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The effects of sowing depth and light intensity on the germination and early growth of *Ricinodendron heudelotii*

Anjah G. M.[1]*, Focho A. D.[1] and Dondjang J. P.[2]

[1]Department of Plant Biology, University of Dschang, Bp 67, Dschang, Cameroon.
[2]Department of Forestry, University of Dschang, Dschang, Cameroon.

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The specific environment, in which a tree grows particularly at the stage of germination and early growth, determines the extent to which it attains its potential development. The climatic, edaphic and biotic factors, all influence the expression of hereditary characteristics. The effects of depth of sowing using forest topsoil on germination of *Ricinodendron heudelotii* seeds, and those of varying the intensity of the climatic factor, light, on the seedlings were determined in this study. Experiments were conducted in a nursery, using soil-filled polyethylene bags where varying sowing depths (5.5, 11, 13.8 and 16.5 cm) were evaluated. Seedlings were grown under light intensity ratios of 1:0.99, 1:1.6, and 1:0.75 lux meters, respectively. The experimental design was a complete randomized design and data collected were subjected to analysis of variance, using LSD for the separation of means at 5% level of probability. Cumulative germination percentages for sowing depths were as follows: 16.5 cm (22%) > 5.5 cm (16%) > 11 cm (14%) > 13. 8 cm (10%) with interactive significant mean differences. Mean value at the depth of 16.5 cm was significantly different from those at the other depths. There was no significant difference among the parameters for early seedling growth under the different light regimes.

Key words: Sowing depth, edaphic, light intensity, *Ricinodendron heudelotii* germination, early growth.

INTRODUCTION

The soil depth available for rooting is a major physical soil factor in silviculture (Nwoboshi, 1982). Shallowness of the soil limits its utilization by restricting the supply of moisture, air, and nutrients available to the forest stand and thus reduction of stand availability. Thus, depths at which seeds are sown into the soil affect the germination of these seeds, and subsequent seedling growth (Bockus and Sholberg, 1996). Some seeds germinate well on the soil surface while others require a little or more depth into the soil.

The sizes of the seeds also play a major role on the emergence of the seedlings and growth. Large seeds produce larger seedlings than small ones, hence are able to emerge from greater soil depths (Jurik et al., 1994). Seiwa and Kikuzawa (1996) observed that large robust seedlings emerged and that seedling emergence through litter is positively associated with seed size.

However, a rule of thumb is to sow seeds approximately three to four times the diameter of the seed, making sure that seeds are in the upper moist layer of the soil (Hudson and Dale, 1975). On the other hand, Harries et al. (1998) stated that sowing depth is generally twice the diameter of the seed.

Light is another important physical factor affecting tree growth, especially at the seedling stage. Research has shown that light acts on both dormancy and release and

*Corresponding author. E-mail: ngracemendi@yahoo.com. Tel: +23777539417.

is a mechanism that adapts plants to specific niches in the environment, often interacting with temperature (Lajzerowicz et al., 2004; Warren and Adams, 2001). The amount of solar energy available for these processes depends upon the intensity and quality, especially beneath the forest canopy and influences the establishment of tree seedlings. Nwoboshi (1982) stated that because seedlings of different trees have different light requirements, some succeed in habitats where others fail. These differences in seedling reactions to shade or low light intensity are exceedingly important in tropical silviculture where reproduction of forests following logging depends on the presence of natural regenerations or seedlings.

Primary tropical forests comprise a mosaic of mature, gap building phase patches resulting in great spatial variation of the distribution of foliage (John and Jeffery, 1999). Light may consequently penetrate into the interior over a wide range of angles. It thus seems possible that understory tree species might be adapted for distinct understory light conditions though it limits leaf production, and high light intensities result in greater leaf production (Lourens and Yaskara, 2000). Warren and Adams (2001) observed that the light nitrogen hypothesis for canopy photosynthesis is maximized when there is a positive relationship between irradiance received by foliage, its nitrogen content, and maximum rate of photosynthesis.

The vast array of species found in the humid lowland tropical forest of the world is frequently divided into two major groups: light demanders and shade tolerators (Daniel and Turna, 1998). Generally, shading reduces the intensity of the incident radiation reaching the plant and the soil (Gbadamoshi, University of Ibadan, Nigeria, personal communication). John (1998) and Droppelmann et al. (2000), observed that under conditions of shading, evapotranspiration is reduced, which favours moisture conservation for use by the plant. In an experiment by Cintra and Horna (1997), it was discovered that, it is advantageous for two common large seeded and shade-tolerant Amazonian tree species, *Astrocaryum murumuru* and *Dipteryx micrantha*, to have their seeds dispersed to gaps. Survival of seeds and seedlings was higher in two gap zones (crown and bole) compared to the shaded understory.

The large-sized seeds of *Ricinodendron heudelotii* are reddish brown-black and usually consist of a testa with a yellow kernel inside. Inside the fruit shell is a soft spongy pulp layer making up about 20% of the fresh fruit, 10% being the fruit skin and the rest of the fruit is the seeds. Five different types of seed numbers are known: single-seeded fruit with an aborted lobe, two-seeded fruit with two lobes, three-seeded fruit with three lobes, single-seeded fruit and two- seeded fruit with unequally developed lobes (Fondoun et al., 1999). It has been recorded that regeneration from seeds of *Ricinodendron* is sparse under dense canopies (Vivien and Faure, 1985), and also that light enhances germination (Fondoun et al., 1999).

Despite these findings, the appropriate depth at which seeds can be sown, and the best intensity of light for seedling establishment for this species are not yet known. Thus, this work was aimed at determining the proper soil depth to which the seeds of *R. heudelotii* can be sown for successful emergence of the seedlings, and the appropriate intensity of light at which emerged seedlings can survive.

MATERIALS AND METHODS

Effects of sowing depth on *R. heudelotii* seeds

A 10 x 10 m piece of fallow land was cleared of grasses and shrubs using a cutlass. Local palm fronds and bamboos were used to construct a shade in the demarcated area to provide a cooling effect to the polyethylene soil-filled pots that were arranged under it. The soil was collected from the forest top soil about (0.6 m deep) and filled into polyethylene bags (15 x 14 cm lay flat).

After depulping the fruits of *Ricinodendron*, hand-picked from under a mother tree, 200 equal-sized seeds were selected. The diameter of seeds passed through a taper provided from the Department of Forestry, University of Dschang, Cameroon, was about 5.5 cm. Dribblers also provided from the same department were used to drill holes into the soil inside the polyethylene bags.

The 200 seeds were divided into 4 lots of 50 seeds each for the four sowing depths. The first lot (T_1) of 50 seeds were sown at a depth equal to the diameter of the seed that 5.5 cm, the second lot (T_2) of seeds were sown at a depth twice the diameter (11 cm) of the seeds, the third lot (T_3), sown at a depth 2.5 times the diameter (13.8 cm), and lastly, the fourth lot, (T_4), sown at a depth of 3.0 times the diameter of the seeds (16.5 cm).

After sowing each seed into the specified sowing depth, the holes were covered with soil. Watering was done daily for the 12 wk period of the experiment. The experimental design was complete randomized design with two replicates.

Effects of light intensity on early seedling growth

This experiment was conducted on the open field by raising a ridge measuring 10 x 3 x 0.5 m using a hoe and partitioned into three subplots 1, 2, and 3. 180 seeds of *Ricinodendron* were collected, depulped by allowing the mesocarp to rot under refuse dump on the farm and dried in an oven at 50°C for one day. Later, the seeds were divided into three lots. The first lot (lot 1), of 60 seeds, was allotted to Subplot 1. The sowing space for seeds was 20 x 20 cm according to Campbell and Lang (1995). The second lot of 60 seeds was sown on Subplot 2 at same sowing space, and the third lot sown on Subplot 3. All the plots were watered daily.

The establishment of shade

After a period of one month, shades were established to regulate the light intensity above Subplots 2 and 3. The Subplot 1 was used as the control and constituted the first treatment (T1) that had a light intensity of 0.99 lux meters (Anjah and Okali, 2003). The second treatment (T2) was partially shaded resulting in a shade with a light intensity of 1:1.6 lux meters. The shade material consisted of erecting bamboo poles in rectangular form around Subplot 2. In addition, drawing 3 layers of 1 mm mesh nettings attained the light intensity over the bamboo poles to cut out direct isolation from reaching the seedlings. The third treatment (T3) was also done like T2 but had 5 layers of green 1 mm mesh netting

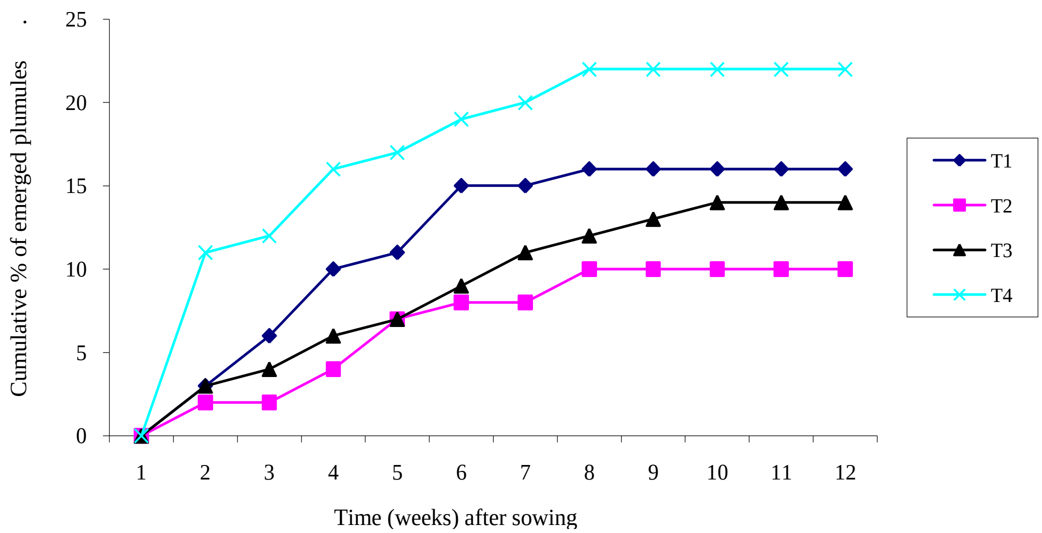

Figure 1. Effect of sowing depth on cumulative germination percentage of *Ricinodendron heudelotii*.

Table 1. Mean percentage values of plumules of *Ricinodendron heudelotii* as affected by sowing depth.

Sowing depth (cm)	% of emerged plumules
5.5	11.67^{ab}
11.0	6.75^{b}
13.6	8.92^{b}
16.5	17.08^{a}

Means with different letter superscripts on the same column are significantly different (P < 0.05).

+ one layer of black 1 mm mesh netting to intensify the shade effect. This treatment produced an intensity of 1:0.75 lux meters. Light intensity was measured using an extech light meter (SDMO France).

Data collection and analysis

Germination was recorded when the plumule emerged above the soil surface for each sowing depth. Data was collected for germination by counting of emerged plumules every after one week, beginning from the date of sowing, and on a cumulative basis. Values were transformed to percents. The analysis of variance was used to examine the differences among the treatments and the means separation by Fisher's LSD (P= 0.05).

In the light intensity experiment, data were collected from 6 seedlings for each treatment. These six seedlings, which were of uniform height, were randomly selected and growth parameters recorded on a cumulative basis included;

1) Plant height,
2) Number of leaves, and
3) Area of leaves.

The height of each seedling was measured using a meter ruler in cm; the cumulative number of leaves and the leaf area were determined by counting and by the grid method, respectively (Adewusi, 1997). Weekly data collection continued for 5 wks.

The experimental design was the complete randomized design with each seedling, constituting a replicate. All data collected were subjected to analysis of variance and mean separation was by Fisher's LSD at 5% level of probability.

RESULTS

Effect of sowing depth on germination of *R. heudelotii* seeds

Sowing at a depth of 16.5 cm (T_4) gave the highest cumulative percentage (17.1%) of emerged plumules. This was followed by T_1 (11.6%) at a depth of 5.5 cm, then T3 (8.9%) at 13.8 cm, and lastly, by T_2 (6.8%) at 11 cm (Figure 1). Sowing depth had a significant (P < 0.05) effect on germination of *R. heudeloti*. However, the differences among the means were variable with T_4 significantly (P < 0.05) different from the others. T_2 was significantly (P < 0.05) different from T_1 but had an interactive significance with T_3. T_1 also had an interactive significance with T_3 (Table 1). However, no linear relationship was observed between the sowing depth and cumulative percentage of emerged plumules.

The effect of light intensity on early seedling growth

Table 2 shows the effect of different light intensities on the height, leaf number, and leaf area of the seedlings. The tallest seedlings were produced under partial shade compared with the other treatments. Plant height increased markedly between 3 and 9 (WAP) irrespective of light treatment (Figure 2). After 9 WAP, growth rate slowed down for all treatments. This trend was observed on T2 and T3 plants from 9 to 15 WAP. However, for the T1 (non-shaded) plants, the decline in growth rate was observed up to the 12th WAP after which a higher and increasing growth rate was recorded at 15 WAP relative

Table 2. Mean values of plant height, number of leaves, and leaf area under shade effect.

Treatment	Plant height (cm)	No. of leaves	Leaf area (cm^2)
No shade	98.67±42.24 (^{ns})	15.00±5.07 (^{ns})	31.05±3.50 (^{ns})
Partial shade	126.67±19.96 (^{ns})	12.00±2.45 (^{ns})	26.20±2.05 (^{ns})
Complete shade	111.67±22.68 (^{ns})	10.00±2.87 (^{ns})	24.40±3.02 (^{ns})

Mean values + SD (standard deviation, n = 6) ns denotes not significant along the same column at 5% probability level.

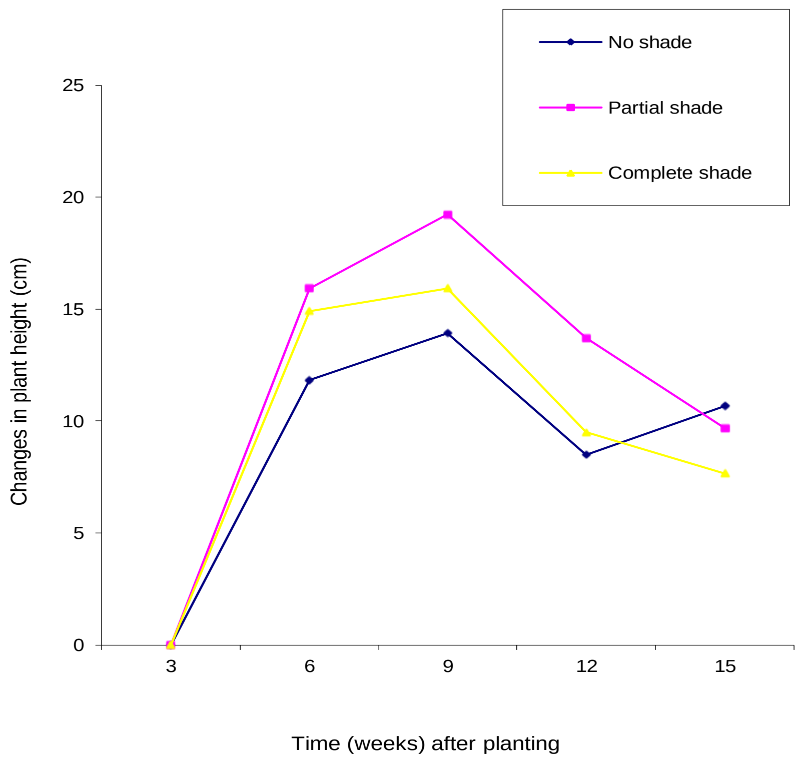

Figure 2. Effect of shade on changes in plant height at three weekly intervals.

to the shaded treatments. Although physical differences in plant height were observed among the different treatments, statistical analysis of data revealed that the mean plant height values were not significantly different among the treatments. Shading also reduced the number of leaves per plant. The differences in number of leaves between shaded and non-shaded plants were not significant. Similarly, there were no significant differences in the mean values of leaf area for all treatments (Table 2).

DISCUSSION

R. heudelotii seeds, which belong to the category of large seeds, germinate better when sown at a depth (16.5 cm) that is three times the diameter of the seed. This confirms the findings of Hudson and Dale (1975) that seeds should be sown at depths equal to 3 to 4 times the diameter of the seed, and Jurik et al. (1994) that large seeds produce larger seedlings and are able to emerge from greater soil depths. However, this finding is not in line with that of Harries et al. (1998), that sowing depth is generally the diameter of the seed.

Although, the sowing depth at T1 (5.5 cm), was equal to the diameter of the seed, the cumulative percentage of emerged plumules was higher (11.6%) than at depths of T2 (11 cm), and at T3 (13.5 cm) which were 6.75% and 8.92%, respectively. Thus, no linear relationship was observed between sowing depth and percentage of emerged plumules although differences among the means are variable with T_4 significantly ($P < 0.05$) different from the others (17.08%). The best sowing depth for *R. heudelotii* seeds is three times the average diameter of the seed. Sowing depth is definitely a factor militating against the establishment of many *R. heudelotii* seedlings in an undisturbed forest. With deep sowing there is adequate covering of the large seed with soil to ensure good seed-soil contact for enhanced imbibitions.

Light intensities beneath canopy greatly influence the establishment of tree seedlings since the production of organic matter and energy required for the maintenance of life and growth originates from photosynthesis (Nwoboshi, 1982). However, because the seedlings of different species have various light requirements, some succeed in habitats where others fail, thus, differences in seedling reactions to shade or low light intensity are exceedingly important in tropical silviculture.

Although, shading reduced the number of leaves per plant, the vigorous growth of *R. heudelotii* was enhanced under conditions of partial shade. Generally, shading reduces the intensity of the incident radiation reaching the plant and the soil (Gbadamoshi, University of Ibadan, Nigeria, personal communication). The differences observed between shaded (T2 and T3) and non-shaded plants (T1) with respect to plant height could not be attributed to light intensity but to dryness of the soil for the non-shaded plants. However, John (1998) and Droppelmann et al. (2000) observed that under conditions of shading, evapotranspiration is reduced, which favours moisture conservation for use by the plant thus, light of a lower intensity required for seedling establishment. In the same vein, higher mean values in height observed at 15 WAP on non-shaded seedlings compared to the partially shaded and completely shaded plants, is an indication that not only light intensity may be responsible for the differences in plant height observed, but another factor like water for example.

Kabakoff and Chazdon (1996) observation that dense subcanopy and under forest vegetation in tropical secondary forests can strongly influence light level and hence establishment of seedlings does not hold for *R. heudelotii* since there were no significant differences among values for the growth parameters under various light treatments. The results contrast that of Cintra and Horna (1997) who observed higher proportion of seedlings survival within gaps than in the shaded understorey over an 18 wk period for Amazonian tree species, *A. murumuru* and *D. micrantha*. These results also contrast those reported by John (1998) that, under well-watered conditions, light limits leaf production as observed in the case of the mean values of the number leaves and leaf area values of seedlings of *Ricinodendron* which were all not significantly different under the different light treatments.

Under partial shade, growth of *R. heudelotii* seedlings was vigorous. Although there were no significant differences among treatments on leaf number, under conditions of sufficient moisture owing to reduced evapotranspiration (John, 1998; Droppelmann et al., 2000) thus, the photosynthate produced from these could not have been sufficient for the establishment of vigorous seedlings.

Further research is however, required to vary the seed-size classes and quantify the intensity of light transmitted under the different levels of shade as well as the moisture contents of the soil.

Conclusion

In conclusion, seeds of *Ricinodendron* should be sown at a burial depth of 16.5 cm in the soil in order to achieve good percentage germination, and for a good establishment of the seedlings, light at variable intensities suffice.

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