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Improving the Efficiency of Wheat and Triticale Androgenesis: Ultrastructural and Transcriptomic Study

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Abstract : Chloroplasts, as essential organelles for photosynthesis, play a critical role in plant development. However, disturbances in the proper functioning of chloroplasts, in the extreme case manifesting as albinism of tissues and whole plants, are a phenomenon often occurring in conditions deviating from natural (e.g., in vitro cultures applied in breeding programs). Using whole-transcriptome analysis (RNA-Seq) together with light, fluorescent and electron microscopy, it was shown, that development of chloroplasts and formation of green or albino plants in the androgenesis process are genotype-dependent; however, they could be modulated by sub-optimal temperature treatment. The reprogramming of the microspore development from gametophytic to sporophytic, and then regeneration of green plant can be positively regulated by cold stress (4 ^{0}C). A high temperature stress (32 ^{0}C) can induce androgenesis, but it is a factor negatively influencing green plant regeneration (promoting albinism). A similar effect on microspores, androgenesis, and subsequent chloroplast formation, is elicited as a result of postponing the date of spike collection from spring to summer in field conditions (natural temperature rise). It is determined in both environmental or genotypic manner. The delay of the sowing date (environmental effect) or growing of late genotypes (genotypic effect) result in spike maturation at higher temperatures and significantly enhance albino plant formation in androgenesis process. Such a temperature system (4 ^{0}C vs. 32 ^{0}C) was used to study the chloroplast biogenesis process in wheat and triticale. It was shown, that efficiency of physiological processes differentiates microspore development during cold reprograming in genotypes susceptible and resistant to androgenesis. Moreover, a great variation in developmental stages of the microspores in one anther is observed for susceptible genotypes. Microspores that are more physiologically active under cold conditions can activate signaling pathways and processes, which provide an appropriate supply of metabolites to cell compartments. This, in turn, fully correlates with the genotype-dependent efficiency of chloroplast formation (or different types of plastid) at particular steps of androgenesis. The effect obtained after applying a high temperature stress is different. High temperature causes a significant acceleration of microspore development and less variation in developmental stages at the end of the treatment. Therefore, the developmental diversity of the microspores in one anther seems to be a critical factor for subsequent cell and chloroplast differentiation. 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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