

Applications of Genetically Modified

Organisms (GMOs) in Agriculture

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(Structured notes for quick reference and study)

1. Overview

- **GMOs** = organisms whose DNA has been altered using recombinant DNA technology.
- In agriculture, the goal is to introduce traits that improve **productivity, sustainability, and resilience**.

2. Major Trait Categories

Trait	Purpose	Representative Genes / Examples	Key Benefits
Herbicide Tolerance	Allows crops to survive applied herbicides, simplifying weed control.	<i>EPSPS</i> (glyphosate-resistant), <i>PAT</i> (glufosinate-resistant)	Reduced tillage, lower labor & fuel costs, broader weed management options.
Insect Resistance	Protects plants from specific insect pests.	<i>cry</i> genes (Bt toxin from <i>Bacillus thuringiensis</i>), <i>Vip</i> genes	Decreased pesticide sprays, higher yields, lower environmental contamination.
Disease Resistance	Enhances defense against fungi, viruses, bacteria.	<i>R</i> genes (e.g., <i>RGA2</i> for Fusarium wilt), RNAi constructs targeting viral genomes	Lower crop loss, reduced fungicide use.
Drought & Salinity Tolerance	Improves performance under water stress or high salt soils.	<i>DREB</i> transcription factors, <i>NHX</i> antiporters, <i>cspB</i> (cold shock protein)	Expanded cultivable area, stable yields in marginal lands.
Nutritional Enhancement	Increases vitamin, mineral, or protein content.	<i>β-carotene</i> (Golden Rice), <i>ferritin</i> (iron-enhanced beans), <i>Bt-Cry</i> (protein boost)	Addresses micronutrient deficiencies, adds value for consumers.

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Yield & Quality Improvement	Directly boosts biomass, grain size, or processing traits.	<i>SAG12</i> (delayed senescence), <i>Bt</i> for reduced lodging, <i>GmSALT3</i> (soybean salt tolerance)	Higher marketable output, better post-harvest quality.
Stress-Responsive Metabolism	Alters metabolic pathways to produce desirable compounds (e.g., oil composition).	<i>FAD2</i> RNAi (high-oleic oil), <i>DGAT</i> overexpression (increased oil content)	Tailored oil profiles for food & industrial use.

3. Crop-Specific Applications

Crop	GMO Trait(s)	Commercial Examples
Soybean	Herbicide tolerance (glyphosate, glufosinate); insect resistance	Roundup Ready® Soy, LibertyLink® Soy
Corn (Maize)	Insect resistance (Bt), herbicide tolerance, drought tolerance	Bt corn (e.g., MON810), Herculex® I, DroughtGuard®
Cotton	Bt insect resistance, herbicide tolerance, fiber quality	Bollgard® II, Roundup Ready® Cotton
Canola (Rapeseed)	Herbicide tolerance, disease resistance	Roundup Ready® Canola, Clearfield®
Rice	Insect resistance, herbicide tolerance, vitamin A enrichment (Golden Rice)	IR64-Bt, Golden Rice (GR2E)
Potato	Late blight resistance, reduced bruising, reduced acrylamide formation	NewLeaf® (Bt), Innate™ potatoes
Papaya	Virus resistance (Papaya ringspot virus)	‘Rainbow’ and ‘SunUp’ papaya