Effect of Seed Size on Seedling Growth of a Shade-Tolerant Tropical Tree (*Hymanea stilbocarpa* Haynes)

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The effect of seed size (weight and length) on seedling growth of a tropical species adapted to shaded environments was tested. Seeds of a climax tree species characteristic of the Atlantic Forest (Hymanea stilbocarpa *Haynes) were sized by weight (heavy, medium, or light) and length (long, mean, or small). Seeds were scarified and sown under 3 light regimes: (1) full sun-an open forest gap (100% full solar radiation flux at noon), (2) partial shade— a closing forest gap (80% full radiation at noon), and (3) deep shade— under a forest canopy (40% full radiation at noon). Twelve weeks after the development of primary leaves, the seedlings were measured for total height and root collar diameter.* Hymanea *seedlings grew best under shaded conditions despite seed category. Seed weight did not significantly influence seedling height or root collar diameter under either shading treatment. Seed length influenced seedling height and root collar diameter when seedlings were grown under either shade treatment. In deep shade, seeds with longer-than-average axes yielded seedlings 24.0 mm taller and 5.5 mm thicker at the root collar than seedlings from short seeds.* Tree Planters' Notes 46(4): 130-133; 1995.

Hymanea stilbocarpa Haynes occurs through Brazil, Argentina, and Paraguay on sites between 40 and 900 m above sea level, with annual precipitation of 1,000 mm and annual mean temperature of 19 to 28 ºC. It is a 10-to 15-m-tall tree with a dbh of 40 to 80 cm and a dense, large rounded crown (figure 1). Leaves are composite and alternate, each with 2 shiny and thick leaflets (figure 2). Inflorescences are hermaphroditic, white or creamlike, with 14 terminal flowers producing long and brown fruits bearing 2 to 8 seeds (figure 2).

One possible adaptation for ensuring successful seedling establishment is the possession of a large (long and heavy) seed that provides an ample reserve of nutrients during the period immediately after germination. This reserve allows the seedling to achieve critical size and capture external resources in competition with other plants. Within a population, a range of seed sizes is produced. Several studies have demonstrated that the seedlings derived from larger seeds consistently maintain a size advantage over the seedlings from smaller seeds— for the species *Lupinus texensis* (Schaal 1980), *Mirabilis hirsuta* (Weis 1982), and *Raphanus raphanistrum* (Stanton 1984)whereas several other species had the opposite or no effects.

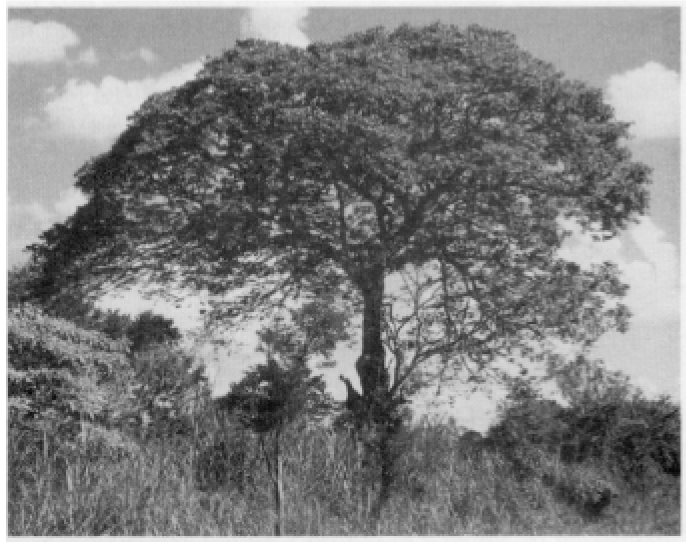

Figure 1— *Full-grown* Hymanea stilbocarpa *Haynes.*

Figure 2— *Close-up of ripe seeds of* Hymanea stilbocarpa *Haynes.*

The importance of seed weight for seedling establishment in the shade is indicated by experiments carried out by Grime and Jeffrey (1965) on saplings of 9 North American tree species. The species used included light-seeded trees characteristic of open woodland and heavy-seeded trees of dense forests. The seedlings were grown in artificial shade conditions by surrounding each with a blackened cylinder that provided a gradient of light to dark. After 12 weeks, mortality was found to be inversely proportional to the weight of a seed's food reserve. More seedlings from light seeds died than did those from heavy seeds.

If the possession of large seeds is an adaptation for establishment in shade, it can be expected that large seeds store more carbon than small seeds because of the need to compensate for reduced carbon assimilation in the early stages of seedling growth. However, seed weight, by itself, cannot always be taken as an indication of shade tolerance. Augspurger (1984) working with light requirements of 18 forest tree species in Central America found that survival in shade was not correlated with seed weight but was related to the successional status of the species. Late-stage successional trees tended to have seedlings that were more shade-tolerant despite their seed weight.

The objective of this study was to test if seed size, as quantified by fresh weight or by long axis, influenced seedling growth under different radiation flux regimes— a distinct characteristic of late successional stages.

Materials and Methods

Fruits of *Hymanea stilbocarpa* Haynes were collected from 5 trees at the Universidade Federal Rural do Rio de Janeiro (UFRRJ) campus, Itaguai (22º 34' S and 42º 19' W), Rio de Janeiro, Brazil. Seeds were manually extracted, individually weighed, and measured at their long axis, then scarified in hot water for 30 minutes.

The seed lot was divided in two sublots: in the first, seeds were classified as heavy, medium, or light, based on their fresh weight (table 1); in the other, seeds were classified as long, medium, or small, based on their length (table 2). The cut-off point was the mean (for either seed weight or seed length) ± 1 standard deviation of the mean. Seeds were sown in plastic boxes measuring 40 X 30 X 10 cm filled with sterilized river sand; 9 boxes were used for each seed category. Each box received 28 seeds randomly chosen within a size class planted in an evenly spaced grid of 4 rows and 7 columns.

After germination indoors, 3 boxes for each seed category were placed under one of the following conditions, all within the UFRRJ campus:

Table 1-*Classification of seeds of* Hymanea stilbocarpa *Haynes based on seed weight*

Seed weight class	Mean wt. (mg)	SD (mg)
Light	439.4	50.3
Medium	537.7	28.2
Heavy	627.8	39.9

Table 2-*Classification of seeds of* Hymanea stilbocarpa *Haynes based on seed length*

Seed length class	Mean length (mm)	SD (mm)
Small	24.03	1.41
Medium	26.35	10.2
Long	28.82	0.81

1. Full sun— large forest gap (100% of full solar radiation flux at noon)
2. Partial shade— partial canopy opening (80% of full solar radiation flux at noon)
3. Deep shade— a secondary forest canopy (40% of full solar radiation flux at noon)

Percentage radiation was measured by a radiometer. Extra seeds were germinated to replace those that did not germinate. After germination, the boxes received water as necessary as well as 500 ml of nutrient solution (10-10-10 NPK plus micronutrients) every other week. Manual weeding was performed accordingly. Seedlings were harvested 12 weeks after the development of primary leaves. Data from the inner 20 seedlings in each box were used for statistics. Analyses of variance (ANOVA), using a randomized design, were conducted to determine the effect of seed fresh weight (SFW) and seed length (SL) on total aboveground length and root collar diameter.

Results

There was 100% germination and no seedlings died during the experiment. As expected with a shade-tolerant tree species, the data analysis (table 3) revealed that seedlings under either shade treatment attained more height ($P < 0.05$) growth (figure 3); mean seedling height, pooled across seed weight and seed length, under full sun after 12 weeks was 231 mm whereas those under the shade treatments were 243 and 254 mm for partial and deep shade, respectively. On the other hand, secondary growth (root collar diameter) did not differ among seedlings submitted to different light regimes (figure 4).

Table 3— *Significant level for seedling height and seedling root collar diamenter due to shading and interactions of shade with seed weight and seed length*

Source of variation	DF	Significance level: Seedling height	Seedling root collar diameter
Shade	2	0.0037 **	0.4245 ns
Seed weight x shade	4	0.8984 ns	0.7066 ns
Seed length x shade	4	0.0266 **	0.0242 **

ns = not significant, ** = significant at P < 0.05.

As for the influence of seed size upon growth, seed weight did not bear any statistical influence on seedling development among radiation treatments. Seed length, on the contrary, had positive effects on the growth of seedlings under deep shade. Long and medium seeds produced seedlings taller than those grown from short seeds (figure 5). Mean root collar diameter from seedlings grown from long seeds was statistically ($P < 0.05$) different from those grown from short seeds (figure 6). Correlation coefficient between seed weight and seed length was 0.486 ($P > 0.05$). Interpretation of the results agreed with the interpretations of Augspurger

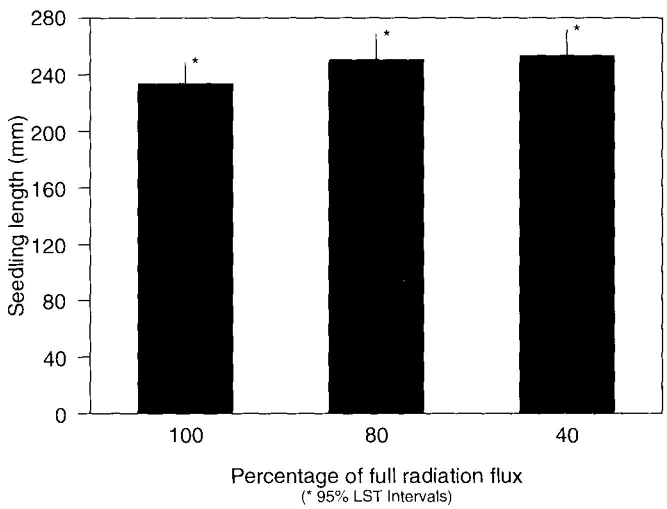

Figure 3— *Effect of radiation flux regimes on seedling length at 12 weeks after development of primary leaves pooled across seed weights and lengths (means and 95% LSD).*

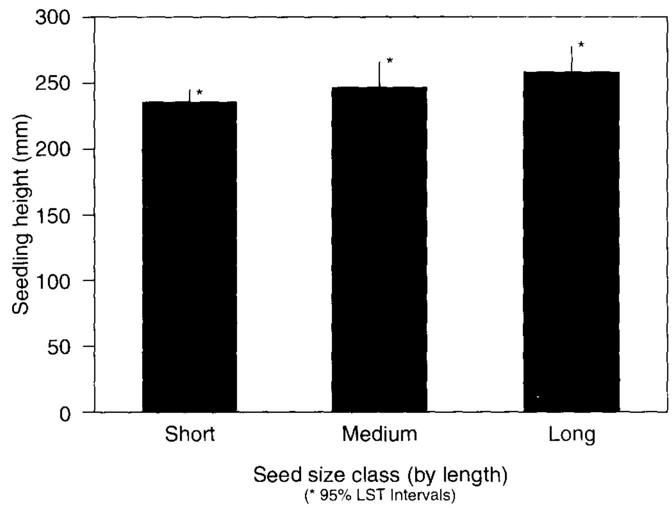

Figure 5— *Influence of seed size class on height of seedlings grown under full shade (40% of full solar radiation flux at noon) (means and 95% LSD).*

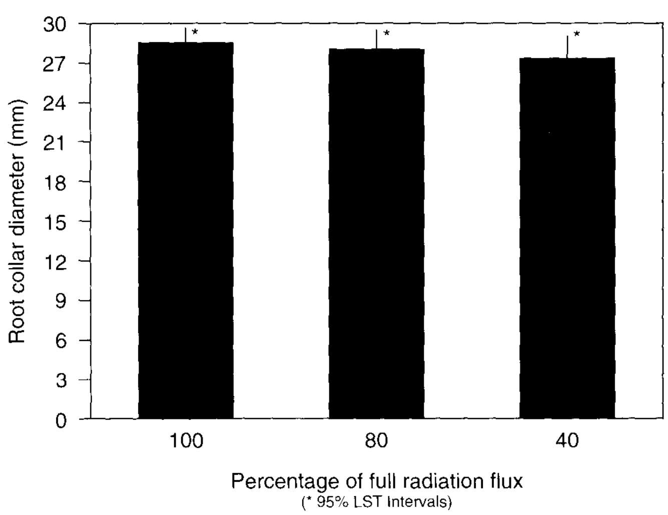

Figure 4— *Effect of radiation flux regimes on seedling root collar diameter at 12 weeks after development of primary leaves pooled across seed weights and lengths (means and 95% LSD).*

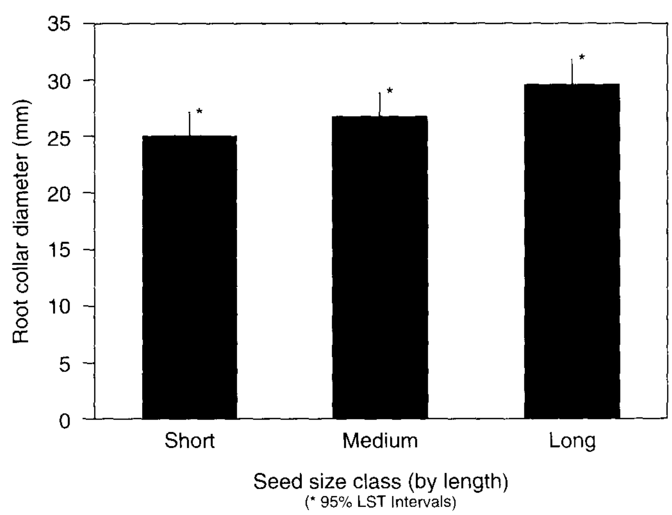

Figure 6— *Influence of seed size class on root collar diameter of seedlings grown under full shade (40% of full solar radiation flux at noon) (means and 95% LSD).*

(1984) and Fenner (1983), for whom seed weight, in itself, is not an indicator of adaptation to shade conditions. With *Hymenae,* seed length had more influence on seedling size attained 12 weeks after development of definitive leaves than seed weight. It is hypothesized (Malavasi and Malavasi 1992) that there may exist a direct relationship between seed length and embryo length for species of shaded environments. Further studies with X-ray techniques to measure embryo length of intact seeds would be appropriate.

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