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Smouldering fire-induced changes in a Mediterranean soil (SE Spain): effects on germination, survival and morphological traits of 3-year-old *Pinus pinaster* Ait.

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Abstract In the present study, a smouldering fire was reproduced in a substrate from a *Pinus pinaster* forest in the southeastern Iberian Peninsula. Experiments were carried out, in laboratory, using soil monoliths to assess the short-term fire-induced effects on germination, survival and morphological traits in young (3-year-old) specimens of *Pinus pinaster* Ait. The fire caused a severe reduction in the litter and humus layer relative to a control (unburnt) soil. A lower percentage of accumulated germination (29% in the burnt soil compared with 71% in the control soil) reduced final seedling density, and a lower seedling height was observed in burnt soil. Furthermore, the amount of biomass fixed per unit of leaf area and the concentration of foliar nutrients were lower in the seedlings grown in the burnt soil. However, the amount of biomass fixed per individual seedling was significantly higher in the burnt soil than in the control soil. The results confirm the observed lesser *P. pinaster* recruitment in burnt stands in southeastern Spain.

Keywords Litter and humus layers · Maritime pine · Post-fire regeneration · Wildfire

Abbreviations

C_d	Crown diameter (mm)
D	Density (seedling/monolith)
G	Accumulated germination (%)
LA	Leaf area (dm^2)
O_a	Humus layer (cm)
O_e	Fermentation layer (cm)
O_i	Litter layer (cm)
$O_i + O_e + O_a$	Total organic layer (cm)
RC_d	Diameter of the root collar (mm)
R_l	Root length (mm)
R_B	Root biomass (g)
S	Accumulated survival (%)
S_B	Shoot biomass (needles + twigs + shoot) (g)
S_l	Shoot length (mm)
SLA	Specific leaf area (m^2/kg)
T_B	Total biomass (g)

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Introduction

Pinus pinaster Ait. is one of the most widespread conifer species in Spain and one of the most seriously affected by forest fires. There exist several ecotypes

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