Plant Synthetic Biology Platforms for the Production of Pharmaceutical Natural Products

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Climate change is increasingly affecting not only crop productivity but also the stable supply of high-value plant-derived pharmaceutical materials. Because many bioactive plant metabolites accumulate at low levels and are influenced by cultivation conditions, environmental stress, and seasonal variation, sustainable and controllable bio-production platforms are needed. In this seminar, I will introduce recent research at the National Institute of Agricultural Sciences, Rural Development Administration, on the production of pharmaceutical materials using plant synthetic biology. As representative examples, our studies established *Nicotiana benthamiana* as a plant-based platform for producing valuable flavonoids. First, we reconstructed and optimized the chrysoeriol biosynthetic pathway by simplifying the native pathway and selecting host-compatible enzyme combinations through a design-build-test-learn strategy. Using a multigene expression system, de novo chrysoeriol production was achieved in *N. benthamiana* leaves. Second, we reconstituted the diosmin biosynthetic pathway from phenylalanine to the final glycosylated product by organizing ten biosynthetic and tailoring genes into modular constructs, enabling diosmin production without external precursor feeding. These studies demonstrate the potential of plant synthetic biology as a sustainable strategy for producing structurally complex pharmaceutical compounds. Building on this platform, our current research is expanding toward new plant production systems and pathway reconstruction for anticancer pharmaceutical materials, contributing to a stable supply of medicinal and functional materials under increasing environmental uncertainty.