Embryogenic callus induction in Carica papaya relies on dose-dependent response to 2,4-dichlorophenoxyacetic acid associated with differential protein regulation

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Somatic embryogenesis, a complex process driven by an intricate network of genes and proteins, presents a promising avenue for efficient plant micropropagation and genetic engineering. 2,4-Dichlorophenoxyacetic acid (2,4-D), a synthetic auxin widely employed in somatic embryogenesis protocols, remains underexplored from a proteomic perspective. This study utilized a high-resolution proteomic approach to elucidate the molecular mechanisms governing embryogenic callus induction in *C. papaya* in response to varying 2,4-D concentrations. Comparative proteomic profiling of explants exposed to 0, 0.2, 2, 20, and 200 µM 2,4-D identified 690 differentially expressed proteins. Proteins were classified into six different groups based on their accumulation profile. Functional enrichment analysis of these proteins indicated their involvement in embryogenesis, phosphorylation, epigenetic regulation, hormone responses, and post-translational modifications. Notably, 20 µM 2,4-D stimulated the accumulation of key auxin response proteins, such as CAND1 and SKP1A, emphasizing the pivotal role of this plant growth regulator in callus induction. Conversely, proteins linked to photosynthesis and starch storage were predominantly observed in the control group, suggesting metabolic reprogramming during embryo germination. The highest 2,4-D concentration (200 µM) was toxic and, inhibit callus induction. Protein-protein interaction network analysis revealed a complex interplay of molecular interactions triggered by 2,4-D, identifying novel targets for optimizing micropropagation and regeneration protocols in *C. papaya*. A profound understanding of the molecular mechanisms governing somatic embryogenesis in this fruit species is crucial for developing effective propagation and genetic improvement strategies.

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