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Ranking of dark chilling tolerance in soybean genotypes probed by the chlorophyll a fluorescence transient O-J-I-P

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Abstract

In the experiments reported in this paper, we demonstrate how the chlorophyll a fluorescence transient O-J-I-P can be utilised in screening for dark chilling tolerance in large numbers of soybean [*Glycine max* (L.) Merr.] genotypes. Thirty South African soybean genotypes of unknown chilling tolerance, and two foreign genotypes of well known, but contrasting chilling tolerance, were grown in growth chambers under rigorously controlled environmental conditions. Plants were dark chilled (6 °C) for seven consecutive nights but kept at normal day temperatures (26 °C). Root zone temperatures were kept at 20 °C to minimise the occurrence of chill-induced drought stress. Before the end of each night of dark chilling chlorophyll a fluorescence transients were recorded in fully dark-adapted attached leaves of control and dark chilled plants. The recorded chlorophyll a fluorescence transients were analysed by the so-called JIP-test that translates stress-induced alterations in these transients to changes in biophysical parameters quantifying the energy flow through photosystem II (PSII). The performance index (PI_{ABS}), a multi-parametric expression that combines the three main functional steps taking place in PSII (light energy absorption, excitation energy trapping, and conversion of excitation energy to electron transport), was used as measure of dark chilling tolerance. Large genotypic differences in the extent by which dark chilling affected the shape of the O-J-I-P fluorescence transients, and thus the PI_{ABS}, were observed. Elaboration of the PI_{ABS} resulted in the formulation of a novel parameter, the so-called chill factor index (CFI), capable of revealing large differences in dark chilling response among the genotypes. The CFI of the two reference genotypes, Maple Arrow (chilling tolerant) and Java 29 (chilling sensitive) correlated with their known difference in chilling tolerance. We used the CFI to rank the 30 genotypes according to dark chilling tolerance and identified five genotypes with comparable dark chilling response to Maple Arrow under experimental conditions that excluded low root temperatures.

Keywords: Chlorophyll a fluorescence; Chilling tolerance; Chill factor index; Dark chilling; JIP-test; Soybean