

# Probability of germination after heat treatment of native Spanish pines

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**Abstract** – Spanish pine forests exhibit a high degree of resilience to frequent wildfires. For this reason, they have been considered as active pyrophytes. However, the primary evidence of the fire response of some of the seven Spanish pines suggests that they are not real pyrophytes because germination enhancement has not been detected. In order to investigate the germination response of the Spanish pine seeds after heating, seeds were submitted to different treatments at varying temperatures (50–130 °C) and exposure times (1–15 min) to simulate responses to different fire regimes and situations. The probability of germination after heating was modelled by means of multiple logistic regressions using temperature, time and their interaction as predictors. Very predictive models were found for all the pines, except for *Pinus pinea*. Seeds germinate readily without treatment, losing their viability within a short time and showing a slight protection from fire. The results suggest that, despite the fact that these pines all occur in fire-prone environments, their germination behaviour has clearly not evolved in relation to fire alone. Furthermore, seed behaviour is not related to the general syndromes described as typical of fire-evolved plants. Whereas most of the Mediterranean seeders base their efficient recruitment after wildfires on the presence of hard-coated seeds, most of the Mediterranean pines have attempted other strategies with some variants related to prolific seed production. Only *P. pinea* regeneration after wildfires depends on the existence of fire-resistant and hard-coated seeds. (© Inra/Elsevier, Paris.)

heat treatments / Mediterranean pine forests / multiple logistic regression / seed germination / wildfires

**Résumé** – Probabilité de germination des graines de pins d'origine espagnole après traitement par chauffage. Les pins espagnols montrent un haut degré de résilience aux feux fréquents. Pour cette raison, ils ont été considérés comme des pyrophytes actifs. Cependant, l'évidence première de la réponse au feu de certaines des sept espèces de pins espagnols suggère qu'elles ne sont pas de réelles pyrophytes car aucune augmentation de germination n'a été observée. Afin de connaître la réponse à la germination des graines après chauffage, des graines furent exposées à différents traitements de gradients de température (50 °C à 130 °C) et de durée (1 min à 15 min) afin de simuler la réponse à différents régimes de situation de feu. La probabilité de germination après chauffage a été modélisée au moyen de régressions multiples logistiques utilisant la température, la durée d'exposition et leur interaction comme variables prédictives. De très bons modèles prédictifs ont été établis pour tous les pins, excepté pour *Pinus pinea*. Les graines germent déjà sans traitement, perdent rapidement leur capacité germinative et montrent une faible protection au feu. Les résultats suggèrent que, en dépit du fait que tous ces pins soient localisés dans un environnement propice à l'incendie, il est clair que leur comportement germinatif n'a pas uniquement évolué en relation avec les feux. En outre, le comportement des graines n'est pas relié au syndrome général décrit comme typique de l'évolution des plantes sous l'influence du feu. Alors que la plupart des semenciers méditerranéens basent leur efficiente régénération après passage du feu sur l'existence de graines à téguments épais, la plupart des pins méditerranéens ont établi d'autres stratégies avec des variantes reliées à une production prolifique de graines. Après incendie, seule la régénération de *P. pinea* dépend de l'existence de graines résistantes au feu et avec des téguments épais. (© Inra/Elsevier, Paris.)

chauffage / forêts de pins méditerranéens / régression multiple logistique / germination des graines / feu sauvage

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## 1. Introduction

As in other Mediterranean ecosystems, pine forests seem to exhibit a high degree of resilience to frequent wildfires [38, 40, 61]. For that reason, Mediterranean pines have been traditionally considered as 'active pyrophytes' [1, 2, 10, 28, 30, 31, 54, 57, 59, 65] and even their forests as 'fire type' or 'fire climax'. The reasons for this biological interpretation must be related to the fact that Mediterranean pine forests are particularly prone to periodic fires [17, 57], thousands of hectares being burnt every year around the Mediterranean basin. Pine forests are usually able to recover their former structure after wildfires [39]. Furthermore, the existence of some remarkable adaptive traits developed to couple with fire-induced disturbances such as seed retention in the canopy (serotiny) or xerochasic opening of the cones of some of them [14, 54], seem to indicate a clear evolutionary relationship between pines and fire. However, evidence of germination enhancement by fire in some of these pines is almost absent [57, 60] and the more realistic term 'adapted to fire' has been applied to them. In this sense, Lamont et al. [29] point out that of the 95 species in the genus *Pinus* only six species are considered obligatory pyriscent, although many of them are highly competitive in the post-fire environment. On the other hand, Mediterranean pines have long been considered photophilous generalist plants with a high capacity for spatial and biological selection to colonization after any type of disturbance [3, 4].

Recently, several authors have noted that some of these pines are not genuine pyrophytes [15, 36, 46] because their germination is not stimulated by heat treatments as occurs in many other Mediterranean shrubs [13, 18, 23, 52, 56, 62, 66, 69]. Furthermore, some difficulties in the re-establishment of some of these pines after intense fires have also been reported, as in the case of *P. pinaster* and *P. halepensis* (Escudero, per. obs.), *P. pinaster* in Portugal [10] and *P. nigra* [15, 63].

Our main goal is to model the germination behaviour of the Spanish pines after heat treatments in order to establish the evolutionary relationships between pines and wildfires at this life stage. For that, seeds were subjected to different 'fire intensity' treatments at varying temperatures and exposure times to simulate responses to different fire regimes or microtopographic fire-driven heterogeneity [46]. The probability of germination after heating was modelled by means of logistic curves using temperature, exposure time and their interaction as predictors.

## 2. Materials and methods

### 2.1. Short description of the pines

Six of the 11 pine species naturally growing in Europe are present in the Iberian Peninsula. Most of these pines have been planted for timber or even for edible seeds for centuries; thus, in many cases the original boundaries of their distributions are not easily definitively established. *P. halepensis* Miller, *P. pinea* L. and *P. pinaster* Aiton are low-altitude pines widely distributed in the Mediterranean Basin. *P. pinea* is found mainly on sandy soils, whereas *P. pinaster* grows on acid soils and *P. halepensis* mainly on calcareous soils. On the other hand, *P. uncinata* Ramond ex DC. is a narrowly distributed sub-Alpine pine, confined to the Pyrenees and some isolated populations in the Sistema Ibérico range. *P. nigra* Arn. is a very variable Mediterranean pine which grows in the supra-Mediterranean and mainly on the oro-Mediterranean belts of the highest ranges of the eastern half of the Iberian Peninsula (biogeographical terms following Rivas-Martínez [48]). The Spanish populations have been ascribed to *P. nigra* Arn. subsp. *salzmannii* (Dunal) Franco. *P. sylvestris* L., a typical and widespread European pine, is basically a Spanish oro-Mediterranean and subalpine pine which reaches here its southern and western limits. Finally, *P. canariensis* Sweet ex Spreng, which is an endemic pine of the Canary Islands, was also included in the study.

### 2.2. Experimental design

Seeds were obtained from the Institute for Nature Conservation, Ministry of Environment (1995–1996 harvest). Seed provenances used in the present study were *P. sylvestris* from Soria province, *P. nigra* from Cuenca province, *P. uncinata* from Huesca province, *P. pinea* from Madrid province, *P. pinaster* from Albacete province, *P. halepensis* from Jaén province and *P. canariensis* from Tenerife Island. Seeds were stored at 6 °C in darkness in open containers. Seeds were submitted to different combinations of high temperatures and times in order to cover a wide range of conditions encountered by seeds during fires. Twenty heat treatments were carried out. Heat treatments were as follows: 50 °C (1, 3, 7, 10 and 15 min), 70 °C (1, 3, 7, 10 and 15 min), 100 °C (1, 3, 7 and 10 min), 130 °C (1 and 3 min) and 150 °C (1 and 3 min). A control treatment was also carried out. Parameters of the control were included in the models as 20 °C and 1 min of exposure time. Germination tests for each heat treatment were performed with 100 seeds in four Petri dishes (9 cm in diameter) on two filter papers moistened with distilled

water. The dishes were placed in controlled environmental cabinets at an alternating temperatures of 15 °C/25 °C with a 16 h light/8 h dark photoperiod (Osram fluorescent tubes L20 W/105, 30–45 Em<sup>-2</sup>s<sup>-1</sup>). The criterion of germination was visible radicle protusion. Germination was checked daily and the germinated seeds were removed. After 30 days the experiments were concluded.

### 2.3. Data analysis

As in most of the cases the difference in final percentage was very slight among the lowest intensity treatments (control, 50 °C/1 min, 70 °C/1 min and 100 °C/1 min treatments), the Kaplan-Meier method was adopted to estimate germination functions due to right censored data. The shape difference in the modelled germination curves was tested by the non-parametric log-rank test [45]. When necessary, differences in the final percentage of germination were evaluated by means of the G-test.

Logistic regressions [21, 27] were performed to determine whether either of the two variables considered were predictors of the germination probability. We tested models with the two variables (temperature and time) and their interaction, and also tested all the reduced models. Logistic relationships are of the following form:

$$p = \frac{1}{1 + e^{-z}}$$

where  $p$  is the probability of germination and  $Z$  is a linear combination of the variables included in the model. The coefficients of  $Z$  are estimated by maximization of the likelihood function. Our hypothesis tests are based on the change in the  $-2 \log$  likelihood ratio after building models with and without variables [19, 21, 67]. The goodness of fit of each model is evaluated by means of the classification table and tested by the model chi-square improvement test. All the models included in *table 1* were highly significant ( $P < 0.0005$ ). The relevance of each variable in the models, including interactions, was tested by means of the likelihood ratio test as recommended by Hosmer and Lemeshow [20] and its partial contribution to the model evaluated by the R statistic. Three criteria were weighted in order to select the final models for each pine: the maximum percentage of overall correctly classified seeds, the minimum  $-2 \log$  likelihood ratio or deviance and simplicity [67].

### 3. Results

Seeds readily germinated without heat treatment (control) in all cases, though some differences were detected between the seven pines ( $G = 63.02$ , d.f. 6,  $P < 0.0001$ ). Germinability ranged between 100 % in the case of *P. sylvestris* to 70 % in *P. uncinata*, the rest being above the 85 % of *P. pinea*. The total number of germinated seeds in each treatment is presented in Appendix 1.

The shapes of the germination curves were compared within each species for the less intense treatments (control, 50 °C/1 min, 70 °C/1 min and 100 °C/1 min). Three different patterns were detected (*figure 1*). The first appeared in *P. pinaster* for which no significant differences (log-rank test) were detected between the curves. *P. halepensis*, *P. uncinata* and *P. sylvestris* presented a second type of response which was based on the fact that control seeds germinate significantly faster than seeds submitted to any heat treatment. Finally, *P. pinea*, *P. nigra* and *P. canariensis* presented significant differences between treatments involving not only control seeds.

All the logistic models developed were highly significant ( $P < 0.0005$ ) for each pine (*table 1*), except for *P. pinea*, with the number of overall correctly classified cases varying between 62.11 % for *P. halepensis* and 89.47 % for *P. sylvestris*. The models for *P. pinea* were not significant ( $P = 0.93$  for the best one). The number of germinated seeds in *P. pinea* was similar in each treatment (around 80 %), being only significantly different in the most severe treatment (150 °C/3 min) ( $G = 31.3$ , d.f. 17,  $P = 0.019$  –n.s. – after comparing all but this last treatment, and  $G = 88.79$ , d.f. 18,  $P < 0.0001$  after including all the treatments). Contour graphs of the probability of germination for the other six pines are presented in *figure 2*. The bold 0.5 isoline masks the line in the temperature  $\times$  time space where the probability of germination is 50 %. Above this line, seeds have a chance to germinate.

### 3. Discussion

Spanish pines can hardly be considered as genuine pyrophytes, since a significant germination enhancement has not been detected after heating treatment in any of them. Nevertheless, the concept of pyrophyte is under revision at present, even for some Mediterranean plants such as *Cistaceae* or *Leguminosae* species described as classical examples of pyrophytes, because their germination has been experimentally proven to be stimulated by heat. Thus, in population dynamic terms, these Mediterranean plants are now considered heliophilous

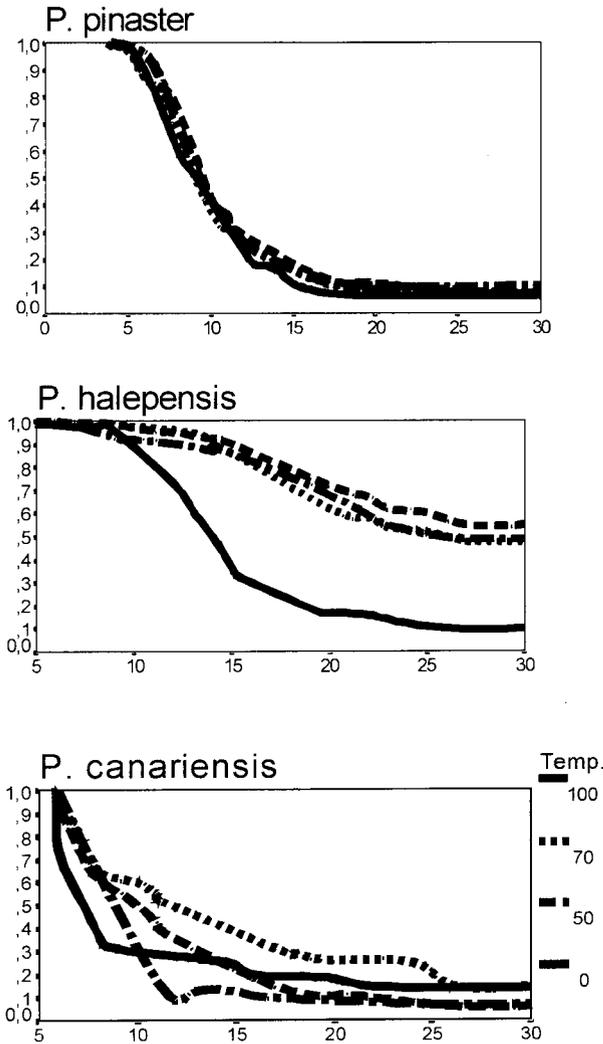
**Table I.** Parameters of the significant logistic models.

Pine species	Terms in the model	-2LL (Constant)	-2LL (Model)	Overall correctly classified (%)	Variables in the model	Significance R statistic
<i>P. sylvestris</i>	T	2 545.66	1 338.19	85.26	T = -0.397	0.000
	T, t		1 252.03	89.47	T = -0.432 t = -0.174	0.000 0.000
	T, t, T*t		1 187.12	89.47	T = -251 t = 0.095 T*t = -0.138	0.000 0.000 0.000
	<b>T, T*t</b>		<b>1 216.04</b>	<b>89.47</b>	<b>T = -450</b> <b>T*t = -.204</b>	<b>0.000</b> <b>0.000</b>
<i>P. uncinata</i>	<b>T</b>	<b>2 562.23</b>	<b>2 088.85</b>	<b>66.95</b>	<b>T = -.355</b>	<b>0.000</b>
	T, t		2 088.20	66.95	T = -0.351 t = 0	0.000 0.420
	T, t, T*t		2 082.37	66.95	T = -0.22 t = 0.02 T*t = -0.038	0.000 0.039 0.016
<i>P. nigra</i>	T	2 444.50	1 840.56	79.95	T = -0.428	0.000
	<b>T, t</b>		<b>1 405.16</b>	<b>85.11</b>	<b>T = -0.438</b> <b>t = -0.326</b>	<b>0.000</b> <b>0.000</b>
	T, t, T*t		1 393.87	85.11	T = -0.32 t = -0.06 T*t = -0.06	0.000 0.002 0.009
<i>P. canariensis</i>	T	2 128.03	1 674.00	81.21	T = -0.405	0.000
	T, t		1 667.59	81.21	T = -0.367 t = -0.045	0.000 0.011
	T, t, T*t		1 578.76	81.63	T = -141 t = 0.044 T*t = -0.183	0.000 0.014 0.000
	<b>T, T*t</b>		<b>1 645.43</b>	<b>84.47</b>	<b>T = -402</b> <b>T*t = -0.111</b>	<b>0.000</b> <b>0.000</b>
<i>P. halepensis</i>	T	2 449.05	2 117.80	62.11	T = -0.323	0.000
	<b>T, t</b>		<b>2 101.95</b>	<b>62.67</b>	<b>T = -0.325</b> <b>t = -0.074</b>	<b>0.000</b> <b>0.001</b>
	T, t, T*t		2 098.97	63.56	T = -257 t = -0.051 T*t = .020	0.000 0.003 0.084
<i>P. pinaster</i>	<b>T</b>	<b>1 950.67</b>	<b>1 532.42</b>	<b>88.11</b>	<b>T = -0.410</b>	<b>0.000</b>
	T, t		1 515.92	88.10	T = -0.365 t = -0.086	0.000 0.000
	T, t, T*t		1 510.95	88.10	T = -0.243 t = 0 T*t = -0.037	0.000 0.521 0.0301

T, Temperature; t, exposure time. -2LL (constant) is the -2 log likelihood value of the model including only the constant. Models in bold are the selected ones - see figure 2. The coefficients of the variables in italics are not significantly different from 0.

pioneers, not only associated with fire, but also with colonizing disturbed areas free of competitors [32, 44, 53, 62]. In this context, physical dormancy of hard-coated seeds can be broken by fire because of the desiccation of

the seed coat [9] but not exclusively [5, 6]. Thus, although seed germination is enhanced by heat shock, germination can also be triggered by any perturbation able to alter the seed coat [5, 6]. This is a widely spread



**Figure 1.** Shape of the germination curves for the less severe treatments (Kaplan-Meier model) expressed as the fraction of seeds not germinated. Three different patterns have been detected: 1) Curves do not show significant differences (log-rank test,  $P > 0.05$ ) between them (*P. pinaster*). 2) Seeds at control conditions germinate significantly faster, whereas the rest are not significantly different (i.e. *P. halepensis*). 3) Curves after different treatments follow complex patterns (i.e. *P. canariensis*).

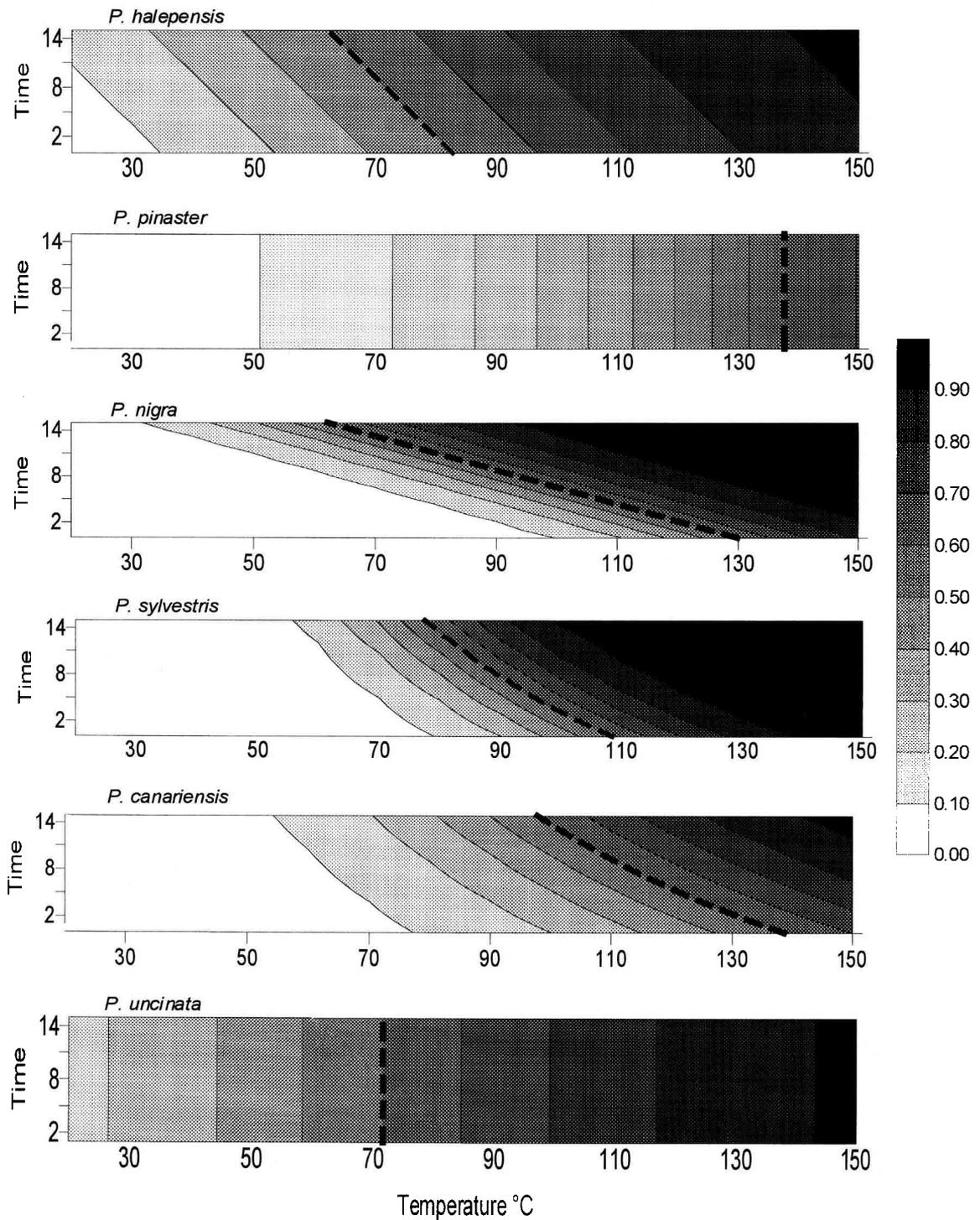
strategy in colonizers adapted to very fluctuating environments such as those of Mediterranean ecosystems [50].

Pine seeds are ready to germinate (germinability above 75 % in all of them at control) in contrast to seeds from typical Mediterranean shrubs, which present a deep

dormancy based on coat hardness and impermeability [7, 13, 43, 55]. This fact suggests that pine adaptation to perturbations must be sustained not in dormancy characteristics or structural properties that prevent immediate germination of seeds as is usual in Mediterranean plants [7, 8, 24, 56], but in other adaptive responses.

As suggested by the differences between germination models, the adaptive traits of each pine species may be specific. Thus, the germination behaviour after heat treatment of two of the Spanish lowland pines (*P. halepensis*, *P. pinaster*) is considerably different in spite of the fact that their establishment is based on a very similar powerful light-induced regenerative capacity [51, 58], a yearly production of prolific seed crops and the safe-guarding of large canopy seed banks [29] as shown by Daskalaku and Thanos [14] in *P. halepensis*.

Germination of *P. pinaster* seems to be mainly controlled by the temperature and not by the exposure time, reaching values of probability of germination below 0.5 only when temperature surpasses 130 °C (figure 2). This suggests that seed cover confers a resistance over a wide range of fire intensities, failing only when high temperatures are reached [36]. This fact agrees with the lack of significant differences (log-rank test) between the germination curves after the less severe treatments (figure 1). Thus, the recruitment of this pine after wildfires seems to be assured by the combination of coat resistance and cone protection and not by the existence of a large soil seed bank, since seed longevity is barely more than 2 years [36]. The low germinability obtained by Reyes and Casal [46] might be a consequence of a fast viability loss of stored seeds [11, 12]. On the other hand, *P. halepensis* which had been considered primarily as a genuine pyrophyte [28, 30, 59], has severe problems in germinating after heat treatment. In this case, seed cover confers a weaker protection and the exposure time becomes relevant (figure 2). A temperature around 70 °C could determine the failure of the seed if the exposure time is higher than 10 min [14, 36]. However, postfire recruitment is always very effective even after very intense fires [41, 35, 54]. Daskalaku and Thanos [14] suggested that the efficient postfire regeneration of *P. halepensis* must first depend upon a high canopy seed bank because seeds found in the soil are killed and those stored in cones are efficiently protected. Furthermore, dissemination from seeds of edge surviving pines is very limited [2, 47]. Thus, though seed mortality can become very important in some wildfires as also shown for our models, a significant number of seeds should survive [49]. After that, early seedling establishment is well adapted to exploit the postfire conditions [64]. Another problem related to fire disturbances arises after comparing the curves of germination: control seeds are faster to



**Figure 2.** Contour maps of the probability of germination in temperature by exposure time space. Selected models are shown in bold in table 1. X-axis is the temperature and y-axis is the exposure time during the fire intensity treatments. The isoline of 0.5 probability is in bold, seeds submitted to treatments located to the right of this line have no chance of germination.

germinate than those submitted to fire intensity treatments (figure 1). Probably, seeds need more time to complete their imbibition after desiccation, and so predation risk by granivorous birds could be increased [49].

Seed behaviour of the third Spanish lowland pine, *P. pinea*, is completely different. Germination percentage is similar after almost all the treatments, a significant decay being detected only after the most severe one (130 °C/3 min). The seed size is one of the highest in the genus [11]. Thus, this pinyon pine has been widely planted for its edible seeds. The seed weight is  $0.70 \text{ g} \pm 0.12$  ( $n = 200$ ) and length  $1.68 \text{ cm} \pm 0.14$ , which is considerably higher than in *P. canariensis*: weight,  $0.12 \text{ g} \pm 0.03$  and length,  $1.11 \text{ cm} \pm 0.13$ ;  $n = 200$ ). These results seem to support the idea exposed by Keeley [22] and Reyes and Casal [46] that larger seeds are more resistant to fire. Then, larger seed size might have evolved not only in relation to dispersal and to secure survival of seedlings, but also as a response to wildfire. This idea should be tested, both intra- and interspecifically. Furthermore, seeds of *P. pinea* are wingless, dispersing only under the canopy of parent trees, and do not require light to germinate [51]. Thus, recruitment after fire disturbance should be a rare event which is controlled by the high fire resistance of *P. pinea* seeds.

Montane pines also show problems in germinating after heat treatment (figure 2). In a recent paper, we commented on the implications at the community level of this behaviour [15]. As also shown by Trabaud and Campant [63] recruitment of *P. nigra* after catastrophic wildfires can become cumbersome. Natural forests of these trees (*P. nigra*, *P. sylvestris* and *P. uncinata*) appear on the oro-Mediterranean and sub-Alpine belts of the highest mountain of the eastern half of the Peninsula or on rocky sites at lower altitudes, such as spurs, crests and step slopes [42]. In such situations, tree population structure results in a patchy distribution of trees, surrounded by a general matrix of creeping scrubs, caespitose grasses and bare rock outcrops. At these conditions, wildfire is rarely catastrophic and many trees can easily survive. It is probably for this reason that these pines base their dispersal strategy on small seeds more easily dispersed by wind (*P. sylvestris*: weight,  $0.01 \text{ g} \pm 0.005$ , *P. uncinata*:  $0.01 \text{ g} \pm 0.01$  and *P. nigra*:  $0.02 \text{ g} \pm 0.01$ ;  $n = 200$ ). Thus, pine recruitment in the postfire environment seems to be secured from surviving pines.

The detected problems [15, 63] and the high incidence of fires of more than 10 000 ha [37, 68] on the extensive pine forests of *P. sylvestris* and *P. nigra* located at lower altitudes on deeper soils (supra-Mediterranean and montane belts) is most likely due to landscape homogenization resulting from a decrease in man-driven disturbances [3]. Thus, after wildfires almost all seeds die.

Dispersion from surviving edge pines is strongly limited because the size of the burnt areas are very important [47, 54]. Consequently, resprouters such as different *Quercus* species which are usually interspersed in the subcanopy can rapidly control the available space [12]. These events may determine notorious landscape changes and pines can become locally extinct.

Anyway, these pines also show some differences in their germination responses after high temperature treatment. *P. uncinata* germinability is highly sensitive to heat treatment, whilst indifferent to the exposure time. A temperature above 70 °C may kill the seeds even after a short period (figure 2). The germination behaviours of *P. sylvestris* and *P. nigra* are similar. Seed cover confers protection on the embryo in a very narrow range of temperatures. Even low temperatures (50–70 °C) can cause the seeds to not germinate after 10–15 min.

Finally, the strategy of the Canarian pine is different. Whereas most pines regenerate by seeds alone because adult plants are killed by fire – obligate seeders, *P. canariensis* is capable of using seeds or resprouts to recover from wildfires. Mature seeds germinate without restriction at control conditions and they can also germinate at lower heat temperatures, the exposure time not being relevant. However, at higher temperatures, a longer time exposure induces seed death (figure 2). In any case, only field experiments can lead us to determine the role of seeds in the regeneration of a natural Canarian pine forest.

#### 4. Conclusions

Whereas most of the Mediterranean seeders base their efficient recruitment after wildfires on the presence of hard-coated seeds, Mediterranean pines have attempted other 'strategies' with some variants. They have chosen another solution related to prolific seed production. Seeds germinate readily without treatment, losing their viability in short periods and only show a slight protection from fire, with most of them being killed. Thus, lowland pines, such as *P. halepensis* and *P. pinaster*, based recruitment in the postfire environment on the existence of a large canopy seed bank and a certain degree of serotiny [14] because thermophilous pine forests are really fire-prone systems; cones of up to 20 years of age contained a considerable fraction of germinable seeds in *P. halepensis* [14]. As shown by Fraver [16] the temperature transmission into cones is not very intense, so some of the seeds can survive and be released to the soil after wildfire. However, *P. pinea* and partially also *P. pinaster*, based their re-establishment strategy after fire on the presence of a very resistant hard coat

which confers protection in a wide range of temperatures. On the other hand, montane pines (*P. uncinata*, *P. nigra* and *P. sylvestris*) based their re-establishment on the landscape heterogeneity and a more efficient dispersal strategy, sustaining their stand regeneration by surviving trees. Finally, the coincidence of prolific crops and resprouting in *P. canariensis* might have evolved as a response to low mean fire intervals and the necessity to exploit new bare territories, both of which are related to the intense volcanic activity of the Canary Islands.

In spite of the fact that all pines occur in fire-prone environments, it is clear that their germination syndromes have not evolved in relation to wildfire alone. Furthermore, seed behaviour is not related to the general syndromes described by Keeley [23] as being typical of fire-evolved plants. This author points out that species that germinate readily without treatments are usually resprouters, which is not the case here, except for *P. canariensis*.

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#### Appendix 1. Number of germinated seeds in each treatment.

Temp.	Time	<i>P. canari.</i>	<i>P. pinea</i>	<i>P. pinaster</i>	<i>P. sylvest.</i>	<i>P. nigra</i>	<i>P. uncinata.</i>	<i>P. halep.</i>
Control		90	85	93	100	97	70	86
50	1	94	72	88	92	96	60	43
	3	84	72	90	95	97	56	51
	7	93	67	93	91	92	61	49
	10	90	82	88	94	95	60	47
	15	93	77	90	90	91	61	50
70	1	85	86	91	92	96	56	53
	3	85	79	92	88	92	53	52
	7	91	83	84	68	43	50	58
	10	97	79	90	92	86	52	56
	15	97	81	94	85	0	57	56
100	1	93	78	92	90	93	53	45
	3	84	74	89	60	88	50	67
	7	20	87	86	1	6	21	57
	10	77	72	61	3	1	5	0
130	1	81	74	93	10	65	0	23
	3	1	80	65	0	0	0	2
150	1	61	79	28	0	0	0	0
	3	0	42	0	0	0	0	0