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PHOTOSYNTHESIS IN MATURE TREES OF *HEVEA BRASILIENSIS* EXPERIENCING DROUGHT AND COLD STRESSES CONCOMITANT WITH HIGH LIGHT IN THE FIELD

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Hevea brasiliensis trees grown in two distinct agroclimatic regions (one experiencing drought and high temperature stress in summer and the other experiencing cold stress in winter, both concomitant with high PPFD) showed severe inhibition of photosynthesis during the unfavourable seasons. The degree of inhibition was so large at high light intensity that the upper canopy leaves of the stressed plants exposed to high PPFD fixed little carbon for most of the day. Photosynthesis rates were higher at lower PPFD, suggesting that the shaded leaves present inside the canopy were important in the overall carbon budget of the stressed plants.

Inhibition of photosynthesis due to high PPFD was also evident in the decreased quantum yield of CO_2 assimilation and *in vivo* PSII activity in the stressed leaves. Pot culture studies showed that the inhibition in PSII activity was higher in the drought and cold stressed leaves than in their respective control leaves as indicated by the reductions in the maximum potential quantum yield (measured as the ratio of variable to maximum chlorophyll fluorescence, Fv/Fm in the dark adapted state) and the effective quantum yield of PSII, (φ_{PSII}, measured at a PPFD of 500 µmol/m²/s). This corroborated the high PPFD-dependent inhibition of photosynthesis observed in mature *Hevea* trees experiencing drought and cold stresses in the field. The activities of several anti-oxidant enzymes such as superoxide dismutase, peroxidase, catalase, ascorbate peroxidase and concentrations of antioxidants like total glutathione in the leaves indicated possible oxidative stress in mature *Hevea* trees experiencing drought and cold temperature stresses concomitant with high PPFD in the field.

Key words: Cold stress, Chlorophyll fluorescence, Environmental stress, *Hevea brasiliensis*, Oxidative stress, Photoinhibition of photosynthesis, PSII, Quantum yield.

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INTRODUCTION

Environmental stresses such as drought, low or high temperature etc. inhibit the photosynthetic C metabolism both *via* the Calvin cycle and the photorespiratory pathway. Under such conditions, the photosynthetic photon flux density (PPFD) absorbed by the leaf is not fully utilized in metabolism and thus becomes excess causing over-excitation of the photosynthetic pigments (Osmond and Grace, 1995; Horton *et al.*, 1996). This aggravates the stress-induced damage to the photosynthetic apparatus resulting in photoinhibition of photosynthesis (Powles, 1984; Bongi and Long, 1987; Ogren and Rosenquist, 1992; Osmond, 1993; Long *et al.*, 1994). Reduction in the rate of CO_2 assimilation, A (Long *et al.* 1983; Powles *et al.* 1983; Powles, 1984; Stamp, 1987; Sassenrath and Ort, 1990) and quantum yield of photosynthesis, φ_c (Powles, 1984; Long *et al.*, 1987; Walker, 1989; Henley *et al.*, 1991) and damage to PSII (Aro *et al.*, 1993; Sundby *et al.*, 1993) are associated with photoinhibition of photosynthesis.

The high PPFD-dependent photoinhibition of photosynthesis can be temporary and reversible; but this becomes irreversible with prolonged exposure to high PPFD in plants experiencing abiotic stresses (Rees and Horton, 1990; Ogren, 1988; Long *et al.*, 1994; Horton *et al.*, 1996). While a moder-