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GOLDEN LIES:

The Seed Industry's Questionable Golden Rice Project

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A foodwatch report
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Content

Summary

Golden Rice is set to be launched on the market after over 10 years of research and development. If everything goes according to the product developers' plans, Golden Rice will be commercially cultivated starting in 2013. Advocates maintain that there is no alternative to this genetically engineered rice variety in the fight against vitamin A deficiency and accuse government agencies and critics of endangering the lives of millions of children. Some even go as far as to charge government agencies and critics of being complicit in bringing about a "Holocaust" (Chassy, 2010). To speed up market approval and limit expenses, they demand a general loosening of standards for the risk assessment of genetically engineered plants (Potrykus, 2010).

This report shows that the managers of the Golden Rice project have demonstrated a disregard for necessary scientific accuracy and precision. They have employed propagandistic methods to push the project beyond the issue of vitamin A deficiency, setting a precedent to increase the pressure on regulatory authorities and accelerate the introduction of agricultural biotechnology.

It is still not possible to judge whether or not Golden Rice is even technically able to combat vitamin A deficiency. No data has been made available on the degradation rate of its carotenoid content (in particular during storage), nor on its bioavailability. Any risks posed by the cultivation or consumption of Golden Rice have been largely ignored. Very little data is available on new active ingredients and changes in the metabolism of the plants, and on the reaction of the plants to changing environmental conditions. So far not a single feeding study on the rice has been published. In spite of all this, a trial has already been conducted on Chinese school children.

It is highly likely that the commercial cultivation of Golden Rice will lead to the irreversible entry of this genetically engineered organism into the environment and to its crossbreeding with local rice varieties. It is not scientifically possible to predict the long-term ecological consequences.

We call on the managers and funders of the project to ensure that comprehensive and independent risk assessment studies be conducted, and to publish the technical data that to this day remains unavailable. The managers of the project should finally agree to participate in an open discussion on risks posed by the Golden Rice project. Available alternatives should be examined more carefully before the project proceeds any further.

Various reports refer to the significant progress that has been made in the fight against vitamin A deficiency in developing countries over the past 10 years. Efficient and low-cost programs that enjoy and offer a high degree of acceptance and reliability, and that can also be very precisely implemented, do exist. In view of this, the scheduled market release of Golden Rice is by no means without an alternative.

1. Introduction

The creators of this genetically engineered rice variety, which is able to generate carotenoids, precursors of pro-vitamin A, named it Golden Rice because its altered metabolism makes the polished rice grains take on a yellow color. The human body can convert carotenoids and use them as a source of vitamin A. Golden Rice is intended for use in the fight against vitamin A deficiency (VAD), which is particularly prevalent in developing countries.

Foodwatch published its first report on Golden Rice in 2009 (Then, 2009). The report revealed that 10 years after the first generation of the genetically engineered rice had been produced, neither its practical suitability to combat vitamin A deficiency nor the risks it posed could be assessed. Work on the product has continued since then, and in spite of a lack of safety data, managers of the Golden Rice project tested the genetically engineered rice on school children in China as early as 2009. In addition, trial testing was conducted on volunteers in the United States. The first crop of the genetically engineered rice from a field release experiment was harvested in the Philippines in 2011. The Bill & Melinda Gates Foundation granted the International Rice Research Institute (IRRI) USD 10 million to promote the seed's commercial release. This new report takes stock of the current situation. It will also take a look at the communication strategies that have accompanied the project.

1.1 Vitamin A deficiency and possible solutions

The aim of the Golden Rice project is to combat widespread vitamin A deficiency, which is a problem in many developing countries. Among other things, this form of malnutrition can lead to eye and skin diseases, to disorders of the immune and reproductive systems, and cause growth deficiency in children. Even mortality is attributable to vitamin A deficiency. The World Health Organization (WHO) estimates that some 190 million children suffer from vitamin A deficiency worldwide, although the range of acute health hazards varies. Children in Africa and Southeast Asia are the most severely affected (WHO, 2009). According to estimates published in 2008 (Black et al., 2008), every year vitamin A deficiency claims the lives of some 670,000 children and causes more than 250,000 children to go blind.

According to a UN report (UNSCN, 2010), the reduction of vitamin A deficiency rates in several regions of the world has come close to the millennium development goal of halving the number of people affected by malnutrition by 2015. Encouraging progress has been made, especially in North Africa, Central and South America, in eastern Asia, and in the Caribbean. However, significantly more effort must be put into reducing deficiency rates in southern and central Asia, and in southern and central Africa. The report considers the vitamin fortification of foodstuffs such as sugar to be a particularly effective strategy in fighting vitamin A deficiency.

A report published jointly by UNICEF, the World Bank and other organizations (Flour Fortification Initiative, GAIN, Micronutrient Initiative, USAID, the World Bank, UNICEF, 2009) confirms the progress made in the reduction of vitamin A deficiency. The report states that the number of people reached by vitamin supplementation programs offered by aid organizations increased fourfold between 1999 and 2007. This corresponds to roughly 80 percent of the target group in the regions most severely affected. The current goal is to supply the remaining 20 percent with suitable supplements. The authors believe that suitable and cost-effective solutions are available. All experts and institutions involved agree that a mix of measures tailored to regional conditions are necessary to combat vitamin A deficiency: these include breastfeeding, the local cultivation of vegetables, the use of palm oil, raising fish in rice paddies, fortification of Vitamin A in staple foods such as sugar, and the distribution of Vitamin A supplements.[1] Thanks to conventional breeding techniques, new varieties of plants such as cassava and maize with improved vitamin A content are available and also promise to be successful.[2]

As we can see, a number of measures and successful programs are already in place to combat vitamin A deficiency. These have achieved significant headway in many regions of the world in spite of financial and political restrictions. On its website, WHO for instance states:[3]

> *In 1998 WHO and its partners – UNICEF, the Canadian International Development Agency, the United States Agency for International Development, and the Micronutrient Initiative – launched the Vitamin A Global Initiative. In addition, over the past few years, WHO, UNICEF and others have provided support to countries in delivering vitamin A supplements. Linked to sick-child visits and national poliomyelitis immunization days, these supplements have averted an estimated 1.25 million deaths since 1998 in 40 countries.*

The Golden Rice project was first presented to the public in 1999. But contrary to initial expectations, it did not deliver simple solutions. Conditions surrounding the fight against vitamin A deficiency have greatly improved since the project was first launched. Efficient and cost-effective programs exist that have been proven to work in practice (for more information see also: Greenpeace, 2010).

Moreover, compared to Golden Rice, the programs in place are considerably more focused and reliable. For instance, one problem with Golden Rice is that its characteristic color could cause it to be confused with other conventional reddish rice varieties. As Golden Rice would probably fetch a higher price than conventional rice varieties, it could invite criminal activity in countries in which red and yellow rice varieties exist or where yellow spices such as turmeric are used in rice dishes. Buyers would then be led to believe that they were getting enough vitamin A when in fact they were not.

Another problem is that in cases of outcrossing to local rice varieties, substantial fluctuations can occur in the rice's vitamin A content. The genetic construct is not always reliably passed on from one rice plant to the following generation of plants (Chikkappa et al., 2011). It is therefore questionable whether a Golden Rice crop would actually reach the regions most in need. In contrast, vitamin A supplements, for example, can be very precisely targeted and administered. The required daily dose can be achieved much more reliably in food staples such as flour and sugar that have been fortified with vitamin A. Against this background, it becomes obvious that there are in fact alternatives to the planned market launch of Golden Rice, and the organizations involved, such as UNICEF and WHO, in no way see it as the method of choice (Enserink, 2008).

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1 See e.g.: http://www.who.int/nutrition/topics/vad/en/

2 See e.g.: http://www.vanguardngr.com/2010/10/stakeholders-plan-release-of-vitamin-a-cassava-in-nigeria/ and: http://www.theecologist.org/News/news_analysis/1159571/can_gmfree_biofortified_crops_succeed_after_golden_rice_controversy.html

3 http://www.who.int/nutrition/topics/vad/en/

1.2. History

The Golden Rice project was initiated back in the 1980s. We can differentiate two stages. The first variety of the genetically engineered rice was presented to the public in 2000 (Ye et al., 2000). At the time, several observers criticized the very low carotenoid content, which was also confirmed by researchers at the University of Hohenheim. The rice they had intended to test with mice was found to contain only very minimal concentrations of the vitamin A precursor (see Then, 2009).

In 2005, the agribusiness corporation Syngenta published data on a genetically engineered rice variety that contained considerably higher amounts of carotenoids (Paine et al., 2005). According to their findings, the rice contained 8.8 to 36.7 micrograms of carotenoid per gram of dry rice. Even more importantly, concentrations of essential beta carotenoids were found to be very high. The managers of the Golden Rice project took the view that such a high level of carotenoids meant that a bowl of rice per person each day would suffice to make a substantial contribution to reducing vitamin A deficiency (Paine et al., 2005).

Table 1 provides a brief outline of the 25-year history of the Golden Rice project. The hope of making simple technical solutions available with the help of genetically engineered plants to combat poverty issues such as vitamin A deficiency never materialized.

Year	Project stage
1984	The idea for the Golden Rice project is developed during a conference in the Philippines.
1999	The first generation of Golden Rice is produced.
2000	It is announced around the world that this rice could save the lives of millions of children.
	A patent for the rice is filed (WO2000/053768).
2004	A second generation of Golden Rice is produced with substantially higher concentrations of carotenoids.
	A patent is also filed (by Syngenta)for this new variety (WO2004/085656).
2005	Managers of the project accuse critics and government authorities of being complicit in the death of children.
2009	The results of experimental tests with five volunteers are published. The aim of the tests was to find out whether carotenoids in the rice could be biologically absorbed.
	Reports surface about tests with Chinese school children.
	At a conference held by the Vatican, representatives of the Golden Rice team demand a significant loosening of safety standards for the market release of genetically engineered plants.
2010	Advocates maintain that the failure to grant Golden Rice cultivation approval had already caused millions of deaths ("Holocaust" accusation).
2011	A trial Golden Rice crop is harvested in the Philippines. The Gates foundation grants the International Rice Research Institution (IRRI) another USD 10 million for the Golden Rice project. Commercial cultivation is scheduled to begin in the Philippines in 2013 and 2017 in Bangladesh.

Table 1: Chronological timeline of the development of the Golden Rice project

2. Lack of technical data

This section discusses the rate of carotenoid degradation and its bioavailability (absorption and conversion rate). It is important to study the degradation rate to assess how much carotenoid content the rice loses during storage and cooking. Bioavailability studies tell us how effectively the body converts carotenoids into essential vitamin A.

2.1 Degradation rates

Golden Rice is only qualified for the fight against vitamin A deficiency if it does not lose drastic amounts of carotenoids during storage and cooking. Although it is relatively easy to determine carotenoid content, very little, if any, data has been made available on this issue to date. Although carotenoids seem to survive the cooking process (Tang et al., 2009), systematic trials with different cooking processes (boiling, steaming, frying) and their respective carotenoid content loss have not yet been published.

Data is also missing regarding the shelf life of the rice. How and to what extent temperature, light and air humidity affect the degradation rate of its carotenoid content is one of the most decisive factors in assessing the potential of Golden Rice. Rice is frequently stored for months after harvesting before it is finally consumed. It is almost certain that significant losses in carotenoid content occur during this time. WHO also points out that storage, among other things, can result in carotenoid content loss (WHO, 2006). Tang et al., (2009), who conducted the first trial studies with volunteers in the United States, stored their rice at –20 degrees Celsius or even –80 degrees Celsius prior to cooking. Loss of carotenoid content is unlikely at temperatures this low. However, reliable data is still lacking on the shelf life of the rice under realistic conditions. Such information remains unavailable to date in spite of the fact that managers of the Golden Rice project have repeatedly announced its publication (see Then, 2009).

2.2 Bioavailability

Tang et al. (2009) published the first data on the conversion rate (or biological availability) of carotenoids generated in Golden Rice. These findings were obtained in trial tests with five adult volunteers (three women and two men) in the United States (see above). The researchers grew the rice used in these tests in a special greenhouse and watered it with water containing added deuterium. This enabled them to spot the deuterium-labeled carotenoids in the human body later on. The rice used in the test contained only 7.6 µg carotene per gram; this is based on the figures of 1.53 mg to 200 g provided in the study. In comparison, the highest concentration detected in Golden Rice by Paine et al. in 2005 was 36.7 µg/g. Even the lowest amount measured in that study was higher than the amount contained in the rice used in the test in the United States. Tang et al. (2009) do not state why the carotenoid content was so low in the rice used.

In their study, Tang et al. (2009) determined a conversion rate of roughly 4 to 1; in other words, 4 mg of carotene obtained from the rice was converted into 1 mg of vitamin A. There was considerable variability among the test persons. Such a conversion rate is nevertheless clearly higher than that of most types of vegetables. However, it is still lower than the bioavailability of vitamin A contained in capsules. Butter was added to the rice during the test, as fats are needed for the absorption of carotenoids. Tang et al. (2009) do not discuss what the conversion rate of Golden Rice might be like under realistic conditions in developing countries.

In view of the test results, the authors conclude that children who consume 50 grams of uncooked genetically engineered rice on a daily basis would be getting over 60 percent of their recommended dietary allowance of vitamin A.[4] This could be achieved on condition that the carotenoid content of the rice is at least 20 to 30 µg/g – a value not reached by the rice used in the test.

The authors conclude that Golden Rice is a suitable instrument against vitamin A deficiency. In his analysis of the Tang et al. (2009) study, Krawinkel (2009) warns against such general conclusions. He points out that the values measured show a high level of variability and that the number of test persons was insufficient. He criticizes the fact that the subjects chosen for the study were very different in terms of their physical constitutions, making the evaluation of their data difficult. Moreover, the diet administered during the test was not suitable to study the conversion rate of carotenoids in persons suffering from malnutrition. Since the study cited (Tang et al. 2009) is the only publication to date regarding the bioavailability of carotenoids from genetically engineered rice, it seems that a careful evaluation of its conclusions is in fact necessary. For instance, rice with butter is rather unusual in developing countries. It is not clear what other oils and fats would have to be consumed with the rice to enable the absorption of carotenoids in the intestine under realistic conditions.

There were also reports in 2009 on trials with Chinese school children (see below), but findings have not been published so far. Moreover the Golden Rice website mentions that feeding trials were carried out with adults in China.[5] No data is available on these studies either.

2.3 Environmental factors

The research conducted by Tang et al. (2009) raises the question as to the real level of concentration of carotenoids in the rice studied. The very low carotenoid content cited by Tang et al. (2009) is particularly conspicuous. It is generally known that the concentration of components in plants can depend on interactions between the environment and the genotype. Genetic characteristics of the different varieties into which Golden Rice genes have been introduced can also be influencing factors.

In transgenic plants, the added genes can bypass natural gene regulation. Among other things, natural gene regulation monitors plant growth and reproduction, and is also responsible for the ability of plants to adapt to changing environmental conditions. In many cases, little is known about their genetic stability under changing environmental conditions. For instance the concentration of Bt toxins in genetically engineered maize varies greatly, but the causes have not yet been completely explained (Then & Lorch, 2008).

4 This calculation is based on the Recommended Dietary Allowance (RDA) established by the US National Academy of Science, which recommends a daily intake of 400 µg of retinol.

5 http://www.goldenrice.org/Content2-How/how3_biosafety.html

3. Risks

As technically engineered products, transgenic plants must undergo specific safety testing. The approval criteria are a matter of controversy. While the majority of member states of the EU call for stricter testing standards,[6] managers of the Golden Rice project advocate significantly laxer testing standards and a faster authorization process (Potrykus, 2010).

Overall, it is striking how little data on Golden Rice has been published thus far. According to a letter from the Rockefeller Foundation, one of the project's sponsors, to the consumer rights organization foodwatch in February 2009, managers of the Golden Rice project have already contacted four countries in Asia regarding authorization for cultivation. In this context, it is possible that more data has been collected, but it has not yet been scientifically published. However, to ensure sufficient transparency and the quality assurance needed for the project, this data must be published in scientific journals. Only then can independent experts review the data. The highest possible degree of transparency is essential in a project that has such lofty humanitarian goals.

3.1 General risks posed by transgenic plants

In the case of Golden Rice, DNA technology is used to manipulate the genome of the plants by inserting an additional metabolic pathway. This causes carotenoids, new components not previously found in rice grains, to be generated. It is not unlikely that this new metabolic pathway will also cause the original genes of the plants to act to differently. As experiments show, the effect of genetic manipulation is not just limited to specific gene segments, but can also influence the activity of thousands of other genes (Batista et al., 2008).

Various experts have pointed out that mutagenesis or crossbreeding causes a higher number of genes to demonstrate altered activity than transgenesis does (e.g., see Batista et al., 2008, ILSI, 2008). Changes in gene activity are in fact quite common in breeding processes. Plants also naturally react to environmental conditions by adapting their gene activity. Reproduction and growth also cause the activity of many genes to change simultaneously. The number of changed genes is of little importance, since individual DNA segments in their entirety are controlled by the complex mechanisms of natural gene regulation; a flexible system that reacts to changes in conditions synchronizes gene activity.

Unlike in mutagenesis or crossbreeding, the mechanisms of natural gene regulation are not used in genetic engineering; on the contrary, they are intentionally bypassed. The gene regulation system of the plants is not the focal point, but rather the effect of the specific components that are introduced like building blocks. The activity of the inserted genes is regulated by promoters that are not subject to general gene regulation in plants, and that regulate the expression of the inserted genes. This is why plants are unable to control the new metabolic pathway.

6 Council Conclusions on Genetically Modified Organisms (GMOs), 2912th Environment Council meeting, Brussels, 4 December 2008, http://www.consilium.europa.eu/uedocs/cms_Data/docs/pressdata/en/envir/104509.pdf

Some plants respond to the introduction of foreign genes by switching off or deactivating the newly inserted genes, a phenomenon referred to as gene silencing. This is a natural protective mechanism found in plants to ward off contamination with viral DNA (Finnegan & McElroy, 1994). To prevent the inactivation of technically inserted gene constructs and ensure their biological expression, promoters are used to force activation of the inserted genes.

In other words, scientists attempt to use genetic engineering to reprogram plants; in contrast, conventional breeding utilizes the natural genetic potential in plants and their gene regulation system. This difference is significant for both the clarification of health risks and the assessment of consequences of an entry of transgenes into ecological systems and the gene pool of wild and cultivated plants (see below). Any changes in the expression of original genes in plants caused by the insertion of additional genes must always be carefully examined because this could be an indication of a disruption in the normal gene regulation system. As transgene insertion in plants is in no way a targeted procedure, but rather a random process, scientists must also expect unintended position and pleiotropic effects (when a gene influences several traits simultaneously).

Genetic intervention can result in a whole series of biological effects relevant to risk assessment. Possible reactions include a general weakening of plants (increased susceptibility to disease, lower yields), decreased tolerance to stressors (such as climatic conditions), but also improved fitness (for example, the increased production of pollen and seeds), or the production of unwanted (antinutritive, immunogenic or toxic) components.

In Golden Rice for example, there is an unintended change in the makeup of carotenoids in stalks (Schaub et al., 2005). The newly inserted genes are active in the entire plant, not only in the grains, so they also interact with components in the green parts of the plant. It is not clear what effect this has on the plant as a whole.

There is the likelihood that certain environmental conditions trigger unintended reactions in transgenic plants, or that it might take several generations for these reactions to occur. Systematic studies of the interaction between genetically engineered plants and their environment are currently not required within the framework of the EU approval process. But the increasing number of publications addressing unintended traits in genetically engineered plants, e.g. in petunias (Meyer et al., 1992), cotton and maize (see Then & Lorch, 2008), potatoes (Matthews et al., 2005), wheat (Zeller et al., 2010) and soy (Gertz et al., 1999) show how badly studies are needed.

The above-mentioned study of genetically engineered wheat demonstrated that, in contrast to greenhouse plants showing no unexpected reactions, field-grown plants had a much lower yield and demonstrated higher rates of infestation with the extremely toxic ergot fungus. This shows how relevant these questions are for risk assessment (Zeller et al., 2010).

There has been very little research so far on the interactions between genetically engineered plants and their environment. Therefore Zeller et al. (2010) demand that studies on the ecological behavior of transgenic plants be conducted. Then & Potthof (2009) recommend that stress tests be introduced. This refers to systematic studies of the reaction of transgenic plants to environmental factors under controlled conditions.

3.2 Health risks

Rice is one of most important staple foods for the human population. It is therefore imperative that we take a very close look at the long-term safety of transgenic rice. To assess the safety of Golden Rice, we must first collect data on the concentration of substances, metabolites and gene expression. Building on this, the next step should be to conduct further studies, such as testing for subchronic toxicity and immunogenic or antinutritive effects.

3.2.1 Research on substances

Surprisingly, there are currently no publications of systematic studies available in which the substances and metabolic profiles of Golden Rice are compared to those of conventional parent plants. But the Golden Rice project website claims that such studies show that differences in metabolism are negligible:[7]

> *Gene expression profiling of thousands of genes was carried out, showing no unexpected changes or gross perturbances in the expression profile as compared to the parent material.*

There is no reference to a publication of these findings. Schaub et al. (2005) published the only study that examined the influence of newly introduced genes on the plant's genome. The paper discussed why genetically engineered rice had its characteristic yellow color. Originally, the scientists who developed the rice had expected grains to be red due to the genes they had inserted. Rice grains were supposed to generate red carotenoids, so-called lycopenes like those found in tomatoes. The authors revealed in their study that the original genes of the plant unexpectedly caused the lycopenes to be converted into yellow carotenoids. The yellow color giving the rice its name (Golden Rice) was the outcome of an unintended reaction, caused by interactions between inserted genes and the genome of the plants. Moreover, the authors (Schaub et al., 2005) determined that the newly inserted genes altered the metabolism of the stalks of Golden Rice plants, causing substances within the carotenoid group to shift. However, the precise mechanisms that provoke this metabolic change and their potential effects are unknown.

Schaub et al. (2005) also measured the metabolic activity of some of the original genes of plants that did not show any irregularities. Schaub et al. (2005) announced that further research on the metabolic profile of plants would be conducted, but corresponding data has not yet been published.

Overall, the data available is rather limited, although it is safe to assume that not all data has been published. As with the question regarding the technical quality of their rice, it is incomprehensible why those involved in the project have not yet published vital data that is essential for the risk assessment of genetically engineered rice.

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7 http://www.goldenrice.org/Content2-How/how3_biosafety.html

3.2.2 Feeding trials

Animal feeding trials to test any potential health risks posed by transgenic rice have not been carried out (or at least not published). Even corporations such as Monsanto conduct feeding trials as part of the regulatory process. Testing methods and the interpretation of findings are the subject of scientific controversy (for an overview, see Then & Potthof, 2009). Various experts have repeatedly criticized current testing methods as inadequate (see for example: Seralini et al., 2011). But the managers of the Golden Rice project would like to completely bypass any such feeding studies. Instead, they point out that such tests are not mandatory. They also claim that the biological availability of carotenoids can only be tested directly on humans:[8]

> *Animal testing is not mandated by FDA, and, as animals metabolise beta-carotene differently from humans, would not have answered the human bioavailability and bioconversion questions which need to be answered for Golden Rice relative to beta-carotene delivered in capsule form, or in spinach.*

When the news broke in February 2009 that the managers of the Golden Rice project had carried out tests with Chinese school children, a public debate ensued in Britain and around the world. The issue was whether it was ethically and medically responsible to conduct such tests on humans without previous animal feeding trials.[9] Representatives of the Golden Rice project denied any wrongdoing and flatly rejected demands for further risk assessment. Adrian Dubock, Golden Rice project manager and formerly an employee of Syngenta, was quoted in the British newspaper the Daily Mail as saying:

> *The Golden Rice contains the food colours found everywhere in coloured natural foods and the environment. There is no possible way the trials could do any harm to the participants.*

Other scientists and advocates voiced similar opinions in a letter to the Daily Mail which could be found for a while on the Golden Rice website:

> *The experiments were no more dangerous than feeding the children a small carrot since the levels of betacarotene and related compounds in Golden Rice are similar. Contrary to the assertions published in the Daily Mail, betacarotene itself is safe to consume at levels far in excess of those present in Golden Rice. The objections to these studies make as much scientific sense as objecting to giving the children a vitamin pill.*

The experts quoted compared the potential health risks that could result from the consumption of genetically engineered rice to the risk posed by eating a carrot. Without ever having presented a comprehensive analysis of the substances contained in Golden Rice, or having conducted animal feeding trials, these experts claimed it was not necessary to assess health risks, because they did not exist.

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8 http://www.goldenrice.org/Content2-How/how3_biosafety.html

9 http://www.dailymail.co.uk/news/worldnews/article-1147635/British-scientists-condemn-using-children-GM-food-trials-unacceptable.html

3.2.3 Further research is essential

Various studies of genetically engineered plants prove that the line of argument presented by the managers of the Golden Rice project does not hold up to scientific scrutiny. Jiao et al. (2010) show how important it is to investigate the substances and the metabolism of transgenic plants in detail.

They studied three different varieties of genetically engineered rice that had been rendered resistant to fungus and insect infestation. All three varieties demonstrated significant and unintended changes in their metabolisms. Amino acids, proteins, vitamins and minerals were among the substances affected. Jiao et al. (2010) point out that testing methods for metabolic changes have improved in recent years. Researchers can now detect changes in plants that were previously overlooked.

Moreover, in a study of genetically engineered peas, certain health risks became apparent only after specific testing had been conducted. In this particular case, researchers had been working with transgenic peas for about 10 years without having detected any risks. Only when the researchers carried out more detailed animal trial feeding did it become clear that the transgenic peas were causing considerable damage to the animals' immune systems (Prescott et al., 2005, Valenta & Spök, 2008). The only study commissioned to date by the managers of the Golden Rice project to assess potential risks to the immune system is a data bank comparison with allergenic proteins. No indications of allergenicity were found.[10] But no empirical studies were conducted to substantiate the assumption derived merely from a comparison.

Following their initial tests with volunteers in the United States, Tang et al. (2009) also assume that further testing would be necessary to assess the safety of Golden Rice:

> *A much longer exposure with a larger cumulative consumption of Golden Rice would be needed to make definitive assertions regarding the inherent safety of this food for human use.*

Therefore it is untenable and irresponsible for the managers of the Golden Rice project to believe that health risks need not be investigated in greater detail.

It is nearly impossible to determine the influence on human health of a single new or genetically engineered food once it has received market approval. The large number of potential influencing factors makes respective studies very difficult. The EU Commission has also pointed this out (European Communities, 2005). Against this background, particular importance must be placed on research that precedes the approval of transgenic plants. Golden Rice is no exception.

Specific announcements regarding further risk assessment studies of Golden Rice were made in 2011. First, the International Rice Research Institute (IRRI) would assess the safety of the plants in accordance with international standards. Then it would be up to Helen Keller International (HKI), a worldwide non-governmental organization also active in the Philippines, to evaluate whether the rice was in fact suitable for human consumption and whether it actually provided the required levels of vitamin A.[11]

10 http://www.goldenrice.org/Content2-How/how8_tests.html

11 http://irri.org/knowledge/publications/rice-today/features/golden-grains-for-better-nutrition
http://www.hki.org/reducing-malnutrition/biofortification/golden-rice/

These announcements regarding further evaluation were welcome news, but the time frame involved is very short – IRRI expects commercial cultivation of the rice to begin as early as 2013. Besides, the impartiality of the institutions involved is doubtful. Gerard Barry is the project's coordinator at IRRI and a former Monsanto employee.[12] Monsanto, an American corporation, is the world leader in genetically modified plants. What's more, IRRI has secured for this project the services of Seed Stories, a communications consultancy[13] whose clients include industry associations such as CropLife International and corporations like Monsanto.[14] Helen Keller International receives donations from food corporations and the pharmaceutical industry. Monsanto has also been supporting HKI for years.[15]

3.3 Environmental risks

The developers of Golden Rice argue that since rice is predominantly a self-pollinating (autogame) plant, outcrossing to neighboring rice fields or varieties of wild rice could only occur in extremely rare cases. But the studies quoted on the Golden Rice website on this subject are generally old. New findings show that pollen flow also plays an important role in self-pollinating varieties.

When transgenic rice is released in regions where weedy rice (a type of wild rice) grows, the transgenic rice can outcross to weedy rice through pollen flow. Wild rice varieties are very common in many agricultural regions (Ferrero, 2003; Chen et al., 2004). Genetic crossing between the rice cultivated in fields and the wild varieties that grow in neighboring surroundings takes place quite extensively (Chen et al., 2004). Under these circumstances, the uncontrolled proliferation in the environment of a genotype whose natural gene regulation has been modified by a technical application can hardly be prevented. There is the possibility that alien genes can spread to and accumulate in rice plants' weedy relatives (Chen et al., 2004):

> *If transgenic rice varieties are released into environments where weedy rice occurs abundantly, the transferred alien genes could spread out and accumulate in weedy populations.*

In this context, Chen et al. (2004) call for a meticulous assessment of the potential for outcrossing and escape, and the risks posed in this regard:

> *In short, as in many other crop species, transgene escape from cultivated rice varieties to their weedy and wild relatives through gene flow has become an indisputable fact. There is, therefore, an urgent need for a thorough assessment of the ecological consequences of transgene escape, including such aspects as the ecological fitness of the hybrids and progeny of cultivated and wild rice, the destiny and establishment of escaped genes in wild populations, and their impact on general biodiversity.*

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12 http://www.lobbywatch.org/archive2.asp?arcid=4222

13 http://irri.org/news-events/hot-topics/golden-rice/golden-rice-blog/potential-benefits-of-golden-rice-highlighted-in-recent-media-articles

14 http://www.seed-stories.com/clients.html

15 http://www.hki.org/about-us/financial-information/annual-reports

Other studies in China show that hybrids resulting from crossbreeding between cultivated transgenic rice and its wild relatives can exhibit unexpected biologic characteristics. For example, the concentration of Bt toxins[16] poisonous to insects increased in some plants that were a cross between transgenic rice plants and wild varieties (Xia et al., 2009). Furthermore, hybrids featured improved fitness in comparison to non-transgenic parent plants (Lu & Yang 2009):

> *(...) the crop-weedy hybrids showed a better performance at the vegetative and reproductive stages, with taller plants, more tillers, panicles, and spikelets per plant, and higher 1000-seed weight than the weedy rice parents.*

These effects could cause a widespread proliferation of plants. The improved fitness of the plants was unexpected and researchers cannot explain it by the specific changes introduced into the plants from genetic engineering. This means that the ability is limited for predicting the potential for proliferation and the biologic characteristics of transgenic rice and their crossbreeds.

In any case, it seems very unlikely that alien genes, once they spread among wild populations, can be retrieved. As Ferrero (2003) writes, populations of weedy rice, to name an example, are very difficult to control:

> *Weedy rice control methods that can be applied in rice crops are expensive, time-consuming and usually do not lead to a total eradication of the weed infestation. Incomplete control of the weed for a given year could lead to eliminating the results of several years of good control. Weedy rice escapes of 5 percent or less can produce enough seeds to restore original soil seed bank population levels.*

This characteristic of rice, which can remain dormant for a long time, to spread its seeds beyond fields and into the surrounding environment, poses risks to ecosystems and can cause serious disruption to the cultivation of rice in general. Genetic exchange is not a one-way street; it works in both directions. Exchanges between fields and surrounding wild rice varieties can develop into a regular cycle. The pollen of wild rice varieties can also carry the alien genes back to the fields – even to fields where conventional rice is cultivated. As experience with transgenic rice made by the Bayer company in the United States showed, concentrations can go unnoticed for years and seeds can contaminate entire regions (GAO 2008). This forced Bayer to announce in 2011 that it would pay USD 750 million in damages to 11,000 American farmers whose crops had been contaminated by the company's genetically engineered rice.[17] Such contaminations also have a considerable impact on international markets. Chinese rice farmers are facing serious problems due to contamination by transgenic rice varieties that have never received official authorization in the country. The EU Commission announced in 2011 that rice imports from China would be subject to stricter monitoring and that an import ban might be imposed.[18] Perhaps this influenced China's decision in 2011 to temporarily suspend plans to commercialize transgenic rice. [19]

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16 Genetic engineering was used to insert these into the rice to protect it from harmful insects.

17 http://www.bloomberg.com/news/2011-07-01/bayer-to-pay-750-million-to-end-lawsuits-over-genetically-modified-rice.html

18 http://www.europeanvoice.com/article/imported/chinese-rice-products-to-be-checked-for-contamination/72416.aspx

19 http://biosafety-info.net/bioart.php?bid=703

These cases show that extensive Golden Rice cultivation threatens to provoke an unpredictable and extremely problematic scenario:

1. The crossing of genetically engineered rice crop varieties and their wild relatives can exhibit surprising biological traits that can lead to speedy proliferation in the environment, with unpredictable ecological consequences.
2. Once alien genes have managed to mix with populations of wild rice, it is no longer possible to control or reverse their spreading.
3. Once alien genes have spread to populations of wild rice, the contamination of conventional rice crops is inevitable and must be expected.

3.4 Responsibility and retrievability

It is extremely likely that the extensive cultivation of genetically engineered rice will lead to an irreversible entry of alien genes into the gene pool of conventional rice plants and their wild relatives. Besides, there is also a strong likelihood that it will be impossible to ban these alien genes from rice fields or ecosystems should damages that researchers did not foresee during the risk assessment stage arise, or should farmers after a few years decide to discontinue cultivation for other reasons.

Transgenic plants are technically engineered products, and under changing environmental conditions they can exhibit production errors, cause long-term damage or simply become technically outdated after a certain period of time. Even among advocates of agricultural biotechnology, there is a lively debate on whether in the future only genes originally derived from the plant itself should be used for gene transfers.[20] In the case of Golden Rice, genes were transferred across the species barrier.

Another problem is that Golden Rice was created using methods developed more than 20 years ago, and which many observers consider outdated because the method used to transfer the genes is neither precise nor can consequences be kept sufficiently under control. Even Monsanto, in a patent application of 2004, states (WO2004053055):

> *Nonetheless, the frequency of success of enhancing the transgenic plant is low due to a number of factors including the low predictability of the effects of a specific gene on the plant's growth, development and environmental response, the low frequency of maize transformation, the lack of highly predictable control of the gene once introduced into the genome, and other undesirable effects of the gene transformation event and the tissue culture process.*

For instance, we have to expect that climate change could cause the genetic stability of transgenic plants to be pushed to its limits, revealing technical defects and creating risks that nobody noticed at the time of approval.

In the meantime, a number of genetically engineered plants, after having been commercially released, have been withdrawn from the market for various reasons (see Table 2). To protect biodiversity and safeguard our food, the option to take plants off the market should be left open to Golden Rice as well.

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20 http://www.nzz.ch/nachrichten/wissenschaft/nur_apfelgene_in_den_apfel_1.759479.html

Plant (Company)	**Reason for withdrawal**
Tomatoes (Calgene)	Quality issues
Tomatoes (Zeneca)	Rejected by consumers
Newleaf Potato (Monsanto)	Rejected by food processing companies
Triffid/linseed (Canadian researchers)	Contamination risk
StarLink maize (Aventis)	Risk of contamination of food supplies, potential for allergenicity
Bt 176 maize (Syngenta)	Availability of products with less risk potential
Roundup Ready soy (Monsanto)	Changes in legislation (Romania)

Table 2: Transgenic plants that were withdrawn after having received market approval

According to various reports in the media, the Philippines will supposedly be the first country to cultivate Golden Rice.[21] Initial field trials have been underway there since 2008.[22] The Philippine Rice Research Institute (PhilRice) is working on crossing local varieties with Golden Rice to make them available to farmers for commercial cultivation. The idea is that the rice will only have to be distributed to farmers once and that they will then be able to use some of their harvest to sow new crops.[23] This distribution plan is praised as being particularly cost-effective, and it seems especially promising for small-scale farming. But it also carries the huge risk that genetically engineered rice could mix with local seed varieties, uncontrolled, and above all, irretrievably. Its presence in seed production would be unavoidable, even if farmers did not wish to cultivate it.

In the meantime, a debate has ensued in the Philippines on whether or not the planned cultivation of genetically engineered rice endangers other forms of agriculture.[24] The Philippines is a country boasting a great many varieties of rice, including conventionally bred red and yellow rice varieties. This renders the phenotypic differentiation of Golden Rice grains impossible or extremely difficult. In the long term, reliable separation in seed production processes seems to be almost impossible. There is the strong probability that the extensive cultivation of Golden Rice will result in the spreading of its alien genes to many different varieties of rice native to the region.

The International Rice Research Institute (IRRI), which holds a large collection of regional rice varieties, has its headquarters in the Philippines and was founded in 1960 by the Rockefeller Foundation. IRRI belongs to the international system of gene banks organized by the Consultative Group on International Agricultural Research (CGIAR) and coordinates the Golden Rice distribution network in charge of supplying farmers in the region with genetically engineered rice. Gerard Barry, a former

21 http://www.mb.com.ph/articles/273971/rp-first-grow-vitamin-afortified-golden-rice
22 http://www.gmo-compass.org/eng/news/358.golden_rice_first_field_tests_philippines.html
23 http://www.goldenrice.org/Content3-Why/why1_vad.html
24 http://www.meattradenewsdaily.co.uk/news/010910/philippines___organic_rice_.aspx

Monsanto employee, is the coordinator of the network.[25] The Bill & Melinda Gates Foundation and the Rockefeller Foundation are the IRRI's major sponsors (Greenpeace, 2010). On the pages of the IRRI website presenting the Golden Rice network, there is no mention of safeguarding local varieties and protecting them from potential contamination.[26]

The retrievability of genetically engineered plants should be a prerequisite for their use. The mid-term and long-term impact of their release on evolutionary processes, biodiversity and human health cannot be scientifically predicted with an adequate degree of certainty. Releases can only be accepted if their duration and location can be controlled (see Breckling, 2009; Then, 2010). It should also be noted that the international convention on biodiversity held in Japan in 2010 called for stricter measures against invasive species, thus emphasizing the need to safeguard ecosystems against the uncontrolled entry of new species.[27] Golden Rice would not lead to the entry of a completely new species, but alien genes would spread to the gene pool of cultivated and wild rice varieties. The spreading of these genes cannot be kept under control and long-term effects on ecosystems cannot be predicted.

25 http://beta.irri.org/index.php/IRRI-Directory/Internationally-Recruited-Staff/Gerard-Barry.html

26 http://beta.irri.org/test/j15/index.php?option=com_content&view=article&id=398&Itemid=100110

27 http://www.spiegel.de/politik/ausland/0,1518,druck-726242,00.html

4. Golden lies?

For a long time, Golden Rice has been associated with the highest humanitarian goals. A Time Magazine cover in 2000 proclaimed: "This rice could save a million kids a year" (Time Magazine, 2000). But what was completely at odds with the lofty project's humanitarian goals was the fact that an adequate evaluation of the project in terms of its technical suitability was not possible at the time – a problem that has not been resolved to this day. At the time, scientists had merely been able to use genetic engineering to produce carotenoids in rice grains for the first time, albeit only in low concentrations. The actual concentration in the rice grains was perhaps even lower than originally stated (see Then, 2009). Managers of the Golden Rice project also viewed the first generation of Golden Rice primarily as a proof of concept.[28]

The first generation of Golden Rice was a valuable proof of concept, but it was recognised that to combat vitamin A deficiency more efficiently higher ß-carotene accumulation levels would be required.

Managers of the Golden Rice project continue to raise high expectations and invoke moral arguments to speed up the approval process. At a biotechnology industry conference in 2005,[29] Ingo Potrykus, the inventor of Golden Rice, not only emphasized the potential of Golden Rice, but also accused government agencies of imposing excessively stringent risk assessment standards on genetically engineered plants. He claimed that there were no significant differences between traditional breeding and genetic engineering – so why should genetic engineering be subject to risk assessment?

The reason for blurring, or rather denying the differences between conventional breeding and genetic engineering is easy to understand – the risk assessment of genetically engineered plants takes time and money. If there were no difference between breeding and gene engineering, agricultural biotechnology companies could expect substantial savings. Genetically engineered plants would not have to undergo risk assessment prior to their market release. These cost arguments are used explicitly (e.g., B. Potrykus, 2010). But the main focus is on serious moral accusations: 'Over-regulation' is costing lives. Genetic engineering must be 'de-demonized', otherwise society would be committing 'a crime against humanity' (see Figure 1).

Figure 1: Presentation held by Ingo Potrykus at the BioVision in Lyon, 2005: Is GMO over-regulation costing lives? http://www.goldenrice.org/Content4-Info/info3_publ.html

28 http://www.goldenrice.org/Content2-How/how1_sci.html

29 Is GMO over-regulation costing lives? http://www.goldenrice.org/Content4-Info/info3_publ.html

Potrykus continued to advance this line of argument in 2010 in an opinion piece in Nature magazine (Potrykus, 2010). Once again it was all about relaxing standards for market approval, a demand that was even brought up at a conference held by the Vatican in 2009:

> *Genetically engineered crops could save many millions from starvation and malnutrition — if they can be freed from excessive regulation. That is the conclusion I've reached from my experience over the past 11 years chairing the Golden Rice Humanitarian project (www.goldenrice.org), and after a meeting at the Vatican last year on transgenic plants for food security in the context of development.*

Potrykus (2010) again maintained that there was no difference between traditional breeding and genetic engineering. He claimed that only the exaggerated requirements of regulating agencies were to blame that the product was not yet on the market:

> *Golden Rice will probably reach the market in 2012. It was ready in the lab by 1999. This lag is because of the regulatory differentiation of genetic engineering from other, traditional methods of crop improvement. The discrimination is scientifically unjustified. It is wasting resources and stopping many potentially transformative crops such as Golden Rice making the leap from lab to plate.*

In his piece, Potrykus completely ignored the fact that technical questions and issues having nothing to do with risk assessment significantly contributed to the delay in realizing the project. For instance, the rice initially displayed a very low level of carotenoid concentration. Nothing was published regarding its bioavailability until 2009, and technical data regarding its shelf life is still not available (see above). Moreover, nearly all the information needed to even begin work on concrete risk assessment is still missing.

On their website, the managers of the Golden Rice project allege that necessary field trials, in particular, have been delayed so that it has not been possible to produce enough rice for further research regarding its bioavailability, for example:

> *A number of tests require kilogram amounts of seed; these tests have been unnecessarily delayed by the difficulties in being able to carry out field trials with Golden Rice, not enough seed can be produced when grown in the glasshouse.*

This argument is misleading; field trials began as early as 2004 in the United States. Research on bioavailability was not published until 2009. But for methodical reasons, the rice used in these studies was grown in greenhouses and not in fields (Tang et al., 2009).

The choice of arguments and the way facts are presented suggest that the interests served by the introduction of Golden Rice are not purely humanitarian. Advocates such as Potrykus (2010) are concerned with the general easing of risk assessment standards for genetically engineered plants. Transgenic plants should be considered equal to conventionally bred plants and exempted from having to undergo detailed risk assessment.

Other experts involved in the Golden Rice project advance arguments similar to those of Potrykus (e.g., see Dubock, 2009). Bruce Chassy, a strong proponent of the planned cultivation of Golden Rice in the Philippines, takes these arguments to an extreme (Chassy, 2010).[30] He even goes so far

30 http://www.scidev.net/en/news/gm-rice-trials-in-the-philippines-will-go-ahead-.html

as to compare the consequences of the delayed market approval of Golden Rice (which he abbreviates as GR) with the Holocaust. Chassy believes that Golden Rice should have been distributed to farmers without further testing as early as 2002 or 2003. In his paper entitled "The Silent Holocaust" he elaborates (Chassy, 2010):

> *As noted previously, VAD kills approximately 2 million people a year – most of them rice-eating children. If GR had been bred by conventional means, two or three years might have been required to propagate and distribute the seeds, and – assuming a reasonable adoption rate – perhaps the lives of a half a million or a million people a year might have been saved until now. (…) GR has instead been confronted with critics who have delivered a long list of ill-founded claims about safety and efficacy. The consequence of these misperceptions about real risks is that GR has also confronted an intransigent regulatory system that requires millions of US dollars and many years to navigate for each new product. (…) Considering the minimal safety concerns associated with GR and the staggering annual toll of VAD, would it not have been a better choice to distribute the seeds just as would have been done if they were conventionally bred? The moral calculus is surprisingly simple: if GR had been distributed in 2002 or 2003, millions of lives might have been saved. Not to have disseminated the seeds of GR until now has allowed as many people to die silently as were killed in the holocaust.*

With his comparison, Bruce Chassy has marginalized himself. The question is whether he speaks only for himself. In connection with the Golden Rice project, he is described as an expert from a high-ranking international task force organized by the International Life Science Institute (ILSI) and chaired by a Monsanto employee. Besides Monsanto, members of the task force include BASF, Bayer CropScience, Dow AgroSciences, DuPont and Syngenta, whose influence on regulatory authorities such as the EFSA is emphasized on the ILSI website.[31]

ILSI is internationally known as an industry-friendly institution. Years ago, WHO criticized ILSI's close involvement in furthering the interests of the tobacco industry.[32] ILSI made the headlines in 2010 when the news broke that one of its members was also on the management board of the European Food Safety Authority (EFSA).[33] The ILSI task force, which lists Bruce Chassy as its expert, addressed Golden Rice and other issues in a case study (ILSI, 2008) and came to the following conclusions:

> *For nutritionally enhanced crops, it is particularly important to balance the intended nutritional benefits (for example, improved health decreased incidence of disease, suffering, and/or death) against the outcome of the risk characterization. The perceived hazards often represent relatively small risks, whereas the potential nutritional benefits are relatively large.*

Against this background, Chassy's Holocaust comparisons (2010) can be seen as part of an international communications campaign. The argumentative patterns of the Golden Rice team, the industry and ILSI are more or less congruent, and not only as far as Golden Rice is concerned. In

31 http://www.ilsi.org/FoodBioTech/Pages/NutritionalandSafetyAssessments.aspx

32 The Tobacco Industry and Scientific Groups ILSI: A Case Study, The Tobacco Free Initiative, WHO, February 2001, www.who.int/tobacco/media/en/ILSI.pdf

33 http://www.nature.com/news/2010/101005/full/news.2010.513.html, http://www.gmwatch.org/latest-listing/1-news-items/12527-efsa-chair-in-conflict-of-interest-scandal

fact, Golden Rice is being used as an opportunity to demand a general loosening of risk assessment standards for genetically engineered plants. The most important argumentative structures that these groups have in common are:

- They describe the risks posed by genetically engineered plants as being the same as those posed by conventionally bred plants.
- They hold regulatory agencies and critics responsible for delays in the development of Golden Rice.
- They do not discuss existing and effective methods for combating vitamin A deficiency, or give them only marginal attention.
- They show no moral qualms in invoking the obligation to help undernourished children in order to achieve a general expedited approval process for genetically engineered plants.

In December 2010 it became evident just how questionable the strategies that Golden Rice advocates use in their campaigns to achieve a loosening of risk assessment standards are: The industry-friendly news portals NovoArgumente[34] and Animal Health Online[35] pitched the story that the Pope had also become a proponent of agricultural biotechnology:

> *The explosive results of a study week for scientists hosted by the Pontifical Academy of Sciences have just been published. The participants of the conference have presented an extensive position paper on green genetic engineering. The statement, a German language version of which has been made available in advance exclusively to NovoArgumente, contains a clear endorsement of the use of modern biosciences for global agriculture and food production. It calls for the relaxation of scientifically unsubstantiated hurdles for green genetic engineering to be removed, and for the expansion of its public support, so that poor countries in particular could profit from the advantages that modern plant breeding methods have to offer. (…) As with the Pope's recent comments on the use of condoms, the Vatican under Pope Benedict XVI again confirms its readiness to react with an open mind to advances in science that regard important issues of the present and future.*[36]

Further, the authors of the statement refer to the "the moral imperative to make the benefits of GE technology available on a larger scale to poor and vulnerable populations" and demand that "regulatory oversight no longer differentiate between genetic engineering and other methods of breeding."[37] The journalist Thomas Deichmann, who for years has actively advocated agricultural biotechnology and Golden Rice, circulated the news (see also Then, 2009). Other journalists like Ulli Kulke of the German newspaper Die Welt, who like Deichmann subscribes to this technology, quickly took it up and spread the word to the wider public.[38] Contact persons named by Novo Argumente included the inventor of Golden Rice, Ingo Potrykus, the well-known lobbyist Klaus Ammann,[39] and Joachim von Braun, who was the head of the International Food Policy Research

34 http://www.novo-argumente.com
35 http://www.animal-health-online.de
36 http://www.novo-argumente.com/magazin.php/novo_notizen/artikel/000759
37 http://www.animal-health-online.de/lme/2010/11/30/der-vatikan-sagt-ja-zur-grunen-gentechnik/5461/
38 http://www.welt.de/politik/ausland/article11310293/Papst-gibt-der-Gruenen-Gentechnik-seinen-Segen.html
39 http://www.gen-ethisches-netzwerk.de/lexikon/klaus-ammann

Institute (IFPRI) until the end of 2009. The IFPRI received more than USD 120 million in funding from the Bill & Melinda Gates Foundation for the HarvestPlus initiative and its biofortification programs (Greenpeace, 2010).

The news of the Pope's allegedly favorable position on genetic engineering was based on the conclusions of a conference held by the Pontifical Academy of Sciences in 2009. Ingo Potrykus, Joachim von Braun, Adrian Dubock (Golden Rice's project manager), ILSI experts Bruce Chassy and Wayne Parrott, and Robert Zeigler of the IRRI were among the participants. The published statement was however neither explosive nor did it reflect the Vatican's position; it merely conveyed the views of the participants of the 2009 conference. The Pontifical Academy therefore promptly reacted to the attempted manipulation. The academy declared that as only a few members of the Pontifical Academy had attended the conference, the paper could not be considered to reflect the opinion of the Pope nor of the Pontifical Academy. Bishop Marcelo Sanchez Sorondo, chancellor of the academy, proclaimed:[40]

> *The statement is not a statement of the Pontifical Academy of Sciences because the Pontifical Academy of Sciences – as such 80 members – wasn't consulted about it and will not be consulted about it.*

All in all, the communication strategies used by the managers of the Golden Rice project are ethically questionable, propagandistic and alarmist. They clearly contradict the humanitarian goals of the project and impede factual debate.

40 http://www.catholicnews.com/data/stories/cns/1004910.htm

5. Conclusions

From the very beginning, the problem with the Golden Rice project was that its managers raised enormous expectations. There is no denying the fact that vitamin A deficiency needs urgently to be combated. New methods that could significantly alleviate the situation should be tested unconditionally. But the manner in which some parties are demanding the market release of Golden Rice arouses suspicions that the prime interest of the project's proponents is to accelerate the introduction of agricultural biotechnology.

As regards essential transparency and due scientific diligence, the project has serious flaws that cannot be overlooked and that undermine its credibility. At the same time, proponents employ a strident and aggressive rhetoric, going as far as using Holocaust comparisons. Furthermore, managers of the Golden Rice project demand a ge neral easing of safety standards and testing requirements for the market approval of transgenic plants. To achieve this, they advance arguments that are obviously driven by partisan interests. This course of action is not consistent with the project's humanitarian approach, besides being scientifically and ethically unacceptable.

To avert damage to their own credibility, the institutions that sponsor the Golden Rice project, such as the Rockefeller Foundation and the Bill & Melinda Gates Foundation, should clearly and unequivocally distance themselves from the argumentative strategies described in this paper. They should take decisive action to ensure that thorough risk assessment is carried out, missing technical data is published as soon as possible, and that an open debate is no longer avoided regarding the short-term, medium-term and long-term risks of the project.

They should also reappraise whether it would not make more sense to invest the money in already existing programs to combat vitamin A deficiency. Since the Golden Rice idea was first presented, other internationally recognized programs have achieved considerable progress in alleviating vitamin A deficiency. These programs will continue to be essential in the future in solving problems locally. In contrast, the long-term problems posed by Golden Rice could turn out to be much greater than any benefits.

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