

# Photosystem II/Photosystem I Ratios in Higher Plants



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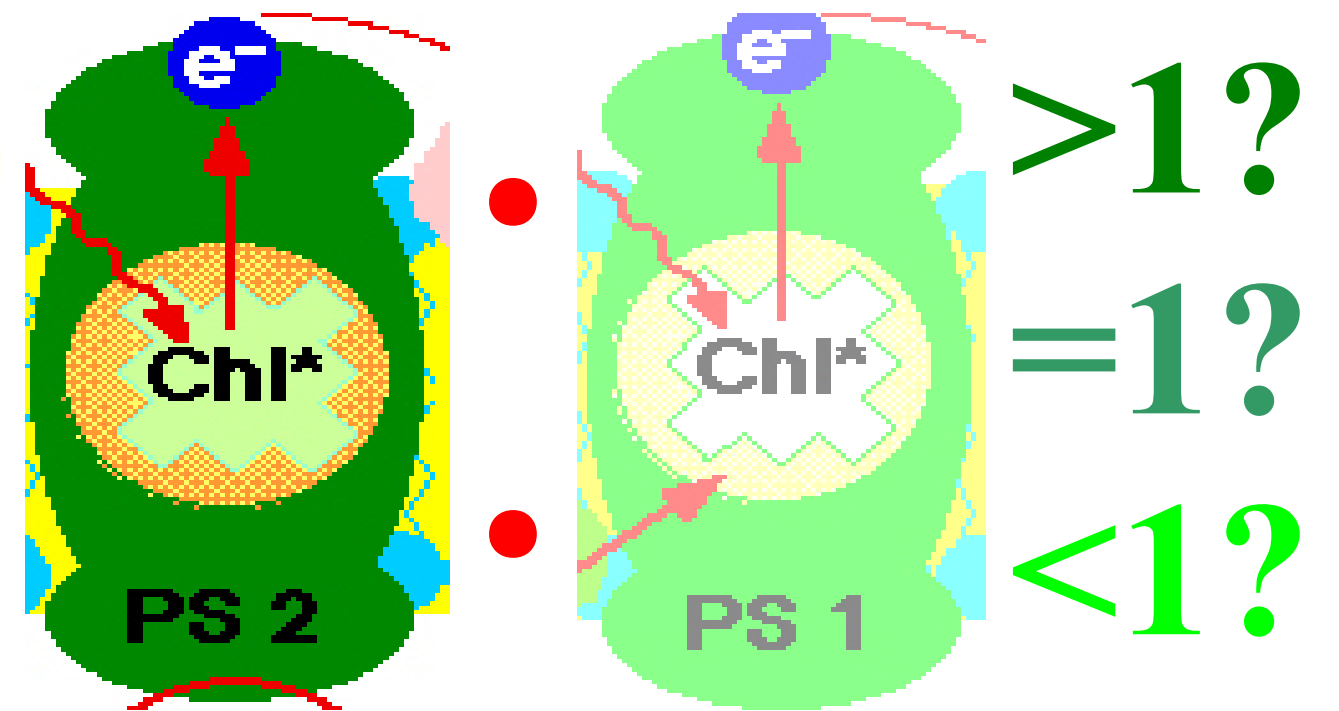
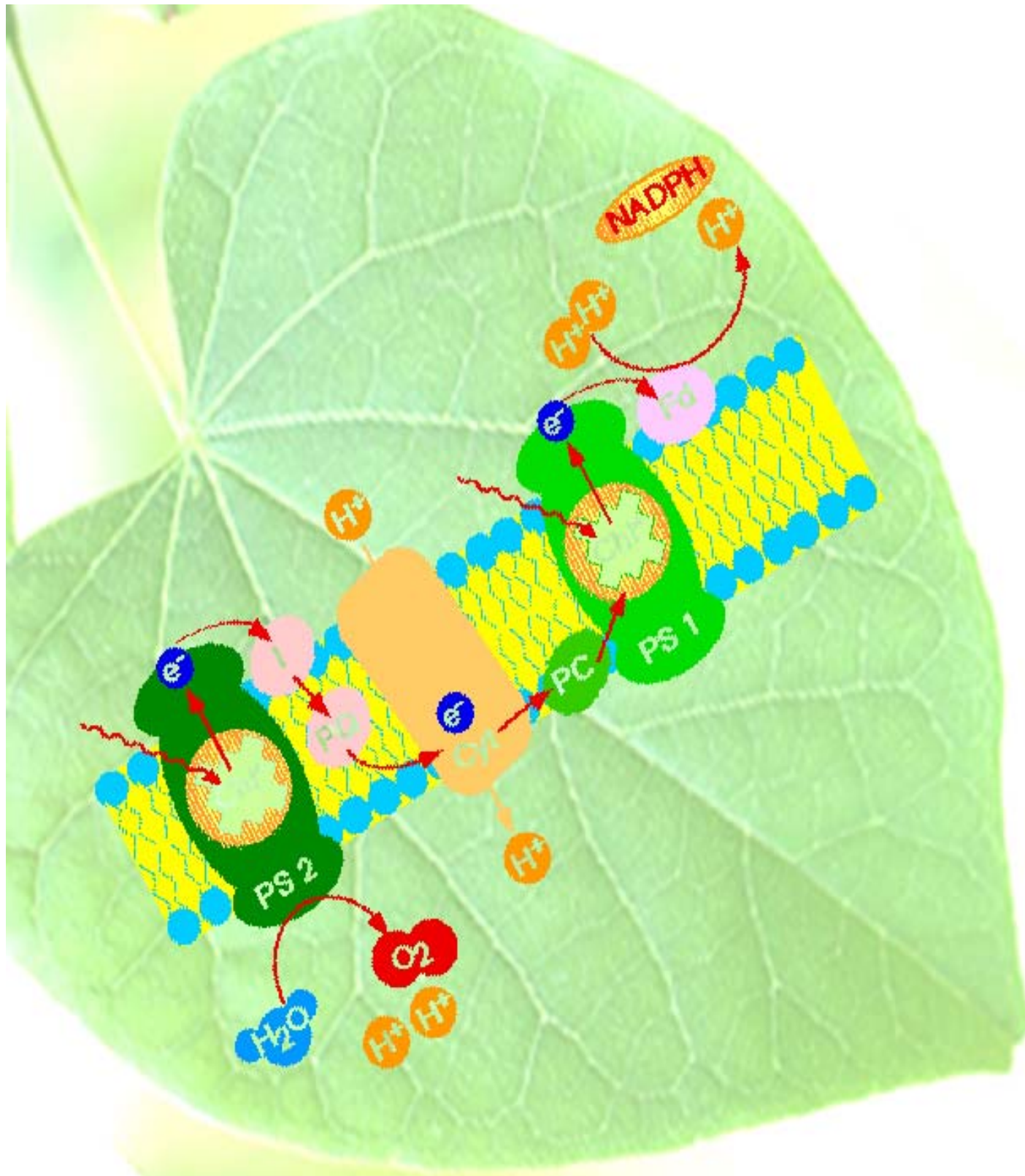
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# Introduction

**Aim:** Is there more, equal or less functional Photosystem II than Photosystem I in higher plants?

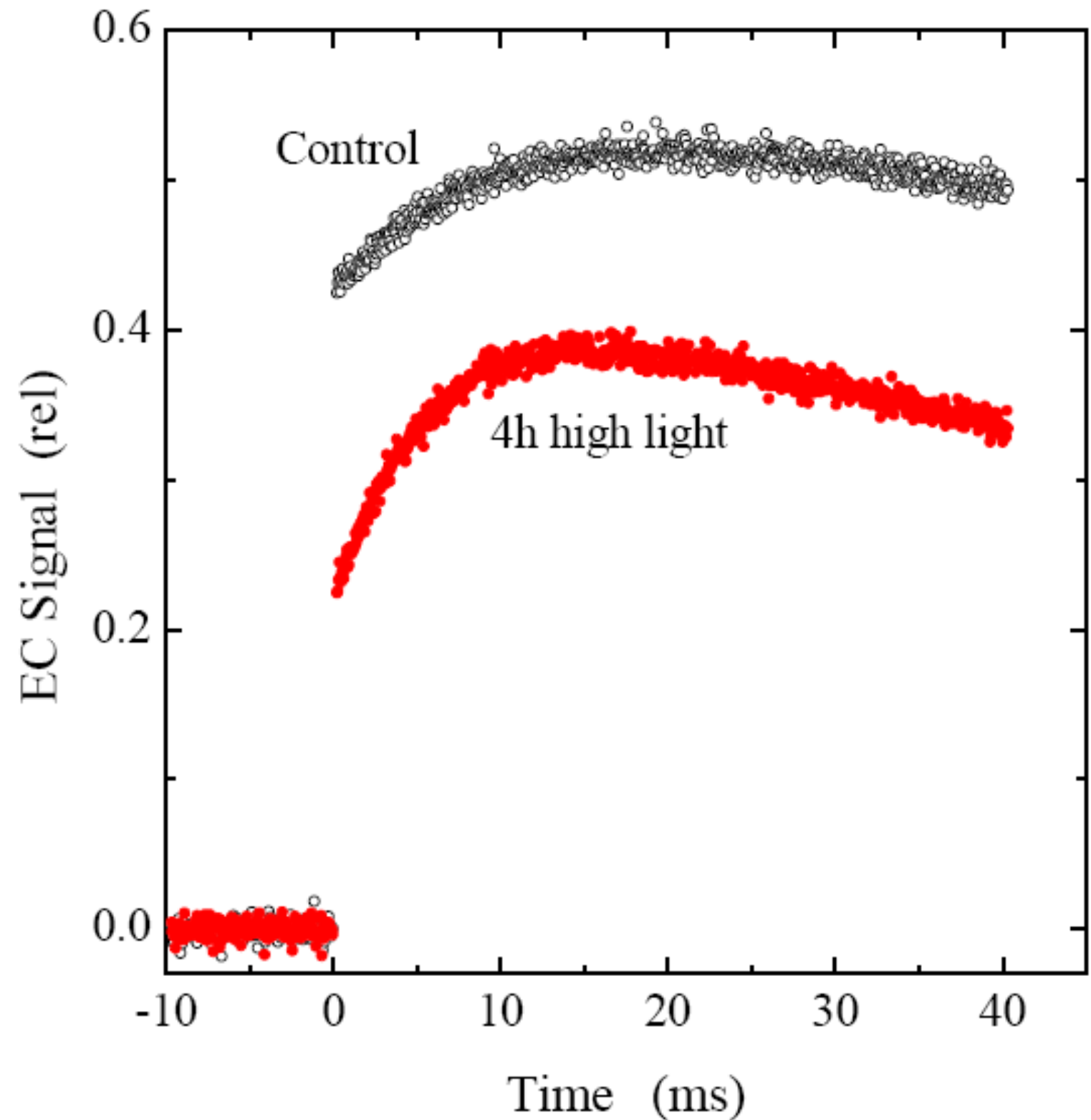


**Methods:** We used two novel methods of Electrochromic (EC) signals and Electron Paramagnetic Resonance (EPR) to directly quantify the two photosystems in one sample.

# Result (1)

- EC signal method used with varying proportions of PSII reaction centres by photoinactivation

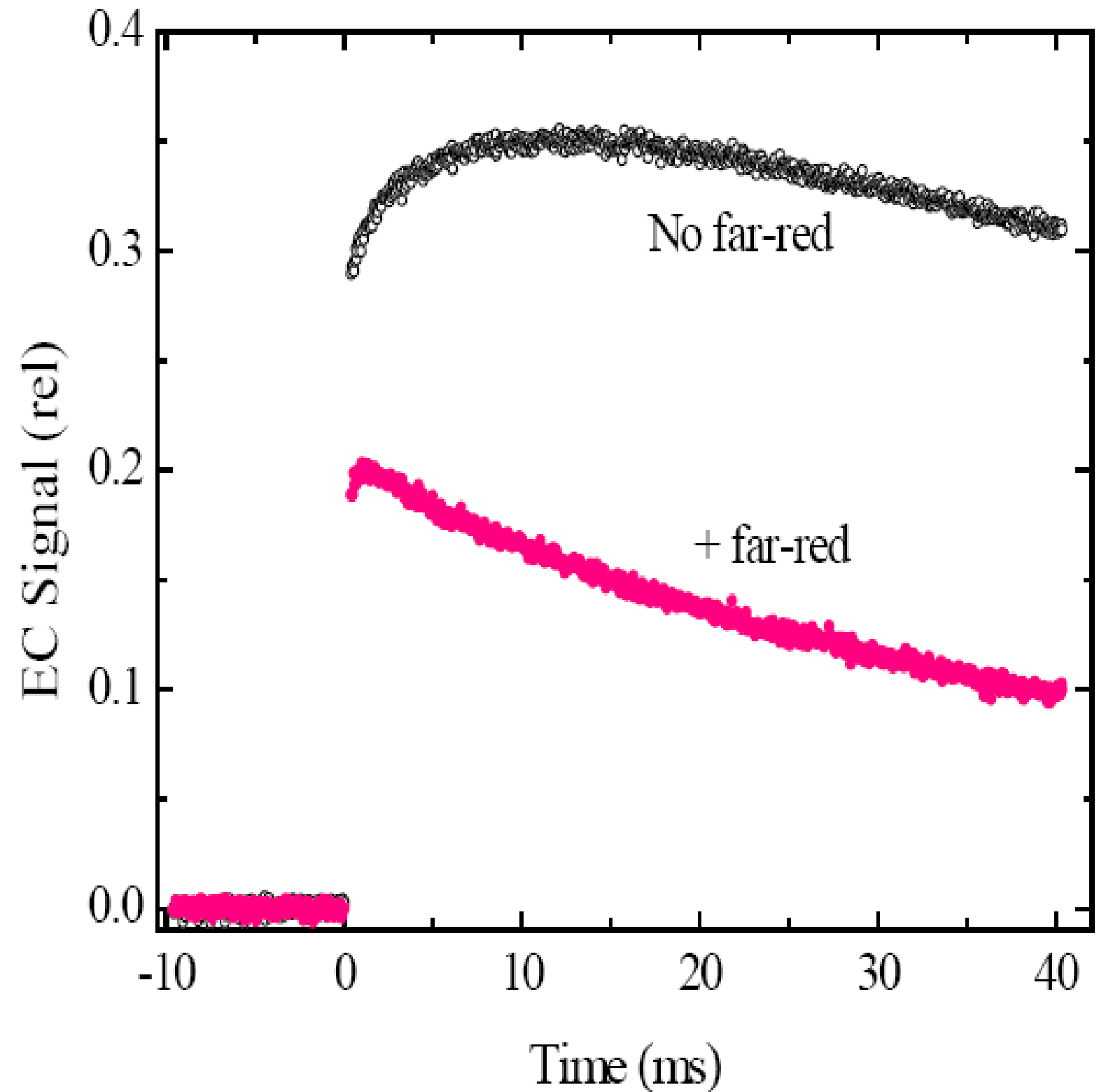
The electrochromic EC signal induced by a single-turnover xenon flash applied at time  $t = 0$  ms. Spinach leaf segments were used either without high light treatment (Control) or after 4h exposure to  $1200 \mu\text{mol photons m}^{-2} \text{s}^{-1}$  in the presence of lincomycin, which resulted in the photoinactivation of a large proportion of PSII.



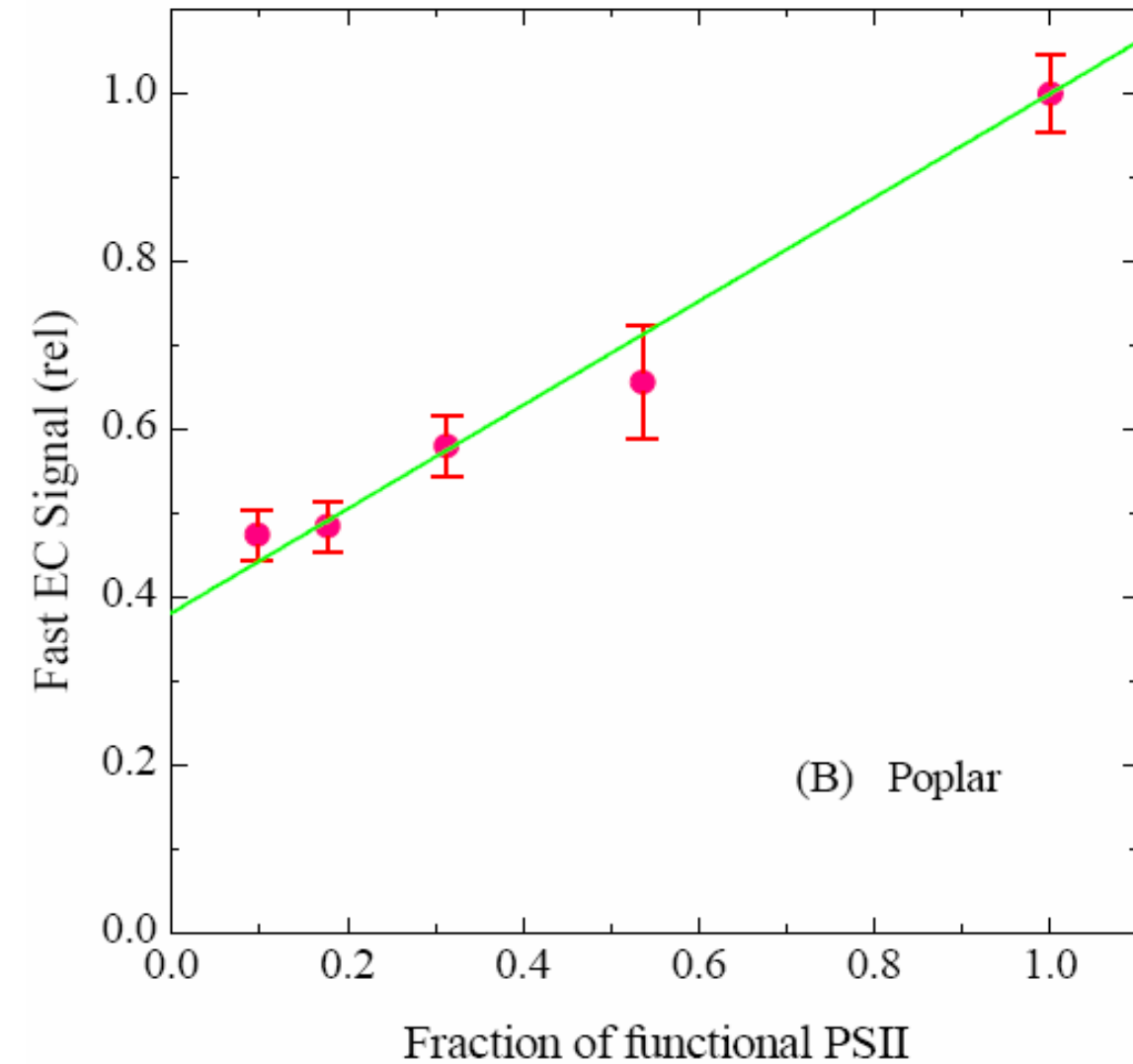
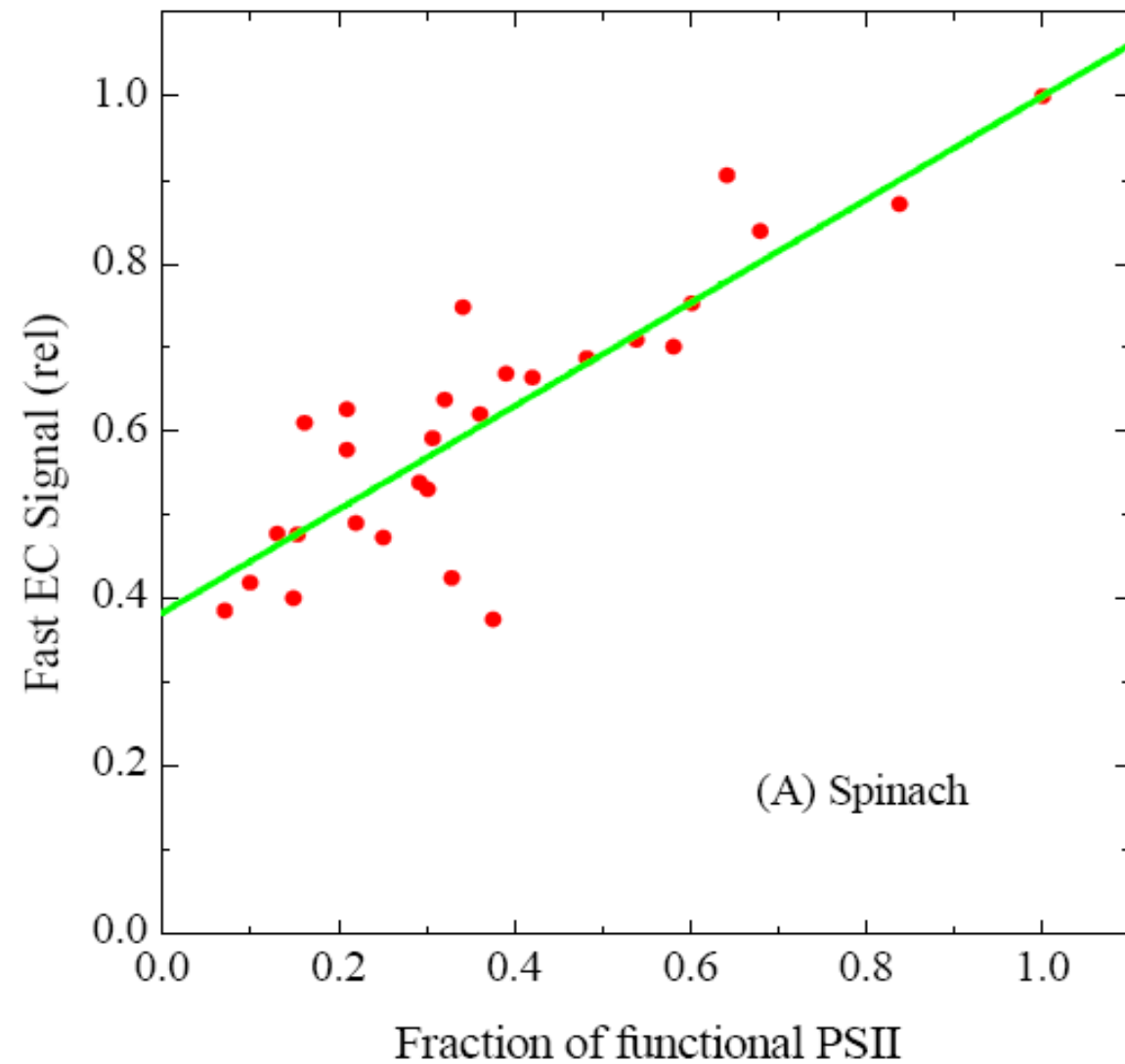
# Result (2)

- EC signal method used with suppression of PSI in the presence of continuous background far-red light

The amplitude of the fast rise in the EC signal, as varied by lowering the fraction of functional PSI by suppression of PSI activity with far-red light given to spinach leaf segments. Moderately strong far-red light was used to photo-oxidize a large proportion (~0.92) of P700.



# Result (3)



**The amplitude of the fast EC signal, as varied by lowering the fraction of functional PSII by a high-light pretreatment of market spinach (A) or fresh poplar (B) leaf segments. The duration of the high-light pretreatment was varied. The content of functional PSII was determined from the oxygen yield per single-turnover flash, and expressed on a Chl basis before being normalized to the control value. Regression lines were constrained to pass through the point (1,1) for the controls.**

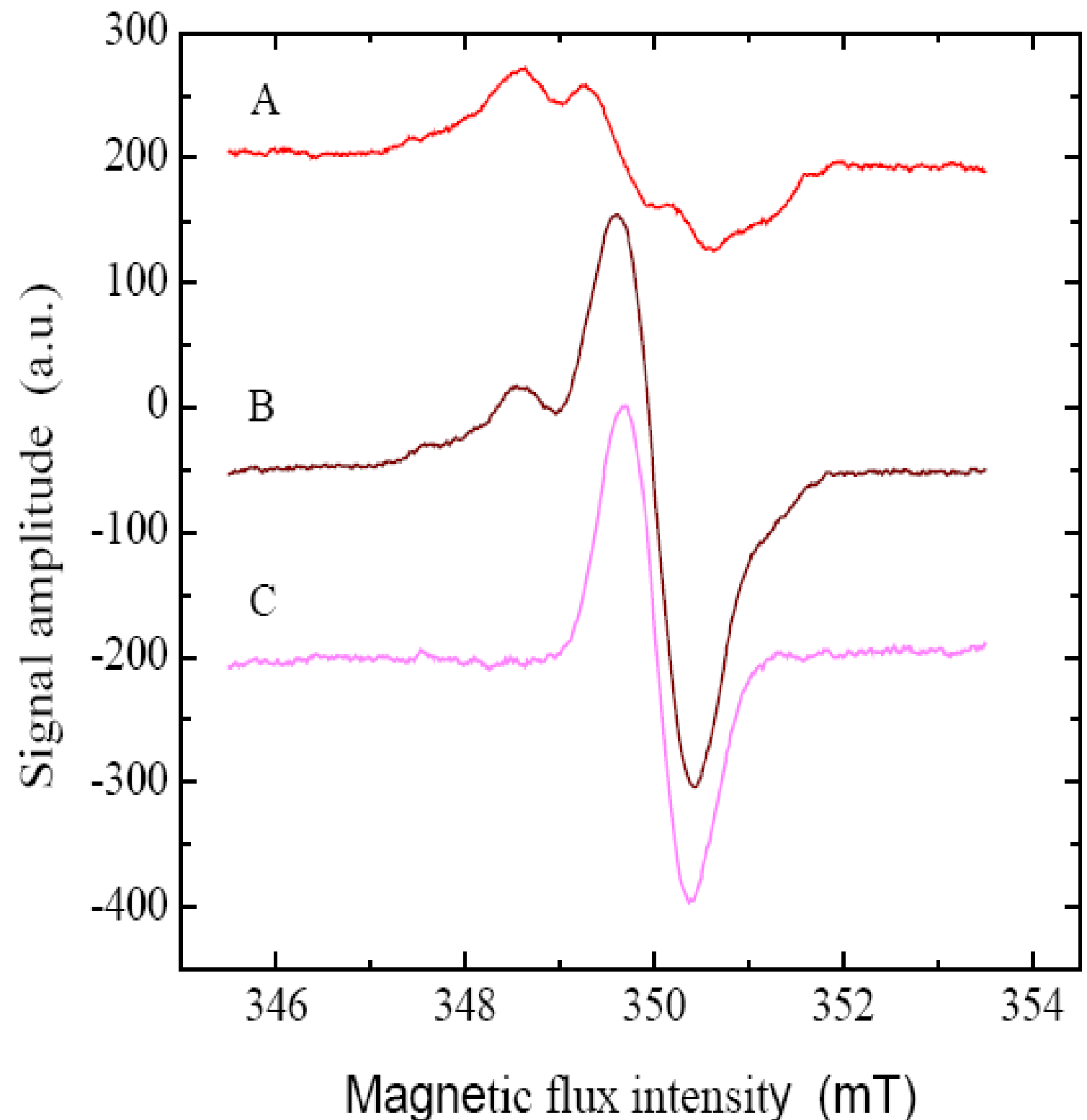
# Result (4)

● Spectra of EPR signals associated with  $Y_D^\bullet$  and  $P700^+$  used for stoichiometric determination of PSII and PSI: method of Danielsson et al (2004) *Biochim. Biophys. Acta* 1680: 53-61

**A** EPR signal recorded for  $Y_D^\bullet$  in PSII, with the amplitude optimised.

**B** EPR signal for  $P700^+$  in PSI, overlying the signal for  $Y_D^\bullet$ . The sample from (A) was subsequently treated with  $Fe(CN)_6^{3-}$  to maximise  $P700^+$  amplitude.

**C** Difference signal spectrum (B) *minus* (A) to isolate the  $P700^+$  signal.



# Result (5)

**Table 1. PSII and PSI stoichiometries, and contents of the two photosystems assayed by methods of EC signal and EPR\***

|   | Fresh spinach      | Market spinach     | Poplar             | Cucumber           | Tobacco            |
|---|--------------------|--------------------|--------------------|--------------------|--------------------|
| <b>PSII/PSI via photo-inactivation of PSII by EC signal</b>       |                    | <b>1.61</b>        | <b>1.62</b>        |                    | <b>1.50</b>        |
| <b>PSII/PSI via far-red light suppression of PSI by EC signal</b> | <b>1.81 ± 0.06</b> | <b>1.54 ± 0.12</b> | <b>1.72 ± 0.08</b> | <b>1.89 ± 0.16</b> |                    |
| <b>PSII/PSI via EPR</b>   | <b>2.12</b>        | <b>1.66</b>        |                    |                    |                    |
| <b>Functional PSII<br/>mmol (mol Chl)<sup>-1</sup></b>            | <b>2.80 ± 0.08</b> | <b>2.62 ± 0.13</b> |                    | <b>2.60 ± 0.10</b> | <b>2.78 ± 0.06</b> |
| <b>P700<br/>mmol (mol Chl)<sup>-1</sup></b>                       | <b>1.68 ± 0.04</b> | <b>1.79 ± 0.05</b> |                    | <b>1.55 ± 0.06</b> | <b>1.76</b>        |
| <b>Functional PSII/PSI</b>  | <b>1.67 ± 0.09</b> | <b>1.46 ± 0.11</b> |                    | <b>1.68 ± 0.11</b> | <b>1.58</b>        |

\* Fan et al (2007) Biochim. Biophys. Acta 1767: 1064-1072

# Conclusion:

- The stoichiometry of the two photosystems that we obtained by the EC methods is consistent with values determined by EPR and by functional PSII and PSI contents (Table 1). Our PSII/PSI ratios for spinach that ranged from 1.5-1.8: much higher than EPR measurements of Danielsson et al (2004) with a PSII/PSI ratio of 0.88.
- We suggest that the lower PSII/PSI ratio of Danielsson et al (2004) is not due to greater accuracy of their EPR measurements but rather to their spinach grown under markedly far-red-deficient illumination.

**We conclude that the PSII/PSI ratio in leaves is greater than unity, in typical higher plants.**

