BRIEF COMMUNICATION

Effects of microenvironment on net photosynthetic rate and growth of four tropical species in the La Mesa watershed

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Abstract

Seedlings of four tree species (*Bischofia javanica, Dracontomelon dao, Erythrina orientalis,* and *Pterocarpus indicus*) were planted in flat and sloping grassland in plantation sites established in May 2002 in the La Mesa watershed, Philippines. Tree growth and net photosynthetic rate (P_N) were monitored. The height, diameter at the root collar, and P_N of the four species grown in the sloping grass site were larger than those of seedlings grown in the flat grass site. In addition, soil moisture contents in the sloping grass site were higher than those of the flat grass site. Growth of the four species was probably strongly associated with microenvironments (*e.g.* air temperature) in both tested sites.

Additional key words: air temperature; *Bischofia javanica, Dracontomelon dao*; *Erythrina orientalis*; grassland; moisture contents; *Pterocarpus indicus*; shade tolerance.

Tropical forests represent more than half of the total area of forestland throughout the world, and are one of its most important natural resources. However, much of these forests have been destroyed by illegal deforestation activities such as cutting, logging, and improper cultivation (Luna *et al*. 1999). Large-scale forest fires resulting from human negligence are also a contributor to tropical forest degradation (Parrotta *et al*. 1997). The deforestation rate of tropical forests is estimated to be 10–16 million hectares per year.

In Asia, most of the Southeast region is covered with tropical rain forests, which boast a vast biological diversity and the highest forest productivity in the world (Parrotta *et al*. 1997). Of the Southeast Asian countries, the forests of the Philippines are considered the centrepiece of the ASEAN natural resource base and ecosystem (Westoby 1989).

Safe site was introduced by Harper *et al*. (1961) and is defined as a site created to foster an immediate environment for a seed that is favourable to its germination and growth. A safe site for seedlings in the degraded area of tropical rain forests represents a detailed understanding of the interrelationship between the plant population and the microenvironments of the particular region (Urbanska 1997). The grasslands exist under varied topography in the tropical region, and individual trees in the forest are affected by abiotic factors such as slope, temperature, nutrients, irradiance, and water relations. The growth of seedlings is affected by the interaction of micro-environmental and genetic characteristics (Kimmins 1987).

Tropical forests have been degraded for many reasons (Luna *et al*. 1999). Restoration aims to improve the standing structure and functioning of the area, including its biodiversity. We surveyed research sites in the Philippines to understand the basic reasons for degradation as well as finding solutions to the problem. The *Save the La Mesa Project*, for the La Mesa watershed near Metro Manila, is an undertaking of the ABS-CBN foundation, the largest media conglomerate in Asia. This project will help fulfil the water needs of 12 million Metro Manila residents. Both natural and artificial restoration techniques were employed.

We tested the artificial planting technique to restore the grassland with several fast-growing species and compared the growth of native seedlings planted in the flat and sloping grass site of La Mesa watershed. We

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hypothesized that the seedling growth in these two areas would show different patterns based on the fact that these areas have different microenvironments.

The research site inside the La Mesa watershed is located at a latitude of 14°45'N and a longitude of 121°05', with an elevation of 104 m above sea level. The 2 700 ha watershed was placed in danger due to illegal logging, quarrying, and destructive forms of farming. This area has two pronounced seasons: the dry months of January to May, and the wet months of June to December. The mean annual rainfall is 2 700 mm and the mean annual temperature is 23.8 to 30.0 °C.

Four tree species were used to study the artificial regeneration in the grassland area, two nitrogen fixing species, *Erythrina orientalis* and *Pterocarpus indicus*, and two shade intolerant species, *Bischofia javanica* and *Dracontomelon dao.* The seeds were collected from the same origin and propagated in the nursery. After germination, seedlings with uniform size were selected to reduce variation. A randomized block design was used to test for sites' effects. The trees were planted at a 4×4 m spacing distance. Three replicates of each species were randomly assigned to each of sites. Each species had two rows as a border and 0.7 ha planting area. After establishing the sites in May 2002, the height and diameter at the root collar were monitored and measured for growth every three months. Diameters of seedlings were measured. We marked the measuring point at the 3 cm above of the seedlings exactly and measured 50 randomly selected individuals.

In both the flat and sloping sites, soil samples were taken at 30 cm depths using a soil auger for five replicates. Soil was sifted using a 2 mm sieve, and then fine roots were removed. Collected soil was immediately weighted with an analytical balance for the field fresh mass (FM). Soil was oven-dried to constant dry mass (DM) in an oven at 105 °C for 24 h and weighed. Soil moisture contents were determined as: (FM – oven DM)/oven DM × 100. Soil pH was determined using a glass electrode (*Vision Science*, model *100*) in a 1 : 5 (v/v) suspension of soil in water. Values were averaged for all measurements of every treatment replicate. In addition, air temperature (T_a) was monitored by a mini weather station attached 3 m above the ground. Weather data were logged from November to January.

Net photosynthetic rate (P_N) was measured on fully expanded, mature leaf number 4 counted from each shoot apex on every individual in the treatments. P_N was measured with a broad-leaf cuvette of the *Licor-6400* Portable photosynthesis system (*LI-COR*, USA). The leaf was sealed and CO_2 concentration was maintained at ambient levels. Airflow through the analyzer was adjusted to maintain leaf cuvette relative humidity near ambient (60–70 %) during measurement. The average cuvette temperature was maintained at 25 °C. In addition, irradiance during the measurement was maintained at 1 200 µmol $m^{-2} s^{-1}$. P_N of five seedlings in each species was determined. The measurements were performed on January, February, May (dry season), August, and November (raining season) four times in a month.

P_N in the sloping grassland site was always higher than that of flat site (Fig. 1). Among the four species, the *E. orientalis* seedlings showed the highest P_N at 1 200 µmol $m^{-2} s^{-1}$ (Fig. 1*A–D*). This is almost three times higher than that of the *B. javanica*, which showed the lowest P_N in both the sloping and flat sites. P_N of the

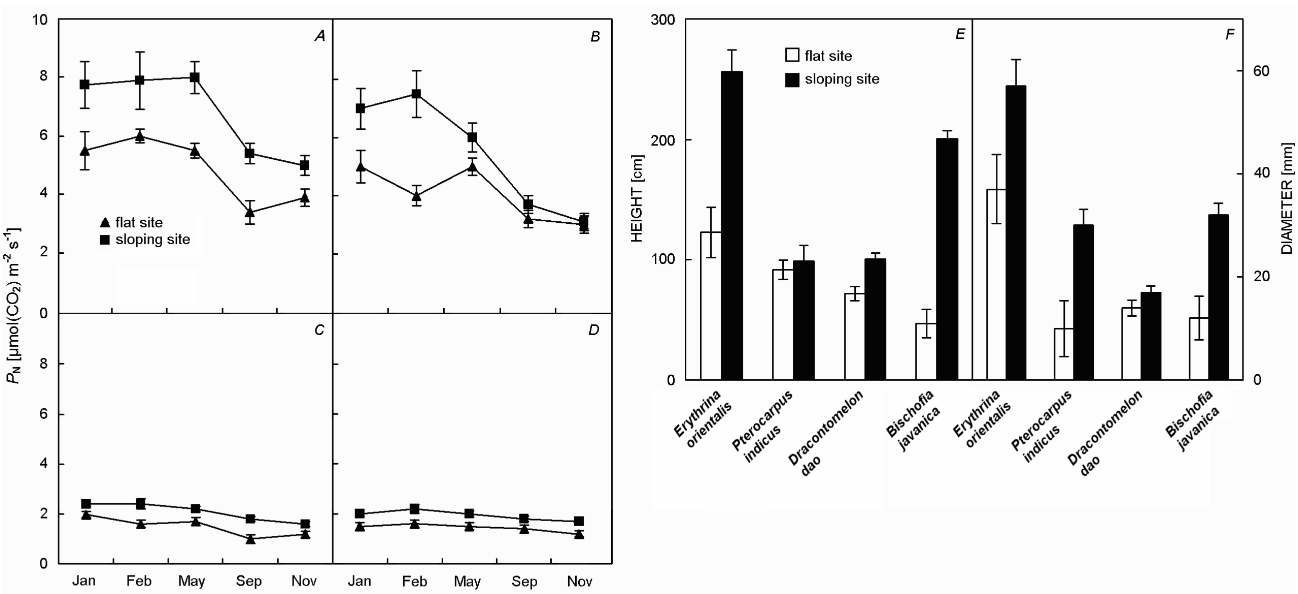

Fig. 1. Means of [*Erythrina orientalis (A), Pterocarpus indicus (B), Dracontomelon dao (C)* and *Bischofia javanica* (*D*); *n = 5*] net photosynthetic rate, P_N and (*E*) height or (*F*) diameter at root collar (*n = 50*) of four species in both flat and sloping sites at the La Mesa watershed. *Vertical bars* indicate standard deviations.

nitrogen-fixing species (*E. orientalis and P. indicus*) were higher than those of *B. javanica* and *D. dao* at the same irradiance, whereby higher P_N for biomass production exhibited greater saccharide gain (Fig. 1).

The height of the species grown in the sloping site exceeded those of the seedlings grown in the flat site (Fig. 1*E*). In particular, *E. orientalis* grown in the sloping site was almost twice the size of the one grown in the flat site. Similar results were observed in the first year. Diameter growth at the root collar showed the same pattern of divergence (Fig. 1*F*).

Moisture contents in July were 29.9 and 32.5 % of the soil in the flat and sloping sites, respectively, and pH values were 5.08 and 5.27, respectively. The values were significantly higher in the sloping site than in the flat site. Soil moistures were associated with the daily T_a. The highest T_a on January 16th in the flat site was 43 °˚C and in the sloping site 36 °C.

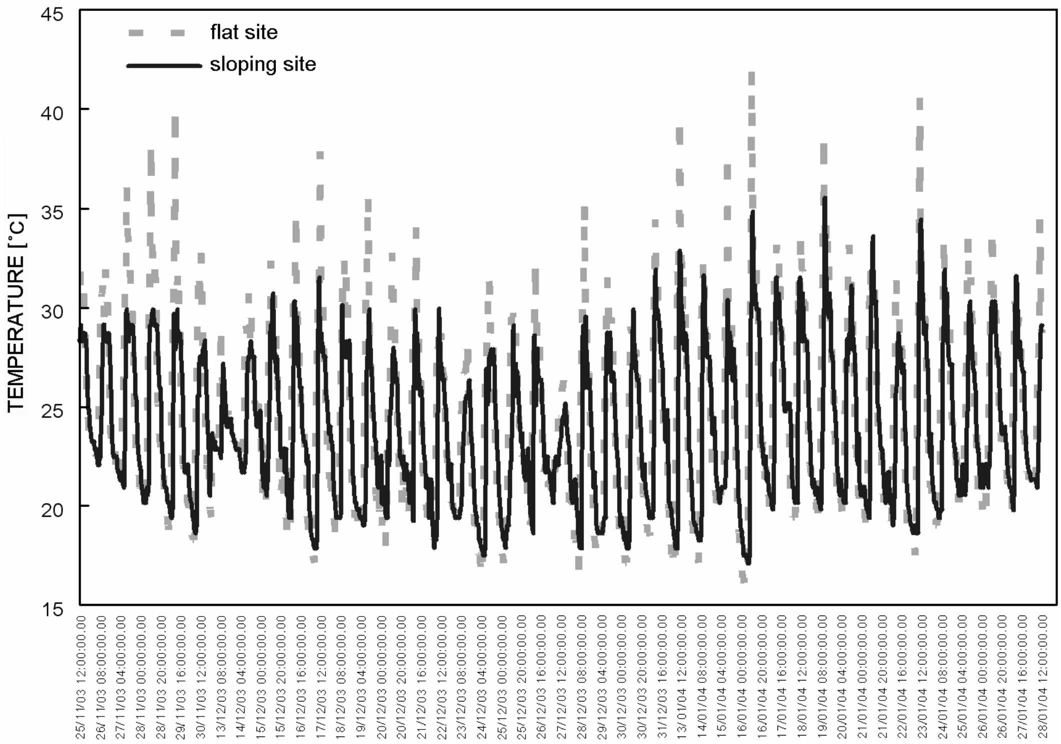

Fig. 2. Air temperature changes in both the flat and sloping sites from November through the end of January.

Water deficiency in the soil is one of the most prominent causes of seedling mortality. Some microclimates such as partial shading from other trees or taller brush would decrease transpiration water loss in the sloping grassland. These factors added to the decreased T_a (Fig. 2) and higher moisture in the sloping site, possibly providing a better photosynthetic microenvironment for the seedlings in the sloping grassland.

North-facing slopes experienced lower daylight irradiance and had higher moisture content (due to less evaporation from the soil) than south-facing slopes. In general, a greater number of remaining trees and taller brush provided greater shade in the sloping site than the flat site (Kozlowski and Pallardy 1997). The variance in T_a probably resulted from the different soil moisture in the two sites (Fig. 2). Correspondingly, the higher T_a in the flat site induced more soil evaporation, making seedling growth in the flat site difficult. Competition with grass might have exacerbated seedling mortality in the flat site as root competition between seedlings and other plants increased water stress for seedlings (Urbanska 1997).

Our results indicate that the microenvironments such as T_a and soil moisture are key factors in the proper implementation of safe site in the initial seedling development stage in degraded grassland. While these two sites were located close together, the four tropical tree seedlings grown in flat and sloping sites showed different P_N based on the microenvironment (sloping topography, soil moisture, and T_a).

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