Title: From Plant Metabolic Engineering to Plant Synthetic Biology: the evolution of the design/build/test/learn cycle

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Highlights

- Historical overview of crop improvement
- Convergence of plant metabolic engineering and plant synthetic biology
- The design/build/test/learn cycle concept
- Overview of technical improvements in plant engineering
- Current and future challenges for crop improvement

ABSTRACT

Genetic improvement of crops started since the dawn of agriculture and has continuously evolved in parallel with emerging technological innovations. The use of genome engineering in crop improvement has already revolutionised modern agriculture in less than thirty years. Plant metabolic engineering is still at a development stage and faces several challenges, in particular with the time necessary to develop plant based solutions to bio-industrial demands. However the recent success of several metabolic engineering approaches applied to major crops are encouraging and the emerging field of plant synthetic biology offers new opportunities. Some pioneering studies have demonstrated that synthetic genetic circuits or orthogonal metabolic pathways can be introduced into plants to achieve a desired function. The combination of metabolic engineering and synthetic biology is expected to significantly accelerate crop improvement. A defining aspect of both fields is the design/build/test/learn cycle, or the use of iterative rounds of testing modifications to refine hypotheses and develop best solutions. Several technological and technical improvements are now available to make a better use of each design, build, test, and learn components of the cycle. All these advances should facilitate the rapid development of a wide variety of bio-products for a world in need of sustainable solutions.

Abbreviations

DNA, Deoxyribonucleic acid; ω3 LC-PUFA, omega-3 long-chain polyunsaturated fatty acids; TNT, trinitrotoluene; DBTL, design/build/test/learn; TAG, triacylglycerol; ZFN, zinc finger nuclease; TALEN, transcription activator-like effector nucleases; RNA, ribonucleic acid, CRISPR, clustered regularly interspaced short palindromic repeats; CAS, CRISPR associated.

Keywords