# Will gene editing boost food production? The potential of a ‘revolutionary technology’

Genome-editing tools provide advanced biotechnological techniques that …. have been utilized in a wide variety of plant species to characterize gene functions and improve agricultural traits …. [W]e review novel breakthroughs that are extending the potential of genome-edited crops [and discuss] [fu]ture prospects for integrating this revolutionary technology with conventional and new-age crop breeding strategies.

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The risks involved in altering genomes through the use of genome-editing technology are significantly lower than those associated with GM crops because most edits alter only a few nucleotides, producing changes that are not unlike those found throughout naturally occurring populations.

Table 1: Crop traits that have been improved by genome-editing techniques

| Crop species | Gene editor | Target gene | DNA repair type | Target trait | |
|---|---|---|---|---|---|
| Maize | ZFNs | ZmTLP | HR | Trait stacking | [ |
| Maize | ZFNs | ZmIPK1 | HR | Herbicide tolerant and phytate reduced maize | [ |
| Rice | ZFNs | OsQQR | HR | Trait stacking | [ |
| Rice | TALENs | OsSWEET14 | NHEJ | Bacterial blight resistance | [ |

| Crop species | Gene editor | Target gene | DNA repairtype | Target trait |
|---|---|---|---|---|
| Sugarcane | TALENs | COMT | NHEJ | Improved cell wall composition |
| Sugarcane | TALENs | COMT | NHEJ | Improved saccharification efficiency |
| Soybean | TALENs | FAD2-1A, FAD2-1B | NHEJ | High oleic acid contents |
| Soybean | TALENs | FAD2-1A, FAD2-1B, FAD3A | NHEJ | High oleic, low linoleic contents |
| Potato | TALENs | VInv | NHEJ | Minimizing reducing sugars |
| Rice | TALENs | OsBADH2 | NHEJ | Fragrant rice |
| Maize | TALENs | ZmMTL | NHEJ | Induction of haploid plants |
| *Brassica oleracea* | TALENs | FRIGIDA | NHEJ | Flowering earlier |
| Tomato | TALENs | ANT1 | HR | Purple tomatoes with high anthocyanin |
| Rice | CRISPR/Cas9 | LAZY1 | NHEJ | Tiller-spreading |

| Crop species | Gene editor | Target gene | DNA repairtype | Target trait |
|---|---|---|---|---|
| Wheat | CRISPR/Cas9 | GW2 | NHEJ | Increased grain weight and protein content |
| *Camelina sativa* | CRISPR/Cas9 | FAD2 | NHEJ | Decreased polyunsaturated fatty acids |
| Rice | CRISPR/Cas9 | SBEIIb | NHEJ | High amylose content |
| Maize | CRISPR/Cas9 | Wx1 | NHEJ | High amylopectin content |
| Potato | CRISPR/Cas9 | Wx1 | NHEJ | High amylopectin content |
| Wheat | CRISPR/Cas9 | EDR1 | NHEJ | Powdery mildew resistance |
| Rice | CRISPR/Cas9 | OsERF922 | NHEJ | Enhanced rice blast resistance |
| Rice | CRISPR/Cas9 | OsSWEET13 | NHEJ | Bacterial blight resistance |
| Tomato | CRISPR/Cas9 | SlMLO1 | NHEJ | Powdery mildew resistance |
| Tomato | CRISPR/Cas9 | SlJAZ2 | NHEJ | Bacterial speck resistance |
| Grapefruit | CRISPR/Cas9 | CsLOB1 promoter | NHEJ | Alleviated citrus canker |
| Orange | CRISPR/Cas9 | CsLOB1 promoter | NHEJ | Citrus canker resistance |

| Crop species | Gene editor | Target gene | DNA repairtype | Target trait | |
|---|---|---|---|---|---|
| Grapefruit | CRISPR/Cas9 | CsLOB1 | NHEJ | Citrus canker resistance | [ |
| Cucumber | CRISPR/Cas9 | eIF4E | NHEJ | Virus resistance | [ |
| Mushroom | CRISPR/Cas9 | PPO | NHEJ | Anti-browning phenotype | [ |
| Tomato | CRISPR/Cas9 | SP5G | NHEJ | Earlier harvest time | [ |
| Tomato | CRISPR/Cas9 | SlAGL6 | NHEJ | Parthenocarpy | [ |
| Maize | CRISPR/Cas9 | TMS5 | NHEJ | Thermosensitive male-sterile | [ |
| Rice | CRISPR/Cas9 | OsMATL | NHEJ | Induction of haploid plants | [ |
| Tomato | CRISPR/Cas9 | SP, SP5G, CLV3, WUS, GGP1 | NHEJ | Tomato domestication | [ |
| Rice | CRISPR/Cas9 | ALS | HR | Herbicide resistance | [ |
| Rice | CRISPR/Cas9 | ALS | HR | Herbicide resistance | [ |
| Rice | CRISPR/Cas9 | EPSPS | NHEJ | Herbicide resistance | [ |
| Rice | CRISPR/Cas9 | ALS | HR | Herbicide resistance | [ |
| Soybean | CRISPR/Cas9 | ALS | HR | Herbicide resistance | |

| Crop species | Gene editor | Target gene | DNA repairtype | Target trait | |
|---|---|---|---|---|---|
| Maize | CRISPR/Cas9 | ALS | HR | Herbicide resistance | [ |
| Potato | CRISPR/Cas9 | ALS | HR | Herbicide resistance | [ |
| Flax | CRISPR/Cas9 | EPSPS | HR | Herbicide resistance | [ |
| Cassava | CRISPR/Cas9 | EPSPS | HR | Herbicide resistance | [ |

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*CRISPR* clustered regularly interspaced short palindromic repeats, *HR* homologous recombination, *NHEJ* non-homologous end joining, *TALEN* transcription activator-like effector nuclease, *ZFN* zinc-finger nuclease

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[T]he CRISPR/Cas -gene-editing] system is characterized by its simplicity, efficiency, and low cost, and by its ability to target multiple genes. Because of these characteristic features, CRISPR/Cas9 …. may be an effective solution to a variety of problems in plant breeding. To date, many crops such as rice, maize, wheat, soybean, barley, sorghum, potato, tomato, flax, rapeseed, *Camelina*, cotton, cucumber, lettuce, grapes, grapefruit, apple, oranges, and watermelon have been edited by this technique

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With the progress already made in the development of genome-editing tools and the development of new breakthroughs, genome editing promises to play a key role in speeding up crop breeding and in meeting the ever-increasing global demand for food. Moreover, the exigencies of climate change call for great flexibility and innovation in crop resilience and production systems. In addition, we must take into account government regulations and consumer acceptance around the use of these new breeding technologies.

**Read full, original article:** Applications and potential of genome editing in crop improvement