Genetically modified rice

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Genetically modified rice are types of rice that have been genetically modified (also called genetic engineering) for agricultural purposes. The rice genome is usually modified using particle bombardment via the use of a gene gun or more commonly, a process known as agrobacterium mediated transformation.[1] Rice plants can be modified in DNA to be herbicide resistant, resist pests, increase grain size, generate nutrients, flavours or even produce human proteins.[1] The natural movement of genes across species, often called horizontal gene transfer or lateral gene transfer, can also occur with rice through gene transfer mediated by natural vectors. Some examples of such natural transgenic events in plants through movement of natural mobile DNAs called MULEs between rice and *Setaria* millet have been identified.[2] The cultivation and use of genetically modified varieties of rice is however controversial and not legal in some countries.

Contents

Rice plants being used for genetic modification

Background

Scientists are genetically modifying rice for several purposes including making rice resistant to herbicides, diseases, and pests, increasing nutritional value, eliminating rice allergies, producing human blood protein, increasing yield; improving tolerance to drought and salinity; and enhancing nitrogen use efficiency.

In 2000, the first two GM rice varieties both with herbicide-resistance, called LLRice60 and LLRice62, were approved in the United States. Later, these and other types of herbicide-resistant GM rice were approved in Canada, Australia, Mexico, and Colombia. However, none of these approvals resulted in commercialization.[3] Reuters reported in 2009 that China had granted biosafety approval to GM rice with pest resistance,[4] but it hasn't been commercialized either. As of December 2012 GM rice had not yet become widely available for production or consumption.[5] A 2013 article calculated that the annual global value of future developments of genetically engineered rice to be US$64 billion. They argued that since rice is a staple crop for a large number of very poor people in the world, this has enormous potential for alleviating hunger, malnutrition and poverty.[6]

Examples

In order to produce "Roundup Ready rice",[7] Monsanto allowed research into it for one year (2000–2001) but has not developed a variety for market.[8] Bayer's line of herbicide resistant rice is known as LibertyLink.[9] LibertyLink rice is a transgenic variety of rice resistant to glufosinate (the active chemical in Liberty herbicide).[7] Bayer crop sciences is currently attempting to get their latest variety (LL62) approved for use in the EU. The strain has already been approved for use in the U.S. but is not in large-scale use. A variety of rice known as Clearfield rice has been bred by selection from variations created in environments known to cause accelerated rates of mutations.[10] This variety is selected for resistance to imidazolinone herbicides and since these are bred by traditional breeding techniques are not considered as genetically modified.[10] Clearfield is cross bred with higher yielding varieties to produce an overall hardier plant.[10]

Nutritional value

Half of the world population's main food source is rice. In Asia, white rice is eaten three times a day. The main concern about white rice is that it has insufficient concentrations of vitamin A.[11] It has been suggested that rice could be fortified to reduce the level of nutritional vitamin A deficiencies. Golden rice was originally created by Dr. Ingo Potrykus and his team in Zurich, Switzerland.[12] This genetically modified rice is capable of producing beta-carotene in the endosperm (grain) which is a pre cursor for vitamin A production.[12] Potrykus's goal is to distribute the rice to poor countries whose citizens suffer blindness and even death from a lack of vitamin A.[12] Syngenta was involved in the early development of Golden Rice and held some intellectual property on Golden Rice,[12] but has since handed it over to non-profit institutes including the International Rice Research Institute (IRRI) to develop on a non-profit basis.[13] The scientific details of the rice were first published in Science in 2000.[14]

The World Health Organization has stated that iron deficiency affects 30% of the world's population. Research scientists from the Australian Centre for Plant Functional Genomics (ACPFG) are helping to address this issue as part of broader program with HarvestPlus and IRRI to increase the amount of iron in rice.[15] They have modified three populations of rice by over expressing the genes: OsNAS1, OsNAS2 or OsNAS3. The research team found that nicotianamine, iron, and zinc concentration levels increased in all three populations of rice relative to the controls.[11]

Golden Rice grains (right) compared to regular rice grains (left)

Ventria Bioscience uses a proprietary system known as Express Tec for producing recombinant human proteins in rice grains.[16] Their most notable variety produces human Lactoferrin and Lysozyme.[16] These two proteins are produced naturally in human breast milk and are used globally in infant formula and rehydration products.[16] The company's primary facility is located in Kansas.[17]

Golden Rice plants being grown in greenhouse

Pest resistance

BT rice is modified to express the cryIA(b) gene of the bacillus thuringiensis bacterium.[18] The gene confers resistance to a variety of pests including the rice borer through the production of endotoxins. The Chinese Government is currently doing trials on insect resistant cultivars.[19] The benefit of this is that the farmers do not need to spray their crops with pesticides to control fungal, viral, or bacterial pathogens. In comparison, conventional rice is sprayed three to four times per growing season to control pests.[19] Other benefits include increased yield and revenue from crop cultivation.[18][20] China has approved the rice for large-scale use as of 2009.[20] India, Indonesia, and Philippines are expected to carry out cultivation of genetically modified rice in the future.[19] In a rat model, no adverse effects from Bt rice consumption were observed, supporting the safety of widespread use.[21]

Allergy resistance

Researchers in Japan are attempting to develop allergen free rice cultivars for people who are allergic to rice. Researchers are trying to repress the activity of the formation of allergen, AS-Albumin.[19] Thus far the researchers have not been successful in completely eliminating the formation of AS-Albumin.[19]

Also in Japan, lead researcher Fumio Takaiwa of Japan's National Institute for Agrobiological Sciences in Tsukuba tested a type of genetically modified rice on macaques (monkeys) that would prevent allergies to cedar pollen which causes hay fever. The symptoms a person can get to cedar pollen are itchy eyes, sneezing, and other serious allergic reactions.[22] The modified rice contains seven proteins within cedar pollen to block these symptoms.[22] When this was tested on the monkeys, the monkeys did not have any allergy symptoms to cedar pollen. More importantly, they did not have any side effects; Japanese scientists conclude that these types of rice are safe to use as an antihistamine to control cedar pollen allergy. Takaiwa is already doing clinical trials on patients to see if it works the same for humans. He states that if it works it, it will pave the way for genetically modified based vaccines and decrease the opposition toward genetically modified foods.

Human blood protein

Human serum albumin (HSA) is a blood protein in human plasma. It is used in treatment such as severe burns, liver cirrhosis, and hemorrhagic shock.[23] More importantly, it is used in blood donations and thus is in short supply around the world.[23] In China, the scientists modified brown rice as a cost-effective way to produce HSA protein. The Chinese scientists put recombinant HSA protein promoters into 25 rice plants using *Agrobacterium*.[23] Out of the 25 plants, nine of them breed (brown rice plants), and contained the HSA protein. They confirmed that the genetically

modified brown rice had the same amino acid sequence as human serum albumin. They called this protein *Oryza sativa* recombinant HSA. The modified rice were transparent compared to regular rice. Additionally, they tested this protein on the rats with liver disease. The rats showed improved liver function.[23]

Controversy

Main article: Genetically modified food controversies

There are controversies around GMOs on several levels, including whether making them is ethical, whether food produced with them is safe, whether such food should be labeled and if so how, whether agricultural biotech is needed to address world hunger now or in the future, and more specifically to GM crops—intellectual property and market dynamics; environmental effects of GM crops; and GM crops' role in industrial agricultural more generally.

Legal Issues

US

In the summer of 2006 the USDA detected trace amounts of LibertyLink variety 601 in rice shipments ready for export.[24] LL601 was not approved for food purposes; it was approved only for experimental and research use.[24] Bayer applied for deregulation of LL601 in late July and the USDA granted deregulation status to the strain in November 2006.[25] The contamination lead to a dramatic dip in rice futures along with massive losses to farmers who grew rice for export.[24] Approximately 30 percent of rice production was affected along with over 11,000 farmers.[24] In June 2011 Bayer agreed to pay 750 million dollars for damages and lost harvests associated with the contamination.[24] The affected farmers in the five states, Arkansas, Louisiana, Mississippi, Missouri, and Texas will split the settlement.[26] Furthermore, Japan and Russia have banned U.S. export of the rice, while Mexico and the European Union imposed strict testing.[26] So this had impacted the U.S. agricultural business because the price of rice declined due to the contamination. "The contamination occurred between 1998 and 2001 (Berry 2011)." [26] The exact cause of the contamination has never been discovered.

China

The Chinese scientists state that human blood protein (HSA) produced in brown rice requires a lot of modified rice to be grown.[23] This raises environmental safety concerns about modified gene transfer during pollination. The Chinese scientists argue that this would not be a problem because rice is a self-pollinating crop, and their test showed less than 1% of the modified gene transfer in pollination.[23] They are still further studying the issue.

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[27] [28] [29]

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