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Reprogramming plants using synthetic signaling systems

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Transcriptional programs sculpt plant morphology and metabolism to meet environmental challenges like droughts or pests. These same programs have been manipulated through selective breeding over generations to increase agricultural productivity and robustness. Studying the genetic basis of these improved traits has elucidated the specific alterations in the expression levels of key master regulator genes that lead to phenotypic improvement. However, breeding these traits into elite crop lines can be challenging for several reasons, including long timescales, linkage drag and hybrid incompatibility. This has limited the use of this information for forward engineering of crop lines. We have implemented a generalizable system for flexibly up or down regulating the expression of genes in a range of monocot and dicot plants. Our system, called ViparíNama (Sanskrit: to change), uses RNA scaffolds to assemble transcription factors at loci of interest to modulate gene expression. We are utilizing this system to reprogram the metabolism of maize and create lines with enhanced production of beta-carotene and the natural insecticide DIMBOA. We are also using this system to create semi-dwarfed varieties of tomato by reprogramming gibberellin-driven developmental pathways. This work showcases how synthetic signaling can rewire transcriptional programs in plants.