GERMINATION AND SURVIVAL OF *SHOREA TRAPEZIFOLIA*: EFFECTS OF DEWINGING, SEED MATURITY, AND DIFFERENT LIGHT AND SOIL MICROENVIRONMENTS

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ZOYSA, de N.D. & ASHTON, P.M.S. 1991. Germination and survival of *Shorea trapezifolia*: Effects of dewinging, seed maturity, and different light and soil microenvironments. *Shorea trapezifolia,* a rain forest dipterocarp endemic to Sri Lanka, shows potential as a plantation timber tree. Several experiments were carried out to determine the effect of seed maturity, removal of fruit wings, and varying light and soil conditions, on germination and survival of this species in the nursery. Results indicate that germination was immediate, occurring between four and ten days after the fruit fall. Seeds are recalcitrant and cannot be stored for periods greater than one to two weeks. The period of maximum seedling mortality between germination and establishment was found to be approximately the first 50 days. Partial shade is recommended for at least the first month after germination in the nursery to ensure maximum survival. The experiments showed significant genotypic differences in seed germination and seedling survival between cohorts of different parent-trees. This draws attention to the importance of selecting suitable maternal parent trees for nursery programmes. Seeds that fell later in a fruit fall were more viable compared to those that fell at the beginning, suggesting that seed collection for nursery propagation should be two weeks after initial fruit fall. Removing fruit wings had no effect on germination or survival and could be safely done for convenience of temporary storage and transport. The germination of seeds planted on forest top soil with litter was little affected by partial shade or exposure to full sun, but shade was more favourable for seedling survival. Germination and survival were poor on compact mineral soil and on compact mineral soil that had been scarified on the surface. Both treatments were exposed to full sun. This suggests the combination of partial shade and forest top soil with litter to be the best condition for nursery propagation. Some form of ground preparation and litter cover is needed for planting or to aid natural regeneration in disturbed sites, where mineral soil is exposed.

Key words: Dipterocarps - germination - nursery - *Shorea trapezifolia* - Sri Lanka - seedling - survival

Introduction

Recent work with *Shorea trapezifolia* (Dipterocarpaceae) suggests that the species has potential as a timber tree for enrichment planting in managed natural forest or for mixed-species plantations. The species regenerates well in logged areas of the forest (de Zoysa *et al.* 1988) and grows fast as a sapling. Unlike most other dipterocarps, mature trees flower and leaf flush almost synchronously and dependable crops of fruit are frequent, often twice a year or more (Dayanandan *et al.* 1990).

Seed germination of many dipterocarps has been investigated under laboratory conditions in relation to their storage (Tompsett 1987). Similar studies on *S. trapezifolia* have shown that seeds are recalcitrant (de Zoysa 1986). Germination and survival under field or nursery conditions have not been previously examined for *S. trapezifolia.* This study investigates seed germination and subsequent seedling survival of this species under nursery conditions in order to better facilitate propagation for forestry purposes.

Experiments were set up to address several specific observations and questions regarding the germination and survival of *S. trapezifolia* pertinent to its nursery propagation. These are listed below:

i) Early seeds of a fruit fall were observed to be smaller in size compared to seeds that fell later. Are there any significant differences in germination and survival between early and later falling seed?

ii) Removal of fruit wings is convenient for temporary seed storage and transport. What is the effect of this practice on germination and seedling survival in the nursery?

iii) When does the highest mortality occur between seed germination and seedling establishment?

iv) Seedlings growing under natural conditions were observed to perform better in partial shade as compared to those growing in the sun. This was confirmed under nursery conditions (Ashton & de Zoysa 1989). What is the effect of these two light environments on seed germination and seedling survival?

v) Seed germination and seedling establishment appeared poor on compacted soil devoid of top soil and litter and exposed to full sun, conditions which are characteristic of sites with a history of past logging operations (skid trails, log landings and verges of logging roads) and shifting cultivation. What is the effect of such a soil condition on germination and survival relative to that with top soil and litter present?

Method

The study was carried out at the field station of the Sinharaja Man and the Biosphere Reserve in the southwest lowlands of Sri Lanka. The forest has been described by Gunatilleke & Gunatilleke (1985) and is classified as lowland wet evergreen rain forest. The climate is aseasonal with an annual rainfall of between 3500 and 5000 *mm* and a mean annual temperature of 27°*C.*

To test these questions and observations experiments were established in September 1985 using the seven treatments listed below:

i) Partial shade, forest top soil with litter, winged fruit, early seed;

ii) Partial shade, forest top soil with litter, winged fruit, later seed;
iii) Partial shade, forest top soil with litter, dewinged fruit, early seed;
iv) Partial shade, forest top soil with litter, dewinged fruit, later seed;
v) Full sun, forest top soil with litter, winged fruit, later seed;
vi) Full sun, compact mineral soil with a scarified surface, winged fruit, later seed;
vii) Full sun, compact mineral soil, winged fruit, later seed.

The fruit is an ellipsoid-ovoid, one seeded nutlet approximately 1 × 2 *cm* long. The pedicel is stout and expands into the fruit base. The persistent calyx more or less encloses the seed with three wing-like, twisted sepals (4.5 cm) and two shorter sepals (1.3 *cm*) (Figure 1).

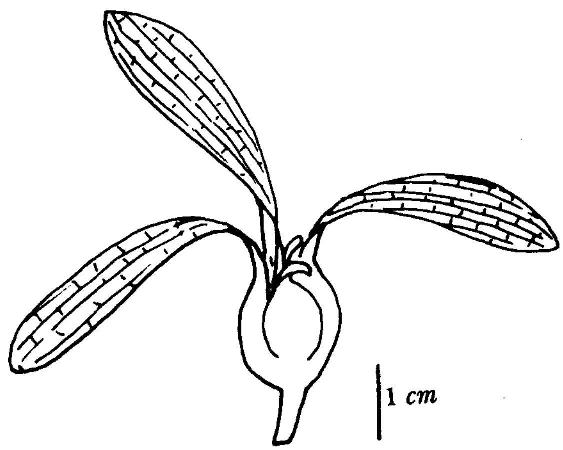

Figure 1. Fruit of *Shorea trapezifolia*

The early seeds were collected as soon as fruit fall began. Later seeds were collected two weeks after the early seed collection, when they were noticeably larger in size. To ensure that fresh seeds were collected for the experiments, an area under the parent tree was cleaned of old fruits the evening before and fresh fruits were gathered in the cleaned area the following day. Immediately after each collection, the seeds were placed in the different treatments and their germination and mortality monitored. Fruit fall started in mid-September and continued through to the middle of October.

For the light and soil treatments, the nursery beds were prepared to reflect conditions in both disturbed and undisturbed forest as far as possible. Coir matting was used to create partial shading without altering the quality of light. At noon on a clear sunny day the light intensity under the partial shade treatment was 1000 $\mu mol\ m^{-2}\ s^{-1}$ (approximately 50 % shade), while in full sun it was 2000 $\mu mol\ m^{-2}\ s^{-1}$. Light readings were taken using a data logger and attached quantum sensor (Li-1000 data logger & Li-190SA Quantum sensor, Li Cor Inc., Lincoln, Nebraska, USA).

The forest top soil used on the nursery beds comprised the upper most 5 *cm* of soil taken from the adjacent forest. The top soil was placed to a depth of 5 *cm* on top of loosened mineral soil that had been compacted from previous logging. Litter fragments taken from the forest were also spread as one to two leaf layers thick on the surface. For the other soil treatments the mineral soil (C horizon) that was exposed at the experiment site was used for the compact condition; a rake was used to loosen the compact surface to 1 *cm* depth for the compact condition with a scarified surface. All seeds were placed on the surface of the soil or litter. No fertilisation or watering was done during the course of the experiment. Experiments received water from rainfall that usually occured daily. Dry spells without rain did not last longer than several days. Seeds were positioned on the compact soil by driving a small nail through a sepal wing to prevent them from being displaced by wind and rain.

For treatments ii) through v) seeds were collected from four different parent trees to compare the effect of maternal genotype. The remaining experiments had seeds from two parent trees for each treatment. Each treatment had 100 seeds for each parent tree. Planting was done in random block design with each seed spaced 10 *cm* apart.

Data were kept separate for seeds from each parent tree. Germination was monitored daily until no more germination occurred. Subsequent survival was recorded approximately once every two months over a two-year period.

Results and discussion

Effect of seed maturity

There was significant difference in total germination percentage between early falling (X = 34%, range 17 - 55%) and later falling seed (X=85%, range 69-96%) (Tables 1a & 1c, Figure 2). This difference might be expected as early falling seeds were observed to be smaller in size compared to later seeds and perhaps were not mature. The germination response among different parent tree seeds was also variable. These results indicate that seed for nursery propagation should be collected approximately two weeks after initial seed fall; earlier fallen seed should be removed prior to the period of collection.

The poor germination of early seed left fewer seedlings on which to assess survival. Therefore, although differences were significant, they were less accentuated. Figure 3 depicts percentage seedling mortality after germination between early and later seed treatments. Percentage survivals calculated from the appropriate totals of seed that germinated from each parent-tree and treatment showed later falling seed (X=62%; range 58-65%) had a greater percentage survival after two years than early falling seed (X=32%: range 0-58%) (Tables 1a & 1c).

Removal of seed wings

Fruit with removed wings showed no significant difference in percentage seed germination or percentage survival when compared to fruit with wings

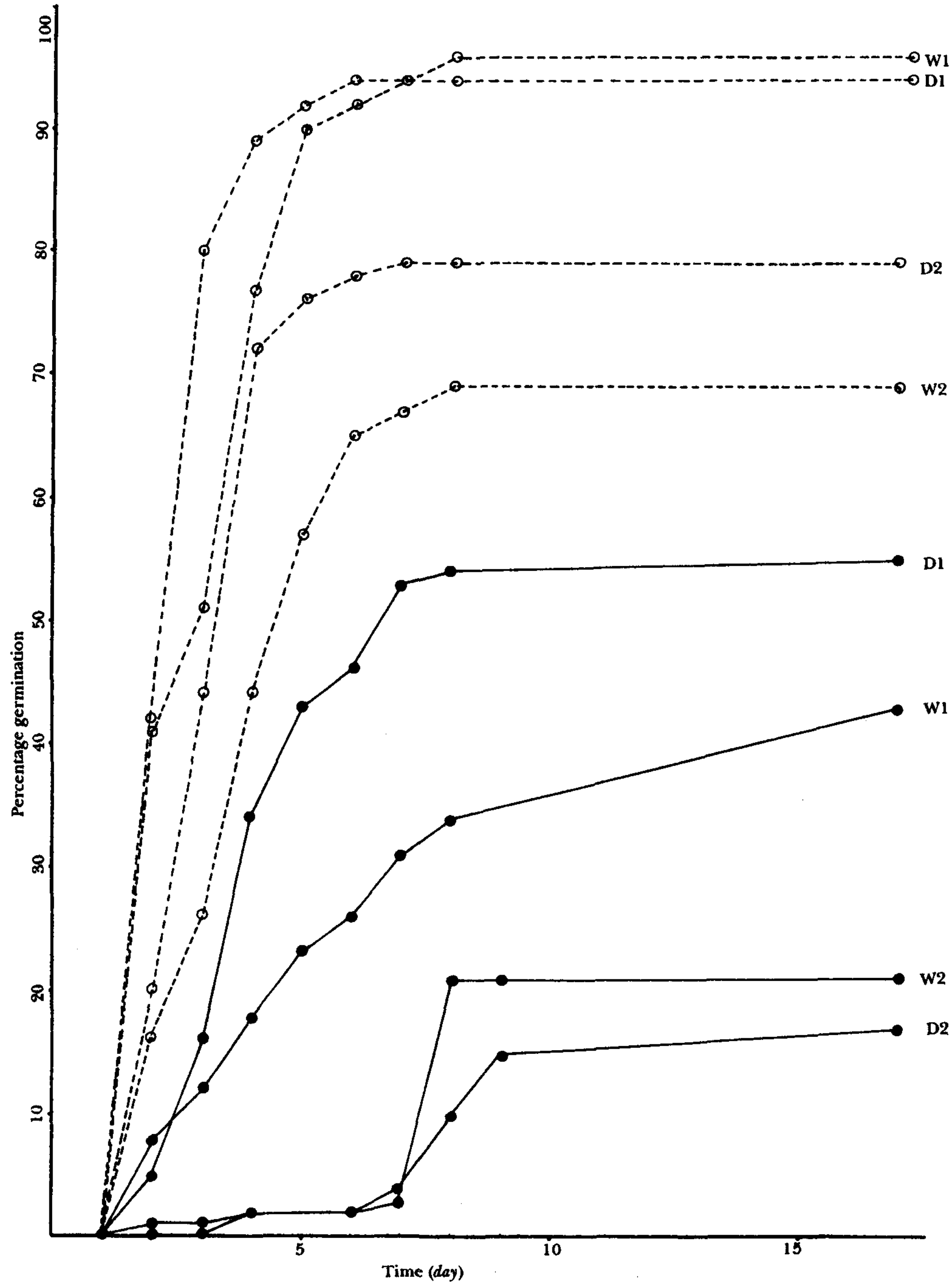

Figure 2. *Shorea trapezifolia* - The temporal pattern of cumulative total percent germination of seed by parent tree (1 & 2) for each fruit condition (winged - W; dewinged - D), and for time of seed fall (early —●—; later --o--)

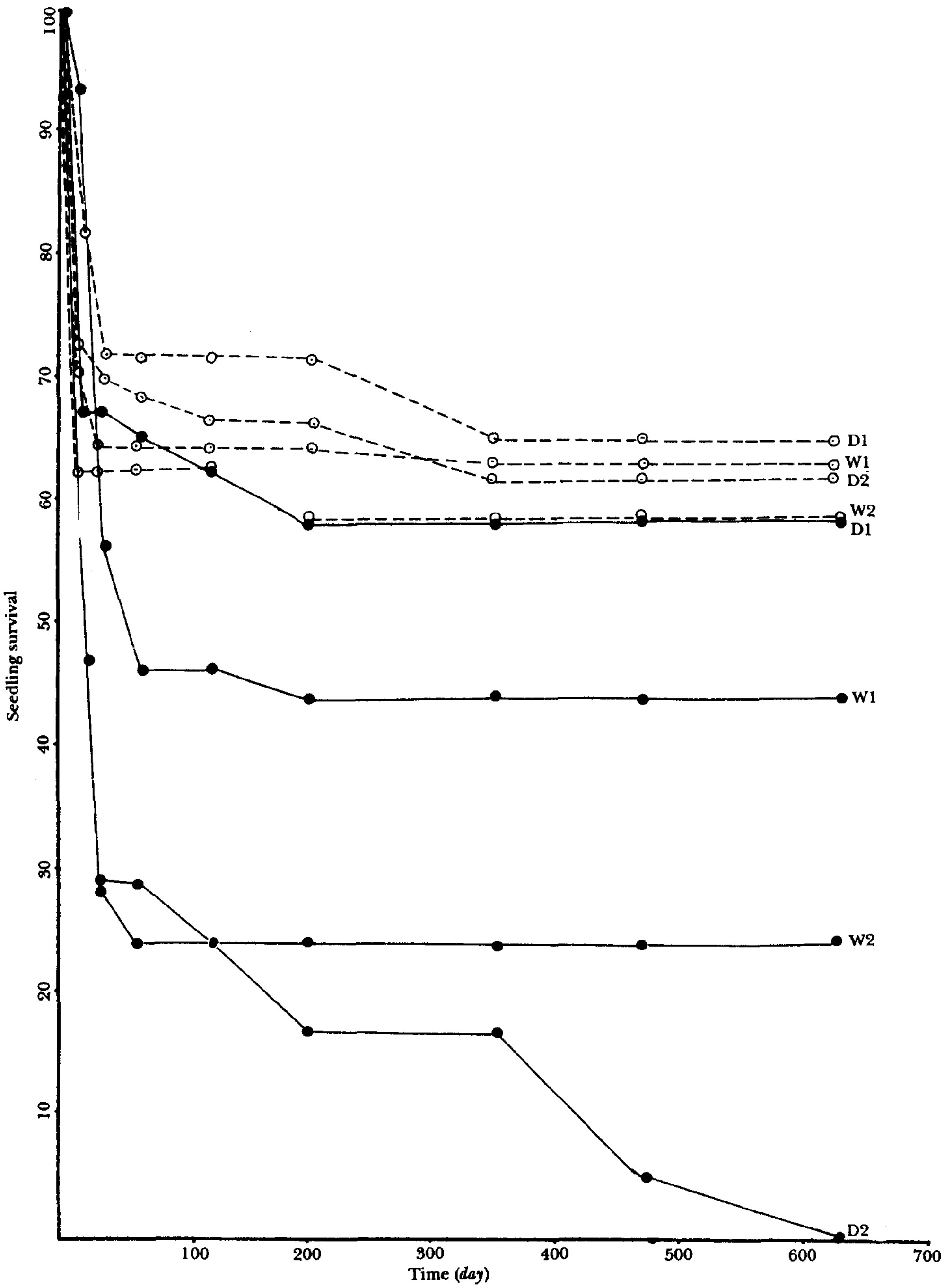

Figure 3. *Shorea trapezifolia* - The percentage of seedlings surviving after germination over two years by parent tree (1 & 2) for each fruit condition (Winged - W; dewinged - D), and for time of fruit fall (early —●—; later --o--) (Values are calculated relative to the percentage of seed that germinated for each parent tree and treatment)

(Table 1c, Figures 2 and 3). Percentage survival was again calculated from those seeds that germinated. These findings concur with observations made by Tang (1971) and De Zoysa (1986). Fruit wings could therefore be removed to facilitate temporary storage or transport for nursery work without affecting germination or survival. A few instances were observed in which the wings hindered the radical from coming in contact with the soil.

Table 1a. Mean percentages of germination and survival for the different treatments (X - Mean percentage; (SD) - standard deviation of the mean; N - total number of seed at the start of each germination treatment and subsequent total numbers for the start of each seedling survival treatment)

	Percent germination			Percent survival		
	X	(SD)	N_{germ}	N	(SD)	$N_{survival}$
Seed maturity:						
Early seed	34.00	(18.07)	400	31.50	(25.21)	136
Later seed	84.50	(12.82)	400	44.75	(2.94)	338
Removal of seed wings:						
Winged	57.25	(32.44)	400	48.75	(18.93)	229
De-winged	61.25	(33.59)	400	44.75	(29.93)	245
Light-Forest top-soil with litter:						
Partial shade	83.50	(7.42)	400	66.50	(4.20)	334
Full sun	81.75	(12.15)	400	47.75	(4.27)	327
Light- Mineral soil (compact & scarified):						
Full sun	56.75	(30.14)	400	12.35	(21.20)	227

Table 1b. Students t-test using arcsine transformation for percentage seedling germination and percentage seedling survival testing for differences between light treatments (Analyses have been separately performed for germination and survival)

	T-test	
	Percent germination	Percent survival
Light:		
Partial shade	NS	**
Full sun		

Table 1c. Analyses of variance using arcsine transformation for percentage seedling survival testing for differences between seed maturity (early and later seed), between seed wing removal (de-winged and winged seed), and in interactions between seed maturity and wing removal; analyses have been separately performed for germination and survival (NS - not significant; * - significant at 0.05%; ** - significant at 0.01%)

	2-way ANOVA	
	Percent germination	Percent survival
Seed maturity	*	*
Wing removal	NS	NS
Seed maturity * Wing removal	NS	NS

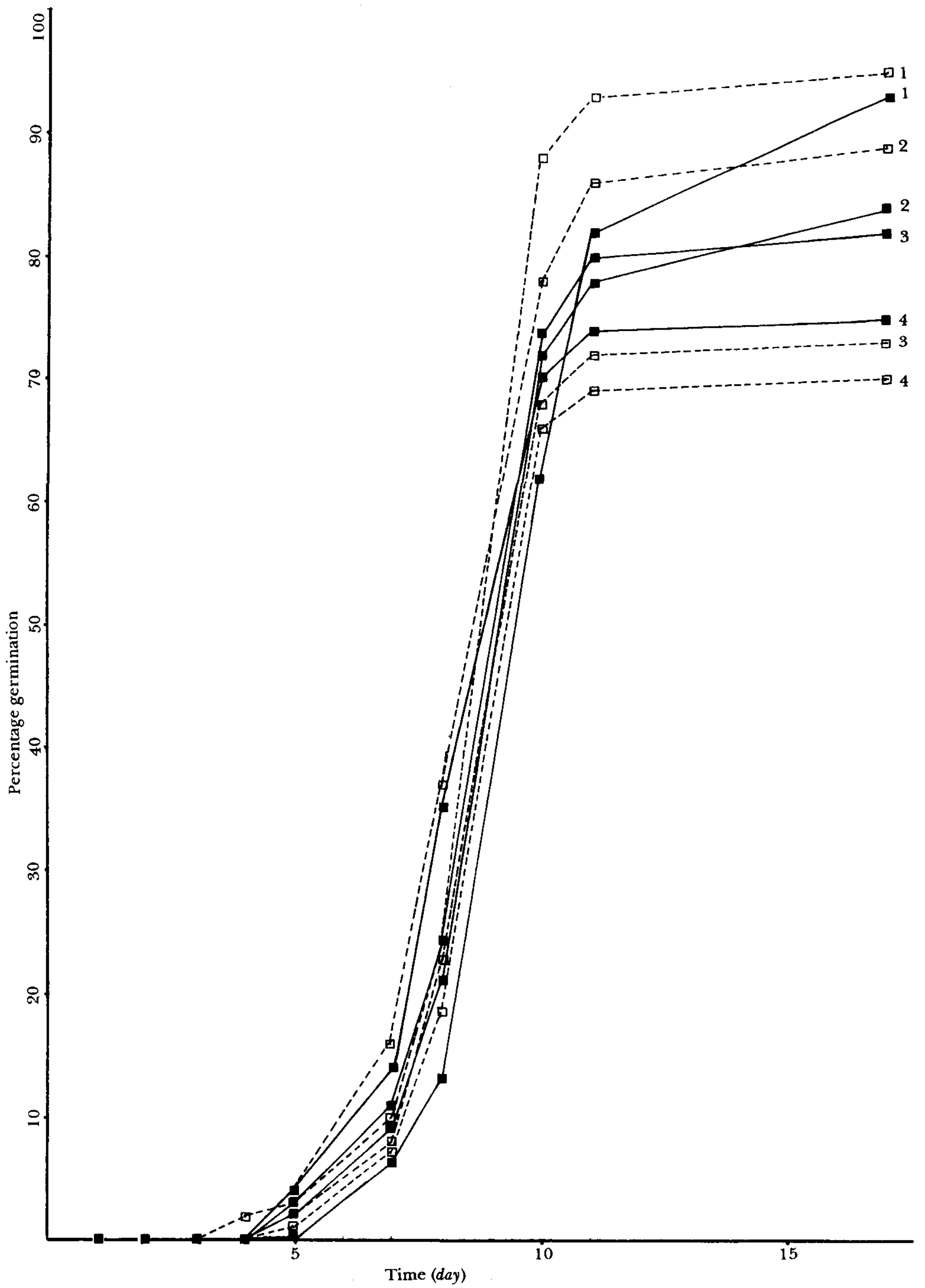

Figure 4. *Shorea trapezifolia* - The temporal pattern of cumulative total percentage germination of seed by parent tree (1, 2, 3 & 4) for partial shade (—■—) and full sun (--□--) on forest topsoil with litter

Effect of light treatments

No significant difference was evident in percentage germination between seeds planted in partial shade and those fully exposed to the sun on forest top soil with litter (Table 1b, Figure 4). All germination had occurred by the seventeenth day, and of those that germinated 96% had done so within ten days. Total seed germination percentages of seed from different parent trees ranged between 70 and 95% (X=83%) (Table 2).

Table 2. *Shorea trapezifolia* - performance rankings for parent tree percentages of germination of seed and percentages of survival of seedlings on forest topsoil with litter

Performance ranking					
Germination			Survival		
Parent tree	Shade	Sun	Parent tree	Shade	Sun
1	93%	95%	1	71%	54%
2	84%	89%	2	69%	47%
3	82%	73%	4	64%	45%
4	75%	70%	3	62%	45%

Although germination showed little difference between partial shade and sun treatments, percentage survivals of seedlings calculated from total seed that germinated for each parent tree and treatment was significantly higher in partial shade (X=66%; range 62-71%) than that of full sun (X=48%; range 45-54%) at the end of the two-year period (Table 1b). Most mortality occurred within the first 50 days after germination for both treatments (Figure 5). Again, deriving percentage seedling mortality for the first 50 days from total seed that germinated for the appropriate parent tree and treatment, percentage mortality in the partial shade (X=23%) was much less than mortality in full sun (X=43%). Most differences in survival between partial shade and sun can be attributed to this critical 50 *day* period. This mortality is perhaps because young meristematic tissues are susceptible to moisture desiccation and high temperatures during the initial period of seedling development. This suggests that full sun is not preferable to the early growth and development of newly germinated seedlings for this species. After 50 days seedling death progressed at a slow but steady rate (6-7% per year) for both light treatments. This mortality might be attributed to the self-thining among seedlings competing for space. Signs of disease and herbivory were not evident. These findings suggest that seedlings require partial shade in the nursery for high levels of survival. Provision for shade is especialy critical during the first 50 days after germination.

Differences in both germination and survival were correlated to maternal parent tree genotype (Table 2). Percentage germination of seed and percentage survival of seedlings for each parent tree both showed performance rankings that were similar between partial shade and full sun treatments.

The genotype effect appears to run throughout the other experiments. It is evident that parent tree selection could play an important role in identifying suitable seed for nursery cultivation and tree improvement programmes.

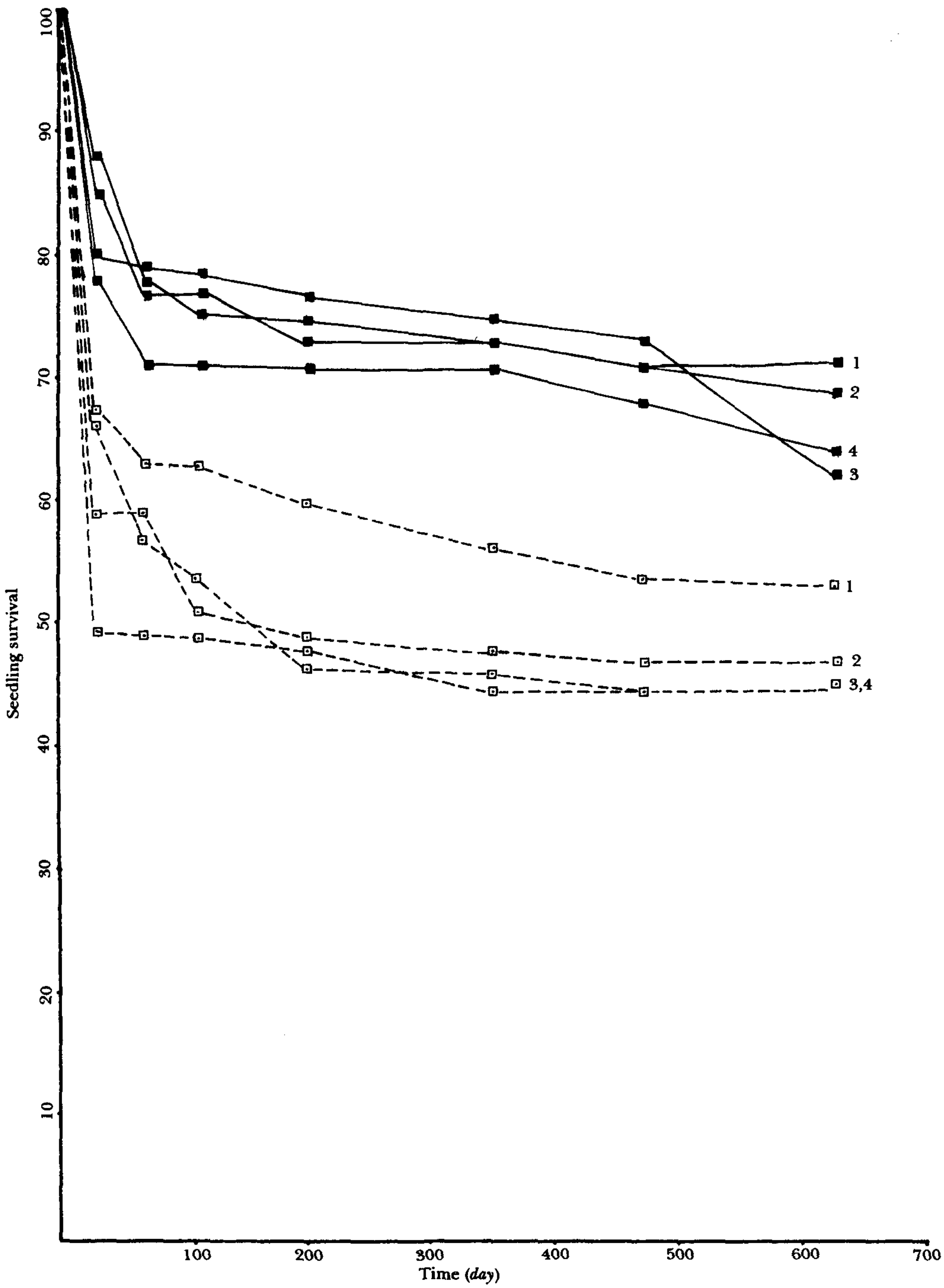

Figure 5. *Shorea trapezifolia* - The percentage of seedlings surviving after germination over two years by parent tree (1,2,3 & 4) for partial shade (—■—) and full sun (--□--) on forest top soil with litter (Values are calculated relative to the percentage of seed that germinated for each parent tree and treatment)

Effect of soil treatment in full sun

Comparison of seed germination on differing soil conditions in the sun showed that percentage germination on forest top soil with litter was the highest (X=82%, range 70-95%) compared to the combined treatments of compact mineral soil with a scarified surface and compact mineral soil (X=57%; range 25-83%) (Table 1a). Germination success was not only lower in both compact mineral soil treatments; it was also highly variable (Table 1a). The extreme soil conditions of the compact and scarified treatments clearly affected the ability of seeds to germinate. The forest top soil with litter treatment appeared to be more conducive to germination, presumably because it was able to retain more soil moisture and mute the extremes in surface temperature. Although differences in maternal parent tree seed source are again apparent, they are not very marked. Here, influences from light, heat and moisture perhaps play a more important role in germination success than does parent tree genotype.

The pattern of percentage seedling survival was similar to germination (Table 1a). Under full sun, percentage survival on the forest top soil with litter (X=48%, range 45-54%) was higher than the combined treatments (X=12%) of compact soil with a scarified surface (X=25%, range 4-44%) and compact soil (X=1%, range 0-3%). In both compact and compact scarified soil treatments, the variation in percent survival was too great to make any definite conclusion about diffrences that might exist between them. Although genotypic differences were also apparent in survival, they again were not marked, due to the greater effect of soil microenvironment.

The results indicate that chances of successful germination and seedling establishment are best under partial shade and on forest top soil with litter. On exposure to sun, opportunities are better if forest top soil with litter is retained. The potential for seedling establishment on exposed mineral soil surfaces which are characteristic of disturbed rain forest sites is poor. Therefore top soil and shade are needed in the nursery, and some form of ground preparation and cover is required when planting out or to aid establishment of natural regeneration on exposed sites after logging.

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