Using Rainforest Research

Root establishment strategies of rainforest seedlings

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The first phase of life for a plant in the rainforest is a period of great adversity, and only the best adapted or luckiest individuals survive. A long-term study by Joe Connell and Peter Green revealed that of one species of *Chrysophyllum* only 6% of seedlings survived after 27 years with average height increasing only from 17cm to 35 cm over the same period.

Seedlings can succumb to branch and tree falls, predation by both invertebrates and vertebrates, trampling by larger animals, drought and pathogens. They also experience stiff competition from mature plants and other seedlings for light, water and soil nutrients. In order to grow beyond this vulnerable stage, each seedling needs appropriate strategies to increase its chances of survival. Evolution of such strategies would be expected as part of natural selection processes.

Although seedlings play such a vital role in rainforest survival, little is known regarding their strategies for establishment and survival, particularly those involving their root systems. The type of root seedlings possess, how those root types vary in response to different conditions, and their relationship with fungal symbionts called mycorrhizae, are the subject of Suzanne Jenkins' doctoral studies.

Distinct root types for different conditions

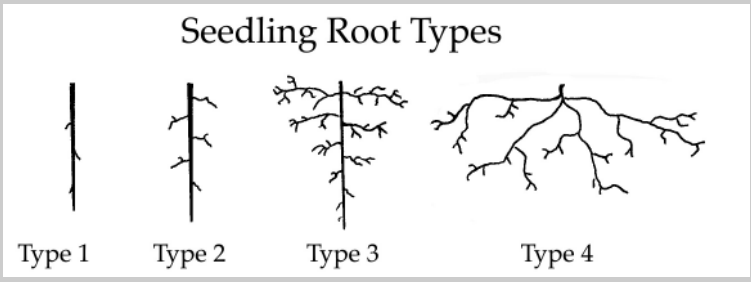
Suzanne began her study with a survey of root types in different environments which included sites with high and low rainfall and soils of contrasting fertility. Seedlings were sampled at each site from four different light regimes as follows:

- subcanopy forest
- canopy gaps
- edges of the forest
- early successions

Type 1 and 2 seedlings on the forest floor

Results showed seedling root systems could be categorised into four types resulting from variations in the dominance of the tap root. The most tap root dominant seedlings had only a tap root with a few very short laterals (Types 1 and 2). At the opposite end of the spectrum were seedlings with no tap root at all but with roots that spread for long distances through the soil (Type 4). These different types are linked to environmental factors, with the light factor showing the strongest correlation. Seedlings surviving in the lowest light environments were those with the greatest tap root dominance, and those in the highest light had root systems with the least tap root dominance.

To determine whether these root types were genetically fixed or grew in response to environment, a range of seedling species were grown under controlled experimental



Types 1 and 2 establish from large seeds and flourish in the low light and humid conditions on the rainforest floor. Types 3 and 4 generally emerge from small seeds in the higher light and drier atmosphere of rainforest edges and early successions

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The Rainforest CRC is a research partnership involving the Commonwealth and Queensland State governments, the Wet Tropics Management Authority, the tourism industry, Aboriginal groups, CSIRO, James Cook University, Griffith University and The University of Queensland

conditions where light and soil nutrients could be manipulated. It was found that these root types were fixed for a species, indicating that each has been selected for establishment in a particular location in the forest. The strongly tap rooted species are adapted to grow in low light levels where the transpiration requirement is low and the soil and air are relatively humid. Their root system is not designed to forage for water because seedling requirements are generally quite low. This type of root is usually associated with large seeds, so roots also do not need to forage for nutrients because the plant can rely on original stores from the seed.

Root systems of species that survive best where light levels are higher and the air generally drier have long foraging roots. These are necessary to find enough water to meet the transpiration requirements that are associated with high levels of photosynthesis and growth, and to seek out soil nutrients. In early successions there is little decomposing leaf litter to provide a ready source of nutrients and seeds of species that grow there are generally small and carry minimal nutrient stores to maintain the plant. In an area that is newly disturbed and devoid of other plants, such roots also allow a seedling to quickly and optimally exploit the soil space potentially making it difficult for later arrivals to establish.

Mycorrhizal associations

Mycorrhizae are fungi that commonly form associations with plants. The fungal strands (*hyphae*) grow partially through the root tissue and partially through the soil surrounding the roots. In most cases, this is a relationship of mutual benefit to both the plant and the fungus. The fungus takes in carbohydrates the plant has produced by photosynthesis and the plant gains soil nutrients, particularly phosphorus, which the fungus has extracted from the soil. In many instances the uptake of phosphorus, a particularly immobile nutrient, is more cost-efficient for the plant if performed by the fungus rather than by the plant's own roots.

Examination of the seedlings surveyed for mycorrhizal fungi associations found that few of the seedlings were infected. An average of only 35% of all the seedlings sampled had myccorhizae in their roots. It is known that the majority of mature rainforest species form these associations, and it was thought that they may be vital for the establishment and persistence of the seedlings. Suzanne is currently exploring the reasons for this low level of infection to discern whether this could be:

- the result of low levels of fungal inoculum in the soil,
- because it is not cost-efficient for seedlings to form myccorhizae when growing in low-light slow-growth situations, or
- because the fungus prefers to colonize plants which have the potential to provide them with more photosynthetic carbohydrate.

Why is it important to understand rainforest root systems?

The study so far has indicated the importance of the type of root system a seedling develops and the conditions in which it is likely to survive best. On a practical level, this knowledge will be useful for managers of reforestation programs, particularly where seedlings are planted out when young. Knowledge of seedling root types will also provide a basis for future studies of revegetation of rainforest from seed, a method of replanting that could potentially be very cost effective. On a theoretical level, it contributes to the understanding of the processes that maintain rainforest plant diversity. Clearly root establishment strategies of particular rainforest species are suited only to particular microenvironments within the forest, outside of which the seedlings are likely to perish.

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