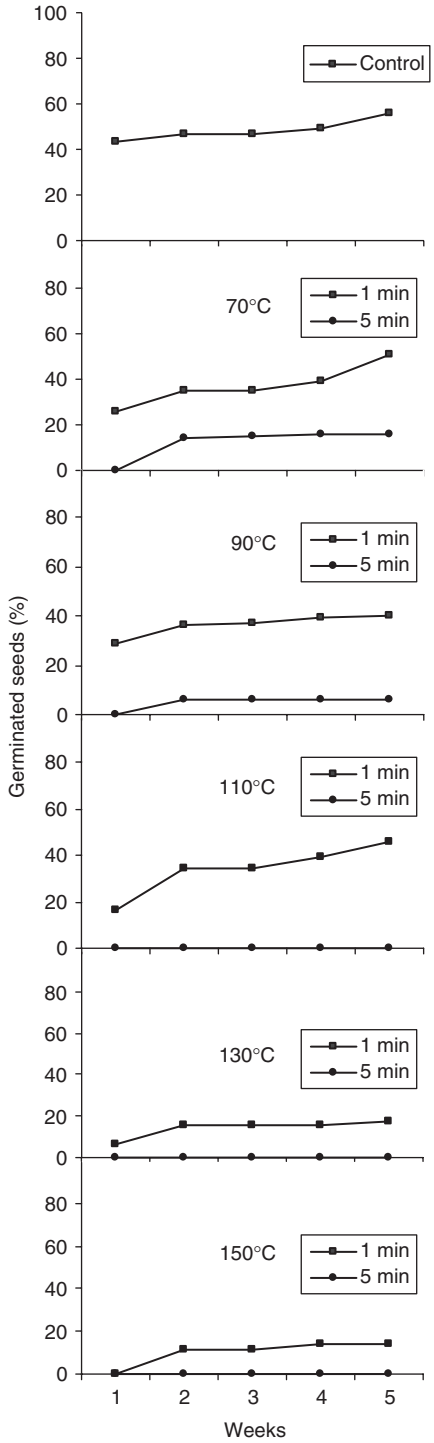


Fig. 2. Effects of temperature and exposure time on Scots pine germination.

Table 1. Analysis of variance for Anatolian black pine and Scots pine germination results

Source	Anatolian black pine				Scots pine			
	df	Sum of squares	*F*	Probability > *F*	df	Sum of squares	*F*	Probability > *F*
Model	10	1182.136	58.662	0.000	10	1182.136	58.662	0.000
Error	33	66.500			33	66.500		
Total	44	2624.000			44	2624.000		
Temperature	4	248.250	30.798	0.000	4	248.250	30.798	0.000
Exposure	1	532.900	264.447	0.000	1	532.900	264.447	0.000
Temperature × exposure	4	89.850	11.147	0.000	4	89.850	11.147	0.000

control. The pattern of germination over time was examined graphically.

Results, discussion and conclusions

Figures 1 and 2 represent the percentage of germination over time for the treatments and control for the seeds of Anatolian black pine and Scots pine, respectively. Figures clearly indicate that exposure time has a significant effect on germination for both species. Germination rates for Anatolian black pine seeds were similar for all treatments above 70°C and control at 1 min exposure, but no germination took place for the treatments above 70°C at 5 min exposure. The germination rate was slightly higher at 70°C and 1 min exposure than the control, indicating that heat may positively affect seed germination under these conditions. Similar results were obtained for the Scots pine seeds, with the exception of a sharp decrease in the number of seeds germinated above 110°C at 1 min exposure. The effect of increasing the exposure time to 5 min was immediate, and no germination took place for the treatments above 90°C. The analysis of variance (Table 1) presents similar results, showing that there are significant differences in germination between the different thermal treatments and exposure times for both species. The results show that heat does not stimulate germination and that seeds may resist short periods of heat (e.g. 1 min), but not much longer. It can thus be inferred from the results of the present study that seeds of the two species do not necessarily need fire for successful regeneration. However, the positive effect of fire on the successful regeneration of these species may be justified with respect to the removal of the crown layer by fire, which, in turn, results in more light for the seeds deposited to the ground. These results are considered to be a valuable contribution to the existing literature.

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