OPINION

Allow Golden Rice to save lives

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Vitamin A deficiency (VAD) has killed millions of children in less-developed countries for at least the last three decades—roughly 2 million annually in the early 1990s alone (1–4). Although the number is declining, it was estimated to be 266,200 (4) at the start of the millennium.

The consumption of the genetically modified rice variety known as Golden Rice (GR) offers a potent and

Widespread consumption of the genetically modified rice variety known as Golden Rice offers a potent and cost-effective strategy to combat vitamin A deficiency. Image credit: International Rice Research Institute; photo licensed under CC BY 2.0.

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cost-effective strategy to combat VAD. But this innovation has been cast aside owing to fear or false accusations, resulting in numerous lives needlessly lost (1–3). With the recent exception of the Philippines, governments have not approved the cultivation of GR (5). We believe it should be broadly approved and given the opportunity to save and improve lives.

In high-income nations where populations have access to a diversity of foods, VAD is rare. In many low-income nations, however, populations have limited access to foods rich in vitamin A or beta-carotene, a vitamin A precursor; hence, VAD rates can be dangerously high in children. There have been recent improvements: from 1991 to 2013, the VAD rate among children in low- and middle-income countries declined from 39% to 29%, with notable improvements among children in East and Southeast Asia (4). However, children in sub-Saharan Africa and South and Southeast Asia continue to disproportionately experience VAD and its associated risks: infectious and diarrheal diseases, irreversible blindness and other sensory losses, and premature death (1, 4, 6).

VAD has not been eradicated despite a variety of strategies used globally, including education on the value of dietary diversity, promotion of home gardens and maternal breastfeeding of infants, and community health programs including vitamin A supplementation with syrups or capsules (7). Principally, VAD is caused by insufficient dietary diversity, a result of poverty and agronomic and market constraints. Animal source foods and many kinds of produce are unavailable or expensive in local markets. Conversely, white rice or other cereal grains are easily available and inexpensive but primarily contain carbohydrates while lacking sufficient micronutrient levels.

GR, developed first in the 1990s and then modified in 2004 with transgenes from maize and a common soil bacterium *Erwinia uredovora*, could be an important public health intervention for VAD populations worldwide. This transgenic, or genetically modified, rice produces beta-carotene, a precursor to vitamin A, in the normally white endosperm (8) and has proven an effective source of vitamin A in humans (9). GR* is now awaiting final approval in Bangladesh. In July 2021, it was approved for cultivation in the Philippines. Other countries will likely follow.

A recent study has estimated that substituting GR for conventional rice could provide 89% to 113% and 57% to 99% of the recommended vitamin A requirement for preschool children in Bangladesh and the Philippines, respectively (10). Even if there were no other sources of vitamin A in the diets, this boost in dietary beta-carotene could do much to prevent diseases associated with VAD.

GR is also financially viable. In Bangladesh, the current practice of fortifying rice with vitamin A and zinc using food additives, although supported by the World Food Programme, increases the cost of rice by 5% to 6% and is applied to only about 1 million metric tonnes of rice of the roughly 25 million metric tonnes produced in Bangladesh per year (11). GR, by contrast, poses no extra cost to governments, growers, or consumers in comparison with white rice.

Meanwhile, VAD has continued to cause severe illness and death among certain populations worldwide, especially children (12). The total estimated deaths from VAD-related diarrheal diseases and measles in children under five years of age in 2013 was 94,500 and 11,200, respectively, totaling 105,700 deaths across the world (4). Had GR become a part of diets in vulnerable populations worldwide, a portion of these lives might have been saved. Hopefully, approval of the commercialization of GR in the Philippines will provide impetus for Bangladesh and other nations with high VAD rates to provide poor consumers with an option that may save lives and improve health.

Unnecessary Delays

Those who oppose transgenic or genetically modified organisms raised concerns that led policymakers to delay the approval of the technologies (13). One argument relates to biotechnology company profits. But because the GR technology to the public sector is available at no cost for humanitarian uses, this concern is irrelevant. There are no limitations, except export, on GR use: replanting or selling or giving away seed, or polishing for consumption or sale.

Greenpeace summarized a food security-related objection to GR in a 2012 statement (14): "If introduced on a large scale, GR can exacerbate malnutrition and ultimately undermine food security." The implication: GR will worsen malnutrition because it leads to a diet based on one staple. However, the replacement of traditional rice with GR would not exclude the development of diversified diets; in the meantime, vitamin A status could improve for many in the population. And optimizing vitamin A delivery could improve public health in at-risk populations.

A reasonable objection concerns possible human or environmental health risks. The United Nations (UN) Cartagena Protocol on Biosafety (15) provides a framework for the regulation of genetically engineered crops in many countries, emphasizing the Precautionary Principle in assessing risks, and leaving out assessment of benefits. This Protocol was signed in 2000 and became effective in 2003, in the relatively early days of agricultural genetic engineering. Since then, multiple studies have reported on benefits of genetically modified organism (GMO) adoption through increased yields, reduced pesticide use, improved farmer income, reduced prices to consumers, and in some cases even improved food safety (16). Meanwhile, there have been no confirmed incidents of adverse human health or environmental effects from genetically engineered crops during nearly three decades of global use (16).

Transgenic crops are subject to many required regulatory tests before approval, including animal feeding and in vitro studies for toxicity and allergenicity. Yet opponents of these crops have continued to amplify

*Many transformation events were produced (8), from which event GR2E has been selected on the basis of molecular structure and insertion in the rice genome, together with agronomic performance. It is the basis of the regulatory data generated and is the only form of GR which is offered for approval and use.

suspicion on the long-term health effects of genetically engineered crops (17). Protection against such risks can be achieved through monitoring of the performance and the impacts of technologies and intervening when setbacks occur. However, the food safety assessments for transgenic crops in many countries are more demanding than for conventionally bred varieties. In fact, often less is known about the properties of plants developed by conventional mutagenesis than those developed by transgenic methods.

Another concern is that GR genes may intermingle with those of conventionally bred rice varieties. This uncertainty, however, applies not just to GR but also to any other new rice variety. Humans have consumed rice for more than 4,000 years, including varieties that have been crossed genetically across multiple strains. Transgenic methods of introducing novel genes is not inherently of greater concern, unless those genes produce proteins with potential adverse health effects—something that food safety tests for approval can determine. Clearly the lives saved with VAD outweigh concerns about these so-called unknown risks. In response to such criticisms, in 2016 more than 150 Nobel Laureates have signed an open letter to the UN, governments of the world, and Greenpeace, urging a more balanced approach toward genetically modified crops in general and GR in particular: "Scientific and regulatory agencies around the world have repeatedly and consistently found crops and foods improved through biotechnology to be as safe as, if not safer than, those derived from any other method of production. … Opposition based on emotion and dogma contradicted by data must be stopped" (18).

Questioning Science

The arguments used by organizations to delay adoption of GR often resemble the arguments of antivaccination groups, including those protesting vaccines to protect against COVID-19. Some of the opponents of GR and agricultural biotechnology more generally see the introduction of GR as forcing the consumption of GMOs on the population. However, for the case of GR, consumers have the option of easily avoiding consumption because GR is very easily identifiable by its color.

The tragedy of GR is that regulatory delays of approval have immense costs in terms of preventable deaths, with no apparent benefit (13). The approval of GR is even more urgent with the ongoing pandemic, which has made access to healthcare services more difficult in vulnerable populations worldwide. The World Bank has recommended that micronutrient biofortification of staple crops, including specifically GR, should be the norm and not the exception in crop breeding (19).

Golden rice can effectively control VAD. Delaying the uptake of a genetically modified product shown to have clear health benefits has and will cost numerous lives, frequently of the most vulnerable individuals. Policymakers must find ways to overcome this resistance and accelerate the introduction and adoption of Golden Rice.

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