Function and molecular organisation of photosystem II in vegetative buds and mature needles of Norway spruce during the dormancy

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Abstract: Two developmental stages of Norway spruce (vegetative buds and mature current-year needles) were compared regarding to function and molecular organisation of the photosystem II. The efficiency of PS II and the relative electron transport rate (rel. ETR) were investigated using the chlorophyll *a* fluorescence measurements. SDS-PAGE and Western blotting were used to analyse the expression of the light-harvesting complex of PS II (LHC II), cytochrome *b*-559 and the large subunit of Rubisco (LSU). The Fv/Fm values of 0.83 and 0.78 in mature needles and vegetative buds, respectively, indicated that fully functional photosystem II was present in both developmental stages. However, the light response curves revealed lower $\Delta F/Fm'$ and rel. ETR values in vegetative buds than in the needles. The differences were due to a lower photochemical quenching. Similar values for the nonphotochemical quenching coefficient (qN) in buds and needles suggested that chloroplasts of both developmental stages possess protecting mechanisms against excess irradiance. Molecular analysis showed that the levels of all three investigated proteins (LHC II, Cyt *b*-559 and LSU) were much lower in vegetative buds than in needles. This may account for the observed functional differences of chloroplasts in vegetative buds and mature needles.

Key words: *Picea abies*, cytochrome *b*-559, light-harvesting complex (LHC II), large subunit of Rubisco (LSU), needles, photosystem II, vegetative buds.

Introduction

Photosystem II (PS II) is located in the grana thylakoid membranes of chloroplasts and functions as a water-plastoquinone oxidoreductase (Barber et al., 1997). The building up of a functional PS II comprises the expression of both nuclear and chloroplast genes and availability of pigments (Plumley & Schmidt, 1995). While in angiosperms irradiance is the major environmental factor that controls the greening process (Wrischer et al., 1986), it is well known, for a long time, that gymnosperm plants have the capability of biogenesis of photosynthetically active plastids in complete darkness (Bogdanović, 1973; Bartlet & Dodge, 1980; Forreiter & Apel, 1993; Wrischer et al., 1998).

Vegetative buds of spruce trees are covered by protecting scales arranged in numerous rows (Romberger, 1966; Hejnowicz & Obarska, 1995) and most probably deprived from irradiance during the whole period of dormancy. Nevertheless, a certain amount of chlorophyll was detected in vegetative buds of spruce during this period (Lepeduš et al., 2001). The plastids inside vegetative buds were shown to have a poorly developed thylakoid system and quite large starch grains. Proliferation of vegetative buds in young shoots was characterised by a delay of the chlorophyll and carotenoid biosynthesis (Lepeduš et al., 2003) as well as a delayed development of the thylakoid system (Senser et al., 1975). A comprehensive characterisation of plastids in vegetative buds requires investigations on the function and molecular organisation of the photosynthetic apparatus in those plastids. The objective of the present study was to examine whether the plastids of vegetative buds acquire a functional PS II during the period of dormancy. For comparison, the function and molecular organisation of the PS II was analysed in fully developed mature needles.

Material and methods

Vegetative buds and current-year mature needles were harvested from a single Norway spruce (*Picea abies* L. Karst.) tree grown in the Botanical Garden at the University of Kiel, Germany. Sampling was done in November 2001. The branches bearing vegetative buds and current-year mature needles were harvested from the lower part of the tree. Buds were dissected from the branch and the protecting scales were removed. Green embryonic shoots were excised from the vegetative buds.