CNR SHORT TERM MOBILITY PROGRAM

REPORT

from Dr. Tsonko Tsonev

Title of the program: Photoinhibitory thresholds of light with different spectral composition
Place of visit: CNR - Istituto per la Protezione delle Piante, Via Madonna del Piano 10, Sesto Fiorentino 50019 Firenze
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The aim of the short-term mobility program was to analyse the photoinhibitory effects of light with different spectral quality on the photosynthetic apparatus of higher plants.

Dark and light adapted chlorophyll fluorescence parameters and photosynthetic activity were studied in 3-4-years-old potted poplar (*Populus x Canadensis*) plants. The degree of photoinhibition was determined via measurements of the chlorophyll fluorescence relaxation kinetics by using modulated Fluorescence Measuring System (FMS, Hansatech Instruments, UK). Prior to measurements, the plants were dark-incubated for at least 30 min to obtain the initial, dark-adapted level of fluorescence. After dark-incubation, the initial fluorescence level (F_0) was measured on intact leaf under a weak measuring beam, and subsequently the leaf was given a saturating white light pulse (0.8 s) to induce maximum fluorescence (F_m). Later, the same leaf was illuminated for 30 min with different wavelength regions of light (red, green or blue) provided by a high-efficient microprocessor-regulated RGB LED system (ENFIS Ltd, Swansea, UK). Five levels of photosynthetic photon flux density (PPFD) (400, 600, 800, 1000 and 1200 μmol m^{-2} s^{-1}) for each color were applied in 3 replications. Immediately after switching off the photoinhibitory light, the dark relaxation of fluorescence was registered by applying a train of saturating pulses (to measure F_m) every 1–2 min during 35 min of dark recovery. The values of maximal quantum efficiency of PSII (F_v/F_m) before the treatment (Control) and after dark relaxation period of leaves treated with photoinhibitory light with different wavelengths and intensities are shown on Fig. 1. A clear trend to decrease of F_v/F_m can be seen with increase of photoinhibitory PPFD. This decrease is more strongly expressed at blue light treated leaves while the effect of red and green light was very similar. The observed essential effect of green light despite its low absobtion from Chl is in support of the suggestion of Sarvikas et al. (2006) that photoinhibition, especially under blue or green light,

cannot be explained without assuming a strong contribution from a photoreceptor other than Chl. The authors consider Mn cluster in the oxygen evolving complex as another photoreceptor of photoinhibition.

The registered relaxation kinetics of Chl fluorescence in a dark period following high-light treatment revealed three distinct phases of recovery, in agreement with previous studies (Dodd et al. 1998, Scholes et al. 1997) and allowed us to differentiate photoinhibitory quenching from other non-photochemical Chl fluorescence-quenching processes. The photoinhibitory non-photochemical quenching (q_I) corresponding to the slow phase of relaxation kinetics (NPQs) was calculated according to Maxwell and Johnston (2000). The results are shown in Fig. 2. Exponential increase of photoinhibitory quenching with increase of PPFD was observed, with higher values at blue light than that at red and green light. The effects of the last two mentioned light bands were similar.

The effects of blue light (BL) on leaf photosynthetic CO_2 exchange was studied on *Populus x canadensis* by using a portable infrared gas analyzer system LI-6400 (LI-Cor, Lincoln, NE, USA). An optic fiber of the pulse-amplitude-modulated fluorimeter was mounted to the top of the cuvette at an angle of 45°. Leaves were first exposed to saturating PPFD of white light (WL), which was then progressively reduced to perform WL-response curves. Then, leaves acclimated to saturating WL were quickly exposed to equivalent BL levels to perform BL-response curves. BL did not significantly affect photosynthetic parameters in the light-limited portion of the PPFD-response curves. Whereas photosynthesis (A), stomatal conductance (g_s), and mesophyll conductance (g_m) were significantly decreased at high PPFDs of BL. The results show that the negative effect of BL on photosynthesis involves coordinate reductions in g_s and g_m. These results indicate that change in light spectral quality, which can vary during the day, among the day and within seasons, can alter photosynthesis depending on the PPFD intensity. Such effects can play a significant role in large-scale simulations of carbon fluxes.

References:

Dodd I.C., Critchley C., Woodall G.S., Stewartet G.R. (1998) J. Exp. Bot. 49(325): 1437–1445.

Maxwell K., Johnston (2000) J. Exp. Bot. 51(345): 659–668.

Sarvikas P., Hakala M., Pätsikkä E., Tyystjärvi T., Tyystjärvi E. (2006) Plant Cell Physiol., 47(3): 391–400.

Scholes J.D., Press M.C., Zipperlen S.W. (1997) Oecologia 109:41–48.

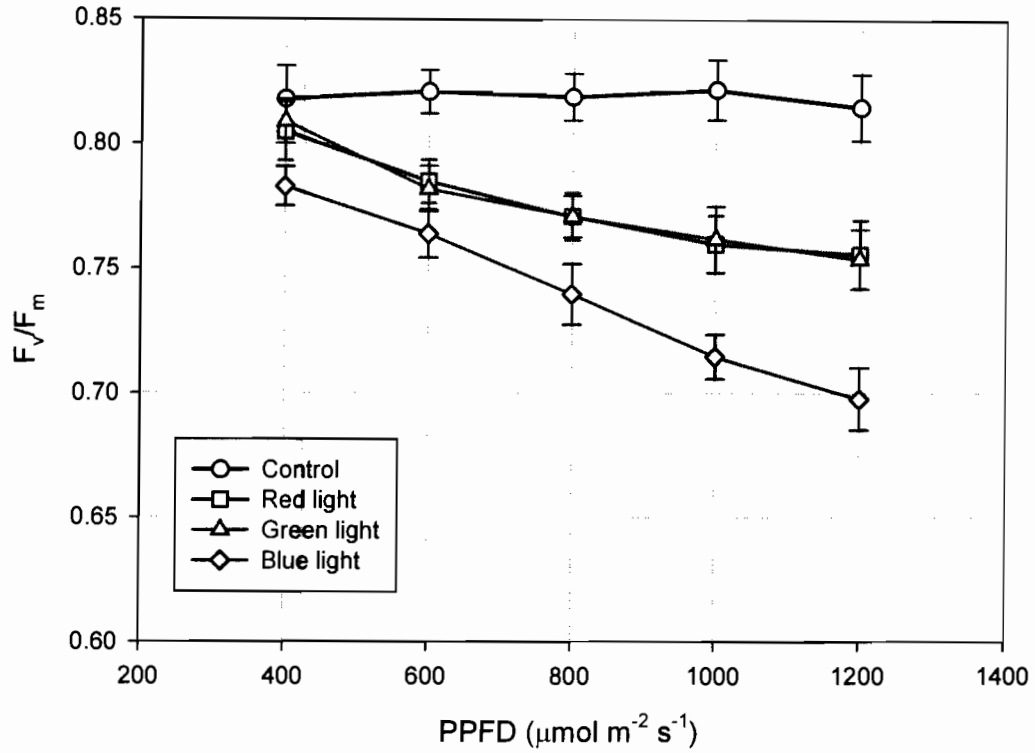

Fig. 1. Maximal quantum efficiency of PSII (F_v/F_m) before the treatment (Control) and after dark relaxation period of poplar leaves treated with photoinhibitory light with different wavelengths and intensities.

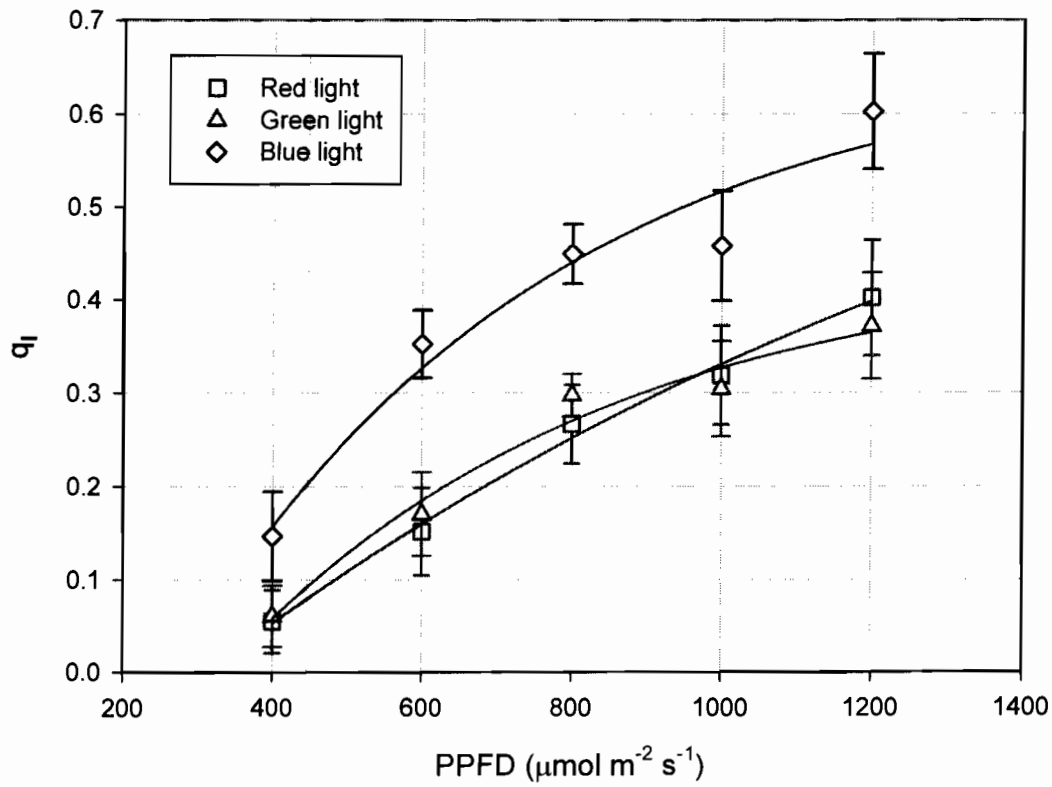

Fig. 2. Photoinhibitory non-photochemical quenching (q_I) in poplar leaves treated with photoinhibitory light with different wavelengths and intensities.

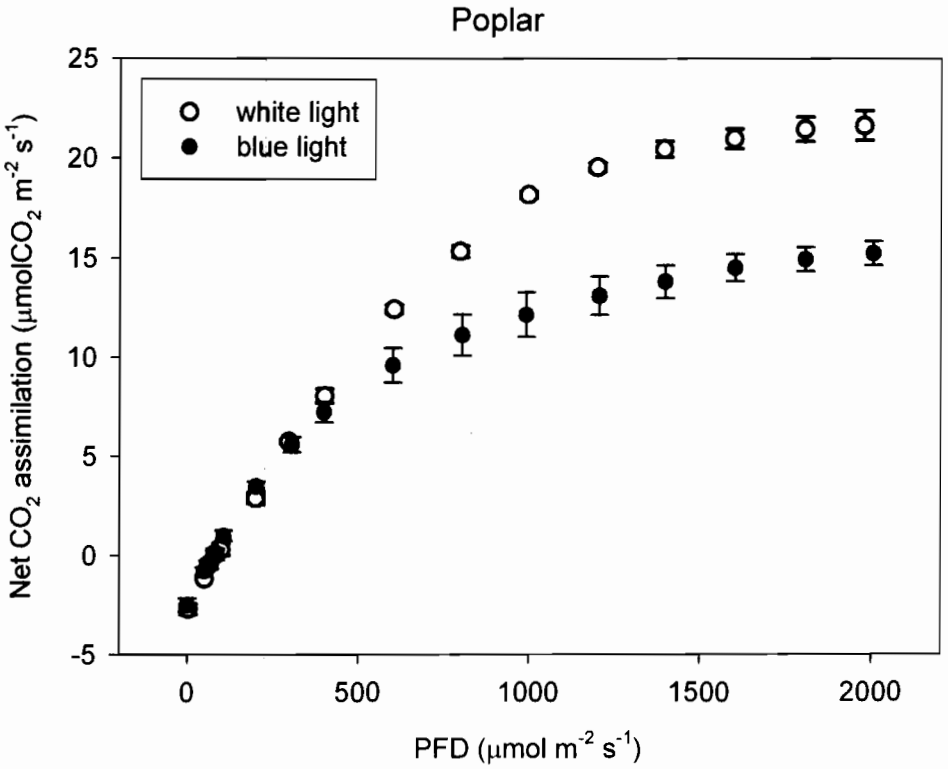

Fig. 3. Light response of net CO_2 assimilation measured under blue and white light.