Predicting responses to soil desiccation from leaf traits in potted saplings among Dipterocarpaceae species

Ever-wet tropical forests of Southeast Asia account for a large fraction of forestry production in the world, but there are increasing concerns that this productivity will decline due to increased intensity and frequency of droughts associated with climate change. Hence, there is an urgent need to implement climate change adaptation measures by improving the drought tolerance of plantation trees. The Dipterocarpaceae, an important timber resource in this region, consists of >470 species, and there are potentially useful species with high drought tolerance. However, the drought tolerance of individual species and its indicators are unknown, which poses a challenge in implementing climate change adaptation through conversion of planting species.

This study aims to evaluate interspecific differences in drought responses and to identify traits which predict species' drought response through soil desiccation experiments on potted saplings of eight dipterocarp species, which differ in their distributions and morphological characteristics.

We artificially dried the soil of pots by stopping irrigation in a growth chamber with controlled environments and monitored the changes in physiological and morphological traits related to drought survival (leaf photosynthesis and degree of wilting) to quantify the drought response of each species (Fig. 1). We found that, regardless of species, stomatal conductance decreased at the earliest stage of soil desiccation, followed by a decrease in electron transport rate. The decline in maximum quantum efficiency and leaf wilting occurred at approximately the same time under severely dehydrated soils (Table 1). There were interspecific differences in the response of stomatal conductance, electron transport rate, and wilting progression to soil desiccation (Table 1). These species' drought responses were significantly associated with leaf-level drought-avoidance capacity, such that species with drought-avoidant leaves can maintain photosynthetic metabolism and avoid wilting under strongly desiccated soils (Fig. 2).

Overall, leaf drought-avoidance capacity is a convenient indicator of drought response in potted saplings of dipterocarps species and can be used to efficiently search for species with high drought tolerance. However, it should be noted that the above results were obtained from young potted saplings under controlled temperature, humidity, and light conditions and need to be validated in plantations and mature trees, where these environmental conditions vary over time and space.

Authors: Kawai, K. [JIRCAS], Ng, K.K.S., Lee, S.L. [Forest Research Institute Malaysia (FRIM)]

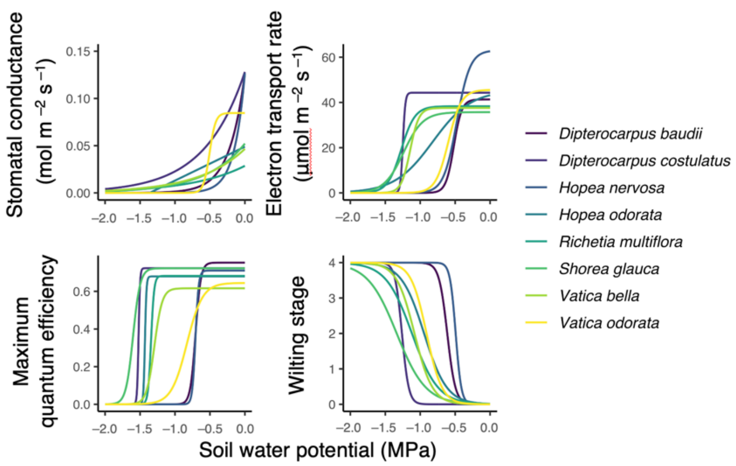

Fig. 1. Decline of photosynthesis and progression of wilting against soil desiccation

Higher absolute values in soil water potential indicate higher drought stress. Higher stomatal conductance and electron transport rate indicate higher photosynthetic rate. Lower maximum quantum efficiency indicates that more photosynthetic apparatus is damaged. Higher wilting stages indicate that wilting is more progressed. Different colors indicate different species.

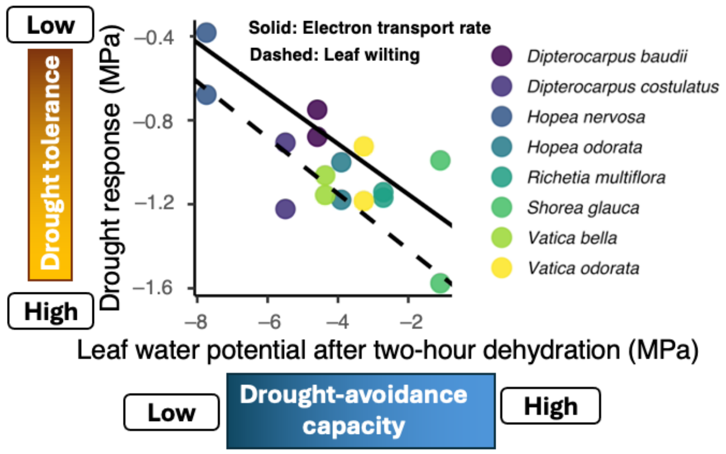

Fig. 2. Relationship between drought response and drought avoidance capacity at the leaf level

Higher absolute values in drought response show that changes against soil desiccation are small and indicate high drought tolerance. Lower absolute values in leaf water potential after two-hour dehydration indicate lower drought stress experienced under desiccating conditions and higher drought-avoidance capacity. Solid and dashed lines indicate trends of electron transport rate and leaf wilting, respectively.

Table 1. Responses of leaf photosynthetic paraments and wilting stage to soil desiccation

Species	Leaf characteristics			
	Stomatal conductance	Electron transport rate	Maximum quantum efficiency	Leaf wilting
Dipterocarpus baudii	−0.21[a]	−0.75[ab]	−0.95	−0.88[ab]
Dipterocarpus costulatus	−0.38[ab]	−0.91[ab]	−1.32	−1.22[ab]
Hopea nervosa	−0.22[ab]	−0.38[a]	−0.84	−0.68[a]
Hopea odorata	−0.67[ab]	−1.00[ab]	−1.34	−1.18[ab]
Richetia multiflora	−0.26[ab]	−1.14[b]	−1.34	−1.17[ab]
Shorea glauca	−0.25[ab]	−0.99[ab]	−1.54	−1.58[b]
Vatica bella	−0.37[ab]	−1.06[b]	−1.26	−1.16[ab]
Vatica odorata	−0.70[b]	−0.92[ab]	−1.04	−1.18[ab]
Average	−0.38[A]	−0.75[B]	−0.95[C]	−0.88[C]

Units: MPa. Higher absolute values show that changes against soil desiccation are small and indicate high drought tolerance. Differences in lowercase alphabets show significant differences among species, whereas differences in uppercase show differences among leaf characteristics (p < 0.05, Tukey test).

Reference: Kawai et al. (2025) *Kanto Shinrin Kenkyu* 76(1): 81–84.