A novel strategy to engineer plant disease resistance without fitness costs

A new cyanobacterial-based method offers a resource-efficient and environmentally sound way to produce L-phenylalanine, moving away from agriculture-dependent raw materials like glucose.

Over $220 billion dollars of global crop production is lost to diseases each year. Plant diseases are controlled primarily through chemical and genetic methods. Unfortunately, chemical control is expensive and harmful to both human health and the environment. In contrast, genetic approaches offer a more sustainable option for management of plant diseases. Current genetic strategies often rely on introduction of resistance genes from various plant sources. These genes encode immune receptors that recognize specific pathogenic effectors to trigger immune responses. However, introgression of resistance genes is time-consuming as it frequently introduces undesirable traits which must be removed through multiple rounds of backcrossing. Additionally, this type of genetic resistance is often narrow-spectrum, effective only against pathogens with recognized effectors, and is not durable as it can be rendered ineffective by mutations of pathogen effector genes. Previous work has shown that plant autoimmune mutants due to autoactivation of immune receptors or loss of negative immune regulators have increased disease resistance but suffer from compromised fitness. In the plant model Arabidopsis thaliana, for example, loss of the callose synthase PMR4 confers strong resistance to both powdery mildew and downy mildew, two of the most widespread and devastating plant diseases. However, Arabidopsis pmr4 mutants also display severe growth defects. Researchers at Purdue University have developed a novel method to suppress fitness cost associated with the pmr4 autoimmunity while retaining high levels of disease resistance. This is achieved through targeted mutations of the genes involved in the biosynthesis of N-hydroxy-pipecolic acid (NHP). As both the PMR4 callose synthase and the NHP biosynthetic pathway are conserved across plant species, this technology can be applied to important crop plants for durable control of powdery and downy mildew.

Technology Validation:

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Category
Biotechnology & Life Sciences/Bioprocessing & Biomanufacturing
Agriculture, Nutrition, & AgTech/Crop Genetics & Breeding
Agriculture, Nutrition, & AgTech/Regenerative Ag & Soil Health
Biotechnology & Life Sciences/Synthetic Biology & Genetic Engineering

Authors
Zhixiang Chen

Further information
Raquel Peron
rperon@prf.org

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-Mutated genes and tested the effects on disease resistance and fitness of plants

Advantages

-Disease resistance strategy not dependent on recognition of pathogen effectors, so no longer susceptible to genetic mutations of pathogens

-No foreign DNA (transgene), so no or less strict regulatory processes for crop production

Applications

-The technology is applicable to other plants including important crop plants as there are homologs of the same PMR4 callose synthase and NHP biosynthetic genes across plant species

Related Publications

Fan B, Li Z, Jannasch A, Xiao S, Chen Z. N-hydroxypipecolic acid and salicylic acid play key roles in autoimmunity induced by loss of the callose synthase PMR4. Plant Physiol. 2025 Apr 30;198(1):kiaf163. doi: 10.1093/plphys/kiaf163. PMID: 40372133.

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