Effect of light intensity on pigments and main acyl lipids during 'natural' chloroplast development in wheat seedlings

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Abstract. The content and composition of pigments and acyl lipids (monogalactosyl diacylglycerol, digalactosyl diacylglycerol and phosphatidyl glycerol) have been investigated in developing chloroplasts isolated from successive 2-cm sections along the leaves of wheat seedlings grown either under 100, 30 or 3 W m⁻². In all examined stages of plastid development chlorophyll a/b and chlorophyll/carotenoid ratios were higher with increasing irradiance, whereas chlorophyll content expressed on fresh weight basis gradually decreased.

Concentrations of monogalactosyl diacylglycerol, digalactosyl diacylglycerol and phosphatidyl glycerol decreased per chlorophyll unit with increasing plastid maturity. The higher was the light intensity applied during plant growth, the higher were galactolipid and phosphatidyl glycerol contents in developing chloroplasts. During plastid development the percentage of α-linolenic acid markedly increased in total and individual acyl lipids. Under high light conditions, the accumulation of this fatty acid proceeded more rapidly. Significantly higher proportion of α-linolenic acid was found in acyl lipid fraction of chloroplasts differentiating in high light grown plants, than in those from plants exposed to lower light intensities. The differences in the double bond index may indicate higher fluidity of thylakoid membranes in sun-type chloroplasts.

Trans-3 α-hexadecenoic acid, virtually absent in the youngest plastids, was found in much higher concentration (per chlorophyll unit and as mol % of phosphatidyl glycerol fatty acids) in chloroplasts developing at high light conditions.

Introduction

During ontogenesis of many plant species an adaptation response to light intensity leads to formation of either shade- or sun-type chloroplasts [5, 22, 24, 43]. The lower photosynthetic capacity of the former is related to the differences in chloroplast ultrastructure and chemical composition of thylakoids, accompanied by corresponding changes in PS I and PS II activities [4, 5, 21–26, 38].

Abbreviations. MGDG, monogalactosyl diacylglycerol; DGDG, digalactosyl diacylglycerol; PG, phosphatidyl glycerol; PC, phosphatidyl choline; DBI, double bond index; PS I, photosystem I; PS II, photosystem II; PSU, photosynthetic unit; LHCP, light harvesting chlorophyll-protein complex.
There is increasing evidence that the efficiency of the photosynthetic light reactions is deeply influenced by the thylakoid membranes fluidity, which depends on its lipid composition [2, 31, 35, 42, 46]. Thylakoid membranes contain highly unsaturated galactolipids, which predominate in the lipid fraction, and a small portion of phospho- and sulfolipid [17, 30]. Although the synthesis of polyunsaturated fatty acids and lipids can take place in the dark [1, 29, 39, 41], it has been shown that light-induced plastid development markedly enhances their accumulation [11, 19, 20, 41]. In *Euglena gracilis* [7, 9] and germinating *Polytrichum commune* spores [18] the production of galactolipids at high light intensity was 50–60% of that at low light intensity, whereas phospholipid accumulation was much less affected [18]. The fatty acid pattern of the lipid fraction was also influenced by light intensity. A higher proportion of polyunsaturated fatty acids (18:3, 16:3, 16:4) was observed at higher light intensities [6, 7, 9, 18].

Relatively less information is available on the effect of light intensity on the chloroplast acyl lipids in higher plants. It has been shown [13, 14] that chloroplasts isolated from some shade and sun plant species differ in ultrastructure and lipid composition, especially with regard to PG molecules. The correlation between trans-3Δ-hexadecenoic acid level in PG of the examined chloroplasts and the differences in their ultrastructure lead to the conclusion that this fatty acid is involved in grana stacking [13, 14]. On the other hand, data clearly indicate that plant species markedly differ in the chloroplast lipid composition [17, 30].

Information on changes in acyl lipids during chloroplast development as influenced by light intensity is still lacking in regard to plant species that are able to adapt to the conditions of illumination. Therefore, the aim of the work presented below was to examine the changes in the main acyl lipids (MGDG, DGDG, PG) and pigments during plastid development under high, moderate and low intensity of white (artificial) light. We have chosen the leaf with basal intercalar meristem that was introduced by Leech and her coworkers [8, 19, 20] as a much more natural model for studying plastid development than greening of the previously etiolated leaf.

**Material and methods**

**Plant material**

As an experimental material the first leaves of 8-day old wheat seedlings (*Triticum aestivum* L. var. 'Kolibri') were used. The plants were grown in a semi-hydroponic culture in constant environment cabinet with 16 h light and 8 h darkness at 25 °C (day) or 20 °C (night). Halogen lamps LH-11-G 1000 W (made in ‘R. Lukensenburg’, Poland) were used as a light source. Light passed through 30-cm running-water filter. The seedlings were exposed to white light of the following intensities at the leaf level (PAR): 100 W·m⁻² (high light),