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On photoblastism in seed germination of *Duabanga sonneratioides* Ham.

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Abstract. The seeds of *Duabanga sonneratioides* Ham. were found to be positively photoblastic and gave fast and maximum germination of 80% in continuous light but failed to germinate in the dark. Longer photoperiod favoured germination. Total length of exposure to light rather than the dark period determined the germination of the seeds. Higher temperature favoured germination at a given light exposure treatment. In the field, seeds up to a depth of 2 mm in the soil could germinate. These results have been related to the light demanding nature of this early successional tree species.

Keywords. Tree adaptation ; seed germination ; positive photoblastism.

1. Introduction

The effect of light on the germination of seeds has received much attention in the past (Crocker 1938 ; Toole *et al* 1956) and light within visible range has been shown to promote germination (Borthwick *et al* 1952). The minimum duration required to increase germination may vary greatly from 0·01 sec for certain tobacco varieties (Kincaid 1935) to 24 hr for some species including *Begonia evansiana* (Nagao *et al* 1959). The germination of long day seeds (Ishikawa 1954) was shown to be promoted by longer photoperiods extending up to continuous irradiation (Sarvas 1950 ; Black and Wareing 1955 ; Vaartaja 1956). Interaction of light and temperature on seed germination has been well documented (Cumming 1963 ; Toole 1973 ; Okusanya 1978). The role of light in the germination of buried weed seeds has been discussed by Wesson and Wareing (1969). Wooley and Stoller (1978) measured light penetration into different soils and its role in the induction of seed germination.

Duabanga sonneratioides Ham., a shade-intolerant early successional species constitutes one of the early tree colonizers of fallows developing after slash and burn agriculture (locally called Jhum) in the north-eastern India. Since the seeds of this species may be induced to germinate only in the presence of light, the nature of photosensitivity and its dependence on temperature was studied in order to understand the adaptive significance of this phenomenon in the colonization of open habitats.

2. Methods of study

Seeds of *D. sonneratioides* were collected from mature dehiscing fruits in May, 1979 and kept dry in polyethylene bottles in darkness at 0 ±2° C or at 25 ±2° C. Germination tests in the laboratory were performed in petridishes (diameter 9 cm). lined with filter paper moistened with 10 ml deionized water. Under field conditions tests were made in containers filled with forest soil. The light sources for photoperiodic experiments were fluorescent tubes in combination with indirect sunlight at day time with a light intensity on the surface of seeds of 1500 lux during the day and 1300 lux during the night (under room temperature conditions of a mean max. of 32° C and mean min. of 20° C). The incubators set at three different temperature regimes (25° C, 30° C and 35° C) with fluorescent light arrangement were used to test the temperature dependence of germination. During dark treaments, the petridishes were covered with cabinets of black paper. Seeds were considered to have germinated when the green cotyledons became visible to the naked eye. All experiments were terminated after 27 days.

The following experiments were carried out

(i) Monthly tests of viability and germination (at 30° C in fluorescent light) of seeds, stored at two temperatures were done starting from June, 1979 to February, 1980. Viability was tested by means of a 0·2% aqueous solution of tetrazolium salt (Lakon 1949).

(ii) To study the effect of light and temperature on germination, seeds stored at 0 ±2° C were treated with light in one of the following ways : (a) in diurnal cycles of 24 hr light, 10 hr light/14 hr dark, 4 hr light/20 hr dark and 24 hr dark at room temperatures, (b) as an initial exposure at the start of imbibition at a length varying from 0·5 to 200 hr at 25, 30 or 35° C, (c) during 8 or 16 hr after a preceding dark period of 48, 96 or 192 hr. After light treatments incubation was continued in darkness.

(iii) Seed germination in the field, using forest soil in pots kept in natural forest situation, was done by placing the seeds in depths of 0, 1–2, 4–5 and 8–10 mm in the soil.

3. Results and discussion

3.1. *Effect of storage on viability and germination*

Dry storage at 25 ±2° C resulted in faster loss in viability and consequent lower percentage germination as compared to storage at 0 ±2° C. After 9 months, only 2 % of the seeds stored at 25 ±2° C germinated which contained only 5 % viable seeds whereas after storage at 0 ±2° C, 50 % of the seeds germinated and 52 % were viable (figure 1). The temperature regime under field conditions which was 33 to 36° C (mean max.) to 22 to 24° C (mean min) during the period of seed dispersal and germination (April–June), may be unfavourable to retain the

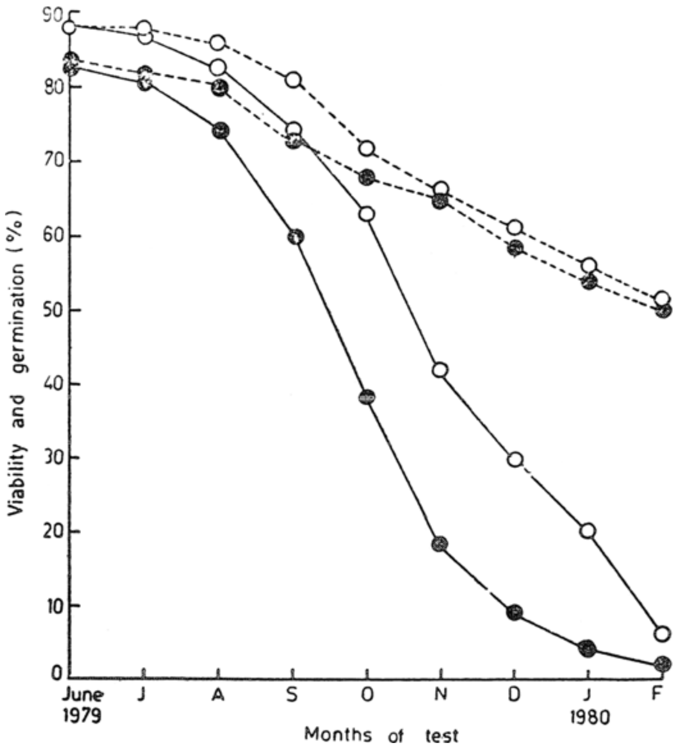

Figure 1. Changes in percentage viability (open circle) and germination at 30° C in continuous fluorescent light (closed circle) of seeds of *D. sonneratioides* with storage at 0 ± 2° C (broken line) and 25 ± 2° C (solid line).

viability of *D. sonneratioides* seeds beyond 9 months after seed dispersal. The seed must germinate as soon after dispersal as possible for successful regeneration.

3.2. *Effect of light and temperature on seed germination*

In a preliminary experiment freshly collected seeds, placed for germination under room temperature conditions in total darkness, completely failed to germinate. Continuous illumination of weak (160–300 lux) or strong (1300–1500 lux) intensity, however, induced over 80 % germination within 9 days.

In the photoperiodic experiment, continuous illumination (24 hr day) induced maximum germination of 81 % within 9 days, thereafter no extra germination occurred (table 1). In the other diurnal cycles no germination occurred during that period. In a cycle of 10 hr light/14 hr dark, it took 18–27 days to reach a similar result. At the end of the 27 day period, cumulative germination was not significantly different under 24 hr and 10 hr day length whereas it was significantly lower ($P < 0{\cdot}01$) under 4 hr day length. In total darkness, no germination occurred. Thus, like certain species of *Hypericum* and *Spiraea* (Ishikawa and Shimogawara 1954), *D. sonneratioides* also requires long photoperiods for high and speedy germination.

Table 1. Effect of day length on seed germination of *D. sonneratioides* at room temperature (germination %, mean ± s.d.).

Day length cycle (hr)	Percentage germination after			Cumulative germination (%)
	9 days	18 days	27 days	
24 (continuous light)	81±4·16	0	0	81±4·16
10	0	75±3·42	3·5±2·51	79±2·00
4	0	33±2·58	27±2·58	60±4·00
0 (continuous dark)	0	0	0	0

Seeds, initially exposed to different durations of light from ½ hr to 200 hr before being transferred back to total darkness for the rest of the test period, showed a significant interaction with the temperature conditions of the test (figure 2). Thus, to obtain the maximum germinability of about 80% for the seeds, it needed only 48 hr exposure to light at 35° C, 100 hr at 30° C but 144 hr at 25° C within a test period of 27 days. At lower exposure time up to 60 hr, significant difference ($P < 0 \cdot 01$) between the temperature treatments of 35° C and 30° C was observed whereas this difference between 25° C and the other two temperatures was observable up to 100 hr light exposure. In all temperature regimes, increase in the time of exposure to light resulted in increased germination but this increase was more rapid at 35° C than at 25° C, germination at 30° C being intermediate between the other two. The rate of germination also improved markedly with the increase in the duration of exposure to light and this was more pronounced at the higher temperatures. Thus, both the length of exposure to light and temperature regime play an important role in the germination of the seeds of this species.

Seeds, initially incubated in the dark for 48, 96 or 192 hr and subsequently given 8 or 16 hr light exposure before being transferred to darkness, showed that the length of dark incubation had no effect on seed germination at the end of 27 days of test (table 2). However, seeds which received only an 8 hr light exposure, showed significantly lower ($P < 0 \cdot 01$) germination than those receiving 16 hr light exposure.

3.3. *Field germination*

Seeds placed on the surface of the soil, gave maximum germination of about 80 % (table 3). Germination declined sharply when the seeds were buried in a depth of 1–2 mm. Seeds, placed deeper, gave poor germination or did not germinate at all. This ability of the seeds of *D. sonneratioides* to germinate more effectively in the surface layer of the soil is obviously related to its light requirement. The

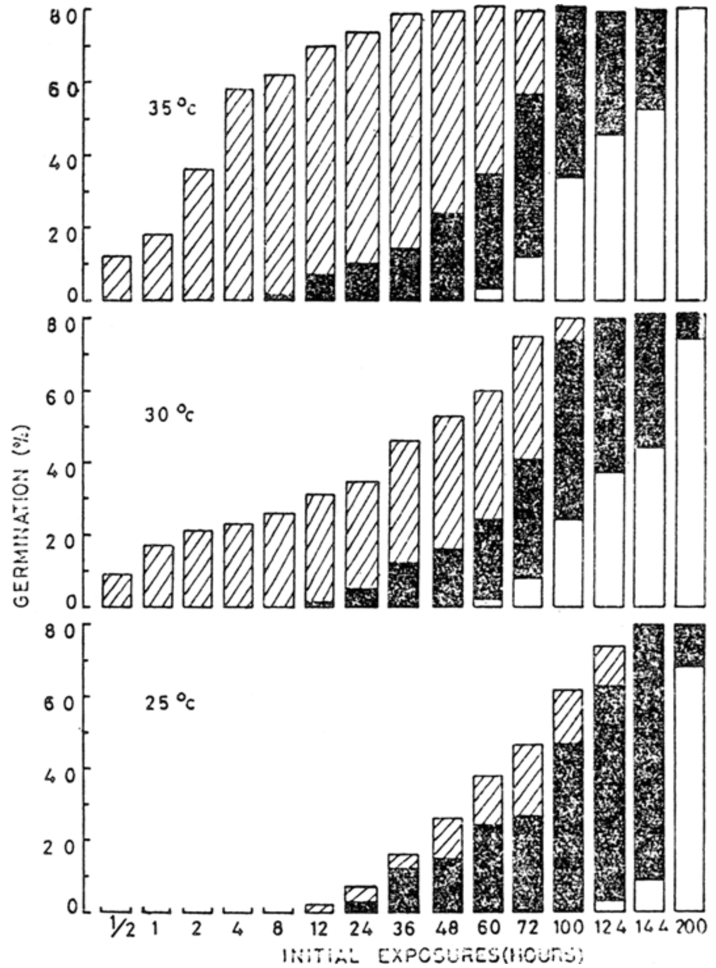

Figure 2. Effect of length of initial exposure of fresh seeds of *D. sonneratioides* to light followed by dark incubation under different temperatures on germination after 9 days (open column), between 9 to 18 days (dark column) and between 18 to 27 days (hatched column).

spectrophotometric measurements of Wooley and Stoller (1978) have also shown that less than 1% of the incident visible light penetrated 2·2 mm of the soil for ped sizes up to 1 mm. The ability of the seeds to germinate in depths up to 2 mm, however, has an advantage that the seeds are protected from dessication. Such a threat exists under natural conditions when water stress often develops during comparatively longer periods of dry spell during the monsoon (Ramakrishnan unpublished).

As an early successional species, *D. sonneratioides* colonizes open habitats. Since the reserve food is meagre in tiny seeds and may prove to be a negative actor in their establishment, the species has adapted itself through its photoblastic

Table 2. Effect of initial dark incubation followed by exposure to 8 and 16 hr light on seed germination (%) of *D. sonneratioides* at room temperature.

Dark incubation period (hr)	germination (%), mean ± s.d. exposure time (hr) 8	 16
48	25 ± 3·60	34·3 ± 2·08
96	27 ± 3·06	34·0 ± 4·00
192	31 ± 6·55	35·0 ± 1·73
Average value	27·4 ± 4·52	34·58 ± 2·15

Table 3. Effect of soil depths on seed germination (%) of *D. sonneratioides*.

Depth of sowing	germination (%), mean ± s.d.
0 mm (surface)	79 ± 3·21
1–2 mm	58·66 ± 4·04
4–6 mm	3 ± 3
8–10 mm	0

seeds for germination in clearings in the canopy or in open early successional communities where light is not a limiting factor so that the seedling may synthesize its food right from the early stages of its growth, thus contributing to its survival. Besides, the photoblastic response of the seeds of this species itself is in agreement with the light demanding nature.

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* Original not seen.