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Short Communication

Heat affected cone bursting in various provenances of *Pinus roxburghii* from Garhwal Himalaya

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All over the world the dominance of pines and fire-returns intervals in the forests are positively correlated. The relation is not simply between pines and the presence of fire, but between tolerance limits of pines and the heat generated through natural fire regimes. The long needle pine maintains a continuous fuel bed across the forest floor, which creates most favourable circumstances for the incidence of wild land fires. The chirpine forests are particularly extending in Himalaya, because the species is fire hardy and inextricably linked with forest fires. In its development from a seedling through sapling and pole sizes over the first 25 years of its life, the *Pinus* may survive as many as 10 fires [1]. Pines have therefore, specilized, unusual adaptations to a range of high frequency, low-intensity fires, which is responsible for wide distribution of *Pinus roxburghii* across its native range.

The present study was therefore aimed at understanding the tolerance level of cone and seeds by subjecting artificial heat conditions, inside the laboratory ovens for cone bursting and subsequent germination of seeds thus extracted, in different provenances of *Pinus roxburghii* from Garhwal Himalaya.

Cones were collected from 5 different seed sources of natural chirpine forests, distributed in 3 districts i.e., Pauri, Chamoli and Tehri of Garhwal Himalaya (latitude 30° 2' to 30° 34' N and longitude 78° 48' to 79° 16' E). The majority of rainfall in these regions (which varied from 1016 to 1778 mm) occurred during monsoon period (i.e., from June to September), and represented by sub-tropical to temperate climates. The seeds were extracted by artificial heating of the cones in laboratory ovens at various temperatures *viz.*, 40°C, 75°C, 90°C, 100°C, 120°C, 135°C and 150°C, with reference to sunlight as a control. Initial moisture contents of cones were determined by the oven dry method (at 105°C for 16-18 hr.). Seed weight and moisture contents were determined for each lot. A representative sample was drawn from each lot consisting of only sound seeds for undertaking further germination tests in laboratory conditions, inside a seed germinator, which was maintained simultaneously at 25°C and 30°C.

The results on artificial heating of cones have indicated that at 40°C, the time required for bursting and complete opening of the cones varied from 6 days to 6 days and 10 hours in all the 5 seed sources, whereas at 150°C the seeds were released by the cones just within 45 minutes in all the provenances. However, in sun drying (as control) the cones took 25 days for releasing the seeds. To test the quality of the seeds (viability and vigour), the seeds extracted at various temperatures were germinated at 25°C and 30°C in a seed germinator and the results are presented in Table 1. It is interesting to note that germination of seeds extracted even at 150°C and germinated at 25°C ranged from 36.4 ± 1.33% (Badiyargarh provenance) to 37.4 ± 2.06% (Kalimath provenance).

In moist cool temperate climate, the method of air drying and extraction of seeds from cones is not much reliable as an increase in the humidity of the air may cause a re-closing of the cones [2]. These problems indicate the importance of developing the methods like artificial heating for efficient seed extraction. Artificial heating provides control on air moisture and temperature, within a much shorter period of treatment and results in more effective work organisation [3]. Cone drying by artificial heating should be carried out in such a way, so as to obtain drying in the shortest period of time, without damaging the seed qualities like viability and vigour. From this experiment it has been brought out that the seeds of *Pinus roxburghii* can be extracted efficiently from cones by using artificial heat. Depending upon the planting schedule, cones can be opened in the sun or at 40°C to 135°C (Table 1), without impairing their qualities, provided the moisture content of cones is reasonably low (3.7% to 6.9%).

Fire can injure trees in several ways: foliage or bud scorch, bole damage or root damage [4], and tissue death is assumed to occur at 60°C for one minute. Hence tree mortality from heat generated from fire can be predicted and cumulatively assessed at the stand level. Also the lethal temperatures can be predicted along with probability of mortality from crown scorch.

Table 1. Effect of different temperature regimes on cone bursting and subsequent seed germination in *Pinus roxburghii* provenances

Treatment/ temperature (°C)	Time required for bursting of cones			Moisture % in cones after bursting	Moisture % in seeds	Weight of 100 seeds (gm)	Germination percentage (25°C)	Germination percentage (30°C)
	Days	Hours	Minutes					
Ashtavakra								
40	6	-	-	6.1 ± 0.74	7.4 ± 0.21	13.92 ±0.85	87.4 ±2.18	52.4 ±1.76
75	-	6	30	5.9 ±0.81	7.2 ±0.34	13.73 ±0.79	84.6 ±1.33	46.0 ±1.28
90	-	4	-	5.6 ±0.42	7.1 ±0.42	12.24 ±0.94	64.0 ±1.42	42.2 ±1.32
100	-	2	15	5.2 ±0.28	7.0 ±0.35	11.79 ±0.86	83.2 ±1.63	44.0 ±1.16
120	-	1	30	4.8 ±0.57	6.8 ±0.53	10.04 ±0.79	62.0 ±1.47	40.0 ±1.80
135	-	1	-	4.5 ±0.71	6.5 ±0.31	9.83 ±0.81	44.2 ±1.54	38.6 ±1.52
150	-	-	45	4.1 ±0.64	6.3 ±0.51	9.68 ±0.71	36.8 ±1.63	34.2 ±1.44
Sun (control)	25	-	-	5.6 ±0.91	7.6 ±0.40	14.57 ±0.69	84.8 ±2.42	50.4 ±1.68
Godnar								
40	6	10	-	6.9 ±0.58	8.0 ±0.35	14.28 ±0.64	84.2 ±1.63	78.0 ±1.36
75	-	6	15	6.4 ±0.72	7.7 ±0.42	13.94 ±0.48	78.0 ±2.72	72.4 ±1.72
90	-	4	30	5.8 ±0.36	7.4 ±0.38	13.66 ±0.56	72.6 ±2.46	74.2 ±1.60
100	-	2	45	5.5 ±0.42	7.1 ±0.26	13.32 ±0.72	64.2 ±1.82	70.0 ±1.44
120	-	1	45	5.1 ±0.28	6.8 ±0.47	13.08 ±0.53	66.8 ±2.28	62.6 ±1.58
135	-	1	15	4.8 ±0.61	6.3 ±0.36	12.85 ±0.67	40.0 ±1.70	40.0 ±1.24
150	-	-	45	4.2 ±0.54	5.9 ±0.32	12.27 ±0.55	36.6 ±2.16	36.2 ±1.14
Sun (control)	25	-	-	6.6 ±0.49	8.4 ±0.48	14.72 ±0.62	74.8 ±2.66	76.0 ±1.68
Badiyargarh								
40	6	-	-	6.6 ±0.72	7.1 ±0.25	13.75 ±0.84	82.6 ±1.67	48.8±1.18
75	-	6	30	5.7 ±0.86	6.9 ±0.33	13.42 ±0.62	78.2 ±2.53	42.0 ±1.36
90	-	4	15	5.4 ±0.60	6.5 ±0.28	13.26 ±0.41	80.4 ±2. 17	46.4 ±1.20
100	-	2	15	5.1 ±0.42	6.2 ±0.56	13.07 ±0.76	64.0 ±1.48	40.6 ±1.28
120	-	1	30	4.6 ±0.63	5.8 ±0.44	12.68 ±0.56	58.2 ±1.36	38.8±1.33
135	-	1	-	4.1 ±0.54	5.3 ±0.42	12.24 ±0.68	40.6 ±1.74	32.2 ±0.96
150	-	-	45	3.8 ±0.56	5.0 ±0.21	11.84 ±0.46	36.4 ±1.33	30.0 ±0.76
Sun (control)	25	-	-	5.8 ±0.76	7.4 ±0.34	13.98 ±0.72	80.6 ±1.63	44.8 ±1.42
Kalimath								
40	6	-	-	5.7 ±0.64	6.6 ±0.29	13.34 ±0.42	80.8 ±2.48	82.6 ±1.70
75	-	6	15	5.5 ±0.78	6.3 ±0.38	13.09 ±0.78	71.6 ±2.05	78.2 ±1.54
90	-	4	30	5.1 ±0.52	6.0 ±0.25	12.63 ±0.81	78.0 ±1.83	80.4 ±1.28
100	-	3	-	4.7 ±0.46	5.7 ±0.41	12.44 ±0.56	69.2 ±1.56	72.0 ±1.46
120	-	1	45	4.3±0.40	5.4 ±0.47	12.18 ±0.47	62.0 ±1.74	60.4 ±1.20
135	-	1	10	4.0 ±0.53	5.0 ±0.34	11.74 ±0.52	40.2 ±1.42	40.2 ±1.14
150	-	-	45	3.7 ±0.82	4.6 ±0.26	11.37 ±0.64	37.4 ±2.06	38.0 ±1.02
Sun (control)	25	-	-	5.2 ±0.68	6.8 ±0.34	13.58 ±0.70	77.6 ±1.87	80.8 ±2.12
Thalisain								
40	6	6	-	6.4 ±0.86	8.6 ±0.36	13.84 ±0.87	85.4 ±2.16	74.6 ±1.84
75	-	6	15	6.1 ±0.65	8.4 ±0.32	13.56 ±0.79	82.6 ±1.35	68.2 ±1.52
90	-	4	-	5.7 ±0.72	8.1 ±0.48	13.35 ±0.92	62.0 ±1.44	66.8 ±1.70
100	-	2	15	5.3 ±0.54	7.9 ±0.30	13.21 ±0.86	81.2±1.65	62.0 ±1.46
120	-	1	30	5.0 ±0.37	7.8 ±0.39	13.08 ±0.81	60.0 ±1.40	56.4 ±1.32
135	-	1	-	4.8 ±0.80	7.4 ±0.56	12.54 ±0.73	40.2 ±1.63	40.8 ±1.10
150	-	-	45	4.5 ±0.38	7.2 ±0.41	12.15 ±0.69	36.8 ±1.30	36.2 ±0.48
Sun (control)	25	-	-	5.9 ±0.74	7.8 ±0.40	14.26 ±0.71	82.8 ±2.44	70.6 ±1.40

But interestingly the cones and seeds of *Pinus roxburghii* are fire resistant and therefore, even high intensity fires for a short period does not pose any threat for their regeneration, which is why *Pinus roxburghii* forests are extending continuously in the fire prone areas of Himalaya.

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