

Golden Rice Deserves a Chance

Abstract: Golden Rice is a genetically modified crop which was developed about 2 decades ago. It contains beta carotene in its endosperm which is a Provitamin A carotenoid. Golden Rice was featured on the cover page of Time magazine in 2000 as a potential lifesaving crop. But faced with heavy criticism by GMO opponents and over regulatory conditions, it is still struggling to reach the poor for whom it was developed. Till now, Golden Rice has received regulatory approval for use as food in only four countries namely USA, Canada, New Zealand and Australia. But these nations do not actually need Golden Rice production, for they are not plagued by the vitamin A deficiency problem. If approved in countries where it is actually needed, this promising crop can save millions of lives and combat night blindness.

Keywords: Golden Rice, Genetically Modified Organisms, GMO, Vitamin A deficiency, VAD

Technological advancements in agricultural biotechnology can effectively address the fundamental problems related to malnutrition. Vitamin A deficiency (VAD) results in the death of a million people every year worldwide¹. It affects the immune system and leads to blindness. South and Southeast Asia rank high among the regions where VAD is prevalent¹. The World Health Organization estimates that along with children less than five years of age, a major percentage of pregnant and lactating women are affected by VAD¹. Western countries are not affected by VAD since people take multivitamins or get sufficient micronutrients from fortified cereals. But in developing countries like India, VAD is responsible for killing more children than HIV, tuberculosis or malaria².

Provitamin A is normally produced in the green tissues of every plant and gets converted to vitamin A in the human body. Golden Rice is a form of normal white rice that has been genetically engineered to contain beta carotene (Provitamin A) in its endosperm. Because of the accumulation of beta carotene in endosperm the rice grain appears golden in colour. Its purpose is to combat vitamin A deficiency responsible for blindness and deaths of about a million people each year in developing countries²⁻³. In Bangladesh, China, India and many Asian countries, where

rice is a staple food, many children survive only on some amount of rice for the whole day. Golden Rice contains sufficient Provitamin A to provide the entire dietary requirement via daily consumption of some 75g of it per day⁴. Despite having been produced in 2002, this potential answer to VAD is struggling to get approval in most nations. The present article discusses scientific evaluation of Golden Rice.

Genetics of Golden Rice: Golden Rice was developed by Ingo Potrykus and Peter Beyer in response to a call from Rockefeller Foundation, a major charitable organisation, for a plant breeding solution to VAD⁵. Golden Rice was first produced in the 1990s by recombinant DNA technology. Two genes, phytoene synthase *phys1* gene from Daffodil (*Narcissus pseudonarcissus*) and carotene desaturase *crt1* gene from bacterium *Erwinia uredovora* driven by endosperm specific promoter were transferred to rice genome via *Agrobacterium* mediated transformation. This work resulted in the first generation of Golden Rice which contained 1.6 µg/g carotenoids in the endosperm⁵ (Figure 1, 2). The second generation of Golden Rice, Golden Rice2, was created using *phys1* gene from Maize and *crt1* gene from bacterium *Erwinia uredovora* (Figure 2, 3). This improved version of Golden Rice was created in partnership with Syngenta, contained up to 37 µg/g carotenoids, sufficient to fulfil half of daily vitamin A requirements with 60 g of uncooked rice (Paine et al. 2005)⁶.

Research conducted with adult volunteers in the USA confirmed that 3.8 molecules of β-carotene derived by consumption of a single meal of Golden Rice converted to one molecule of circulating retinol⁷⁻⁸. Similar research carried out on Chinese children reported bioconversion in the ratio of 2.1:1.

GMO (Genetically Modified Organisms) opponents like Greenpeace have always questioned the relevance of these studies and alleged that these publications are only to pave the way for GM crops developed by multinational corporations. The papers with these studies were later withdrawn by the publishers following severe criticism by Greenpeace^{4,7}.

The journal is in the category 'Group A' of UGC-CARE list and falls under the broad category of Multidisciplinary Sciences covering the areas Arts and Humanities, Science and Social Sciences.



Fig. 1: Golden Rice Compared to White Rice (Image credit: Wikipedia 2023)

Apprehensions with Golden Rice: It took Golden Rice almost two decades to get approval for release in four countries (Australia, New Zealand, the United States, and Canada)². Its initial introduction was delayed by 13 years because of an international treaty known as the Cartagena Protocol on Biosafety, an agreement which aims to ensure the safe handling, transport and use of living modified organisms, and which came into force in 2003³. This protocol was adopted in 2000 by more than 100 nations, including members of the European Union but not by United States and Canada. The approval of Golden Rice into countries where it is actually required has not been achieved because of the lengthy regulatory procedures necessary to obtain permits to allow seed for field testing⁹.

There are many apprehensions about the approval of golden rice for consumption. Critics, activists and environmental organizations like Greenpeace fiercely oppose it¹⁰⁻¹². GMO opponents and Greenpeace in particular considers this development as “ineffective” and “superfluous”. In fact, Indian anti-GMO activist Vandana Shiva calls Golden Rice a “hoax.”^{9,13} GM Opponents are

of the view that Golden Rice might hamper the existing vitamin A supplementation and fortification programmes⁹. However, these programs of Vitamin A supplementation require lot of money per country every year and do not cover individuals living in remote rural areas. These programs are therefore not sustainable⁹. The other question is regarding the speed at which beta-carotene present in Golden Rice degrades once the rice is harvested, and how much of it remains after cooking¹⁴. However, not much research has been done on the response of beta-carotene in cooked rice, or during long periods of storage. These tests require time, adoption and free field trials which are proving to be very difficult to accomplish in case of Golden Rice till date. Some anti-GMO groups believe Golden Rice is overrated and if approved will pave way for clamour for global approval of other more GMO crops as well¹⁵. However, fact remains that Golden Rice was never developed for profit but for the sole purpose of helping the malnourished poor suffering from VAD^{10,11}. To express their opposition some anti GMO Activists also destroyed the Golden Rice test plot in the year 2013 in the Philippines^{4,15}.

Benefits of Golden Rice: The developers, Scientists and supporters of Golden rice are of the view that because rice is widely grown and eaten, these bio-fortified rice varieties have the potential to reach many people, contributing to food security in countries where VAD is prevalent¹³.

They believe it to be compatible with the current food system and, therefore, more realistic to implement than other interventions^{14,16}. According to Stein et al., with public support and awareness, Golden Rice could halve the burden of disease caused due to VAD. This rice might prove to be a positive example of technological fix as suggested by Scott (2011). It can bring a lot of positive changes in the life of poor people in countries where rice is grown as a staple food crop. Golden Rice is a sustainable solution for low income farmers because after the harvest they could save the seeds and plant them in the next season¹⁰. Safety, toxicity and allergenicity tests have already been conducted on it¹⁷⁻¹⁹. Studies have found it to be more effective in providing vitamin A than spinach and almost as effective as pure beta carotene oil itself^{10,11,20}.



Fig. 2: Wild type rice compared to Golden Rice 1 and Golden Rice 2 (Image Credit: Golden Rice Project https://www.goldenrice.org/Content2-How/how1_sci.php)

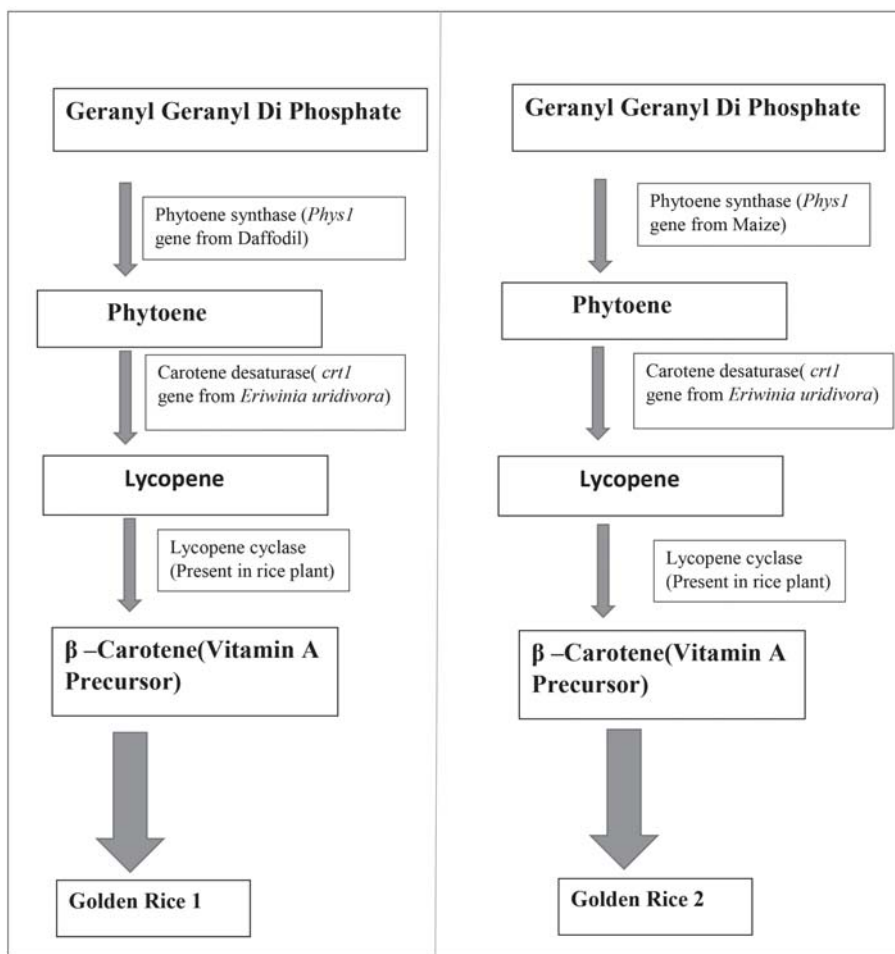


Figure 3: Schematic Diagram to show β -Carotene production from precursor Geranyl Geranyl Diphosphate in Golden rice 1 and Golden Rice 2.

Golden Rice is Unique GM Crop: Golden Rice is a unique Genetically Modified crop. It was developed as a humanitarian, non-profit project for the purpose of helping the malnourished poor suffering from VAD^{10,14}. Golden Rice was one of the seven winners of the 2015 Patents for Humanity Awards by the United States Patent and Trademark Office^{4,21}. It was conceived to be donated free for the benefit of children suffering from VAD. Syngenta gave up its right to commercialize Golden Rice even in rich countries. Rather in 2004, Syngenta renounced all commercial interest in Golden Rice. It was supposed to be given free of charge to poor farmers who can then also save seeds and plant them from one harvest to the next, without restriction or payment of fees or royalties^{2,10,11}.

Recent Approvals: Recently Golden Rice has been approved in the Philippines for consumption¹⁷. Rice is a major part of the diet in that country. According to the World Health Organization many children under five suffer from VAD even after being given vitamin A supplements

in the Philippines. In December 2019, the Philippines Department of Agriculture-Bureau of Plant Industry (DA- BPI) has granted biosafety permits to GR2E Golden Rice for direct use as food, feed and processing¹⁸. It is expected that it will substantially help in reduction of VAD¹⁷⁻¹⁹. Thus the Philippines has become the first country with a serious VAD problem to grant approval to Golden Rice¹⁷⁻¹⁸. Bangladesh is another Asian country which suffers from VAD and is also expected to adopt Golden Rice soon^{11,12,19}.

In 2016, more than a hundred Nobel-prize winners urged Greenpeace to put a stop to its campaign against Genetically Modified Crops, particularly Golden Rice²². More than 13,000 supportive citizens across the globe have also appealed to governments worldwide, the United Nations and to Greenpeace to stop discriminating against genetically-modified crops in general and Golden Rice in particular¹¹.

Conclusion

New technologies invariably attract Criticism. Instead of criticizing GMOs and hampering their progress with unscientific questions, what is actually needed is unbiased purely scientific evaluation and possible solutions for the welfare of people keeping in mind the huge potential that GM crops hold²⁴. A detailed unbiased analysis by Kettenburg et al. (2018), by taking various parameters into consideration has evaluated Golden Rice positively, with a few shortcomings on the socio economic front²⁵. Massive public awareness by scientific communities can overcome the above problems²⁴.

If this crop is freed from overly restrictive regulatory conditions, this technological miracle can save millions of lives and prevent millions of children from going blind^{2,10,11}. Golden Rice is the first nutritionally enhanced genetically modified rice to receive regulatory approval for use as food in four countries as mentioned above^{18,23}. It

definitely deserves a chance in other countries also so that it can benefit the needy poor. □

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Received: 18 May, 2023

Revised: 21 June, 2023

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