BRIEF COMMUNICATION

Dipterocarpus obtusifolius exhibits enhanced photosynthetic capacity at high temperatures

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Abstract

Seedlings planted on degraded lands experience high leaf temperature in daytime because of the lack of vegetation shading. The effect of high temperature on the photosynthetic capacity was investigated in *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. and *D. chartaceus* Sym. seedlings planted on degraded sandy soils in southern Thailand. Neither species showed decrease in photosynthetic capacity at leaf temperature over 38 °C as compared to that at 28 °C. *D. obtusifolius* showed higher photosynthetic capacity at high temperatures. Enhanced photosynthetic capacity at high temperatures would be a key for high photosynthetic performance of *D. obtusifolius* planted on degraded sandy soils.

Additional key words: *Acacia*; electron transport; *Hopea*; leaf temperature; photon- and CO_2-saturated photosynthetic rate; RuBP regeneration.

As the importance of reforestation on degraded lands in tropical areas has been further recognized, demand for basic information on physiological characteristics of tropical tree species has been expanding. Photosynthetic performance at open sites is crucial for the survival and growth of seedlings planted on degraded lands where vegetation has considerably disappeared. At open sites, leaf temperature increases to over 35 °C (*e.g.* Königer *et al.* 1995, Clearwater *et al.* 1999, Leakey *et al.* 2003), which could adversely affect photosynthesis. At high temperatures, decrease in photosynthesis occurs through an increase in resistance to CO_2 diffusion from the ambient air to the carboxylation site, stomatal (*e.g.* Leakey *et al.* 2003) or mesophyll resistance (Bernacchi *et al.* 2002), and by reduced biochemical activity as well (Feller *et al.* 1998, Salvucci *et al.* 2001, Wise *et al.* 2004). We investigated the effects of high leaf temperatures on photosynthetic capacity of mature leaves of *Dipterocarpus obtusifolius* Teijsm. *ex* Miq. and *D. chartaceus* Sym. seedlings planted on degraded sandy soils in southern Thailand.

The study site (lat. 6°30'N, long. 101°44'E, 10 m a.s.l.) is located near Narathiwat, southern Thailand. The soil is thoroughly sandy and vegetation is generally sparse. A detailed site description was given in Norisada *et al.* (2005). Leaf temperature of seedlings planted at the open site was measured on a sunny day in March 2000 in a thermocouple-equipped leaf chamber of a portable gas exchange system (*Li-6400*; *Li-Cor*, Lincoln, NE, USA); the temperature inside the chamber was controlled to trace that of the ambient air. Leaf temperature was measured during the day on a mature leaf of each of five seedlings for *D. obtusifolius*, *D. chartaceus*, *Hopea odorata* Roxb., and *Acacia mangium* Willd. Air temperature, air vapour pressure deficit (VPD), and photosynthetic photon flux density (PPFD) were measured as well and the data were logged to a data logger (*CR10X*, *Campbell Scientific*, Logan, UT, USA). To assess photosynthetic capacity, net photosynthetic rate was measured in March 2001 under photon- and CO_2-saturated conditions on two to six mature leaves for *D. obtusifolius* and *D. chartaceus* with the portable gas exchange system at leaf temperatures of 28, 33, 38, and 40 (*D. obtusifolius*) or 41 (*D. chartaceus*) °C. Photosynthetic photon flux density (PPFD) was set at 1 000 μmol m^{-2} s^{-1} with an LED light source. CO_2 concentration within the leaf chamber was maintained at over 950 μmol mol^{-1} with a CO_2 injection system. Both the light source and the CO_2 injection system were part of the gas exchange system. Preliminary measurements showed that this setting fulfilled the photon- and CO_2-saturated condition. Temperature effects on photosynthetic capacities were analyzed with ANOVA, followed by Tukey HSD-test for unbalanced data (Spjotvoll/Stoline test).

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Leaf temperature increased in parallel with air temperature in the early morning, then rose above the air temperature as PPFD and VPD increased (Fig. 1). Leaf temperature reached 35 °C or above in the middle of the day (Fig. 1). At the study site, we observed a small but significant increase in air temperature at open sites as compared to that under an *A. mangium* canopy (Norisada *et al.* 2005). We found that the seedlings planted at open sites experienced considerably more increase in leaf temperature than was expected from the air temperature.

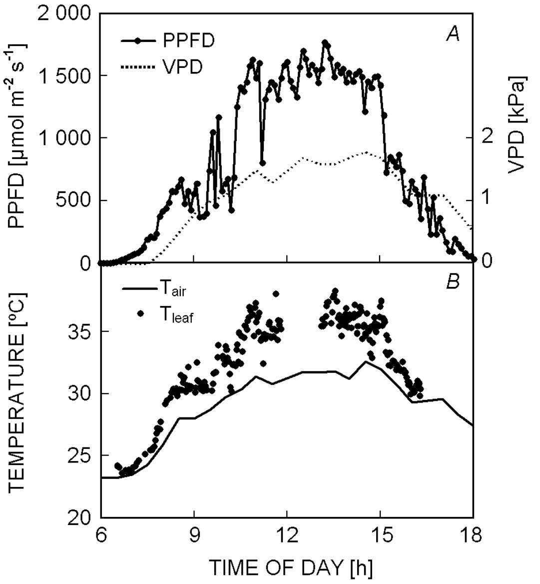

Fig. 1. Leaf temperature of seedlings planted on degraded sandy soil. (*A*) Photosynthetic photon flux density (PPFD) and air vapour pressure deficit (VPD) of air on the measurement day. (*B*) Leaf temperature (T_{leaf}) and air temperature (T_{air}) on the measurement day. Leaf temperature was measured on mature leaves of *D. chartaceus*, *D. obtusifolius*, *Hopea odorata*, and *Acacia mangium* seedlings.

Neither species showed any decrease in photosynthetic capacity at leaf temperatures above 30 °C as compared to that at 28 °C (Fig. 2). *D. chartaceus* showed no change in photosynthetic capacity at leaf temperatures ranging from 28 to 41 °C (Fig. 2). The photosynthetic capacity of *D. obtusifolius*, on the other hand, increased at higher temperatures (Fig. 2). Photosynthetic inhibition at high temperatures can be attributed to decreased CO_2 diffusion and/or reduced biochemical activity such as ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBPCO) activity or electron transport. Reduced biochemical activity at high temperatures has been reported in a range of species (*e.g.* Dreyer *et al.* 2001, Medlyn *et al.* 2002, Haldimann and Feller 2004). Feller *et al.* (1998) proposed the deactivation of RuBPCO as the primary constraint to photosynthesis and denied the involvement of electron transport inhibition in the reduced photosynthesis at moderately high temperatures. Salvucci *et al.* (2001) reported vulnerability of RuBPCO activase to high temperature, to which the deactivation of RuBPCO was attributed. Wise *et al.* (2004) demonstrated, however, that photosynthesis in field-grown Pima cotton (*Gossypium barbadense* L.) leaves is limited by ribulose-1,5-bisphosphate (RuBP) regeneration and not by RuBPCO activity. They proposed that the deactivation of RuBPCO could be an adaptive response to the reduced RuBP regeneration at high temperatures. We observed no reduction in photosynthetic capacity as seen in RuBP-regeneration-limited photosynthesis at high temperatures in either species in the present study (Fig. 2), suggesting that, in contrast to the work by Wise *et al.* (2004), a reduction in RuBP regeneration, reflecting decreased electron transport, does not occur in mature leaves of *D. chartaceus* and *D. obtusifolius* seedlings planted on degraded sandy soils over the range of leaf temperatures that the seedlings experience in the fields.

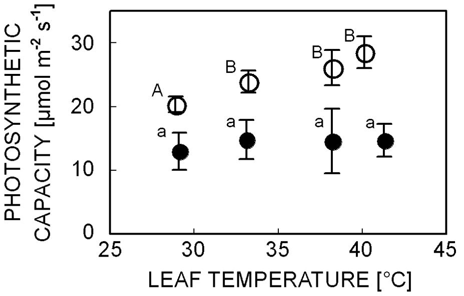

Fig. 2. Temperature effects on the photosynthetic capacity of mature leaves of *D. obtusifolius* (○) and *D. chartaceus* (●) seedlings planted on degraded sandy soil. *Error bars* denote standard deviations. *Data with the same letters* are not significantly different at p=0.05 (Spjotvoll/Stoline test).

The photosynthetic capacity of *D. obtusifolius* increased at higher leaf temperatures (Fig. 2). When planted at open sites on degraded sandy soils, this species showed a higher photon-saturated photosynthetic rate and a higher maximum quantum yield of photosystem 2 than other dipterocarp species for which these variables have been measured, including *D. chartaceus* (Norisada and Kojima 2005). Enhanced RuBP regeneration, *i.e.* electron transport rate, at higher temperatures could be a factor contributing to high photosynthetic performance in *D. obtusifolius* planted on degraded sandy soils.

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