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Metabolic Changes during Reprogramming of Wheat and Triticale Microspores

Authors : Natalia Hordynska, Magdalena Szechynska-Hebda, Miroslaw Sobczak, Elzbieta Rozanska, Joanna Troczynska, Zofia Banaszak, Maria Wedzony

Abstract : Albinism is a common problem encountered in wheat and triticale breeding programs, which require in vitro culture steps e.g. generation of doubled haploids via androgenesis process. Genetic factor is a major determinant of albinism, however, environmental conditions such as temperature and media composition influence the frequency of albino plant formation. Cold incubation of wheat and triticale spikes induced a switch from gametophytic to sporophytic development. Further, androgenic structures formed from anthers of the genotypes susceptible to androgenesis or treated with cold stress, had a pool of structurally primitive plastids, with small starch granules or swollen thylakoids. High temperature was a factor inducing androgenesis of wheat and triticale, but at the same time, it was a factor favoring the formation of albino plants. In genotypes susceptible to albinism or after heat stress conditions, cells formed from anthers were vacuolated, and plastids were eliminated. Partial or complete loss of chlorophyll pigments and incomplete differentiation of chloroplast membranes result in formation of tissues or whole plant unable to perform photosynthesis. Indeed, susceptibility to the andro-genesis process was associated with an increase of total concentration of photosynthetic pigments in anthers, spikes and regenerated plants. The proper balance of the synthesis of various pigments, was the starting point for their proper incorporation into photosynthetic membranes. In contrast, genotypes resistant to the androgenesis process and those treated with heat, contained 100 times lower content of photosynthetic pigments. In particular, the synthesis of violaxanthin, zeaxanthin, lutein and chlorophyll b was limited. Furthermore, deregulation of starch and lipids synthesis, which led to the formation of very complex starch granules and an increased number of oleosomes, respectively, correlated with the reduction of the efficiency of androgenesis. The content of other sugars varied depending on the genotype and the type of stress. The highest content of various sugars was found for genotypes susceptible to andro-genesis, and highly reduced for genotypes resistant to androgenesis. The most important sugars seem to be glucose and fructose. They are involved in sugar sensing and signaling pathways, which affect the expression of various genes and regulate plant development. Sucrose, on the other hand, seems to have minor effect at each stage of the androgenesis. The sugar metabolism was related to metabolic activity of microspores. The genotypes susceptible to androgenesis process had much faster mitochondrium- and chloroplast-dependent energy conversion and higher heat production by tissues. Thus, the effectiveness of metabolic processes, their balance and the flexibility under the stress was a factor determining the direction of microspore development, and in the later stages of the androgenesis process, a factor supporting the induction of androgenic structures, chloroplast formation and the regeneration of green plants. The work was financed by Ministry of Agriculture and Rural Development within Program: ‘Biological Progress in Plant Production’, project no HOR.hn.802.15.2018.

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