SEED GERMINATION OF SELECTED DRY DECIDUOUS TREES IN RESPONSE TO FIRE AND SMOKE

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SINGH A & RAIZADA P. 2010. Seed germination of selected dry deciduous trees in response to fire and smoke. Seasonally dry tropical forests are facing threat of extinction due to repeated lopping and forest fires. In the present study seed germination of four dry tropical trees, *Acacia catechu, Bauhinia variegata, Dalbergia latifolia* and *Tectona grandis,* was studied in response to smoke and fire. All four species showed enhanced germination and seedlings had better vigour than the untreated seedlings. Fire resulted in greater response than smoke. This study suggested the possible roles of fire and smoke in producing high quality seedlings to be used for plantation purposes.

Keywords: Dry tropical trees, growth, vigour, threat

SINGH A & RAIZADA P. 2010. Gerak balas percambahan biji benih beberapa pokok daun luruh iklim kering terhadap asap dan api. Pangkasan serta kebakaran hutan yang berulang-ulang menyebabkan hutan tropika kering yang bermusim diancam kepupusan. Dalam kajian ini, percambahan biji benih empat pokok tropika kering iaitu *Acacia catechu, Bauhinia variegata, Dalbergia latifolia* dan *Tectona grandis* dikaji dengan mendedahkannya kepada asap dan api. Keempat-empat spesies menunjukkan peningkatan percambahan dan penghasilan anak benih yang lebih cergas berbanding kawalan. Gerak balas daripada rawatan api lebih tinggi daripada rawatan asap. Kajian ini mencadangkan bahawa api serta asap dapat diguna untuk menghasilkan anak benih berkualiti untuk tujuan perladangan.

INTRODUCTION

Seasonally dry tropical forests account for nearly 40% of all forests in India (MoEF 1999). Tropical dry forests are currently facing a large-scale anthropogenic disturbance such as repeated lopping of trees for fuelwood or leaf fodder and heavy grazing (Jha & Singh 1990). In addition, these forests are subject to forest fires especially during the driest part of the year when adequate amount of litter deposits on the floor. In India and other tropical parts of the world, large areas of tropical dry forests have been converted to grasslands as a result of fire and other uses (Sagar & Singh 2004). Anthropogenic fire arising from rapid industrialisation and related landuse changes in the past few decades also threatens these forests (Prasad *et al.* 2002). In India, it is estimated that forest areas prone to forest fires annually range from 33% in some states to over 90% in others (Prasad *et al.* 2002).

Fire stimulates germination of many plant species in the chaparral (southern California), kwongan (Australia) and fynbos (South Africa) (Sparg *et al.* 2005). Heat shock or exposure to chemicals produced by fire or smoke promotes germination (Pierce *et al.* 1995, Keeley & Fotheringham 1998). Many studies have been performed to determine the effects of light, temperature, substrate and water stress on seed germination of forest tree species in the dry deciduous forest of India. However, effects of smoke and fire have not been discussed in detail. Therefore, the present study was aimed at investigating inter-specific variation in seed germination of four dominant dry deciduous trees in response to the two integral components of dry deciduous forests, namely, smoke and fire.

MATERIALS AND METHODS

Acacia catechu, *Bauhinia variegata*, *Dalbergia latifolia* (all Leguminosae) and *Tectona grandis* (Verbenaceae) are common trees in the dry deciduous forests of India. All four plants are widely used in plantation forestry.

Seeds for the present study were obtained from different stands in Uttar Pradesh, Madhya

Pradesh and the Forest Research Institute, Dehradun Uttaranchal. The study was conducted in the polyhouse at the Botanical Garden, Banaras Hindu University in Varanasi (25° 18' N, 80° 01' E, 126 m asl). Climate of the area is tropical monsoonal with mean annual rainfall of 821 mm.

In the present study a triplicate set of 100 seeds was used for each treatment of each species, including the control. For germination, seeds were placed on cut sheets of filter papers in Petri dishes and moistened with distilled water. The criterion for germination was radical emergence of at least 1 mm long (Thomas *et al.* 2003). The viability of seeds was tested with 2,3,5-triphenyltetrazolium chloride (TTC) (ISTA 1993).

Smoke treatment

Seeds were exposed to smoke using smoke-fumigated filter papers. Smoked filter papers were prepared by hanging filter papers over the fumigation tents in which litter was burning till they turned completely brown due to smoke (Dixon *et al.* 1995). Litter used in this smoke treatment was collected from locally-grown dry deciduous trees.

Fire treatment

Seeds were exposed to fire as proposed by Khurana (2002). Quadrats (50 × 50 cm) were laid on the forest floor after which 100 seeds of each species were randomly spread within each quadrat. An amount of 390 g m^{-2} dried fuel (e.g. leaves, twigs) was then spread over the seeds. The amount of fuel represented the litter layer available just before the rainy season in native dry tropical forests (Roy 1992). One hour after each fire treatment, the seeds were sieved from the burnt fuel and surface sterilised for 30 s by immersing them in 0.1% $HgCl_2$.

Germination velocity index

The germination velocity index (GVI) was calculated to determine the impact of smoke and fire on seed germination using the formula (Woodstock 1976):

$$GVI = \frac{N_1}{1} + \frac{N_2}{2} + \frac{N_3}{3} + \frac{N_4}{4} + \cdots$$

where N_1, N_2, N_3 and N_4… = number of new germinants on a particular day of the test and germination 1, 2, 3, 4… = number of days after germination test began.

Since the number of new germinants on a particular day is divided by the number of days, the GVI is higher if more seeds germinate in lower number of days. Effects of smoke and fire on seed germination and GVI were analysed by *t*-test using SPSS Version 10.0.

RESULTS AND DISCUSSION

Seed viabilities were 87, 50, 69 and 30% for *A. catechu, B. variegata, D. latifolia* and *T. grandis* respectively. Smoke and fire increased germination in all four species but at different rates. A significant increase in seed germination was observed in response to smoke ($F_{1, 23}$ = 64.016, p = < 0.001) and fire ($F_{1, 23}$ = 793.688, p = < 0.001) in the present study but always greater in the latter (Figure 1). *Dalbergia latifolia* showed the highest increase in seed germination in response to smoke and fire compared with control, i.e. 74 and 124% respectively. The rest of the species showed increases of 44–58% and 56–85% in smoke- and fire-treated seeds respectively (Figure 1).

In addition to enhanced germination, seeds of all species studied also showed significantly higher GVI in response to smoke ($F_{1, 23}$ = 136.405, p < 0.001) and fire ($F_{1, 23}$ = 482.444, p = < 0.001). *Acacia catechu* responded least to smoke and fire exposure, whereas *B. variegata* seeds showed maximum increase (Table 1).

Fire induced the breaking of seed coat dormancy and this may be the reason for enhanced seed germination with improved quality of seedlings in the present study as also reported by Kulkarni *et al.* (2007). There are also reports for stimulated regeneration of *T. grandis* in burnt areas as fire stimulates seed germination and facilitates establishment (Champion & Seth 1968). Smoke has a combination of chemicals (Baldwin *et al.* 1994) and is known to enhance the germination in several tree species such as *Emmenanthe penduliflora* (Keeley & Fotheringham 1997, 1998), *Leucopogon glacialis, Stylidium soboliferum, Laxmannia orientalis, Centrolepis aristata, Leptospermum myrsinoides, Epacris impressa, Ixodia achillaeoides* (Enright & Kintrup 2001), *Epacris impressa* (Marsden-Smedley *et al.* 1997) and also in some common vegetables (Drewes *et al.* 1995,

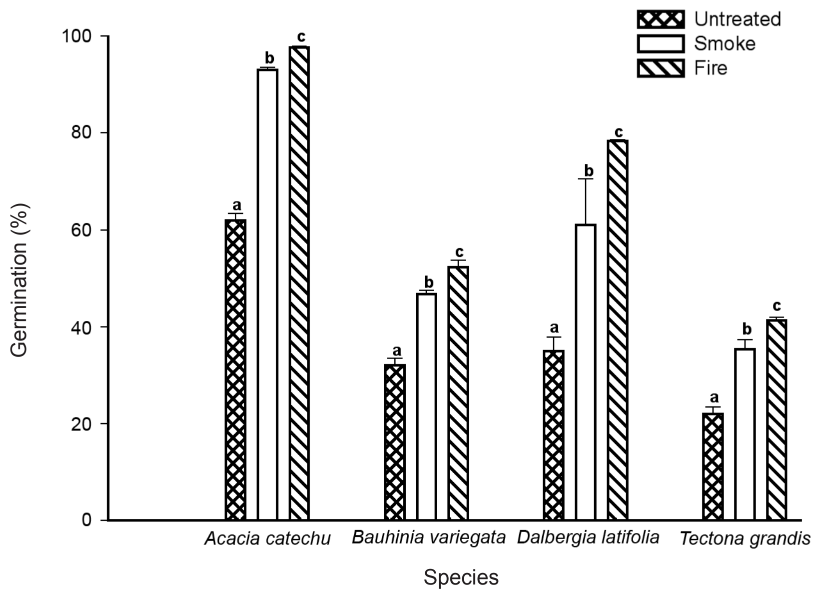

Figure 1 Germination (%) of four dry deciduous tree species in response to smoke and fire treatment; bars in each species, affixed with different letters are significantly different at 0.05 level.

Table 1 Germination vigour index of untreated and treated (smoke and fire) seeds of dry deciduous trees

Species	Untreated	Smoke	Fire
Acacia catechu	2.40 ± 0.144 a	2.48 ± 0.017 a	2.96 ± 0.006 b
Bauhinia variegata	1.08 ± 0.073 a	1.79 ± 0.147 b	2.46 ± 0.109 c
Dalbergia latifolia	1.94 ± 0.023 a	3.53 ± 0.018 b	3.87 ± 0.015 c
Tectona grandis	0.53 ± 0.009 a	0.85 ± 0.015 b	1.11 ± 0.007 c

Different letters mean significant differences across a row.

Thomas & van Staden 1995, van Staden *et al.* 1995). Smoke enhances the permeability of subdermal cuticle in the dormant seeds and it is also found to be effective for the germination enhancement in species with slow germination (Keeley & Fotheringham 1997, Baskin & Baskin 1988, Flematti *et al.* 2004, van Staden *et al.* 2004). Increased permeability in hard seeds is promoted by nitrogen oxides present in the smoke, either directly by oxidation or after hydration as acids.

Heat shock or chemical products of combustion are known to promote germination. Many plants from Fabaceae, Rhamnaceae, Convolvulaceae, Malvaceae, Cistaceae and Sterculiaceae showed improved germination in response to heat shock (e.g. Keeley 1992, Kelly *et al.* 1992, Thanos *et al.* 1992, Bell *et al.* 1993). Fire also provides chemical stimuli such as ethylene and ammonia, nitrogenous substances, ash and smoke which contain unidentified cues that stimulate germination (Baldwin & Morse 1994, de Lange & Boucher 1990, Brown & Botha 1995).

This study has proven that smoke and fire are able to enhance and improve germination and thus can be adopted to produce high vigour seedlings. Seed germination studies in dry deciduous forests of India are lacking with regard to fire and smoke. Such studies are required to determine the response of seeds and seedlings to periodic fires which are common in dry deciduous forests. Results from such studies will help to develop management plans for seedling recruitment and afforestation purposes in fire-prone forest areas.

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