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Growth Allocation Of Co-Occurring Species With Similar Regeneration Strategies Under Contrasting Moisture And Light Regimes: A Comparison Between Two Genera Of Moist Temperate And Moist Tropical Forests

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Introduction

Deforestation in the moist tropics is a phenomenon which has been recognized by foresters for a long time, particularly in Asia (Brandis 1897). Only with the accelerated development in the Neotropics in the last twenty years has it become a prominent issue. Moist regions of temperate countries have also suffered periods of severe deforestation as land was cleared for agriculture, though many of these areas, through successional processes, have reverted to forest. These land changes have been well documented by Raup and Carlson (1941), Raup (1944), Rackham (1976), Peterken (1987) and others.

Natural forest management will play a significant role in both temperate and tropical regions where forest area is extensive and population low, and where there is an appropriate socio-political climate. Yet, much more research is needed to further refine the management techniques used in both regions. To hasten this process, scientists are exploring the validity of applying silvicultural knowledge and expertise generated in the management of natural forest from the temperate zones to the tropics and vice versa.

Study Proposal

A key problem in forest types of both regions is the establishment of advanced regeneration where this is required for future regrowth. The red oaks (family Fagaceae; genus Quercus; section erythrobalanus) of eastern North America and the beraliyas (family Dipterocarpaceae; genus Shorea; section doona) of Sri Lanka have this problem. Moreover, 90 percent of the hardwood timber on the international market is provided by these two genera, which are experiencing extremely heavy exploitation in forests. This study attempts to examine their regeneration strategies in an effort to link physiology with ecology, by conducting controlled growth chamber experiments concurrently with field experiments of seedlings. It proposes to determine the occurrence and significance of physiological specialization of seedlings among three species of red oak (Quercus coccinea, Q. rubra, Q. velutina) and four species of beraliya (Shorea disticha, S. megistophylla, S. trapezifolia, S. worthingtonii) with response to different soil moisture and light regimes. For each genus, the study species co-occur together in the same forest type but on different sites. A summary of the common characteristics of both genera is shown in figure 1. This study provides a unique opportunity to compare two genera with similar regeneration strategies which occur in markedly different forest types. It allows one to ask the question: Are physiological traits that govern species seedling distribution and performance along light intensity and quality and/or soil moisture gradients the same between genera that have similar growth patterns?

**FIGURE 1.**
A summary of characteristics that certain species of Quercus & Shorea have in common.

altitudinal distribution of Quercus & Shorea species in study

Q. coccinea

Q. velutina

S. worthingtonii

S. disticha

S. megistophylla

S. trapezifolia

Q. rubra

valley

valley

valley

The hypotheses and objectives of the study are listed below:

**Hypotheses**

* A moisture gradient determines species distribution along the slope, starting in the seedling stage.

* Light is a major factor influencing moisture regimes across a particular site. This factor and the shade tolerance of the species determine its performance.

**Objectives**

1. Determine, at the end of the growing season, whole plant carbon gain and allocation to roots, stems and leaves.

2. Determine a time series of events for above ground plant growth rates and component growth rates.
3. Determine a time series of shoot architecture over the growing season by measuring stem height, number of branches, number of leaves, flush rate, number of internodes, leaf area, leaf orientation, leaf life.

4. Test whether population structure and growth rates of individuals in established seedling population, whose soil and light conditions have been measured, confirm the predictions of species performance in the experiments using the controlled growth chamber environment.

5. Relate the anatomy and physiology of each species to their growth performance in the different soil moisture and light regimes.

Field Experimental Design

Experiments were started in the fall of 1987 on the berarliyas at the Sinharaja Man and the Biosphere Reserve in Sri Lanka, and in the spring of 1988 on the red oaks at the Yale-Myers Forest in northeastern Connecticut, U.S.A.

Three circular gaps have been created in each forest along the gradient from bottomland (wet) to mid-slope, to ridgetop (dry). Each gap was made large enough to get the maximum diversity of microclimates across the site. Within each gap, five plots have been laid out along a transect covering the range in micro-environmental regimes. Each plot has one spacing matrix, with four replications, each with twenty five newly germinated individuals for each species (see figure 2). Herbivores and pre-existing vegetation have been excluded. Environmental measurements (light intensity, soil moisture, temperature, relative humidity) for each plot are being made at seasonal intervals. Seedling size, architecture and weight, and their components are being measured at one and a half month intervals.

FIGURE 2.

Growth Chamber Experimental Design

The controlled experiments are being conducted in growth chambers in order to compare seedling survival and growth between and within the species across an array of light and soil moisture regimes. These experiments were started at the same time and location as the field experiments. They are a series of matrix tests comprised of five light regimes, three watering levels, and one spacing level. The light regimes include both quality duration and intensity. Light quality has been altered by using a particular mix of paint pigments added to a varnish base and sprayed on a plastic film (Lee, 1978). Light conditions resembling those of a forest understory were then created. Light intensity was altered by the amount of paint spray applied to the film. Response of seedlings to time exposed to sunlight is also being examined by subjecting seedlings to different durations of full sunlight. This has been done by using different spacings between the slats of Venetian blinds that have been laid horizontally over the seedlings to artificially create forest understory sunflecks. The watering levels range from well watered (continuously moist) to water stressed (periodically dry). The same micro-environmental and seedling measurements are being made in the growth chambers as for the field experiments.

Leaf Anatomy and Physiology

Seedlings of each species will be grown in different controlled environments. Two light intensities, full sun and deep understory shade, and two moisture regimes, water stressed and non-stressed, will be created to represent the different environments. Leaves from each species will be sampled from the different growing environments and various anatomical characteristics measured: cuticle thickness; upper and lower epidermal cell size and number of layers; palisade cell size and number of layers; whole leaf thickness; stomata frequency, location and size; leaf hair frequency and size.

Leaf samples from seedlings in the different environments will also be sampled for tissue water content, water potential, conductance and maximum carbon dioxide assimilation.

Results

Results should determine the degree of physiological specialization or non-specialization of species that co-occur in the same forest type. They would also provide a better understanding of the maintenance of species rich forests and shed further light on similarities and differences in dynamics between temperate and tropical forest systems.

Findings will also provide a better understanding of the establishment of advanced regeneration and hence allow for a further refinement of the silvicultural systems used.
They also will connect directly with current studies on natural populations that are concerned with predicting *Quercus* and *Shorea* seedling growth and performance in different environments (Sander, et al. 1977, 1984, Ashton 1987). Preliminary information will be provided for their establishment in plantations.

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Selected Bibliography


