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Different regulation of fatty acid desaturation of the chloroplast membrane lipids in chilling-sensitive plants and chilling-resistant ones

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The sensitivity of plants to chilling is closely correlated with the degree of fatty acid unsaturation of their membrane lipids. Fatty acid desaturation of chloroplast membrane lipids is assumed to serve an important role in maintaining membrane fluidity during photosynthesis at low temperatures. We tried to investigate the regulation of low-temperature-induced desaturation of chloroplast membrane lipids with reference to the growth and photosynthesis of chilling-sensitive species and chilling-resistant ones. Plants of chilling-sensitive groups (Chinese cabbage, pea and barley) and of chilling-resistant ones (cucumber, squash and rice) were grown at 15°C in light at intensity of 150 (μmol quanta $m^{-2}s^{-1}$) with the photoperiod of 16 h. Then their growth and photosynthetic oxygen evolution were analyzed as well as the fatty acid compositions of the chloroplast membrane lipids. When the plants were grown under chilling, the growth of chilling-sensitive (CS) species was markedly retarded compared to chilling-resistant (CR) species, even though CR plants also showed a rather slow growth due to chilling. When the photosynthetic oxygen evolutions were measured, chilled CR plants showed quite a comparable profile of photosynthesis to non-chilled control CR plants, in contrast to the chilled CS plants that showed a marked decline in photosynthesis. When the chloroplast membrane lipids were analyzed from plants that had been grown with chilling at 15°C for a week, CR plants showed a marked enhancement of 18:3 ratios in MGDG, DGDG, PG, and SQDG. In particular, PG exhibited the largest chilling-induced increase in 18:3, and furthermore, its 16:0 versus 16:1 ratios were most prominently affected by chilling. In contrast to this, CS plants showed a very minor change in 18:3 ratios in those membrane lipids upon chilling. On the basis of these observations, we suggest that chilling-resistant plants possess higher capacity to desaturate their membrane phosphatidylglycerols (PG) during growth at low temperature, thereby enabling them to grow better under chilling condition.

Keywords: photosynthesis, chilling stress, chloroplast membranes, fatty acid unsaturation, phosphatidylglycerol