QUESTIONS & ANSWERS

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GOLDEN RICE

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What is Golden Rice?

Golden Rice is a new type of rice that contains beta carotene, a precursor of vitamin A. This gives the grain the yellow-orange or gold color; hence, the name "Golden Rice". Beta carotene is converted into vitamin A only as needed by the body; excess amount is excreted in a natural way. This nutrient is also found in orange-colored fruits and vegetables like papaya, carrots, and squash.

Golden Rice was developed through the use of genetic engineering technique. Ordinary rice does not contain beta carotene in its grain. To improve its nutritional value; scientists added the desired trait to rice using genetic engineering. They added two genes from maize and a common soil bacterium, which together completed the rice biosynthetic pathway and made possible the production of provitamin A (beta carotene) in the Golden Rice grain.

Golden Rice is being developed as a potential new food-based approach to improve vitamin A status. Vitamin A can be obtained from fruits, vegetables, and animal food products, however, limitations in terms of accessibility, affordability and availability of these sources remain a challenge. Other interventions to provide vitamin A like food fortification, vitamin A supplementation, and promotion of optimal breastfeeding have made some successes, yet gaps still exist. Once Golden Rice is available, it is expected to complement these existing vitamin A interventions to improve vitamin A status.

Why do we need Golden Rice?

Golden Rice is a potential source of vitamin A, an essential micronutrient needed by the body. Vitamin A is crucial for the visual system, growth, development, and a healthy immune system. Lack of this nutrient in the diet results in a condition called vitamin A deficiency, which weakens the immune system and increases one's vulnerability to infections and diseases, causes blindness, and even results in death if left untreated. Golden Rice, offers a great opportunity to be a very good source of vitamin A, especially among those who depend primarily on rice for nourishment.

Worldwide, millions are still suffering from vitamin A deficiency. This commonly affects young children and pregnant and nursing mothers. The World Health Organization (WHO) estimates that 190 million preschool children and 19 million pregnant women are vitamin A-deficient globally. Each year, up to 500,000 children go blind as a result of this condition, and half of them die within 12 months of losing their sight.

In the Philippines where rice is a staple food, vitamin A deficiency remains a serious and persistent public health problem. The Food and Nutrition Research Institute survey shows that vitamin A deficiency among preschool children, 6 months to 5 years old, has increased from 15.2% in 2008 to 20.4% in 2013; this is about 2.1 million children. A number of pregnant (9.0%) and lactating mothers (5.0%) are also vitamin A deficient. Once available, Golden Rice could be a sustainable and cost-effective way to help those still affected by vitamin A deficiency in the Philippines, including some of the most vulnerable children and women, especially those in far flung areas with existing interventions.

Is Golden Rice Safe?

Golden Rice is a safe source of beta carotene. Recent food safety-related studies conclude that beta carotene in food is a safe source of vitamin A. The beta carotene in Golden Rice is the same as the beta carotene that is found in other foods. This beta carotene is converted only to vitamin A as needed by the body and any excess amount is safely excreted, thus ingesting even large amount of this nutrient is still safe.

Golden Rice is as safe as ordinary rice. Research shows that (proteins from new genes in) Golden Rice do not show any toxic or allergenic property. It also has the same nutrient composition with its conventional counterpart, except the beta carotene content as desired. Collectively, the data have not identified potential health and safety concerns, and support that Golden Rice is as safe and nutritious as conventional rice varieties.

Moreover, Golden Rice can co-exist with organic agriculture and other production systems. It is unlikely to impact organic agriculture through cross-pollination (outcrossing, or gene flow) for a number of reasons that apply to all cultivated rice:

- Cross-pollination in rice is rare if plants are separated by a short distance of a few feet or meters.
- Cross-pollination is uncommon in rice unless all the rice plants are flowering at the same time.
- Therefore, organically-grown rice will not cross-pollinate naturally with other cultivated rice unless they are growing close together and flowering at the same time.
- Rice pollen is normally viable for only a few minutes after flowering.

When will Golden Rice be available?

Golden Rice is still on research stage and will only be made available to farmers and consumers once successfully developed into a rice variety suitable in the Philippines. Golden Rice is being bred into well-known Philippine local inbred rice varieties (*i.e.,* PSB Rc82) readily acceptable by farmers and consumers. As part of the research process, it is being studied in the laboratory and in the field, to generate data required by regulators. It will also be planted in different agro-climatic conditions to compare its performance with the conventional counterpart, in terms of yield and other agronomic aspects.

In addition, Golden Rice will be made available if proven to improve vitamin A status. A simulated analysis study by De Moura *et.al* (2016) as published in the American Journal of Clinical Nutrition suggests that beta carotene rice (*i.e.* Golden Rice) could improve vitamin A intake and could reduce the prevalence of vitamin A deficiency among women and children. Once Golden Rice gets food approval by competent authorities, an independent community bioefficacy trial will be conducted to ascertain if consumption of Golden Rice can improve the vitamin A status of humans.

Lastly, Golden Rice should pass all required tests and be approved by regulators before it could be released. The Golden Rice research is being conducted in compliance with safety and regulatory requirements in the Philippines. At all stages in the development of Golden Rice, data are being gathered, analyzed, and submitted to the respective regulatory body. Regulators review the data and assess the food, feed, health, and environmental safety of Golden Rice as part of the approval process before it can be made available for commercialization.

How much will Golden Rice cost?

The cost of Golden Rice is expected to be comparable to other rice varieties. The Golden Rice technology was donated for humanitarian purpose, thus, there should be no additional cost on the Golden Rice seeds. It is bred into inbred rice varieties; hence, it can be cultivated in the same manner as other inbred rice with comparable production cost. Farmers can also save the Golden Rice seeds and use it again for the following planting season.

Once Golden Rice gets all necessary approvals, a sustainable delivery program will be designed to ensure that Golden Rice will be available to vitamin A-deficient communities. Marketing studies will be conducted to explore best possible options on effective distribution of Golden Rice. We will also be partnering with various players in the market chain to establish a sustainable delivery program and make Golden Rice available and affordable especially to those most in need.

Who is involved in developing Golden Rice?

Golden Rice was first developed by then Professor emeritus Ingo Potrykus of the Swiss Federal Institute of Technology, and Peter Beyer of University of Freiburg, Germany. This started off as a Rockefeller Foundation initiative in 1982. After years of research by various groups, a meeting was convened in New York in 1992 where they first met and decided to embark on the project. In 1999, they successfully developed Golden Rice by adding genes from daffodil and bacterium through genetic engineering technique.

Golden Rice inventors in partnership with other developers came up with an improved version of Golden Rice with 20 times higher beta carotene content than the first version, and donated it to developing countries as their contribution in the fight against vitamin A deficiency. This new version was developed using a gene from maize and the same soil microorganism. In 2004, the donation of the first transgenic events was made through the Golden Rice Humanitarian Board, which transferred the technology to target countries where vitamin A deficiency is prevalent including Philippines, Bangladesh, and Indonesia - through the Golden Rice Network.

DA-PhilRice, in partnership with IRRI, leads the development of Golden Rice in the Philippines. One popular rice variety currently being developed by PhilRice is the Golden Rice version of PSB Rc82 (Peñaranda), a popular, high-yielding, and widely grown rice variety. Together with IRRI, PhilRice has conducted researches to advance new Golden Rice varieties, in accordance with regulatory requirements.

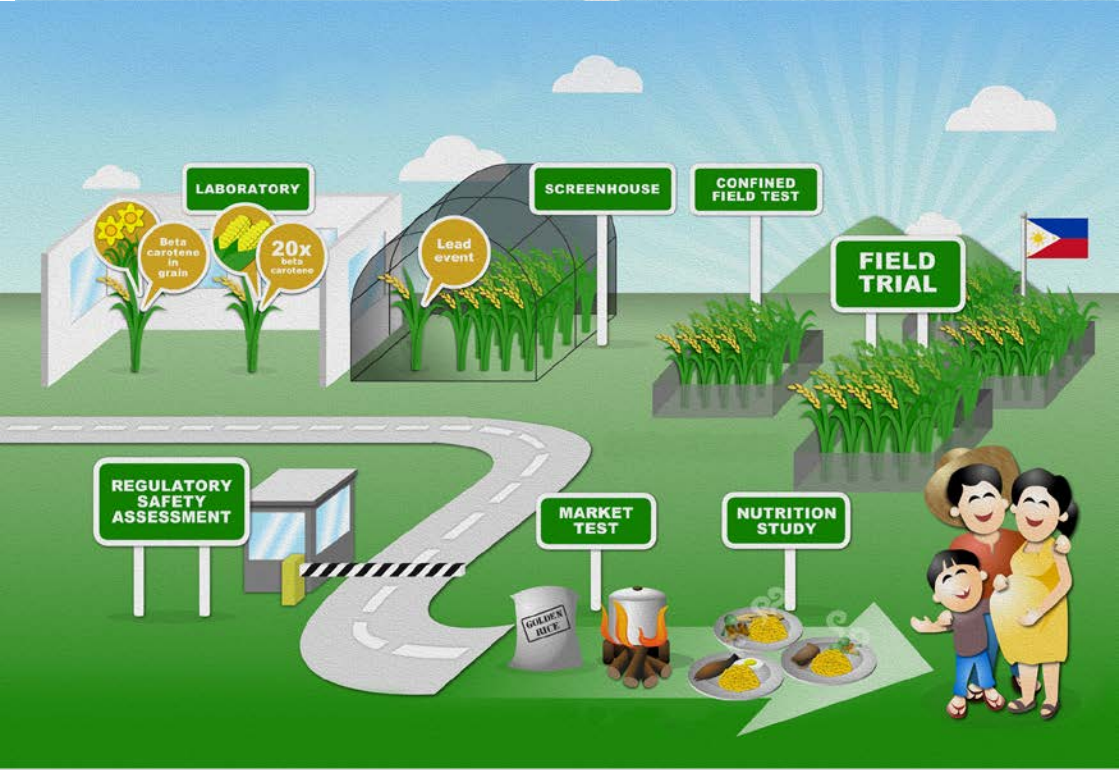
What is the status of the Golden Rice Project?

Golden Rice research is still ongoing. Research in the laboratory, screen house, and field are being conducted to determine the agronomic performance of Golden Rice.

These are being conducted in full compliance with the country's regulatory requirements. At all stages in the development of Golden Rice, DA-PhilRice and its partners have complied with all regulatory requirements in the country. Golden Rice has to pass food, feed, and safety assessments as well as environmental and health safety assessment as required by regulators. Golden Rice will only be released once all necessary testing is completed and it is approved for commercialization by the government.

DA-PhilRice and its partners remain committed to developing a high-performing Golden Rice variety that could benefit both farmers and consumers, especially those who are suffering from vitamin A deficiency. The project stands by its commitment to:

- develop Golden Rice varieties suitable for Filipino farmers;
- help assess the biosafety of Golden Rice;
- evaluate whether consumption of Golden Rice improves vitamin A status; and
- explore how Golden Rice could reach those most in need



How is Golden Rice developed?

Initial stage in the development of Golden Rice was done in the laboratory to incorporate the beta carotene trait in rice and improve its beta carotene content. Selected Golden Rice event was then moved to the screenhouse to begin breeding of Golden Rice in local rice varieties. Crops are then grown in confined field to help breeders advance new Golden Rice varieties that retain the same yield, pest resistance, and grain qualities. Field test and other evaluation also generate environmental and other data that will be used to assess the safety of Golden Rice. Regulators review the data and assess the food, feed, and health and environmental safety of Golden as part of the approval process before it can be released.

Once food approval is obtained, an independent nutrition/bioefficacy study will evaluate if eating Golden Rice will improve vitamin A status in real-world conditions. Information will also be collected on the best practices for storing and cooking Golden Rice, and strategies will be developed to ensure that Golden Rice reaches farmers and consumers, especially those most in need.

What else can be done with Golden Rice?

There is an initiative to further improve Golden Rice by also increasing the amount of other micronutrients, such as iron and zinc, as well as the quality of protein in the grains.

PhilRice is also breeding Golden Rice (so called 3-in-1) into rice varieties that are resistant to tungro and bacterial blight, two of the most devastating rice diseases in the country.

Golden Rice will also be bred into other popular local rice varieties in the future to cater to the preferences of our farmers and consumers.

Why Rice?

Rice is a staple food of more than three billion people worldwide. It is eaten and grown in more than 100 countries, including the Philippines. It is a very good source of carbohydrates but lacks several essential nutrients for the maintenance of health, such as carotenoids exhibiting provitamin A activity. Reliance on rice for nutrition contributes to a serious public health problem of vitamin A deficiency in at least 26 countries in Asia, Africa, and Latin America.

In the Philippines, where rice is widely eaten and grown, vitamin A deficiency remains a persistent public health problem affecting millions of children, and hundreds if not thousands of pregnant women and nursing mothers. These people are at higher risks to diseases, blindness, and even death.

As a staple, rice presents a unique opportunity to be used as a vehicle to deliver a very important nutrient to vitamin A deficient population, especially those hard to reach with existing vitamin A interventions.

Given the scenario, Golden Rice offers a potential new way to help overcome vitamin A deficiency. Farmers could grow it in the same manner as they grow rice today while consumers could incorporate it into their regular diet.

Why resort to genetic engineering?

Genetic engineering is a type of modern biotechnology that allows the transfer of a specific gene(s) from the same or another organism to produce desirable trait. As a tool in plant breeding, genetic engineering has a great potential to safely deliver unique benefits to farmers and consumers that cannot be achieved through conventional breeding methods.

Unlike conventional breeding, this breeding method is more precise. It greatly increases the accuracy of incorporating only the gene of interest, and its associated trait, into a new variety.

Genetic engineering is only used in crop improvement when the trait to be introduced is not present in the germplasm of the crop; the trait is very difficult to improve by conventional breeding methods; and it will take a very long time to introduce and/or improve such trait in the crop by conventional methods.

Prior to developing Golden Rice, scientists initially screened the rice germplasm to search for varieties that contain beta carotene in the grains, but unable to find any. Thus, it is impossible to employ conventional breeding method in this case. They understand, however, that rice plants possess the whole machinery to synthesis beta carotene, and while this machinery is fully active in leaves, parts of it are turned off in the grain. To accumulate the beta carotene in the grain, the pathway must be turned back on. This was made possible in Golden Rice by adding two genes, a plant phytoene synthase (psy) and a bacterial phytoenedesaturase (crtI), using genetic engineering technique.

The development of Golden Rice was greatly driven by the need to address vitamin A deficiency. This is the ultimate reason why it was donated by its inventors and developer to developing countries, including the Philippines, where vitamin A deficiency is prevalent.

Why does it take so much time to develop Golden Rice?

Using modern biotechnology, specifically genetic modification, to develop new plant traits *(e.g.,* beta-carotene content in Golden Rice) and integrate them into existing varieties acceptable to farmers and consumers normally takes many years. In addition to meeting regulatory requirements of a country, additional tests *(e.g.,* bioefficacy) must be conducted to show that Golden Rice will be useful as a complementary intervention to address vitamin A deficiency. These tests are often sequential; passing one is a prerequisite for the next and the requirements for each phase could take a while *(e.g.,* a cropping season plus data analysis) to complete.

Golden Rice gained prominence in 1999, but that was the "proof of concept" phase. Subsequent work resulted in newer versions we call them "events" expressing higher beta-carotene levels. These were generated in 2005 and donated as public good in 2006. Since then, intensive research and development had been done and is being continued.

Rigorous research cannot and should not be rushed. Rigor and time are required to produce a high-performing variety like Golden Rice. The climate-smart flood-tolerant rice, for instance, which millions of farmers now have access to, took more than two decades to develop.

Why spend much money in developing Golden Rice when there are readily available proven solutions to address vitamin A deficiency?

Existing interventions to address vitamin A deficiency like vitamin A supplementation, food fortification, diet diversification, and promotion of optimal breastfeeding, have made some successes in combating vitamin A deficiency.

However, despite some improvements, vitamin A deficiency remains a persistent public health problem in the country. In fact, vitamin A deficiency incidence among preschool children (aged 6 months to 5 years old) has increased from 15.2% in 2008 to 20.4% in 2013.

Millions are still suffering from vitamin A deficiency; and Golden Rice could fill in the gaps and complement the existing interventions once available.

Since rice is widely planted and consumed, Golden Rice has a great potential to be a sustainable solution to vitamin A deficiency along with other interventions. As our staple, biofortified rice will give easy access to the poor to good nutrition.

How is the safety of GM crop assessed?

GM crops are examined based on existing safety assessment standards according to the Codex Alimentarius guidelines on food safety.

This safety assessment of GM foods generally focuses on: (a) direct health effects (toxicity); (b) potential to provoke allergenic reaction (allergenicity); (c) specific components thought to have nutritional or toxic properties; (d) the stability of the inserted gene; (e) nutritional effects associated with genetic modification; and (f) unintended effects which could result from gene insertion.

In the Philippines, research of GM crops is governed by the Joint Department Circular (JDC) titled Rules and Regulations for the Research and Development, Handling and Use, Transboundary Movement, Release into the Environment, and Management of Genetically-Modified Plants and Plant Products Derived from Use of Modern Biotechnology. This JDC involves various government departments, such as the Department of Agriculture, Department of Science and Technology, Department of Environment and Natural Resources, Department of Health, and Department of Interior and Local Government.

Are GM foods safe?

GM foods that are currently available in the market have passed safety assessment and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved.

In May 2016, the National Academies of Science, Engineering, and Medicine recently issued a report attesting that GM crops are safe. This is based on the review of over 20 years of data since GM crops were introduced, including nearly 900 studies and publications on GMOs.

Safety of biotech crop is also overwhelmingly endorsed by health authorities (*i.e.*, World Health Organization, American Medical Association, Royal Society of Medicine, *etc.*); scientific experts *(i.e.,* American Association for the Advancement of Science, National Academies in many countries, International Council for Science, Pontifical Academy of Science, *etc.)*; and government agencies (European Commission, Food and Agriculture Organization of the United Nations, US Food and Drug Administration, Philippine Food & Drug Administration, *etc.)*.

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*2008, 2010 & 2011 versions

For more up-to-date information on Golden Rice, please refer to the links below:

http://www.philrice.gov.ph/golden-rice/about-gr/
http://irri.org/golden-rice

We are a chartered government corporate entity under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding, cost-reducing, and environment- friendly technologies so farmers can produce enough rice for all Filipinos. We accomplish this mission through research and development work in our central and seven branch stations, coordinating with a network that comprises 58 agencies and 70 seed centers strategically located nationwide. To help farmers achieve holistic development, we will pursue the following goals in 2010-2020: attaining and sustaining rice self-sufficiency; reducing poverty and malnutrition; and achieving competitiveness through agricultural science and technology.

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