

Synthetic symbiosis: reprogramming microbes to boost plant productivity.

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Introduction

As global agriculture faces mounting pressures from climate change, soil degradation, and the need to feed a growing population, scientists are turning to nature's most ancient partnerships for solutions. One of the most promising frontiers in plant science is synthetic symbiosis the deliberate reprogramming of microbes to enhance plant productivity. By engineering microbial traits and interactions, researchers aim to create custom-designed symbiotic relationships that go beyond what nature offers, unlocking new pathways for sustainable crop improvement [1, 2].

Synthetic symbiosis refers to the intentional design or modification of microbial partners to establish or enhance beneficial interactions with plants. Unlike natural symbiosis, which evolves over millennia, synthetic symbiosis is built using tools from synthetic biology, genetic engineering, and systems biology to create tailored microbial functions [3, 4].

Nitrogen is a critical nutrient, but most crops cannot fix atmospheric nitrogen. Researchers are engineering bacteria like *Azotobacter* and *Klebsiella* to colonize non-legume roots and express nitrogenase genes, enabling nitrogen fixation in cereals like maize and wheat. Phosphorus is often locked in insoluble forms in soil. Engineered microbes can produce organic acids and enzymes like phytases to release bioavailable phosphorus, reducing fertilizer dependence [5, 6].

Microbes can be modified to produce osmoprotectants, antioxidants, and heat-shock proteins, helping plants withstand drought, salinity, and temperature extremes. Synthetic microbes can be programmed to secrete antimicrobial peptides,

lipopeptides, or volatile organic compounds that suppress pathogens like *Fusarium* and *Pythium*, reducing the need for chemical pesticides. Rather than relying on single strains, synthetic symbiosis often involves microbial consortia communities of engineered microbes that work synergistically [7, 8].

Successful synthetic symbiosis requires effective molecular communication between plants and microbes. Conversely, microbes can be programmed to produce synthetic signaling molecules that trigger plant responses, such as root elongation or immune priming. As synthetic biology matures, synthetic symbiosis will become a cornerstone of next-generation agriculture, offering sustainable solutions to global food and environmental challenges [9, 10].

Conclusion

Synthetic symbiosis represents a paradigm shift in plant-microbe interactions. By reprogramming microbes to perform targeted functions, scientists are creating novel partnerships that enhance plant productivity, resilience, and sustainability. While challenges remain, the integration of synthetic biology, systems thinking, and agricultural innovation promises to redefine how we grow food in the 21st century.

References

1. John DA, Babu GR. Lessons from the aftermaths of green revolution on food system and health. *Front Sustain Food Syst.* 2021;5:644559.
2. Wu K, Ali I, Xie H, et al. Impact of fertilization with reducing in nitrogen and phosphorous application on growth, yield and

- biomass accumulation of rice (*Oryza sativa* L.) under a dual cropping system. *PeerJ*. 2021;9:e11668.
3. Li S, Tian Y, Wu K, et al. Modulating plant growth–metabolism coordination for sustainable agriculture. *Nature*. 2018;560(7720):595-600.
 4. Spielmeier W, Ellis MH, Chandler PM. Semidwarf (sd-1), “green revolution” rice, contains a defective gibberellin 20-oxidase gene. *Proc Natl Acad Sci*. 2002;99(13):9043-8.
 5. Medina M, Kaplan D, Milbrandt EC, et al. Nitrogen-enriched discharges from a highly managed watershed intensify red tide (*Karenia brevis*) blooms in southwest Florida. *Sci Total Environ*. 2022;827:154149.