PHYSIOLOGIA PLANTARUM 117: 476–491. 2003
Printed in Denmark – all rights reserved

ISSN 0031-9317

Dark chilling effects on soybean genotypes during vegetative development: parallel studies of CO_2 assimilation, chlorophyll *a* fluorescence kinetics O-J-I-P and nitrogen fixation

Philippus D. R. van Heerden[a], Merope Tsimilli-Michael[b,c], Gert H. J. Krüger[a,*] and Reto J. Strasser[b]

[a]*School for Environmental Sciences and Development: Section Botany, Potchefstroom University for CHE, Potchefstroom 2520, South Africa*
[b]*Laboratory of Bioenergetics, University of Geneva, CH-1254 Jussy, Switzerland*
[c]*Cyprus Ministry of Education and Culture, CY-1434 Nicosia, Cyprus*
**Corresponding author, e-mail: plbghjk@puknet.puk.ac.za*

Received 16 July 2002; revised 11 October 2002

The effects of dark chilling on CO_2 assimilation, chlorophyll *a* fluorescence kinetics and nitrogen fixation were compared in two *Glycine max* (L.) Merr. genotypes. The aim was to elucidate the mechanisms by which photosynthesis was inhibited as well as identification of selection criteria for dark chilling tolerance. Seedlings were dark chilled (8°C) for 9 consecutive nights but kept at normal day temperatures (28°C). CO_2 gas exchange analysis indicated that photosynthesis in Maple Arrow was inhibited largely as a result of stomatal limitation, while in Fiskeby V, it indicated inhibition of the mesophyll reactions. Increased intercellular CO_2 concentration and decreased carboxylation efficiency suggested loss of Rubisco activity in Fiskeby V, although no effect on the K_M (CO_2) of Rubisco was observed. Quantification and deconvolution of the Chl *a* fluorescence transients into several phenomenological and biophysical parameters (JIP-test) revealed large genotypic differences in the response of PSII to dark chilling. These parameters differentially changed in the two genotypes during the progression of the chilling treatment. Among them, the performance index, reflecting several responses of the photochemical apparatus, provided the best preliminary overall assessment of the genotypes. In contrast, the quantum yield of primary photochemistry φ_{Po} (F_V/F_M) was quite insensitive. The recovery of most of the JIP-test parameters in Maple Arrow after 6 and 9 nights of dark chilling was a major genotypic difference. Genotypic differences were also observed with regard to the ureide response and N_2 fixation appeared to be more sensitive to dark chilling than CO_2 assimilation. The JIP-test provided information consistent with results derived from CO_2 assimilation and N_2 fixation studies suggesting that it can substitute the much more time-consuming methods for the detection of chilling stress and can well satisfy the requirements of a rapid and accurate screening method.