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# Comparative Study on Field Germination and Establishment of Early vs. Late Successional Trees in North-Eastern India

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Observations on seed germination and seedling establishment of 12 important tree species of different successional status were made by seed introduction under two conditions of light and depth of seed burial in a sub-tropical humid forest. The germination percentage of early successional species was higher in the open at shallower depth (2 cm) while shade and deep burial (5 cm) adversely affected the germination percentage of these species. Mid and late successional species did not respond to differences in these conditions. The survival of seedlings of early successional species at the end of the rainy season was more adversely affected than that of mid- and late successional species. The higher seedling survival of late successional species in shade than in the open and the reverse behaviour of early successional species are related to their adaptaion to different light regimes in the forest community.

**Key Words: Seed germination, Seedling establishment, Biology of Tree, Successional status, Adaptation, Seedling mortality**

## Introduction

Germination and seedling establishment are two very critical phase in the life-history of a species (Ramakrishnan 1972, Gomez-Pompa & Vazques-Yanes 1974 and Harper & White 1974). The duration of suitable conditions and the rate at which the seed is able to respond to these, are major factors which determine germination and establishment under field conditions. Factors like light, temperature and moisture regime of seed bed, soil compaction and depth of burial are much discussed (Harper et al. 1965, Hett & Loucks 1971, Sheldon 1974 and Nobel & Whalley 1978).

Not much is known about the ecology of germination and establishment of tree seedlings under natural conditions (Kinnaird 1974). Our understanding of tropical tree species in this regard is even less. The present study, therefore, deals with the germination and establishment of 12 important tree species of a sub-tropical forest under different conditions of light and depth of burial in the soil.

**Study Area**

The germination and establishment studies were carried out in a sub-tropical forest community at Lailad (lat. 25°45″–26°N; long. 91°45″–92°E and alt. 296 m) in the north-eastern India. The study site is a part of the reserve forest known as Nongkhyllem reserve under Meghalaya Forest Department. The peripheral zone of this forest is disturbed by local tribes and developing forest community at different stages of succession may be found. The climate is typically monsoonic with about 84% of the total annual rainfall (2200 mm) occurring during May to September. This is a warm period followed by winter season which extends up to February. The dry season extends from mid-February to May. The annual maximum and minimum temperatures are 35°C and 11°C respectively. The angle of the slope was not more than 5°.

**Methods of Study**

The division of tree species into early, mid– and late successionals was made on the basis of their relative appearence during the succession in the forest after clear cutting (Ramakrishnan et al. 1980). Estimations of dry weight of seed reserve for all the species were made on the basis of 100 seeds in each case after drying them at 80±2°C for 48 hr. Except for *Mesua ferrea* and *Amoora wallichii* the seed coat contributed little to the seed weight and therefore, the seed weight was considered to be an indicator of seed reserve.

For the first experiment, sites with level ground (slope, 0–5°) were selected in the opening (80–90 thousand lux) of the forest as well as in the shade (8–10 hundred lux) under the forest canopy. These sites were located in the undisturbed region of the forest. At each of the two sites 36 quadrats of 1 m² were marked after clearing the litter and herb layer on the soil surface. Each quadrat was divided into two-halves for germination test at two different depths. Seed extracted from fruits were sown at depths of 2 and 5 cm using graduated pegs and a card-board sheet with 50 uniform holes to place 50 seeds at equal distances from each other. Seed sowing was done in July, 1979 followed by monthly observations of the emergence and establishment of seedlings. All treatments were replicated three times.

In the second experiment, seedlings of *Duabanga sonneratioides* Ham., a shade-intolerant early successional species and *Artocarpus chaplasha* Roxb., a shade-tolerant late successional species were raised in the forest soil in open condition. After one month, 100 randomly chosen seedlings of these two species were planted in each of the five quadrats (1 m²) at equal distances, both in the open and under a forest canopy.

**Results**

The early successional species generally had smaller seeds with low seed reserve ($P=0.05$) compared to mid- and late successional ones except for *Dillenia pentagyna* which had light seeds with low seed reserve (table 1).

Percentage of seedling emergence for early successional species like *Sterculia villosa*, *Premna miliflora* and *Lagestroemia parviflora* was higher ($P<0.01$) at 2 cm depth of seed burial than that at 5 cm depth except in case of *Erythrina stricta*. Seedling emergence in the shade was either not significantly different or was less than that in the open, depending upon the species. Mid-successional species like *A. wallichii* and *Bauhinia purpurea* responded little to differences in light regime or depth of seed burial with respect to seed germination ($P=0.05$)

**Table 1** *Average weight/seed in fresh and oven-dried condition (based on the basis of 100 seeds in each case)*

| Species | Fresh seed (g) | Dried seed (g) |
|---|---|---|
| EARLY SUCCESSIONALS | | |
| *Sterculia villosa* Roxb. | 0.30 | 0.24 |
| *Erythrina stricta* Roxb. | 0.22 | 0.14 |
| *Premna miliflora* Clarke | 0.02 | 0.008 |
| *Lagerstroemia parviflora* Roxb. | 0.01 | 0.006 |
| MID-SUCCESSIONALS | | |
| *Bauhinia purpurea* L. | 0.22 | 0.17 |
| *Amoora wallichii* King | 12.04 | 9.86 |
| LATE SUCCESSIONALS | | |
| *Dillenia pentagyna* Roxb. | 0.22 | 0.01 |
| *Artocarpus chaplasha* Roxb. | 0.64 | 0.42 |
| *Sterculia coccinea* Roxb. | 0.92 | 0.41 |
| *Pithecolobium longan* Benth. | 0.74 | 0.58 |
| *Mesua ferrea* L. | 3.94 | 3.31 |
| *Garcinia cowa* Roxb. | 0.33 | 0.22 |

and a similar behaviour was noted for the late successional species too (table 2) except *D. pentagyna*.

The survival of seedlings of different species under two light regimes at the end of the rainy season (October), the winter (February) and the summer drought (May) is expressed as the percentages of total seedlings present after the germination was complete (figure 1). The number of survivors after rainy season declined drastically ($P=0.01$) for all the early successional species except for *S. villosa* under both the light conditions. Among the early successional species, *S. villosa* and *L. praviflora* suffered higher seedling mortality during winter than the other two ($P<0.05$) under both the light conditions. The mid- and late successional species all showed very low rainy season mortality except for *A. chaplasha* and *D. pentagyna* ($P=0.01$), Mortality during the winter months and the summer drought was more pronounced

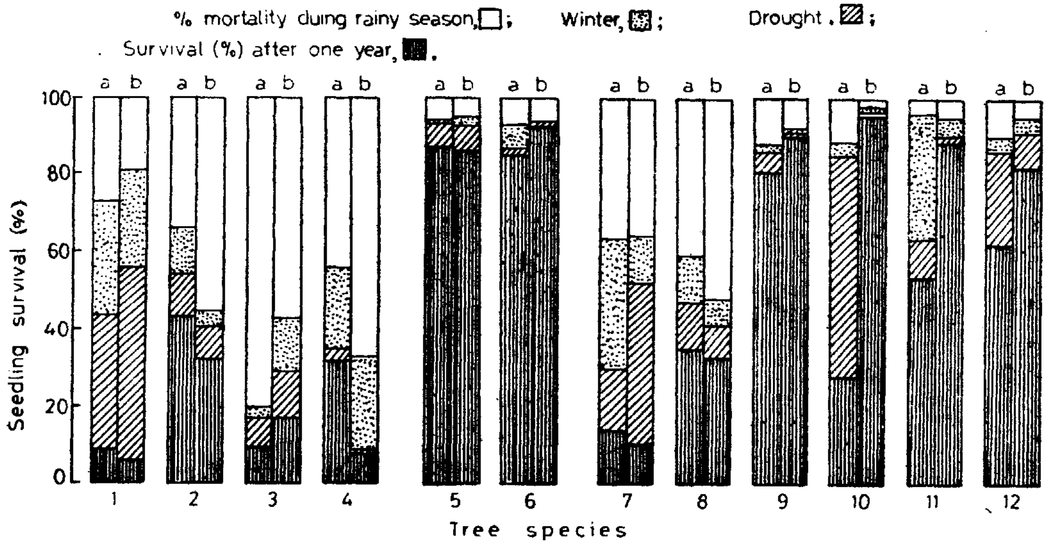


**Figure 1** Survival (%) and mortality (%) of seedling growing in the open (a) and under forest canopy (b) during rainy season, winter season and drought with final establishment (%) after one year in early successional (1–4), mid-successional (5–6) and late-successional (7–12) species. **1**, *Sterculia villosa;* **2**, *Erythrina stricta;* **3**, *Premna miliflora;* **4**, *Lagerstroemia parviflora;* **5**, *Bauhinia purpurea;* **6**, *Amoora wallichii;* **7**, *Dillenia pentagyna;* **8**, *Artocarpus chaplasha;* **9**, *Sterculia coccinea;* **10**, *Pithecolobium longan;* **11**, *Mesua ferrea;* and **12**, *Garcinia cowa*

**Table 2** *Percentage emergence of different species in the field under two different depth and light conditions*

| Species | Open | | Shade | |
|---|---|---|---|---|
| | Depth of seed burial | | Depth of seed burial | |
| | 2 cm | 5 cm | 2 cm | 5 cm |
| EARLY SUCCESSIONALS | | | | |
| *Sterculia villosa* Roxb. | 87.3±3.7 | 43.3±5.7 | 79.7±1.8 | 48.0±5.0 |
| *Erythrina stricta* Roxb. | 58.3±4.4 | 70.0±5.7 | 68.3±7.3 | 76.7±8.8 |
| *Premna miliflora* Clarke | 90.0±2.9 | 68.3±4.4 | 81.7±3.0 | 41.7±6.0 |
| *Lagerstroemia parviflora* Roxb. | 35.0±5.1 | 30.7±3.5 | 36.0±5.5 | 20.0±3.6 |
| MID SUCCESSIONALS | | | | |
| *Bauhinia purpurea* L. | 96.0±1.2 | 98.7±4.3 | 93.3±0.7 | 100±0.0 |
| *Amoora wallichii* King | 96.7±3.4 | 96.7±3.4 | 93.3±3.4 | 96.3±1.9 |
| LATE SUCCESSIONALS | | | | |
| *Dillenia pentagyna* Roxb. | 40.1±4.9 | 27.8±2.6 | 34.4±5.1 | 16.7±3.9 |
| *Artocarpus chaplasha* Roxb. | 85.3±2.2 | 88.7±3.4 | 90.0±3.2 | 86.7±2.6 |
| *Sterculia coccinea* Roxb. | 89.2±2.2 | 90.0±2.9 | 95.8±1.4 | 98.3±2.9 |
| *Pithecolobium longan* Benth. | 95.0±2.5 | 95.0±3.7 | 98.3±2.9 | 94.2±6.3 |
| *Mesua ferrea* L. | 67.3±4.7 | 74.7±7.1 | 81.3±3.5 | 81.3±5.8 |
| *Garcinia cowa* Roxb. | 76.0±2.0 | 72.7±4.4 | 75.3±1.2 | 77.3±3.1 |

Mean ± standard error

in the open than in the shade ($P<0.01$) for the late successional species. The mid- and late successional species also showed generally high survival at the end of one year period compared to early successional species ($P=0.01$), the only exception being *D. pentagyna*.

The monthly pattern of seedling survival of an early successional, *D. sonneratioides* and a late successional, *A. chaplasha*, in the open and under the shade was observed (figure 2). *D. sonneratioides* showed steep decline ($P=0.01$) in population under shade with total mortality after 8 months whereas in the open the mortality in this species was very low so that 55% of the seedling survived at the end of theone year. On the other hand, heavy mortality occurred in both the open and shade-grown seedlings of *A. chaplasha* during the first few months. However, the final survival value was higher in the shade than in the open ($P<0.05$) for this species.

## Discussion

After escape from predation and pathogens, the chance that a non-dormant surface-lying seed will develop into an established seedling is dependent on its fixation in safe-site which provide the specific conditions for its germination and establishment (Harper et al. 1965, Sheldon 1974, and Grime 1979). Shaw (1968) found 50% more germination from the buried acorns of *Quercus petraea* compared to surface-lying seeds and attributed the seed burial, a protective nism which is created by natural soil disturbance in the forest. In the present case, seed burial at a shallow depth was found to be more favourable for the

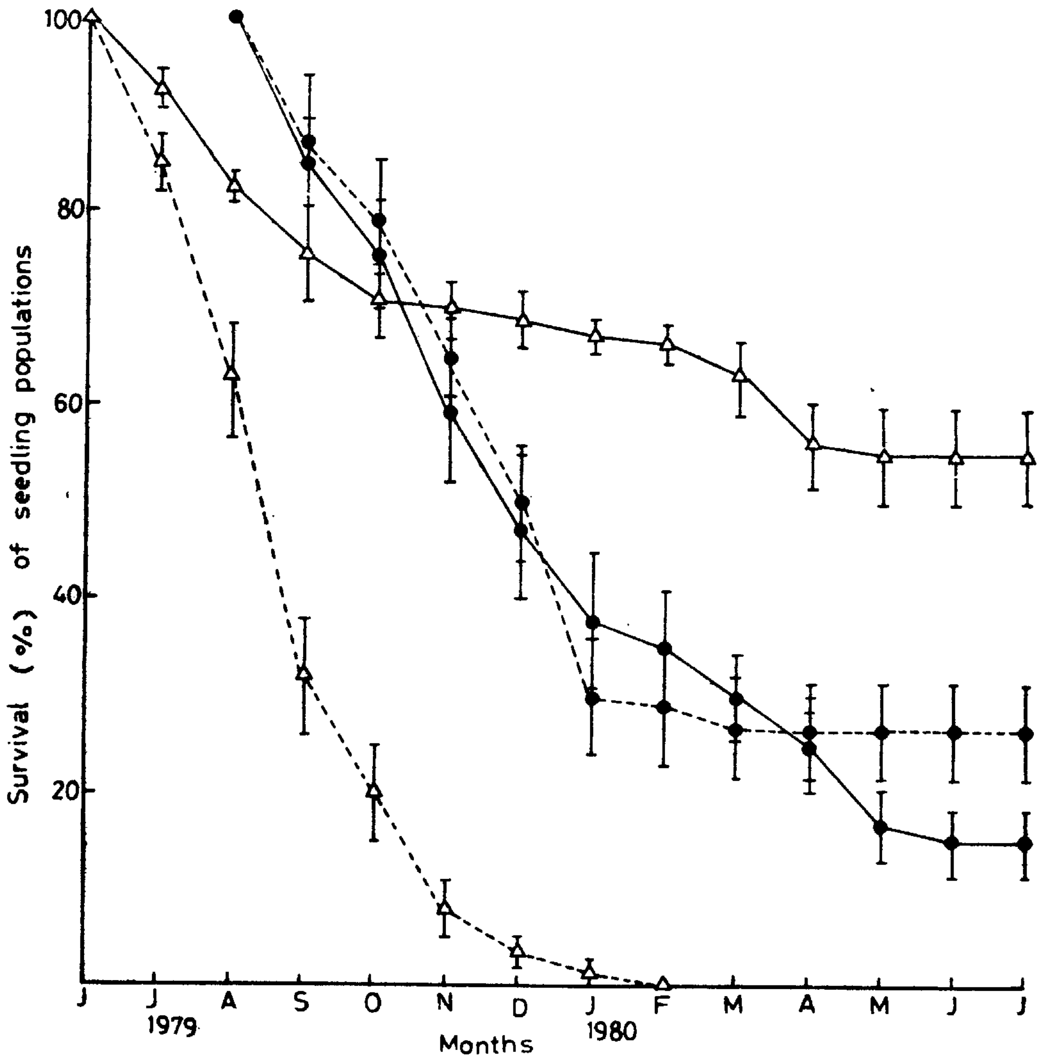


**Figure 2** Pattern of seedling survival of one early successional species, *D. sonneratioides* (open triangle) and one late successional species, *A. chaplasha* (closed circle) in field conditions. Continuous line, open-grown seedlings; broken line, forest-grown seedlings. Vertical lines across the values denote standard error of the mean

germination of early successional species which generally have light seeds. The deep-seated seeds of these species may fail to germinate because of the low-potential of seedlings due to meagre seed reserves to penetrate through the soil profile (Sheldon 1974). The late successional species generally with heavier and larger seeds showed equally good germination at both the depth of seed burial. Further, this could also be related to the light availability at these depths, as early successional species generally do better under higher light regimes (Lugo 1970). However, the present study on germination in the open and under shade show significant reduction under shade for some of the early successional species.

The mortality patterns, in general, of the early and late successional species are quite different from one another. The generally high mortality of the early successional species at the end of the rainy season may be related to heavy washout of the soil and the consequent exposure of the superficially placed root system of this category of the species (Marks 1975). Further, the seedling survival of the late successional species, generally was more in shade than in the open, probably related to their shade-tolerant nature (Horn 1971 and Grime 1979) which provides protection from water stress. Conversely, the drastic reduction in the survival of the early successional species under the shade may be due to their requirement of high light intensity (Horn 1971). Further, the shade-intolerant species are reported to be more susceptible to fungal attack under shade compared to the shade-tolerant species (Vaartaja 1962 and Grime & Jeffrey 1965). Such a different pattern for early and late successional species in the open and shade has been further supported by that of *D. sonneratioides* belonging to the former category and *A. chaplasha* belonging to the latter category.

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