

The two crops that have had the most impact on human civilization and society are wheat and rice. The wild grasses that helped hunter-gatherers survive and settle into agriculture. Wheat and rice each provide 20% of the global calories and are now threatened by climate change and disease. Efforts are on to improve these crops to withstand the challenges and yield more, by using knowledge from wild relatives and technological interventions.

John Innes Centre in Norwich has been working on a project to make wheat more resistant to heat and drought by gene editing Zip4.5B gene whose main function is to allow wheat chromosomes to pair correctly and maintain yields but lacks the ability to block the creation of new variants with attributes from wild grasses. The edited plants will be evaluated in Iberia, Spain for heat and drought tolerance. Similar research is being done by University of Sheffield for developing salt and temperature tolerant GM rice. The Sheffield scientists found that reduction in size and number of rice stomata led to 60% lower water use by the plant, so that the crop can survive in less water or saltwater regions.

Rice is also being engineered for enhanced beta-carotene and zinc content. These nutritionally enhanced rice is being developed and grown in south Asia, a major rice consuming region will a higher vulnerable population. The importance of developing resilient crops and strengthening the food system has been recognized at United Nations Climate Change Conference. In food insecure nations like Haiti or South Sudan, only 10% of farmers have access to the latest seeds and planting material, leaving 90% of farmers exposed to climate change and disease. Even though innovative varieties of cereals, roots, and vegetables that can withstand severe weather and disease have been developed and are available elsewhere.

In this issue of Agri Innovation post we share multiple reports of wheat and rice improvement as well as nutritional enhancement of rice and other crops using new and available data. We hope you find the reading fruitful.



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## News from India and Around the World

### Three cheers for gene-editing – but we need GMO as well

<https://iea.org.uk/three-cheers-for-gene-editing-but-we-need-gmo-as-well/>

Precision breeding has already been used to engineer disease-resistant wheat, heart-healthy soy and tomatoes that boost vitamin-D levels. The technology has also helped immunise animals against deadly infections that cost farmers hundreds of millions of pounds every year. But this is just the beginning; there are hundreds of agricultural gene-editing applications in development that will benefit growers, consumers and the planet. Precision breeding tools will undeniably yield a plethora of benefits. But to unlock all the blessings of biotechnology, England should give its farmers access to GMO crops and animals as well.

### Gene-edited crops market growth spurred by regulatory progress and approvals

<https://www.en.krishakjagat.org/global-agriculture/gene-edited-crops-market-growth-spurred-by-regulatory-progress-and-approvals/>

Gene-editing (GE) is a set of novel techniques used to manipulate the genome of an organism at desired locations. It is being utilized extensively by the private and public sectors to develop new traits in crops of interest. There are currently more than 500 products are being developed worldwide using the technology and are at different stages of product development, ranging from basic research to advanced R&D and near-commercialization. Currently, the private sector contributes to 43% of the total product development, with 5% of the products at the pre-commercialization stage and 49% in the advanced research phase. The most active companies in the agricultural gene-editing space are Corteva Agriscience, Yield10 Bioscience, Benson Hill, Arcadia Biosciences, Calyxt and Inari Agriculture.

### Heat-tolerant wheat: How we can increase yields of this staple crop despite rising temperatures

<https://www.theguardian.com/environment/2023/jan/07/holy-grail-wheat-gene-discovery-could-feed-our-overheated-world>

It is the plant that changed humanity. Thanks to the cultivation of wheat, *Homo sapiens* was able to feed itself in ever-increasing numbers, transforming groups of hunter-gatherers struggling to survive in a hostile world into rulers of the planet. In the process, a species of wild grass that was once confined to a small part of the Middle East now covers vast stretches of the Earth. As the historian Yuval Noah Harari has observed: “In the great plains of North America, where not a single wheat stalk grew 10,000 years ago, you can today walk for hundreds upon hundreds of kilometres without encountering any other plant.”

### Public acceptance and stakeholder views of gene edited foods: a global overview

[https://www.cell.com/trends/biotechnology/fulltext/S0167-7799\(22\)00339-0#%20](https://www.cell.com/trends/biotechnology/fulltext/S0167-7799(22)00339-0#%20)

The increasing popularity of gene editing in plants has prompted research on stakeholder views. Gene edited foods are often more accepted than genetically modified foods, though differences occur within target groups, regions, and products. Nevertheless, marketing challenges related to a lack of familiarity with the technology, labeling, and risk perception remain.

### Nutrition improvement with Zinc-rich rice

<https://www.daily-sun.com/printversion/details/669219/Nutrition-Improvement-with-ZincRich-Rice->

Rice is the primary grain in Bangladesh and the country has achieved food self-sufficiency as a result of favorable agricultural policies and incentives provided by the government. Through the development of rice varieties that are enriched with vitamins and minerals, the government is working to improve nutrition for all citizens, particularly for the poor. The government fully supports agricultural research, allowing rice scientists to develop rice varieties that are rich in vitamins and minerals. To celebrate the Golden Jubilee of Bangladesh's Independence and to mark the Mujib Centenary, scientists at the Bangladesh Rice Research Institute have released a high-grade zinc-enriched variety, namely, BRRI-100 variety. With this new variety, there are now six varieties of rice that are zinc-rich.

### Food and Industry 5.0: Modernisation of facilities and closing the digital divide needed for food security benefits

Information and communication technologies (ICTs) from Industry 5.0 have significant

potential to improve food security and mitigate the vulnerability of the food system, providing that production processes can be modified and the digital divide between countries closed, say experts.

### **Can Science Finally Create a Decent Cup of Decaf?**

[https://slate.com/technology/2023/01/decaf-coffee-genetic-engineering.html?utm\\_source=Nature+Briefing&utm\\_campaign=0e9793851a-briefing-dy-20230119&utm\\_medium=email&utm\\_term=0\\_c9dfd39373-0e9793851a-43919645](https://slate.com/technology/2023/01/decaf-coffee-genetic-engineering.html?utm_source=Nature+Briefing&utm_campaign=0e9793851a-briefing-dy-20230119&utm_medium=email&utm_term=0_c9dfd39373-0e9793851a-43919645)

Who cares about decaf coffee? I do. I'm a slow caffeine metabolizer, like many millions of others. We folks with a particular type of CYP1A2 gene may adore a perfectly pressed single-origin *Arabica* but cannot drink a fully caffeinated cup without the caffeine accumulating too quickly, making our hearts beat like bass drums and our brains feel momentarily vaporized. At parties, we leave half cups of cold coffee to be tossed into the sink. At coffee shops, we pronounce, "half-caff or decaf" like our day depends on it (because it does). Baristas wince at the thought of heavily stripped decaf grounds grazing their precious portafilter. Many of us give up and drink tea. Pregnant women know our pain. But now there's a chance for us, the metabolically mismatched. A whole new kind of coffee may be on the horizon.

### **What Are Purple Tomatoes and Are They Healthy?**

<https://www.eatingwell.com/article/8019221/purple-tomatoes/>

There was groundbreaking news in the produce world in the fall of 2022. If you missed it, the **USDA** approved the sale of a purple tomato that boasts more nutrients than traditional red ones. On the surface, this may seem like a win-win for health and adding color to dishes. However, bringing these purple fruits to market isn't without controversy. This is because they were created using genetic engineering, also known as genetic modification—an area of concern among many health-conscious consumers.

### **Cautious China approves GMO alfalfa import after decade-long wait**

[https://ca.finance.yahoo.com/news/china-approves-import-bayers-gmo-123109946.html?utm\\_source=substack&utm\\_medium=email&guccounter=1](https://ca.finance.yahoo.com/news/china-approves-import-bayers-gmo-123109946.html?utm_source=substack&utm_medium=email&guccounter=1)

China approved imports of eight genetically modified (GM) crops, permitting shipments of GM alfalfa for the first time after a decade-long wait, the country's agriculture ministry said on Friday. Global seed makers and the U.S. government welcomed the decision after Beijing's slow approval process disrupted grain exports and launches of crops that need clearance from China because it is one of the world's biggest agriculture markets.

### **Regulating the Regulator of Plant Growth Regulators**

<https://www.cato.org/regulation/winter-2022-2023/regulating-regulator-plant-growth-regulators>

As the world confronts population challenges, limited resources, environmental pressures, climate change, and market competition, advances in agriculture will be essential. They will likely include increased plant productivity as well as more nutritious foods and other new products. However, some of the very valuable improvements now possible using innovative and cost-beneficial molecular technology such as gene-editing are being stifled by burdensome and costly regulation from the Environmental Protection Agency. Federal regulation / An example is the EPA regulation of a "plant regulator," which is any agricultural input applied to plants to alter how quickly or large they grow, their maturity, and other desirable characteristics. The Nematocide, Plant Regulator, Defoliant, and Desiccant Amendment of 1959 added these substances to the categories of pesticides regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The law was intended to ensure that chemicals are not "adulterated." It sets tolerances for their use when applied to the exterior of plants, and it includes requirements on the labeling of the contents and directions. A legislative fix to exclude gene-edited PGRs from the EPA's definition of "plant regulator" that follows the Panetta-Baird proposal to exclude biostimulants from the "plant regulator" definition would remove a troublesome barrier to innovation in plant agriculture. It is encouraging that lawmakers are moving to reinvigorate the role of Congress to rein in regulatory agencies and claw back costly and excessive regulation.

### **CRISPR technology: A decade of genome editing is only the beginning**

<https://www.science.org/doi/10.1126/science.add8643>

In the decade since the publication of CRISPR-Cas9 as a genome-editing technology, the CRISPR toolbox and its applications have profoundly changed basic and applied biological research. Wang and Doudna now review the origins and utility of CRISPR-based genome

editing, the successes and current limitations of the technology, and where innovation and engineering are needed. The authors describe important advances in the development of CRISPR genome-editing technology and make predictions about where the field is headed. They also highlight specific examples in medicine and agriculture that show how CRISPR is already affecting society, with exciting opportunities for the future.

#### **EFSA Publishes Criteria for Risk Assessment of Plants Produced by Targeted Mutagenesis, Cisgenesis, and Intragenesis**

<https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=19950>

The European Food Safety Authority (EFSA) has published the criteria for risk assessment of plants produced by targeted mutagenesis, cisgenesis, and intragenesis. The statement is published in the *EFSA Journal*. On April 28, 2022, the European Commission requested EFSA, in accordance with Article 31 of Regulation (EC) No 178/2002, to develop a statement on possible criteria for risk assessment of plants produced by targeted mutagenesis, cisgenesis, and intragenesis. The statement was requested as advice for consideration by the European Commission to support the ongoing policy initiative on plants produced by targeted mutagenesis and cisgenesis.

#### **A GM solution to help address climate change: Genetic tweak tailors rice to survive increasing salt and temperature levels**

[https://geneticliteracyproject.org/2023/01/23/a-gm-solution-to-help-address-climate-change-genetic-tweak-tailors-rice-to-survive-increasing-salt-and-temperature-levels/?mc\\_cid=d7489134c2&mc\\_eid=b993433273](https://geneticliteracyproject.org/2023/01/23/a-gm-solution-to-help-address-climate-change-genetic-tweak-tailors-rice-to-survive-increasing-salt-and-temperature-levels/?mc_cid=d7489134c2&mc_eid=b993433273)

Genetically engineering rice to have better salt tolerance could allow it to be grown in places it would otherwise fail, new research from the University of Sheffield has found. As sea levels rise as a result of climate change, more and more places around the world are struggling with seawater inundation — where salt water from the sea is flooding further inland and destroying crops which can't cope with the increased salinity. Rice is one of the worst affected crops — the most important carbohydrate on earth, it is relied on by 3.5 billion people every day, but in countries like Vietnam it is becoming harder and harder to grow due to increasing seawater interference.

#### **67 tons: Harvest of first commercial-quality GMO beta carotene-enriched Golden Rice nears completion in Philippines**

[https://geneticliteracyproject.org/2023/01/18/67-tons-harvest-of-first-commercial-quality-gmo-beta-carotene-enriched-golden-rice-nears-completion-in-philippines/?mc\\_cid=d7489134c2&mc\\_eid=b993433273](https://geneticliteracyproject.org/2023/01/18/67-tons-harvest-of-first-commercial-quality-gmo-beta-carotene-enriched-golden-rice-nears-completion-in-philippines/?mc_cid=d7489134c2&mc_eid=b993433273)

More than 67 tons of fresh paddy of beta carotene-enriched rice have been harvested in 17 Golden Rice production sites in the country as of October 2022. The harvested seeds will be dried, milled, and distributed to the target households with pre-school children identified at-risk for Vitamin A Deficiency (VAD) and undernutrition, as well as households with pregnant and lactating mothers.

#### **Opinion: Food security in a climate crisis must start with seeds**

<https://www.devex.com/news/opinion-food-security-in-a-climate-crisis-must-start-with-seeds-104691>

In recent years, public investment into developing hardier crops that can withstand higher temperatures, water stress, and pests has flatlined. In countries faced with serious food security issues such as Haiti or South Sudan, only around 10% of farmers have access to the latest generation of planting material. This means 90% of farmers are very likely exposed to the threat of climate change even before the first shoots emerge. And yet advances in science, technology, and innovation mean crop breeders are better placed today to model climate projections and fine-tune varieties of cereals, roots, and vegetables that can keep pace with rapidly changing growing conditions. The importance of strengthening food systems in a climate crisis was clearly recognized at the recent United Nations Climate Change Conference. What is needed before COP 28 are clear and decisive actions that bridge the current gap between crop science and farmers around the world to safeguard future food supplies and security.

#### **Role of experts in Kenya's GMO discourse**

<https://www.businessdailyafrica.com/bd/opinion-analysis/columnists/role-of-experts-in-kenya-s-gmo-discourse-cannot-be-gainsaid--4098094>

In a recent opinion article the MP for Gatundu South, who serves on the parliamentary

departmental committee on agriculture and livestock, made a case for genetically modified organisms (GMOs) as an additional weapon in our food security armoury. It was apparent from the article that he understands biotechnology and how it fits into the bigger narrative on food security. It was encouraging to note that these lawmakers engaged experts to better understand this complex subject. It is critical that our lawmakers and policymakers make evidence-based policy decisions devoid of individual biases and interests.

#### **Adoption Delay of New Technology Always Disadvantageous to Consumers**

<https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=20001>

By assessing the economic welfare implications of developing and introducing a gene-edited banana on global production, researchers were able to determine that consumers will always benefit from the adoption of a technological solution, but it is not necessarily the same for producers. Moreover, a five-year delay in adoption can result in discounted losses of US\$94 billion. The researchers from Ecuador and the United States used a model that incorporated disease dynamics, the banana disease *Fusarium* wilt in this case, and the diffusion of a technological solution to quantify the gains from reducing regulatory delay and improving the speed of development when adopting a new technological innovation.

#### **First successful gene editing of Cowpea – Israeli Genetics & Seeds Company ‘BetterSeeds’ redesigns architecture of Cowpea plant to enable its mechanized harvesting**

<https://www.prnewswire.com/news-releases/first-successful-gene-editing-of-cowpea---israeli-genetics-seeds-company-betterseeds-redesigns-architecture-of-cowpea-plant-to-enable-its-mechanized-harvesting-301730441.html>

The first Cowpea plant made suitable for mechanized harvesting is being developed by BetterSeeds, an Agri-Tech company that genetically enhances agricultural crops by using its proprietary genome editing technology. BetterSeeds is set to plant their enhanced Cowpea seeds in the United States in the Spring of 2023, in order to test its potential for mass scale cultivation. BetterSeeds redesigned Cowpea by targeting the gene which alters the plant's architecture into a determinant and erect plant with simultaneous pod appearance, thus fitting Cowpea for mechanized harvesting by a combine. BetterSeeds' is further enhancing Cowpea with its upcoming trait of herbicide resistance.

#### **EU: Is CRISPR-Cas a solution to climate change & biodiversity conservation?**

<https://www.lexology.com/library/detail.aspx?g=0406af15-5409-4920-bdbf-fb13ef070606>

Following the adoption of the EU Green Deal, the European Commission has presented a new proposal for plant modification on the back of the EU Study which includes the possibility to breed plants that have been developed using CRISPR. The adoption of the proposal is planned for the second quarter of 2023. More likely, CRISPR would be removed from the scope of GMOs legislation on the basis that it has no foreign DNA intentionally added to the crops genome and is key to achieving the EU Green Deal.

#### **Crispr Wants to Feed the World**

<https://www.wired.com/story/crispr-gene-editing-climate/>

TEN YEARS AFTER its discovery, the implications of Crispr genome editing are profound and far-reaching, and we are only getting started. This tool, adapted from a bacterial immune system, allows us to cut and edit the genetic code in any living cell to make highly targeted changes and repairs. A small number of people with genetic diseases have been helped by Crispr therapies, highlighting the potential to impact the lives of those suffering from the approximately 7,000 genetic diseases with known causes. Trials are ongoing in diseases ranging from diabetes to infectious disease.

#### **GM crops can help address the food security problem: Venki Ramakrishnan**

<https://www.veetrack.com/showarticles.aspx?UName=496465616C6D65646961&id=3233393836353632>

Indiaborn Nobel laureate Venki Ramakrishnan said the government and agricultural research institutions in India could focus on developing genetically modified (GM) crops to address the problem of food security caused by burgeoning population and the impact of climate change.

### **Research News**

#### **Research Finds GM Rice Key to Tackling Food Shortages Caused by Climate Change**

<https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=19982>

A new study from the University of Sheffield reveals that genetically modifying rice for better salt tolerance could allow it to be grown in places it would otherwise fail, making the crop adapted to survive in environments that have become harsher due to climate change and also help tackle global food insecurity. As sea levels rise as a result of climate change, saltwater floods more land and destroys crops that cannot cope with increased salinity. Rice is one of the most affected crops and is becoming harder to grow due to increasing saltwater interference. A research group from the University of Sheffield's Institute for Sustainable Food revealed that genetically modifying rice to reduce the number of stomata makes it more salt resistant.

#### **China Develops High Dual Herbicide Tolerant Maize**

<https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=19984>

To decrease the effects of herbicide resistance on weeds, scientists from the College of Agriculture and Biotechnology in Zhejiang University developed a dual herbicide tolerant maize that aims to assist Chinese farmers in crop management. Glyphosate resistance in weeds is considered a severe threat to weed management systems. To address this, the scientist developed and characterized herbicide tolerant maize event SCB-29 that expresses *cp4 epsps* and *bar* genes. It is a single-copy T-DNA insertion event with an intact T-DNA fragment inserted into chromosome 10. The line is intended to be tolerant to the quadruple recommended rates of glyphosate and glufosinate.

#### **Brazil and Colombia Approve First Drought Tolerant Gene-Edited Soybeans**

<https://www.isaaa.org/kc/cropbiotechupdate/ged/article/default.asp?ID=19979>

In December 2022, GDM, an Argentinean company working on improving soybeans, announced that Brazil's National Technical Biosafety Commission (CNTBio) has approved its first gene-edited drought tolerant soybean. André Beló, manager of new technologies at GDM, said that the gene-edited soybean was approved by CNTBio in Brazil in May, and greenlighted by the Argentine government in November. The company plans to commercialize the variety in Brazil during the 2027/28 harvest. The gene-edited soybeans that were developed for temperate climates will take a little longer to be planted in Brazil because they will need to be adjusted to tropical climates. In studies that began in late 2018, researchers isolated a gene in the plant responsible for sensing water scarcity. This gene influences the plant's growth response in dry environments.

#### **Researchers Discover a New Type of CRISPR Gene Scissors**

<https://www.isaaa.org/kc/cropbiotechupdate/ged/article/default.asp?ID=19980>

CRISPR-Cas systems have diverse proteins and functions that help protect themselves against foreign invaders. This defense is based on a common mechanism, a CRISPR ribonucleic acid (crRNA), a "guide RNA" that helps detect regions of a foreign genome, such as the DNA of a virus, for targeted cleavage. The CRISPR-associated (Cas) nuclease directed by a crRNA can cut its target like a pair of scissors, a strategy of nature that humans have harnessed in many technologies. "Considering how well different nucleases have been translated into new and improved technologies, any discovery in this field could bring new benefits to society," says Chase Beisel from the Würzburg Helmholtz Institute for RNA-based Infection Research (HIRI).

#### **CRISPR Speeds Up Poplar Flowering Time from Decade to Months**

<https://www.isaaa.org/kc/cropbiotechupdate/ged/article/default.asp?ID=19988>

Researchers from the University of Georgia (UGA) used CRISPR gene-editing to make poplar trees flower within months instead of seven to 10 years. This breakthrough may help speed up breeding trees with improved traits such as cold or drought tolerance. The findings are published in *New Phytologist*. "Previous methods for inducing early flowers in poplars were inconsistent and labor intensive. This is a major barrier to research," said CJ Tsai, professor and eminent scholar with the Georgia Research Alliance. "But using CRISPR to edit a flowering repressor gene, we are able to compress the flowering time from more than seven years to three to four months, and the yearlong floral organ development period down to a few days."

#### **CRISPR Template Successfully Creates Herbicide-tolerance Trait for Basmati Rice**

<https://www.isaaa.org/kc/cropbiotechupdate/ged/article/default.asp?ID=19985>

Scientists were able to establish a template-directed CRISPR-Cas9 system for Super Basmati Rice by detecting desired substitutions at the target site *Acetolactate Synthase (ALS)* gene. Using the template, they developed a genome-edited herbicide tolerant Basmati rice. Rice is a

staple food in many countries, especially in Asia. Weed management is vital to rice cultivation and some farmers find it convenient to use herbicides. Thus, a group of researchers from Pakistan attempted to develop a herbicide tolerance trait in Basmati rice by establishing a homology directed repair-base genome editing, a study that has not been conducted before according to the publication.

#### **Experts Develop CRISPR-Cas9-based Cytosine Base Editors for Phytopathogenic Bacteria**

<https://www.isaaa.org/kc/cropbiotechupdate/ged/article/default.asp?ID=19987>

A team of researchers from the University of Missouri and partners reported efficient CRISPR-Cas9-based cytosine base editors for phytopathogenic bacteria. The results are published in *Communications Biology*. Phytopathogenic have crucial functions in plant productivity. The advances in gene editing could help improve the genetic tools used in the identification of vital genes in the pathogenesis process. Thus, the researchers developed CRISPR-dCas9 (dead Cas9) and nCas9 (Cas9 nickase) deaminase vectors for a broad range of phytopathogenic bacteria. Furthermore, a gene for a dCas9 or nCas9, cytosine deaminase CDA1, and glycosylase inhibitor fusion protein (cytosine base editor, or CBE) was applied to base editing under the control of different promoters.

#### **Single Guide RNA for CRISPR-Cas9 System Based on Rice Bacterial Blight Resistance Gene**

<https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=20003>

A team of researchers from the University of Jember, Indonesia, successfully developed a single guide RNA for CRISPR-Cas9 system based on the *xa13* resistance gene of rice. The research article is published in the Journal of Tropical Plant Pests and Diseases. *Xa13* is a recessive resistance gene against rice bacterial blight pathogen *Xanthomonas oryzae* pv. *oryzae* (Xoo) found in several rice varieties. As this gene is activated, the production of sucrose for *Xoo* growth is also turned on. Thus, the researchers aimed to design and construct the gRNA-targeting *xa13* in rice using bioinformatics tools.

#### **UC Riverside Researchers Discover Building Blocks of Photosynthesis**

<https://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=19965>

Scientists at the University of California Riverside (UC Riverside) have successfully decoded previously unknown signals that plants send to themselves to initiate photosynthesis. Led by UCR botany professor Meng Chen, the research team found four proteins containing building blocks that trigger photosynthesis.

#### **Scientists want to 'edit' rice genes to make it more heat tolerant**

<https://www.publico.pt/2023/02/06/azul/noticia/cientistas-querem-editar-genes-arroz-tornalo-tolerante-calor-2036819>

Portuguese publication *Publico* connected with researchers at the Faculty of Sciences of the University of Porto, who are working on a gene-edited rice strain that will be more climate-resilient by tolerating heat; researchers note that field trials are functionally impossible in the EU due to current regulations.

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