Golden rice's lack of lustre

Addressing **vitamin A** deficiency without genetic engineering

GREENPEACE

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List of Abbreviations

CGIAR - Consultative Group on International Agricultural Research
CIAT - International Center for Tropical Agriculture
CSISA - Cereal Systems Initiative for South Asia
CIMMYT - International Maize and Wheat Improvement Center
DBT - Indian Department of Biotechnology
GC9 – Grand Challenge 9
GE – Genetic Engineering
HFP – Homestead Food Production
HKI – Helen Keller International
IFPRI - International Food Policy Research Institute
IRRI – International Rice Research Institute
IITA - International Institute for Tropical Agriculture
MAS – Marker Assisted Selection
MDG – United Nation's Millennium Development Goal
NID – National Immunisation Days
SDC - Swiss Development Corporation
UN – United Nations
UNICEF – United Nations Children Fund
UNSCN – United Nations Standing Committee on Nutrition
USAID – United States Agency for International Development
VAD - Vitamin A Deficiency
VAS - Vitamin A Supplementation
VITAA – Vitamin A for Africa partnership
WHO - World Health Organisation

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Introduction 1.0

Vitamin A deficiency (VAD) continues to be one of the most serious health problems in the developing world. The last two decades have seen tremendous improvements in the treatment of VAD, and it has been virtually eliminated among specific sectors of the population in many countries. The number of countries achieving vitamin A supplementation (VAS) targets nearly doubled between 2003 and 2005. These improvements are due to a combination of four strategies, well-tested and proven to be successful: vitamin A supplementation with capsules, the fortification of food with vitamins and minerals, oral supplements or food additives, and dietary diversification.

However, VAD has also been used as a reason to develop so-called 'golden' rice - a variety of rice that has been genetically-engineered (GE) to biosynthesise beta-carotene, a precursor of vitamin A, in the inner edible parts (endosperm) of rice.

Greenpeace considers the term 'golden rice' to be a misnomer – calling this rice 'golden' suggests that it is a panacea or miracle cure, which - after 20 years of development, millions of dollars of funding and significant promotion by a number of organisations - it clearly is not.

The marketing of so-called golden rice is often promoted as a solution to VAD in countries where rice is a staple food. This solution is not only ecologically irresponsible - introducing GE rice on the Asian continent, a centre of origin and diversity for rice, has the potential to contaminate invaluable genetic resources for combating future disease in rice varieties - but it also misses the point: **VAD is routinely associated with other nutritional deficiencies**. Thus, programmes that improve the intake of all necessary vitamins and minerals and promote access to a healthy balanced diet are the only truly sustainable solution to the widespread problem of chronic undernourishment.

Examples of successful VAD programmes that do not include GE can be found in all areas of the world, and many of them include an effort to increase dietary diversity, the most sustainable method of dealing with VAD, which simultaneously addresses multiple micronutrient deficiencies. This report reviews the current status of VAD, the strategies employed to combat it, success stories from countries that have made improvements to their VAD status or reduced the number of those affected by VAD drastically. It also reviews the development of the genetically-engineered golden rice, and the global financial investments spent on it to date that could have instead been supporting existing programmes to combat VAD. Successes in tackling VAD highlight the fact that where efforts are not successful, it is due to political instability, lack of will or funds, not because there is a lack of tools or knowledge to make it happen.

Despite the tools and knowledge to fight VAD being readily available, large amounts of money have been spent on GE rice research, and particularly on the development of the so-called golden rice. Until now there have been no tangible results of this research. The International Rice Research Institute (IRRI) continues to conduct a number of GE rice development projects, and organisations like the Bill & Melinda Gates Foundation continue to bank roll these efforts. In so doing, they divert valuable resources from programmes that are proven to be successful, as well as those with a holistic approach that actually address the full suite of vitamin and mineral deficiencies.

The data presented in this report prove that generous funding channelled into the development of golden rice would be far better applied toward existing methods to fight VAD, those which favour sustainable food systems, provide food security and increase agricultural diversity in a way that is empowering women, providing income to rural farmers, and improving the nutritional status of women and children around the globe.

Vitamin A deficiency: the problem 2.0

There are an estimated 1.02 billion undernourished people in the world in 2009 (FAO 2009). Vitamin A deficiency (VAD) is a significant contributor to these statistics; approximately 33% of children up to 5 years of age and 15% of pregnant women worldwide are vitamin A deficient at either an acute or sub-clinical level (UN MDG 2010).

Long recognised for their importance to overall health and immune function, vitamin A is found in meat and pro-vitamin A compounds (which are transformed by the body into vitamin A) are present in dark green vegetables and orange fruits and tubers. VAD has been among the most prevalent micronutrient deficiencies in the world, and causes dry eye, night-blindness, and total blindness in the worst cases. Critically, Vitamin A deficiency has also been shown to result in a reduction of immune function.

Decades of work by international health organisations and non-profit groups have seen a substantial decrease in VAD worldwide. Violent conflict, unpredictable market forces, natural disasters and a variety of other global crises have caused the international development community to alter its timeline with respect to the eradication of VAD, originally called for by the year 2010. The latest global development targets (United Nations Millennium Development Goals) call for a two-thirds reduction in mortality of children under five years old by the year 2015 (UN MDG 2010). Elimination of VAD is critical to the achievement of this goal (UNICEF 2009, UNICEF 2008).

2.1. VAD in a global health context: multiple micronutrient deficiencies

It has long been known that effective vitamin A metabolism is reliant on sufficient levels of other micro and macronutrients in the body, particularly those of fat, protein, vitamin E and zinc (Butt et al. 2007; Rahman et al. 2002; Smith et al. 1973). Simultaneous deficiencies of multiple micronutrients in young children in developing countries are widely reported, and thus it may be inferred that the presence of one micronutrient deficiency is indicative of others (Ferraz et al. 2007). Recent research indicates that the simultaneous provision of more than two micronutrient supplements improves outcomes in deficient populations (Allen et al. 2009). However, this also underscores the importance of a healthy, balanced diet containing all micro and macronutrients.

A recent example can be found in Cambodia, where anaemia and iron, zinc, and vitamin A deficiency were found to coexist in stunted children; 44% of all children studied had two or more simultaneous micronutrient deficiencies (low haemoglobin (Hb), serum retinol, and/or serum zinc) (Anderson et al. 2008). The authors recommended an intervention strategy that addresses multiple deficiencies. Similar examples can be found in Bangladesh (Ahmed et al. 2008), Kazakhstan (Hashizume et al. 2005) and Brazil (Ferraz et al. 2007).

Successful vitamin A supplementation (VAS) programmes in target countries have in many cases been integrated with other efforts to improve health, and have played a major role in the improved status of mothers, newborns and young children (UNICEF 2008). Most of the countries targeted to meet the MDGs by 2015 have made simultaneous improvements in vitamin A supplementation, vaccinations and malaria prevention (UNICEF 2008). It has been shown that controlling parasitic infections would also help control VAD and other micronutrient deficiencies (Hesham Al-Mekhlafi et al. 2007). A multi-tiered approach to global health is thus recommended by the UN Standing Committee on Nutrition (UNSCN) as the most economically and biologically efficient means of eradicating undernourishment and raising the health status of mothers and children (UNSCN 2008).

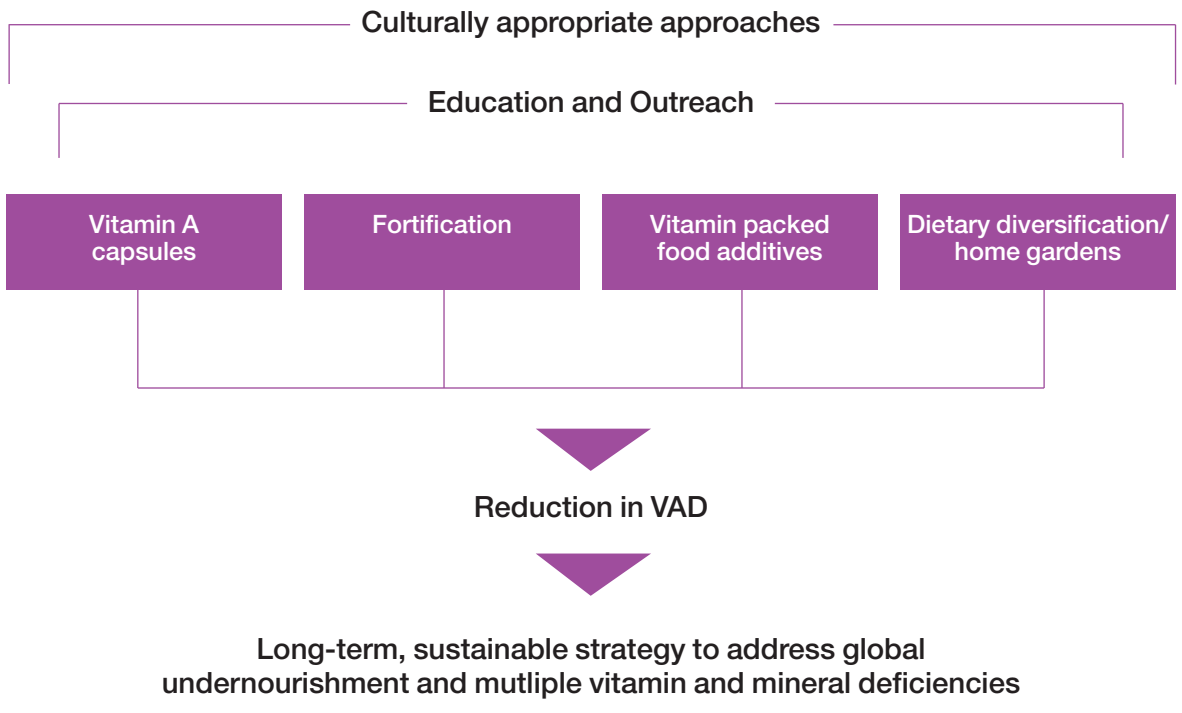
Specifically, the UNSCN recommends that an integrative approach includes early and exclusive breastfeeding, improved complimentary feeding, iron/folate or multiple micronutrient supplementation, calcium supplements for mothers during pregnancy and lactation, fortification of complementary foods, fortification of salt with iodine, zinc supplementation and vitamin A fortification or supplementation (UNSCN 2008). Greenpeace acknowledges vitamin and micronutrient supplements as an immediate intervention in the fight against VAD and other micronutrient deficiencies. However, no programme should lose sight of the fact that a diverse diet and measures (such as home gardens) to encourage this are the most sustainable and long-term solutions. Greenpeace would advocate a tiered approach, with supplements providing immediate relief for people suffering from micronutrient deficiencies, food fortification and additives as an intermediate step, and dietary diversification and home gardens as the long-term, sustainable strategy for combating VAD.

Addressing VAD: diverse strategies

3.0

Traditional strategies focused on vitamin A intervention have consisted of one or more of four well-tested approaches (Figure 1): VAS capsule programmes (often in conjunction with National Immunisation Days), post-harvest fortification of staple foods such as sugar, flours or cooking oil, distribution of food additives with a variety of essential vitamins and minerals, and dietary diversification programs, often involving the promotion of small-scale local food production by women in rural households. As mentioned above, all these strategies have their place in combating VAD, however supplementation, fortification and food additives are not sustainable long term strategies, whereas dietary diversification and particularly small scale food production and home gardens empowers those affected by VAD by giving them the ability to grow the food their bodies need.

Figure 1. A diverse approach to VAD ensures long-term success.



3.1. Vitamin A supplementation with capsules

Longstanding success of National Immunisation Days (NID) around the globe in eradicating polio and other infectious disease led to the eventual integration of VAS in this effort. Brazil was the first country to successfully integrate these complimentary actions in 1983. Building upon their well-coordinated efforts to eradicate polio, many countries have since followed, where teams of health workers, volunteers and community members administer 1to 2 high-dose vitamin A capsules each year to those in need (Table 1). VAS programmes are routinely monitored around the globe, and there is good data to suggest that their success has been substantial in recent years, particularly in the administration of the preferred two doses a year (UNICEF 2009). From 2003-2005, the number of countries achieving 80% of two-dose coverage nearly doubled (UNICEF 2009; UNICEF 2008). The greatest gains have been made in many of the least developed countries, 85% of which achieved 2-dose coverage by 2008 (UNICEF 2009).

The Millennium Development Goals for 2015 now identify only 66 priority countries for VAS (UNICEF 2008). A summary of VAS progress in the 103 countries originally targeted for VAS is presented in Appendix 1, which shows many priority countries now achieving over 80% coverage. Some countries, such as Nepal, Bangladesh, and Korea, already had successful VAS programs by 1999. Gaps remain, however, in successful delivery of vitamin A capsules to some of the poorest and most rural families. In addition, while many countries saw tremendous improvement in VAS from 1999-2005, some areas showed little progress or worsening situations.

Table 1. Summary of target countries and current VAS programmes by region for children up to 5 years (UNICEF 2005).

	# target countries	# target countries with national or sub-national VAS programmes
CEE/CIS[a] and Baltic States	7	4
East Asia/Pacific	15	14
Latin America/ Caribbean	17	10
Middle East/North Africa	11	11
South Asia	8	8
Sub-Saharan Africa	45	44
TOTAL	**103**	**91**

a *CEE/CIS: Central and Eastern Europe, Commonwealth of Independent States*

3.2. Food fortification

The post-harvest fortification of staple foods such as sugar, flours, cooking oils and dairy products has proven to be a very efficient means of delivering micronutrients to people in nearly every region of the world, including the developed countries of Europe and North America (WHO et al. 2009); it is estimated that between 25% and 50% of additional vitamin A in the European diet comes from fortified foods such as cereals and flours (Wagner et al. 2005). Zinc, iodine, B vitamins, vitamin D and iron are also commonly added to staple foods. Particularly where the supply of staple foods is centralised, rather than grown and distributed at the local level, large-scale fortification programmes are a cost-effective and very successful means of vitamin A supplementation (Klemm et al. 2010). Fortification programmes have been tremendously successful in curbing or eradicating VAD in countries such as Guatemala, the Philippines, Bangladesh, South Africa, Niger and many more.

As well as fortification of food, plant breeders now use bio-fortification as a means to boost nutrient contents in plants. Bio-fortification is widely defined as the process of breeding edible plants with higher micronutrient content. There are a number of methods of bio-fortification, from traditional plant breeding, genetic engineering and modern techniques such as Marker Assisted Selection (MAS). MAS complements traditional breeding and can make it more efficient. It does not include the transfer of isolated gene sequences as GE does, but involves identifying a genetic sequence that is linked to a desirable trait (high pro vitamin A content for example). Once this genetic sequence (the 'marker') is identified there is no longer the need to test every single offspring plant. Instead, plant breeders only need to look for the marker using a rapid DNA test, and can immediately identify which plants have the trait and which do not.

Using MAS, the International Maize and Wheat Improvement Center (CIMMYT) and the International Institute for Tropical Agriculture (IITA), along with other partners, have developed 'Orange' Maize, bred with higher pro-vitamin A content. This maize is already being grown and distributed in a pilot programme in Zambia, a country whose population is affected by VAD (Boaz 2010). This and other examples of bio-fortification are reviewed in a recent Greenpeace report (Vogel 2009).

3.3. Vitamin packets/food additives

A wide variety of multivitamins, micronutrient-rich food additives and supplemental foods are distributed to populations in need around the world. One of the most common products is 'Sprinkles', a packet of vitamins and minerals (iron, zinc, vitamins A, C and E, folate, and often others) that is added to prepared foods on a daily or weekly basis. Sprinkles is currently distributed or sold in at least 15 countries worldwide (SGHI 2009). Many of these products are distributed following natural disasters or periods of crisis that cause severe malnutrition. These products should therefore be seen, like supplementation and fortification, as interim measures on a path to a more empowering and sustainable strategy to treat VAD.

3.4. Dietary diversification

With the knowledge that a diverse diet that includes daily servings of fruits, vegetables and animal products can provide more than enough of the minimum daily requirement of vitamin A, some VAD eradication programmes have focused on nutrition education and dietary diversification in undernourished populations. Poor families in developing countries often lack access to fresh foods, and instead rely on an affordable but nutritionally inadequate diet of grains and starches (Keatinge et al. 2010). There are many advantages to approaching micronutrient deficiencies from a dietary diversification perspective. Multiple deficiencies can be addressed simultaneously, and thus the status of vitamin A, iron, zinc, etc. can all be improved through regular meals. Recent work on Homestead Food Production by Helen Keller International has found that homestead gardens successfully reduce the incidence of night blindness in children, and cost just $9 US dollars per garden (HKI 2010). Programmes that focus on home gardens to increase dietary diversity can have the added benefits of providing income, saving money otherwise used to purchase foods, improving the status of women and building communities (Faber et al. 2002; van Averbeke & Khosa, 2007).

It should be noted that the problem of insufficient dietary intake of essential vitamins is not limited to the developing world. Wealthy populations of Europe and North America often suffer from micronutrient deficiencies, where diets focused on breads and cereals rather than fruits and vegetables have led to a variety of health problems (Elmadfa & Meyer, 2009). A focus on healthy eating habits, including the daily intake of fresh vegetables, would greatly improve the health status of all populations (Keatinge et al. 2010).

Addressing VAD: Success Stories

4.0

4.1. Asia

While Asian countries have made considerable progress in combating VAD in recent years, South Asia remains the most seriously affected region in the world. Nearly half of all VAD and xerophthalmia (extreme dryness of the eyes) cases occur in south and southeast Asia (UNSCN 2004). Efforts to combat VAD in the region are substantial; in 2008, of children under 5 years old, 70% are receiving full VAS in Asia (UNICEF 2009). Foods fortified with vitamin A are available in Malaysia and the Philippines, with some progress towards fortification in the Democratic People's Republic of Korea, Indonesia, Thailand and Vietnam. South Asia is also working toward fortification of oil-based staples such as ghee (UNICEF 2007a).

Despite the work left to be done, successful models for combating VAD in this region are abundant.

Work done by Helen Keller International (HKI) in Bangladesh over the last four decades provides a particularly impressive model for the eradication of VAD. Rural Bangladesh is one of the most undernourished regions of the world, with 46% of children under five underweight and 36% of mothers chronically energy deficient (HKI/IPHN 2006a). Micronutrient deficiencies affect 50% of children and women of reproductive age (HKI/IPHN 2006a). In the early 1990s, HKI began a home gardening project in rural Bangladesh to address VAD. This has since been expanded to a formal Homestead Food Production (HFP) programme to include animal husbandry and consumption of animal products (HKI/IPHN 2006b) on thousands of rural properties, largely managed by women (HKI 2010). HFP and other food-based strategies have increased food security, reduced micronutrient deficiencies and empowered women in Bangladesh (Bushamuka et al. 2005). The wide-ranging benefits of these programmes have included a lowered risk of night blindness in children living in homes with a homestead garden (Talukder et al. 2000) and increases in pro-vitamin A carotenoid intake (de Pee et al. 2007). Following implementation of the HFP programme, Bangladeshi mothers' daily consumption of pro-vitamin A carotenoid from vegetables and fruits increased eightfold, and their children's (aged under 5 years) consumption increased fourfold (Taher et al. 2004). Combined with the availability of vitamin A-fortified wheat flour, VAD and night blindness are no longer at a level to be considered a public health problem in children under 5 in Bangladesh (UNICEF 2007b).

Country	**Bangladesh**	**Philippines**	**Pakistan**
VAD reduction strategy	• Vitamin A capsules • Fortifications • Dietary diversification / home gardens	• Vitamin A capsules • Fortifications • Vitamin packets / food additives • Dietary diversification / home gardens	• Vitamin A capsules • Dietary diversification / home gardens
Success stories	HFP programme shown to reduce night-blindness, dramatically increase pro-vitamin A uptake in mothers and children.	86% of children receive 2 annual VAS doses; holistic approach includes home, school and community food production, micronutrient supplementation, food fortification, food assistance and nutrition education.	Since 2003, incidence of VAD has dropped from between 35% and 48% of children to less than 5%; government programmes are promoting the intake of green vegetables, yogurt and mangos to address multiple micronutrients.
Status	VAD below 5%	VAD below 5%	VAD below 5%
Source(s)	See above paragraph	Barba and Feliciano 2002; UNSCN 2006a	Sher 2003; WHO database 2010; UNICEF 2009; Khan et al. 2006; Panhwar 2005

4.2. Africa

Malnutrition and food insecurity are serious problems in many African countries. While VAD has improved dramatically in the last 10 years, lack of access to adequate and nutritious foods is widespread. Comprehensive agricultural and economic development that increases dietary diversity and addresses multiple micronutrient deficiencies are clearly needed in this region.

A combination of food fortification, VAS and dietary diversification, particularly the promotion of orange-fleshed sweet potatoes, has contributed to substantial improvements in VAD in Africa. White-fleshed sweet potatoes are a major staple in many areas of Africa, but have little to offer in terms of micronutrients. Their orange-fleshed counterparts contain high levels of beta-carotene, which is converted to vitamin A when consumed; just 125 grams a day provides twice the recommended daily allowance of vitamin A (HKI 2010). The cultivation of the new sweet potato varieties also offers a significant source of income for rural African farmers and is promoted as an important option for combating VAD by the Vitamin A for Africa (VITAA) partnership (Kapinga et al. 2005). HKI efforts have successfully helped over 100,000 families in Niger, 150,000 families in Burkina Faso and 200,000 families in Mozambique to produce and consume these more nutritious forms of this culturally appropriate food staple (HKI 2010).

Food fortification with micronutrients is mandated in South Africa, Nigeria and Zambia, but many additional African countries have well-established voluntary fortification programmes for wheat flour, corn flour, sugar and cooking oils that have made dramatic improvements in child health and mortality (FORTAF, 2010). Cooking oils are particularly valuable candidates for vitamin A fortification, as their high fat content increases the absorption and storage capacity of vitamin A (Zeba et al. 2006). A regional initiative to fortify cooking oils in Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo is well underway (WBI 2009).

VAS programmes are well established in many African countries. Capsules are usually administered through biannual child health days. Africa saw a fivefold increase in the numbers of children receiving two capsules a year between 2000 and 2008 (UNICEF 2009). HKI developed Africa's first ever National Micronutrient Day in 1999 in Niger (Aguayo et al. 2005), which has served as a model for many other target countries. In addition to VAS, HKI's micronutrient programmes include vital education on nutrition and diet for pregnant and lactating mothers (HKI 2010).

Country	Niger	Burkina Faso	Tanzania
VAD reduction strategy	• Vitamin A capsules • Dietary diversification / home gardens	• Vitamin A capsules • Dietary diversification / home gardens	• Vitamin A capsules • Dietary diversification / home gardens
Success stories	VAS coverage improved from 20% in the early 1990s to 94% in 2005, covering 2.8 million children with 2 doses a year; developed a nutrition education programme using traditional village theatre and radio messages, increasing consumption of leafy greens, liver and mangos.	Following the eradication of polio, VAS is now part of Child Health Weeks; school and community gardens increase dietary diversity; production of orange-fleshed sweet potatoes has gone from 0 to more than 30 tonnes a year in one of the country's poorest provinces.	VAS integrated with Day of the African Child and World AIDS day, increasing coverage from 21% in 1999 to 95% in 2005; de-worming, zinc supplementation, nutrition education and promotion of orange-fleshed sweet potatoes work together to combat multiple deficiencies and infant mortality.
Status	VAS coverage more than 90%	VAS coverage at 100% by 2008	VAS coverage more than 90%
Source(s)	UNICEF 2009; UNSCN 2006b; Parlato & Gottert, 1996	HKI 2010; UNICEF 2009; Bendech et al. 2005	UNICEF 2008; A2Z 2008; HKI 2009

4.3. Latin America

Sub-clinical vitamin A deficiencies throughout Latin America were recognised as a serious health problem in the 1960s and 70s. Several decades of an integrated approach to reducing the incidence of this and other micronutrient deficiencies have dramatically improved the VAD status of both rural and urban populations. Many countries introduced VAS to national immunisation days, and coupled with a variety of food fortification programmes, most Latin American countries are no longer target countries for VAS.

Early food fortification programmes focused on sugar, and sugar fortification is now mandated in El Salvador, Guatemala, Honduras and Nicaragua (Mora 2003). Sugar that has been fortified with vitamin A is now available throughout Latin America (FAO 1988). In addition, many countries fortify staples such as wheat flour, corn flour and cooking oil.

MAS is offering new potential for increased vitamin A delivery in Central America and sub-Saharan Africa, where maize is a major staple. This work offers another tool in the effort to combat VAD with integrated, multi-tiered approaches around the world. (Vogel 2009)

Country	Guatemala	Cuba
VAD reduction strategy	• Fortification	• Vitamin packed food additives • Dietary diversification / home gardens
Success stories	One of the first governments in the world to take decisive action toward VAD, mandating sugar fortification in 1974; fortification has been shown to be a very cost effective means of reaching the population.	Government addressed VAD in 1993 with 2 initiatives: Multivit daily multivitamins, and a daily subsidised litre of milk for children under 7 years old; fresh fruit and vegetable intake increased significantly between 1993 and 2003 due to government agriculture and nutrition programmes.
Status	VAD below 5%	VAD below 5%
Source(s)	Fiedler et al. 2000	Macías-Matos et al. 2007; WHO database 2010

So-called 'golden' rice: a distraction

05

So-called 'golden' rice has been under development since 1990 (Potrykus, 2000). However, the first prototype was unveiled only in 2000 (Ye et al. 2000). Once the intention to commercialise the rice was announced, it was accompanied by a strident media campaign asserting that it could save millions of lives: the headline "This rice could save a million kids a year" appeared on the front page of Time magazine (2000). The developers also placed moral pressure on organisations or institutions opposed to the cultivation of GE crops: "The consequences will be millions of unnecessary blind children and Vitamin A deficiency related deaths." (Potrykus, 2001).

In 2004, Syngenta claimed that it had harvested the first field trial of golden rice in the US, in collaboration with Louisiana State University. It is ironic that the reason for this was that "the USA is one of the few countries in the world where field trials with transgenic (GE) plants can be carried out after complying with an acceptable, well-defined set of regulatory requirements" (Golden Rice Project 2008c). In 2006, an experimental rice variety LL601 was found to have contaminated the US rice supply chain (USDA 2006). As the US Department of Agriculture's Animal and Plant Health Inspection Service has reported, the LL601 contamination originated from Louisiana State University, the same University responsible for the first field trials of golden rice (USDA APHIS 2007). Thus, the possibility of contamination with this experimental GE rice is very real.

Golden rice was initially developed to only include increased levels of Vitamin A. Recently, however, supporters of the rice have stated their intention to genetically engineer it with other micronutrients, presumably with the understanding that VAD is routinely associated with other micronutrient deficiencies (Golden Rice Project 2008a). As discussed in section 1.1 of this report, the UNSCN has recommended a multi-tiered approach to global health in order to tackle problems such as VAD, which often exist alongside other micronutrient deficiencies as well as other health problems. In addition, the complexity of genetically engineering multiple vitamin-enhancing pathways into rice makes this a non viable approach. Such complex genetic engineering would take a very long time (if even possible) to develop and give rise to serious health concerns because of the changes induced in the plant chemistry.

Funding ‘golden’ rice

06

6.1. Initial funding

Over the last 15 years many organisations have been involved in the funding and development of golden rice. The initial stage of the development was financed by ETH Zurich, the Rockefeller Foundation, the Biotech-Programme of the European Union (as part of the Carotene Plus project) and by the Swiss National Science Foundation to a total of $2.6 million US dollars (ETH 2004).

After having successfully published their research, the inventors struck a deal with Syngenta for the next stage in 2000 and beyond: the company would develop the product and be granted the licence for golden rice for commercial use in developed countries. In return the technology would be freely available in developing countries. The cut-off amount between humanitarian and commercial use was set at $10,000 income from the rice (Potrykus 2000). However, a press release issued by Syngenta in October 2004 marked the end to the company’s commercial involvement in the project and stated that Syngenta would be donating all of its research to the Golden Rice Humanitarian Board (Syngenta 2004). At the same time the Rockefeller Foundation’s annual reports show a small number of grants were given to the University of Freiburg, Swiss Federal Institute of Technology and the International Service for the Acquisition of Agri-Biotech Applications at Cornell University for work on the rice after 2000 (Rockefeller Foundation). More significant funds were likely provided by the Indo-Swiss Collaboration in Biotechnology, which is jointly financed by the Indian Department of Biotechnology (DBT) and the Swiss Development Corporation (SDC), as well as the Indian Council for Agricultural Research (Potrykus 2000; Beyer 2002). Thus, initial funding for golden rice came from a number of different sources.

6.2. Current funding

The International Rice Research Institute (IRRI)

The International Rice Research Institute (IRRI) was established in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines. It was designed to undertake basic research on the rice plant and applied research on all phases of rice production, management, distribution and utilisation, with the objective of attaining nutritive and economic benefits for the people of Asia and other major rice-growing areas. Today IRRI has offices in 13 countries in addition to its headquarters in the Philippines (IRRI 2007).

Currently, the funding of the so-called ‘golden’ rice is often channelled though the International Rice Research Institute, which has been critical in the development of the rice. The idea to develop ‘golden’ rice came from a discussion at IRRI in 1984 and to this day IRRI is also the base of the Golden Rice Network (IRRI 2009c).

IRRI has two major funding streams: restricted and unrestricted grants. Unrestricted grants are those which the Institute may freely use for its mandated activities, which are largely unreported. Restricted contributions from philanthropic foundations are linked to specific projects and generally report where the investments are going, although few details are usually provided. IRRI receives donor support primarily through the Consultative Group on International Agricultural Research (CGIAR), an alliance of investors, members and international agricultural centres. CGIAR was established in 1971 to “reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership and leadership.” (CGIAR 2010)

Table 2. IRRI 2009 income overview (IRRI 2010a)

	Total contributions	Of which CGIAR provides
Government	46.9%	96.2%
Private sector	1.6%	0.0%
Philanthropic foundations	30.8%	1.7%
Non-profit agencies	14.4%	93.1%
Universities	0.4%	0.0%
CGIAR-specific programs	5.8%	100.0%

In 2008, IRRI received a total of $37.2 million US dollars in grant income (IRRI 2009), roughly two thirds of which was restricted grants. Table 2 outlines IRRI's 2009 funding sources for that year.

IRRI and 'golden' rice

Today the development of so-called 'golden' rice is driven by the Golden Rice Network, which is under the strategic guidance of the Golden Rice Humanitarian Board. The management of the project is carried out by a network coordinator based at the IRRI in the Philippines (Golden Rice Project 2009). The current network coordinator is Dr Gerard Barry, a former employee of Monsanto between 1995 and 2003 (IRRI 2010f).

Details of IRRI's recently received grants were analysed in order to identify the projects that are potentially connected to GE rice. Table 3 lists the findings of this analysis, but it is worth noting that it is almost certainly underestimates the Institution's financial investment in GE rice, as the use of unrestricted funds is not reported and the information provided for restricted grants is often insufficient.

The projects likely linked to golden rice have been highlighted in red in Table 3 and show that that the principal funders of IRRI in regards to the rice include the Harvest Plus program and the Rockefeller Foundation, one of the original founders of IRRI (See Table 3). Other funders via IRRI include the University of Freiburg, which has been involved from the beginning, and the United States government's foreign aid agency, USAID.

Beyond 'golden' rice, IRRI is researching the development of a number of other GE rice varieties. Most of the funds for these projects are provided by the Bill & Melinda Gates Foundation. In fact in total the Foundation has provided at least 71% of the funds available to current GE projects at IRRI (Table 3). These GE rice projects include traits for:

- drought, heat, and salinity tolerance;
- increased photosynthetic capacity to improve yield and enable more efficient water and nitrogen fertiliser use (C_4 rice); and
- increased nutritional value of the grain, including improved protein quality, and higher iron content (IRRI 2010b).

Table 3. Major IRRI grants received related to projects that include research on GE plants since 2008 (IRRI 2009, 2010c). All values in $1,000 US dollars. Grants likely related to golden rice are highlighted in red.

Donor	Grant Period	Total Grant	2008 expenditure	Previous years expenditure	Project
Gates Foundation	15/10/08 - 31/10/11	11,017	11,017	-	Creating the Second Green Revolution by Supercharging Photosynthesis: C_4-rice
Gates Foundation	01/12/08 - 31/11/11	19,954	19,954	-	The Cereal Systems Initiative for South Asia (CSISA)
China	11/01/08 - 31/10/11	4,633	4,633	-	"Green Super Rice" for the Resource-Poor of Africa and Asia
Albert - Ludwig's University of Freiburg	28/09/05 - 27/09/10	1,213	1,213	306	Engineering Rice for High Beta-Carotene, Vitamin E and Enhanced Iron and Zinc Bioavailability
HarvestPlus	01/01/03- 31/12/08	2,203	2,203	1,664	Biofortified Crops for Improved Human Nutrition
HarvestPlus	2010 - ?	n/a	n/a	n/a	Equipment support to the Workplan "Development of Golden Rice for Philippines, Bangladesh, and Eastern India"
USA (USAID)	01/01/05 – 31/12/09	385	385	59	The Development of Adapted Germplasm for India with High Levels of Pro Vitamin-A Carotenoids
Rockefeller Foundation	1/1/2009 – 12/31/2012	4,000	4,000	n/a	Golden Rice Product Development and Deployment

HarvestPlus: channelling funding to IRRI and golden rice

The 'HarvestPlus Challenge Program' was launched in 2004 when it became the first recipient of funding for bio-fortification research granted by the Bill & Melinda Gates Foundation. It is co-convened by two CGIAR centres: the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI) (HarvestPlus 2010). The goal of HarvestPlus is to deliver micronutrients to people in the global south affected by hunger. This is done through bio-fortification to breed higher levels of micronutrients directly into key staple foods.

While most of the work being done by HarvestPlus to bio-fortify staple foods relies on traditional plant breeding techniques, genetic engineering of plants is a key component of HarvestPlus activities.

According to CGIAR, HarvestPlus funds a portion of the upstream research on golden rice under its biotechnology component (CGIAR 2007). HarvestPlus provided $2.2 million US dollars to IRRI for the project titled Bio-fortified Crops for Improved Human Nutrition' (Table 3), which includes some golden rice development (CGIAR 2002). In addition to developing GE plants, this funding is also being used to implement the marketing and promotion of these GE plants, including rice (Partnership for Sustainable Development 2004).

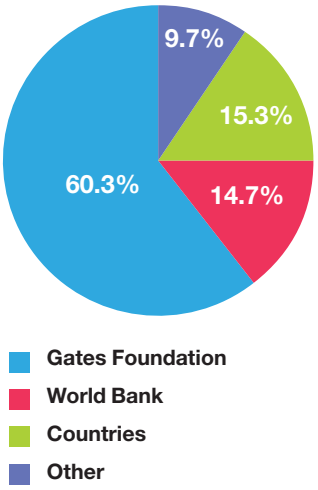
The value of the HarvestPlus-funded project Equipment Support to the Workplan Development of Golden Rice for Philippines, Bangladesh, and Eastern India" (Table 3) is unknown, but, from the title, this work is clearly devoted to the 'golden rice' effort.

Overall, the vast majority of funding to HarvestPlus in recent years has been provided by the Gates Foundation in the form of unrestricted grants, making it impossible to estimate what percentage of these funds have been used in the development and research of golden rice and other GE crops. In total the Gates Foundation is estimated to have provided 60% of all the unrestricted grants received by the HarvestPlus program between 2003 and 2010 (See Figure 2). Other donors include the World Bank (15%) and various countries (15%) (Table 4) (HarvestPlus 2009).

Table 4. Unrestricted grants received by HarvestPlus in $million US dollars (HarvestPlus 2009, 2007)

Donor	2003/04	2005	2006	estimate 2007	2008	estimate 2009	projected 2010
Gates Foundation	6.25	6.25	7.75	7.75	10.35	13.95	11.15
World Bank	5.50	2.00	2.00	2.00	2.00	2.00	
UK		0.45	1.36	0.95	1.02	3.34	
USA		1.80	2.36	2.05	0.45	0.04	
Other countries		0.60	0.93	0.40	0.14	0.15	
Syngenta Foundation						0.90	
International Life Sciences Institute			0.20	0.71			
Others	0.17	0.16	0.69		0.27	0.28	6.77
Total	**11.92**	**11.27**	**15.28**	**13.86**	**14.23**	**20.65**	**17.92**

Figure 2: How grants received by HarvestPlus 2003-2010 (HarvestPlus2009) are apportioned



The Gates Foundation

The Bill & Melinda Gates Foundation, which was founded in 1994, is directed by Bill and Melinda Gates and Warren Buffet, who are also the key contributors to the foundations asset trust endowment of $33 billion US dollars. (Bill & Melinda Gates Foundation 2010). The Foundation started out making grants in areas such as global health and US libraries before expanding to include US education and global development. When Warren Buffet came onboard in 2006, the grant-making ability doubled (Bill & Melinda Gates Foundation 2010b) and is now widely considered the world's largest philanthropic foundation (MSNBC 2008).

The Bill & Melinda Gates Foundation is emerging as a key driver of the development of GE crops such as rice and potentially also golden rice. Even though the Rockefeller Foundation provided the initial funding for the project and has recently given another significant grant, the Bill & Melinda Gates Foundation provides the CGIAR HarvestPlus programme with unconditional funding. In turn, HarvestPlus provides funds to IRRI for, among other projects, the development of Golden Rice.

The Bill & Melinda Gates Foundation has pledged more than $120 million to HarvestPlus (Table 5) via the International Food Policy Research Institute for the purpose of supporting "the activities of the HarvestPlus Challenge Programme to reduce micronutrient deficiencies in developing countries by breeding higher levels of essential micronutrients into staple crops" (Bill & Melinda Gates Foundation 2010). With the Foundation funding such a large proportion of HarvestPlus, it is possible if not likely that some of this funding has been used in IRRI's development of Golden Rice. However, because the detailed funding agreements are not made public it is not possible to confirm the extent to which funds provided by the foundation are used in the development of the rice.

Table 5. Funds pledged to HarvestPlus by the Bill & Melinda Gates Foundation, in US dollars (Bill & Melinda Gates Foundation 2010a)

Year	2003/04	2005
2009	5 years	$ 45,000,000
2008	5 years	$ 45,000,000
2007	1 year	$ 8,850,000
2003	4 years	$ 25,000,000
Total		**$ 123,850,000**

Below: Organisations likely to be involved in the funding and development of 'golden' rice

Conclusions 07

There is ample evidence that the so-called 'golden' rice is a misguided answer to vitamin A deficiency and malnutrition that will have minimal impact while costing millions of dollars. Instead, those funds would be more wisely invested in successful VAD treatment programmes, already tried and tested in many countries. By looking at the root causes of vitamin A deficiency, projects such as Homestead Food Production have tackled not only VAD, but also other vitamin and mineral deficiencies in the process. Those genuinely concerned with the eradication of VAD face a choice; devote additional resources to untested, costly experiments which stand to endanger the diversity of rice genetic resources, or scale up existing and proven solutions, without any risk of genetic contamination.

Greenpeace calls on IRRI to:

1. Stop field trials of 'golden' and other GE rice.
2. Stop GE rice research programmes
3. Shift research funding towards ecological rice farming that is resilient to the impacts of climate change.
4. Focus investment and research on improving the ecological aspects of rice production and moving from synthetic to organic fertilisers, phasing out chemical pesticides and developing ecological state-of-the-art solutions to rice production.

Greenpeace calls on investors in golden rice to change their approach to one clearly aimed at scaling up funding for existing and successful programmes of VAD eradication. This challenge is aimed primarily at those funders who - like the Bill & Melinda Gates Foundation, the Rockefeller Foundation and others – possess substantial resources and are offering growing support for GE-driven fixes to global food security issues. 'Golden' rice is not necessary and takes funding away from available solutions to VAD.

Greenpeace promotes ecological farming that ensures healthy farming and healthy food for today and tomorrow, by protecting soil, water and climate, promotes biodiversity, and does not contaminate the environment with chemical inputs or genetic engineering.

Appendix 1

UNICEF priority VAS Countries	Percentage receiving 2 doses a year			
Country Name	**1999**	**2003**	**2005**	**2008**
Afghanistan	67	85	91	96
Angola	0	68	65	82
Antigua and Barbuda				90
Azerbaijan				
Bangladesh	79	87	82	97
Belize				
Benin	0	95	92	52
Bhutan				
Bolivia	68	38	39	45
Botswana				
Burkina Faso	0	80	95	100
Burundi	0	0	17	80
Cambodia	55	47	65	88
Cameroon	0	21	95	
Cape Verde				
Central African Republic				68
Chad				0
Colombia				
Comoros				20
Congo	0	0	9	10
Congo, Democratic Republic of the				85
Costa Rica				
Côte d'Ivoire				
Cuba				
Djibouti	0	0	0	86
Dominican Republic				
Egypt				68

UNICEF priority VAS Countries	Percentage receiving 2 doses a year			
Country Name	**1999**	**2003**	**2005**	**2008**
Equatorial Guinea				
Eritrea	0	0	50	49
Ethiopia	86	22	59	88
Gabon				0
Gambia	0	52	16	28
Ghana	0	78	95	24
Guatemala				20
Guinea	0	93	95	94
Guinea-Bissau				66
Guyana				
Haiti	0	0	42	
Honduras				
India	0	45	64	53
Indonesia	0	62	76	86
Iran (Islamic Republic of)				
Iraq				
Jamaica				
Jordan				
Kazakhstan				
Kenya	0	0	69	27
Kiribati				
Korea, Democratic People's Republic of			98	
Kyrgyzstan				99
Lao People's Democratic Republic				
Lesotho	0	75	2	
Liberia				
Macedonia, The former Yugoslav Republic of				

UNICEF priority VAS Countries	Percentage receiving 2 doses a year			
Country Name	**1999**	**2003**	**2005**	**2008**
Madagascar	0	84	95	97
Malawi	0	14	86	95
Malaysia				
Maldives				
Mali	0	61	66	97
Marshall Islands				
Mauritania				87
Mauritius				
Mexico				
Micronesia (Federated States of)				
Mongolia				
Morocco				
Mozambique	0	0	16	83
Myanmar	0	87	95	94
Namibia				
Nepal	85	96	96	93
Nicaragua				
Niger	80	68	94	92
Nigeria	0	0	73	74
Occupied Palestinian Territory				
Oman				
Pakistan	0	95	95	97
Panama				
Papua New Guinea	0	0	0	
Peru				
Philippines	78	76	85	86
Rwanda	75	8	99	

UNICEF priority VAS Countries	Percentage receiving 2 doses a year			
Country Name	**1999**	**2003**	**2005**	**2008**
Saint Vincent and Grenadines				
Sao Tome and Principe				23
Senegal				90
Sierra Leone	20	84	95	12
Somalia				100
South Africa				39
Sri Lanka				
Sudan	31	0	90	67
Swaziland	0	0	40	44
Syrian Arab Republic				
Tajikistan				87
Tanzania, United Republic of	21	91	95	93
Thailand				
Timor-Leste				
Togo	0	72	92	64
Turkmenistan				
Uganda				67
Uzbekistan				38
Viet Nam				98
Yemen	0	0	15	
Zambia	0	73	66	96
Zimbabwe	0	0	81	20

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