

BIOFORTIFIED CROPS OR BIODIVERSITY?

The fight for genuine solutions to malnutrition is on



A scientist stands outside a field trial of genetically-modified bananas at the National Agricultural Research Laboratories in Kampala, Uganda. (Photo: Christopher Bendana)

“Biofortification is a business strategy, not a solution to global malnutrition.”

Sylvia Mallari of the People’s Coalition on Food Sovereignty¹

At the end of 2018, the government of India announced that the use of biofortified rice will become mandatory in all school meals and public nutrition programmes across the country by December 2019. India is one of the target countries for the release of several biofortified crops like iron and zinc pearl millet, iron and zinc rice and provitamin A rice.

Since they were first released in 2004, the use of biofortified crops has been growing in many developing countries. Biofortification is the process of increasing a few nutrients in crops through plant breeding, whether using conventional techniques or biotechnology. From Peru to Tanzania to Indonesia, governments are accepting these crops with open arms. National agriculture research agencies have made biofortification a priority and donors are putting a lot of money into it. The argument that this is a cheap way to address malnutrition seems to have won governments over. But do they really address health problems? Who is behind them and what is their agenda? Could they actually make things worse?

GRAIN took a look at the current status of biofortification in Asia, Africa, and Latin America and the emerging critiques from feminist perspectives and food sovereignty movements. What we found is a worrisome push for a top-down and anti-diversity approach to food and health that may ultimately undermine people’s capacities to strengthen their local food systems.

Key takeaways

- By emphasising dependence on just a few market-based crops, biofortification actually promotes a poor diet with little nutritional diversity.
- Biofortification projects use women as leverage by targeting them with training programmes, marketing efforts and feeding tests.
- While the first wave of biofortified crops was produced through conventional breeding, the next wave will use genetic modification.

- In order to promote healthy, diversified diets, we must promote biodiverse farming. Peasant-led agroecology that empowers women is the most sustainable approach to producing diverse, nutritious and culturally appropriate food while improving health.
- We hope women’s groups will look more closely at the issue of biofortification and invite all our allies to consider a global boycott of biofortified crops.

Background

The Green Revolution—which from the 1960s onward focused on breeding new varieties of a few staple crops like rice, wheat and maize—raised calorie consumption in developing countries but helped destroy diversity in farmers’ fields. Although it is often credited with solving world hunger, sixty years later 821 million people remain undernourished (lacking calories) while two billion are malnourished (lacking essential nutrients), according to the United Nations Food and Agriculture Organisation (FAO). Malnutrition impacts women and children most severely: the FAO finds that it is still responsible for more than half of child deaths in developing countries.

It is well known that a diverse diet rich in vegetables, fruits, legumes, nuts and whole grains provides all the nutrients needed for good health.² Yet in the last several decades, agricultural research has focused almost entirely on raising yields of just a handful of crops, notably cereals, with little emphasis on nutritional quality. Studies in the United States show that today’s food contains lower levels of iron, zinc, protein, calcium, vitamin C and other nutrients than in the past.³ For example,

1. PCFS Global, ‘On World Consumer Rights Day: Rural groups slam market release of GM rice in Bangladesh’, 15 March 2019, <https://foodsov.org/on-world-consumer-rights-day-rural-groups-slam-market-release-of-gm-rice-in-bangladesh/>

2. World Health Organisation, “Healthy diet”, 23 October 2018, <https://www.who.int/en/news-room/fact-sheets/detail/healthy-diet>

3. Figures are debated, as are the methods of measuring. For a critical review of the literature see Robin J. Marles, “Mineral nutrient composition of vegetables, fruits and grains: The context of reports of apparent historical declines”, *Journal of Food Composition and Analysis*, March 2017, <https://www.sciencedirect.com/science/article/pii/S0889157516302113>



Busted! Dr Howarth Bouis, the “father” of biofortified crops, gives a speech about the fight against malnutrition and then downs a Diet Coke. Right.

scientists at Washington State University analysed 63 spring wheat varieties grown between 1842 and 2003 and found an 11 per cent decline in iron content, 16 per cent decline in copper and 25 per cent decline in selenium.⁴ Similar studies have been done in India, the UK and elsewhere, confirming what is generally viewed to be a global trend.⁵ Breeding is largely to blame for decreased nutritional quality, followed by soil depletion and production methods.

In the mid-1990s, scientists at the Consultative Group on International Agricultural Research (CGIAR), the global consortium of research institutions that

spearheaded the Green Revolution, decided to bring nutrition back into the picture. But rather than turn to diversified farming, varied diets, local knowledge and agroecology as the solution, they chose to stay on the same path. That meant continuing to promote monocultures and focusing on just a handful of crops. Diets would remain monotonous, or become even more so, but centred on “nutritionally enhanced” foods.

Global overview

“It’s really just as simple as that. We just need to take all the white maize in Africa and switch it over to orange maize.”

Dr Howarth Bouis, 2016 World Food Prize winner for biofortification⁶

Global research on biofortified crops is led by the CGIAR system, with research currently underway to develop biofortified rice, wheat, sorghum, banana, lentil, potato, sweet potato, cassava, beans and maize. This work is managed across three CGIAR units: the

4. See Alana Herro, “Crop yields expand, but nutrition is left behind”, Worldwatch Institute, <http://www.worldwatch.org/node/5339>, Donald Davis, “Declining fruit and vegetable nutrient composition: What is the evidence?”, American Society for Horticultural Science, February 2009, <https://journals.ashs.org/hortsci/view/journals/hortsci/44/1/article-p15.xml>, and “Dirt poor: Have fruits and vegetables become less nutritious?”, Scientific American, <https://www.scientificamerican.com/article/soil-depletion-and-nutrition-loss/>

5. Vibha Varshney, “Food basket in danger”, Down to earth, 1 December 2017, <https://www.downtoearth.org.in/news/health/food-basket-in-danger-57079>

6. Center for Strategic and International Studies, “Biofortification: Better crops, better nutrition”, 16 June 2017, <https://youtu.be/OZ6DRNsB4YM?t=2084> (34:44)

A word about terminology

Proponents of biofortification often use deceptive language to promote biofortified crops—starting with the word “biofortified” itself. As social movements in Brazil point out, the word suggests that all other foods or plants are inherently weak or deficient. Terms like “golden rice”, “super banana” and “orange maize” really amount to marketing strategies to convince consumers that the biofortified versions of these seeds or foods are superior to their non-biofortified counterparts. These names, not to mention the crops themselves, are sometimes registered as intellectual property, even if intended to be used free of charge.

For the purposes of this report, we choose to speak of provitamin A maize or iron beans, indicating they are bred to be high in that nutrient—instead of using other adjectives (like “super”) or colours (“golden”), which are primarily marketing lingo. We specifically say provitamin A, not vitamin A, because these crops carry beta-carotene, which only becomes vitamin A through our bodies’ metabolism after consumption.

We also found it important to use the phrase “genetic modification” and avoid the word transgenic since new breeding techniques like gene editing result in GM crops even though they are not transgenic.

International Rice Research Institute, focusing on genetically modified rice; the International Potato Centre, focusing on sweet potatoes; and the HarvestPlus programme, which coordinates all the rest.

While there are 40 nutrients that we must get from our food for good health, these institutions only focus on three: zinc, iron and vitamin A. Why? According to the director of HarvestPlus, “of the 40, these are the three recognised as the most widely spread, significant public health problems.”⁷ But the multi-stakeholder World Nutrition Report questions this claim.⁸ And some researchers question whether biofortification initiatives are legitimatising a reductionist focus on vitamin A, iron and zinc deficiencies.⁹

To date, about 300 biofortified crop varieties have been developed and released worldwide with support from HarvestPlus and are now grown by 10 million

farmers and consumed by 30 million people (see table¹⁰). While this is still a very small portion of the crops grown by the developing world’s 1.5 billion farmers, the CGIAR hopes to significantly increase the reach of biofortified crops in the next decade. Its goal is to make biofortified crop breeding the default strategy, so that it may account for 90 per cent of the global food supply.¹¹

So far, none of the biofortified crops released to farmers have been genetically modified (GM). However, quite a number are in the pipeline (see map). While HarvestPlus has expressed concern that people will confuse “biofortified” with “GM” and reject it, the development of biofortified crops is clearly moving from conventional breeding to genetic modification.

While there is some evidence of positive outcomes from the consumption of biofortified crops, the methods used to promote these crops, such as the targeting of women, have come under sharp criticism.¹² In

7. Dr Howarth Bouis, personal communication, 6 March 2019.

8. They state that there is insufficient data to make these claims in “Global Nutrition Report 2018”, <https://globalnutritionreport.org/reports/global-nutrition-report-2018>

9. See for example Sheila Rao “Sweet success? Interrogating nutritionism in biofortified sweet potato promotion in Mwasongwe, Tanzania”, 2018, https://curve.carleton.ca/system/files/etd/a7ded06b-6df1-428f-94a5-85ca7e4bdec8/etd_pdf/fde-32c889036a0e6aaf98e358fe47470/rao-sweetsuccessinterrogatingnutritionisminbiofortified.pdf

10. Available at: <https://grain.org/e/6246>

11. Swagata Yadavar, “Fighting hidden hunger: ‘Our mission is 90% of crops must be biofortified’”, IndiaSpend, 17 February 2019, <https://www.indiaspend.com/fighting-hidden-hunger-our-mission-is-90-of-crops-must-be-biofortified/>

12. Evidence is summarised in Howarth Bouis and Amy Saltzman, “Improving nutrition through biofortification: A review of evidence from HarvestPlus, 2003 through 2016”, ScienceDirect, March 2017, <https://www.sciencedirect.com/science/article/pii/S2211912417300068>.

What is HarvestPlus?

HarvestPlus is a programme of the Consultative Group on International Agricultural Research (CGIAR) and operates under the CGIAR Research Program on Agriculture for Nutrition and Health. The work of HarvestPlus is coordinated by two of the CGIAR's 15 international research centres: the International Food Policy Research Institute (IFPRI) in Washington DC, where HarvestPlus is housed, and the International Research Centre for Tropical Agriculture (CIAT) in Cali, Colombia. Its main goal is to get biofortified crops in the hands of farmers throughout the global South.

HarvestPlus was formally launched in 2003 and is mainly funded by the UK (which provided 41 per cent of its funding in 2017), the Bill and Melinda Gates Foundation (30 per cent), the United States (9 per cent) and the European Union (6 per cent).

More information: <https://www.harvestplus.org/>

many parts of the world, women and children suffer disproportionately from malnutrition. At the same time, women are seen as decision makers about food in their households. Therefore, many initiatives to promote biofortification focus on women. For example, women receive training about the benefits of switching from traditional crops to biofortified crops and are typically the subjects in feeding tests to analyse the health effects of biofortified foods.

Much of this work is funded through the CGIAR system, its member governments, private foundations and multinational corporations. CGIAR has spent \$500 million on biofortification since 2002.¹³ Of this, about US\$21 million has been spent on a programme to develop GM cassava high in iron, zinc and provitamin A. Another \$100 million has been spent on efforts to develop GM rice high in provitamin A.

The CGIAR's largest private funder, the Bill and Melinda Gates Foundation, has earmarked tens of millions of dollar to support the biofortification of sweet potato, rice and cassava in Africa.¹⁴ Between 2009 and 2016, the Gates Foundation spent US\$69 million on

biofortified sweet potato for Africa, with 80 per cent going to the CGIAR's International Potato Centre.¹⁵ The foundation also reportedly invested US\$15 million in the development of the GM provitamin A banana for Uganda at a university in Australia.¹⁶

In another example of private funding of biofortification, Aliko Dangote, the wealthiest businessman in Africa, has committed US\$50 million through his foundation to tackle malnutrition in Africa, including through biofortification. The private sector is also very actively involved through grants, in-house research, seed production and distribution and generating demand for biofortified crops.

13. Charles Hymas, "British government sparks new green revolution with £100m investment in 'super-crops'" *The Telegraph*, 25 May 2018, <https://www.telegraph.co.uk/news/2018/05/25/british-government-sparks-new-green-revolution-100m-investment/>

14. Matthew Schnurr et al., "Limits to biofortification: farmer perspectives on a vitamin A enriched Banana in Uganda", *Journal of Peasant Studies*, 27 November 2018, <https://www.tandfonline.com/doi/abs/10.1080/03066150.2018.1534834>

15. Sheila Rao "Sweet success? Interrogating nutritionism in biofortified sweet potato promotion in Mwasongwe, Tanzania", 2018, https://curve.carleton.ca/system/files/etd/a7ded06b-6df1-428f-94a5-85ca7e4bdec8/etd_pdf/fde32c889036a0e-6aaf98e358fe47470/rao-sweetsuccessinterrogatingnutritionism-in-biofortified.pdf.

16. John Woodhouse, "Say no to GMO bananas in Hawaii & biopiracy news", 25 October 2015, <https://mauihawaiitheworld.wordpress.com/2015/10/25/say-no-to-gmo-bananas-in-hawaii/>

Global policy concerns around biofortified crops

Internationally, there are several major legal issues in the push for biofortified crops:

Labelling debate: There is no internationally agreed upon definition of biofortification, so there is no standard for what can be marketed as “biofortified”. Zimbabwe and South Africa are leading the charge to change this at the Codex Alimentarius Commission.¹⁷ One stumbling block is that the European Union refuses to entertain formalising anything using the prefix “bio-” because it means “organic” in EU law, and biofortified crops are not necessarily organically grown. Other members are not sure that Codex should formally adopt a definition of biofortification at all, since this would promote a single-nutrient (or few nutrients) approach to nutrition as opposed to a biodiverse diet. Another risk is that the term might mask the existence of (biofortified) GMOs, which some governments consider deceptive. Yet another problem is deciding on what level of nutritional enhancement would need to be met in order to qualify for the “biofortified” label. US authorities, for instance, have commented that golden rice could not be labelled for its nutritional properties under US law because the amount of beta-carotene it contains is not high enough.

GM contamination: The release of GM crops is contested in many countries, due to human health and environmental safety concerns. The debate is further complicated today as governments decide whether or not to regulate crops produced through new breeding techniques, like gene editing, as “GM”.¹⁸ Quite a number of biofortified crops are being developed through genetic modification now, so this pressure will only grow. The World Health Organisation considers cross contamination from GM biofortified crops and loss of biodiversity to be two possible threats posed by biofortification.¹⁹ The transfer of genetic material from GM to non-GM plants through natural outcrossing is a concern with virtually all the GM biofortified crops currently being developed (maize, wheat, rice, mustard, sorghum and cassava). Even in the case of the banana, mechanical contamination through the sharing of suckers is a concern. But since no biofortified GM crops have been released yet, we have no data on actual contamination yet. Ironically, the opposite kind of gene flow can also occur. Scientists conducting trials have found that normal maize can pollinate GM biofortified zinc maize and dilute its nutritional enhancement because it comes from recessive genes.²⁰

Patenting and biopiracy: Patent hurdles can also appear. For example, a biofortified GM maize developed in Spain for use in Asia and Africa involves 36 patented technologies for which licenses may need to be negotiated. Syngenta, a Swiss company which was bought by ChemChina in 2018, holds more than 70 patents on golden rice. Licensing arrangements up to now mean that the technology can be used for free in developing countries, while the company maintains that it has no interest in commercially exploiting the technology in developed country markets, but this may change. More recently, a professor at Purdue University took the research he did with HarvestPlus to develop provitamin A maize and created his own

17. See Codex Alimentarius, Report of the 39th session of the Committee on nutrition and foods for special dietary uses, 4-8 December 2017, <http://www.jhnfa.org/k173.pdf> and Report of the 40th session of the Committee on nutrition and foods for special dietary uses, 26-30 November 2018, http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FMeetings%252FCX-720-40%252FREPORT%252FREP19_NFSDUe.pdf

18. Argentina, Brazil, Japan and the United States have opted not to regulate products of new breeding techniques like CRISPR as GMOs. The EU authorities, on the other hand, are handling them under the current GM legislation for now. Australia has taken an in-between approach while India’s position is soon to be released.

19. WHO and FAO, “Technical consultation: Staple crops biofortified with vitamins and minerals: considerations for a public health strategy”, 6-7 April 2016, https://www.who.int/nutrition/events/2016_consultation_staplecrops_biofortified_vitminerals_5to8april.pdf?ua=1

20. Muhammad Amir Maqbool and Abdu Rahman Beshir, “Zinc biofortification of maize (*Zea mays* L.): Status and challenges”, *Plant breeding*, 22 November 2018, <https://onlinelibrary.wiley.com/doi/full/10.1111/pbr.12658>

limited liability corporation around it with his son. In February 2019, they launched an exclusive product line in the United States, based on their publicly funded research.²¹

Although not discussed much, the question of biopiracy is also a concern. The biofortified millets being developed by ICRISAT in India get their enhanced nutritional characteristic from millets developed by peasant farmers in Togo, the ancestral home of millet.²² Will farmers in Togo get anything for their contribution? Similarly, in Africa, the biofortified sweet potatoes, cassava and maize being promoted are derived from Latin American varieties. Will these contributions get recognised? Some also say that provitamin A banana already existed across island communities spanning from Indonesia to Hawai'i.²³ In fact, the gene isolated by the Australian scientists work on a biofortified banana for Uganda was isolated from a variety used in Papua New Guinea. What are the benefits to those original farming communities that are responsible for the development and stewardship of plant varieties now being used in biofortification?

21. Evan Rocheford, CEO of Nutramaize, personal communication with GRAIN, 7 Feb 2019.

22. "Almost all identified iron sources are based on iniaidi germplasm (early-maturing, large-seeded landrace materials from a geographic area adjoining Togo, Ghana, Burkina Faso, and Benin) or have a large proportion of iniaidi germplasm in their parentage," ICRISAT reports in HarvestPlus "Biofortification progress briefs", August 2014, https://www.harvestplus.org/sites/default/files/Biofortification_Progress_Briefs_August2014_WEB_0.pdf

23. John Woodhouse, "Say no to GMO bananas in Hawaii & biopiracy news", 25 October 2015, <https://mauihawaiitheworld.wordpress.com/2015/10/25/say-no-to-gmo-bananas-in-hawaii/>

Notice a pattern?



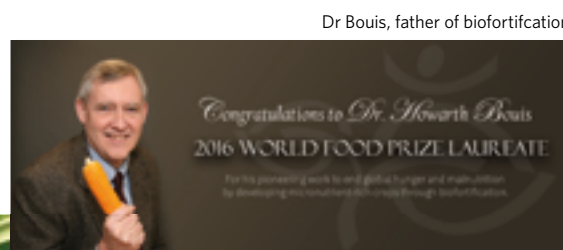
Dr Potrykus, biofortified rice



Dr Dale, biofortified banana



Dr Taylor, biofortified cassava



Dr Bouis, father of biofortification

All. White. Men.

Biofortified crops are part of a very Western and very white male approach to what food and agriculture should look like: capitalist markets, serviced by formal scientific research.

On the ground in Asia

South Asia is home to most of the world's people who suffer from micronutrient malnutrition. Ironically, the region boasts an incredible diversity of fruits and vegetables that are excellent sources of micronutrients. The rates of anaemia in pregnant women, for example, are higher in South Asia than anywhere else, with more than half of pregnant women suffering from this condition.²⁴ South Asia also has the highest number of children suffering from stunting, or impaired growth and development caused by malnutrition, often with lifelong consequences.²⁵

Status of biofortification in Asia: CGIAR centres like IIRI and ICRISAT (International Crops Research Institute for the Semi Arid Tropics) have been at the forefront of developing biofortified crops in Asia.

The most famous biofortified crop is IIRI's provitamin A rice, dubbed golden rice. It is a GM crop which is yet to be released anywhere because of strong pushback from farmers and civil society since the early 2000s. It is currently being considered for regulatory approval in Bangladesh and the Philippines.

IIRI has also developed a non-GM rice variety that is high in zinc and iron, which has not faced the same hurdles as golden rice. It was released in Indonesia in December 2018, as well as earlier in China, without much debate.²⁶ IIRI is now working to develop another high zinc and iron rice through genetic modification.²⁷ Its ultimate goal is to get a three-in-one biofortified GM rice: high in zinc, iron and provitamin A. Through HarvestPlus, provitamin A sweet potato and high iron beans have also been distributed in several Asian countries. High iron and zinc sorghum is also under development.

24. Hannah Ritchie and Max Roser, "Micronutrient deficiency", Our world in data, August 2017, <https://ourworldindata.org/micronutrient-deficiency>

25. UNICEF, "Malnutrition rates remain alarming: stunting is declining too slowly while wasting still impacts the lives of far too many young children", April 2019, <https://data.unicef.org/topic/nutrition/malnutrition/>

26. Peg Willingham and Ben Uchitelle-Pierce, "Launch of high-zinc rice in Indonesia could help stem childhood stunting", HarvestPlus, January 2019, <https://www.harvestplus.org/knowledge-market/in-the-news/launch-high-zinc-rice-indonesia-could-help-stem-childhood-stunting>

27. IIRI, "Healthier rice varieties. High iron and high zinc rice", January 2017, http://books.irri.org/Healthier_Rice_Varieties_brochure.pdf

Indian national research institutes are also getting involved in biofortification. The National Agri-Food Biotechnology Institute in Punjab has developed a provitamin A banana using CRISPR technology.²⁸ And a highly controversial GM mustard developed by the University of Delhi's Centre for Genetic Manipulation of Crop Plants is considered a candidate for biofortification, in order to carry provitamin A. As both China and India have their own independent nationally-funded biofortification programmes, we can expect more national research projects to emerge.

The Indian private sector is getting active as well. For example, the Indian Council of Agricultural Research is doing biofortification work with PepsiCo.²⁹ And since 2016, ICRISAT has been collaborating with Indian seed companies like Karnataka State Seeds Corporation Ltd and Maharashtra State Seeds Corporation Ltd to get high iron pearl millet seeds into farmers hands.³⁰

In addition, the UK's John Innes Institute has developed a GM wheat variety using CRISPR technology that yields 20 milligrams of iron per kilo of milled flour. An application for field testing this biofortified crop has just been approved and trials will begin later in 2019. Apart from its possible use in the UK, proponents of this biofortified GM wheat would like to see it grown in Pakistan, India and Bangladesh.

Emerging critiques: The number one critique of biofortification in Asia is that it's an extension of the Green Revolution, which led to the erosion of agro-biodiversity by imposing just a few, less nutritious, high-yielding crop varieties. Until the 1970s, Indian farmers grew 110,000 varieties of rice; today, only 6,000 have survived.³¹ By pushing such a small number of crops, the CGIAR centres have contributed to the Asian diet becoming much more monotonous. Diets in Southeast Asia once included a broad range of staple foods like

28. CRISPR stands for "clustered regularly interspaced short palindromic repeats". It's a technique that allows scientists to snip out or paste in segments of DNA in a plant or animal cell. For that reason it's also called gene or genome "editing", although the term is contested.

29. "CGIAR-ICAR collaboration", 2017, <https://icar.org.in/file/2957/download?token=B9DeiKAS>

30. ICRISAT, "Mainstreaming biofortification of pearl millet to tackle malnutrition", 10 March 2017, <https://www.icrisat.org/mainstreaming-biofortification-of-pearl-millet-to-tackle-malnutrition/>

31. Debal Deb, "We have more hardy, nutritious grains than GM can offer", India water portal, 16 February 2017, <https://www.indiawaterportal.org/articles/we-have-more-hardy-nutritious-grains-gm-can-offer>

Rice and diabetes

Rice is a good example of the damaging public health impacts caused by promoting a single-crop diet. Most of the world's rice is produced and consumed in Asia. The Green Revolution launched in the 1960s pushed new, potentially high-yielding forms of rice on Asian farmers as a way to increase food production and therefore stop the spread of left-wing political movements in the region (which were thought to be fuelled by hunger). As a result, white rice has come to dominate once-diverse Asian diets—with dramatic health consequences.³² White rice has a particularly high glycemic index: it causes blood sugar to rise quickly and then drop, disrupting the body's ability to produce insulin and regulate blood sugar levels. Today, 60 per cent of all people suffering from diabetes are in Asia, 90 per cent of whom suffer type 2 diabetes, the preventable form of the disease. The president of Malaysia's Endocrine and Metabolic Society claims soaring obesity in his country is due not to Western junk food, but to white rice.³³ From India to China, type 2 diabetes, as well as the growing obesity epidemic across Asia, is said to be caused by white rice.³⁴ How can packing a few more nutrients into rice, with a view to people eating more of it, not make this worse?

32. Historically, white rice has been the preferred form because the oil in the grain's endosperm turns rancid quickly in the tropics - meaning you cannot keep brown rice long, it spoils.

33. See Simon Baroke, "White rice exacerbates diabetes threat in Asia", Euromonitor International, 8 September 2014, <https://blog.euromonitor.com/white-rice-exacerbates-diabetes-threat-in-asia-pacific/>

34. See Arun Nanditha et al, "Diabetes in Asia and the Pacific: Implications for the global epidemic", Diabetes Care, American Diabetes Association, March 2016, <http://care.diabetesjournals.org/content/39/3/472>

cassava, maize, beans, taro and sweet potato; now people in this region eat rice three times a day, largely due to the Green Revolution's focus on promoting rice. This diet not only results in micronutrient deficiencies, but also contributes to diet-related diseases like diabetes. (See box: *Rice and diabetes*.)

Promoters of biofortified crops argue that biofortification is the most efficient approach to addressing micronutrient deficiency among low-income communities who cannot afford to buy diverse foods like fruits and vegetables. But participatory research in Andhra Pradesh and Telangana with adivasi and small peasant communities shows that traditional farming systems provide diets already highly nutritious, supplying ample levels of vitamin A, folic acid, vitamin D, zinc and other micronutrients.³⁵ So the question is which system you choose to promote: diverse traditional diets based in diversified farming systems or replacing these diverse systems with a small number of "nutritionally enhanced" crops.

35. Read the wonderful research by Food Sovereignty Alliance India and Catholic Health Association of India, "Exploring the potential of diversified traditional food systems to contribute to a healthy diet", 2018, <https://foodsovereigntyalliance.files.wordpress.com/2018/12/Report-1.pdf>

Dhaka-based UBINIG has conducted research showing that people are concerned about monocultures of biofortified crops such as zinc rice destroying the ecological foundations of farming in Bangladesh.³⁶ There is also concern about targeting women and children as a marketing ploy for biofortified crops. As they put it, "While it is true that women and adolescent girls suffer from nutritional deficiencies that have led to high percentage of stunting (40 per cent), the solution is not to have a 'capsule-like' food such as industrial varieties of biofortified rice. Rather, we need to shift to biodiverse agriculture."³⁷ Bangladeshi people do not consume rice alone, they point out, but with vegetables, fish and lentils. Even the very poor will also have potato, spinach and lentils along with rice. The distribution of new biofortified rice and wheat in Bangladesh is not based on evidence, but rather on the assumption that poor women are zinc-, iron- and vitamin A-deficient. In fact, poor women recipients are frequently unaware of why they are being given biofortified rice.

Rural communities and women's groups across the region view diversified local food systems and traditional diets as the real solution to poverty and malnutrition.

36. Personal communication, March 2019.

37. Ibid.

Many of these communities are actively resisting the takeover of their crops, livestock, territories and cultures. As part of these struggles, women are fighting to maintain their traditional knowledge as the foundation of health and culture, such as knowledge of different uses of leafy greens and other foods found in forests and semi-arid areas where they live.

On the ground in Africa

In Africa, which is always portrayed as a hungry continent, biofortified crops are marketed as a magic bullet for addressing nutrient deficiencies. The president of the African Development Bank, Dr Akinwumi Adesina, stated: "Biofortified crops are going to be game-changers with dealing with the issue of malnutrition in our world today."³⁸ In 2018, the African Union went so far as to adopt biofortification as a new food security strategy for the continent. However, Africa has rich local food cultures informed by locally-specific social relations in which women often play a central role. The push for biofortification on the continent is therefore met with scepticism in many circles.

Status of biofortification in Africa: The most emblematic case of the promotion of biofortified crops in Africa is that of the genetically modified provitamin A banana in Uganda. The crop was developed to address vitamin A deficiency, which is currently affects 28 per cent of the country's pre-school children. Bananas are the staple food of the Baganda people, who account for 17 per cent of Uganda's population. Starting in the late 2000s, the Bill and Melinda Gates Foundation began funding work at Queensland University in Australia to produce the GM variety. While there are over 20 types of banana widely grown and consumed in Uganda, the work is concentrated on one, the Nakitembe variety. Some US\$10 million have gone into the project so far. Feeding trials were carried out in 2014 in the United States and the banana is expected to be released in 2021, pending the finalisation of Uganda's recently introduced biosafety regulations.

Another major crop being biofortified for Africans is the sweet potato. While many people in Africa eat white and yellow varieties, work began in 1995 to develop orange-fleshed varieties that are high in provitamin A. It was originally led by the CGIAR's CIP together with the Kenyan Agricultural Research Institute, but in 2006 the Bill and Melinda Gates Foundation stepped in with additional funding. This non-GM sweet potato

38. "Biofortified crops will be game changers", HarvestPlus, 7 July 2017, <https://youtu.be/3IWPuWpOiu4>

is has already been released in 15 countries including Tanzania, Uganda, Mozambique, Rwanda, Côte d'Ivoire and Nigeria.

Cassava, another staple food in many African communities, is also being biofortified to carry iron, zinc and provitamin A. Some of this research involves conventional breeding and some involves genetic modification. One of the most well-known initiatives is the work spearheaded by the Monsanto/Bayer-funded Donald Danforth Plant Research Centre in the United States in partnership with the CGIAR's International Institute for Tropical Agriculture as well as national research institutes. This work aims to develop a GM iron and zinc cassava for Kenya, Nigeria and Uganda. So far, one field test has been carried out in Puerto Rico for release in Kenya planned for 2020 or 2021. A GM provitamin A sorghum is also on the agenda for Kenyans, after years of research funded by the Gates Foundation, DuPont and others.

Maize is also being biofortified through CGIAR's International Maize and Wheat Improvement Centre (CIMMYT) to carry provitamin A and zinc. Like the biofortified sweet potato, it is orange instead of the common yellow or white. It has been released in about eight countries, including Ghana, Mali, Nigeria, Zimbabwe, Tanzania, Malawi and Rwanda, with funding from governments and the private sector. An iron pearl millet was released for the first time in Africa in 2018 in Niger, the historical home of millet.

Corporations are keenly pursuing their own biofortification programmes as well. Nestlé has been developing biofortified cassava, millet, rice and maize for Côte d'Ivoire, Madagascar, Nigeria and Senegal.³⁹ The work is being done at Nestlé's own research centre in Abidjan. By 2018, the company was integrating biofortified Vitamin A maize in its Golden Morn line of cereal products in Nigeria—although not without problems. A lack of incentives for farmers has led to inadequate supply of the corn.⁴⁰ And the level of vitamin A in the orange maize is reportedly below the fortification levels required for the porridge.⁴¹ In Madagascar, the work

39. "Bridging the micronutrient gap: Nestlé's approach to biofortification in Africa", Nestlé, 4 August 2015, <https://www.nestle-cwa.com/en/media/newsandfeatures/documents/biofortification%20en.pdf>

40. "Biofortification" by Yerry Mendoza, Nestlé, May 2018, <https://www.nestle.com/stories/biofortification-addresses-micronutrient-deficiencies>

41. MQSUN+, "Where business and nutrition meet", 15 June 2018, http://demo-mqsunplus-path.ml/wp-content/uploads/2018/09/MQSUN_Report-Where-Business-and-Nutrition-Meet_15June2018_FINAL.pdf, page 64



Biofortified beans on sale in Rwanda. (Photo: Harvestplus)

focuses on rice and goes back to 2010.⁴² As of 2019, just 1,000 farmers have been provided seeds and the company is now focusing on training seed producers.⁴³

Under HarvestPlus' strategy, private companies are expected to produce and commercialise biofortified crop seed for farmers.⁴⁴ In Zambia, HarvestPlus is working directly with Zamseed, providing the company with marketing materials and sales expertise. Zamseed's most profitable biofortified crop is provitamin A maize. In Zimbabwe, HarvestPlus has signed agreements with Prime Seed Co and Zimbabwe Super Seeds to lead seed

production.⁴⁵ While HarvestPlus contends that no intellectual property advantage is possible from marketing their crop varieties, companies are being encouraged to develop hybrid variants, which need to be purchased each planting season, for their own profit.⁴⁶ Such hybrids are already being grown in Zambia, Nigeria, Ghana, Zimbabwe, Malawi and Tanzania.⁴⁷

42. Madagascar Voly Vary rice project, <https://www.nestle-ea.com/en/csv/individuals-families/micronutrient%20fortification/madagascar%20voly%20vary%20rice%20project/home>

43. Voly Vary rice project press release, 12 March 2019, <https://www.nestle-ea.com/en/media/pressreleases/voly-vary-rice-project>

44. MQSUN+, "Where business and nutrition meet", 15 June 2018, http://demo-mqsunplus-path.ml/wp-content/uploads/2018/09/MQSUN_Report-Where-Business-and-Nutrition-Meet_15June2018_FINAL.pdf (page 61)

45. CGIAR, "A4NH annual performance monitoring report - January to December 2016", https://a4nh.cgiar.org/files/2018/08/2016-A4NH-Annual-Performance-Monitoring-Report_final.pdf

46. MQSUN+, "Where business and nutrition meet", 15 June 2018, http://demo-mqsunplus-path.ml/wp-content/uploads/2018/09/MQSUN_Report-Where-Business-and-Nutrition-Meet_15June2018_FINAL.pdf

47. Margaret Sowa et al, "Retention of carotenoids in biofortified maize flour and -cryptoxanthin-enhanced eggs after household cooking", ACS Omega, American Chemical Society, 27 October 2017, <https://pubs.acs.org/doi/full/10.1021/acsomega.7b01202>

Emerging critiques: Experience with biofortified crops in Africa has raised a number of issues. First, they are seen as a top-down approach to addressing malnutrition. While some projects claim to consult women, it's not clear how widespread the consultations are and to what extent they are merely about convincing women to accept the new crops as "consumers" of the research establishment's outputs. This kind of process was documented in Mwasongwe, Tanzania, around the provitamin A sweet potato pushed by the Bill and Melinda Gates Foundation.⁴⁸ In Tanzania, sweet potatoes are not a commodity; rather, they are a subsistence food crop, usually grown by women. The biofortified sweet potato was introduced in Mwasongwe without proper consultation with women, health practitioners or "mama lishes"—culturally important street vendors who provide wholesome and nutritious meals. When women did adopt the new biofortified sweet potato they did so in order to make money selling it, not out of health considerations.

Biofortification in Africa also overlooks the nutritious crops farmers are already growing. For example in Malawi, as in other countries, there has been a push to market biofortified maize high in provitamin A. But these efforts have overlooked the existence of a popular local variety called mthikinya that is high not only in provitamin A but also in protein and lipids, requires little fertiliser, is early-maturing and stores well. Mthikinya was lost in the 1960s, but was recently recovered by local farmers and is now widely used by farmer field schools to promote agroecology. This maize variety is highly drought resistant, allowing farmers to withstand the growing pressures of climate change.

Similar questions can be raised around African palm. Red palm oil, which is pressed and purified from traditional oil palm kernels, has the highest amount of provitamin A of any natural food.⁴⁹ But rather than support community palm production and processing, which is often led by women, development banks and governments are subsidising large-scale industrial production led by foreign multinationals for international markets. Industrial palm oil is highly refined, which destroys its

provitamin A content. Supporting traditional red palm oil production should be an obvious approach to combatting vitamin A deficiency that would also promote indigenous biodiversity, women's entrepreneurship and local economies. But instead, we see this push for provitamin A biofortified crops.

Finally, many biofortified crops in Africa are genetically modified, posing serious risks to biodiversity and people's health. Much pressure has been put on African states to adopt laws that allow for the approval of GMOs and the privatisation of seeds so that companies will want to produce them. But this is contested by peasant, women, youth and other social movements across the continent that are fighting to protect their local crops, lands and food systems.

On the ground in Latin America

While the push for biofortified crops is concentrated in Asia and Africa, similar trends in Latin America are raising questions about threats to local food systems and crop diversity among women and peasant organisations.

Status of biofortification in Latin America: As in Asia and Africa, a few CGIAR centres have spearheaded research on biofortified crops in Latin America. CIMMYT, for instance, has played an important role in the biofortification of maize, a crop that originated in Mexico and holds enormous cultural and symbolic value for indigenous and other communities across Latin America. CIMMYT began biofortification research on maize in 2004 and is now starting to release varieties. CIP is also important because of its work not only on sweet potato but also the potato, which originated in the Andes. CIAT, based in Colombia is also playing an active role, including with the recent release of new biofortified beans. Across the region, these three centres are collaborating with national programmes to test, release and promote biofortified crops, often in collaboration with the private sector and non-governmental organisations. In fact, Panama and Colombia were among the first to include biofortification in their national food security plans, and Brazil now has a very strong nationally-funded biofortification programme.

In the Caribbean, the Interamerican Institute for Agricultural Cooperation (IICA) is partnering with CGIAR centres to develop non-GM biofortified beans, cassava, maize, rice and sweet potato. As elsewhere, the target nutrients are zinc, iron and provitamin A. In November 2018, the ministers of agriculture of the Caribbean and the Council for Trade and Economic Development adopted IICA's proposal to promote

48. Sheila Rao "Sweet success? Interrogating nutritionism in biofortified sweet potato promotion in Mwasongwe, Tanzania", 2018, https://curve.carleton.ca/system/files/etd/a7ded06b-6df1-428f-94a5-85ca7e4bdec8/etd_pdf/fde32c889036a0e-6aaf98e358fe47470/rao-sweetsuccessinterrogatingnutritionism-in-biofortified.pdf.

49. Just two to six teaspoons can provide 100% of a person's daily requirement for infants up to adults.



Indigenous greens like “quelites” in Mexico form an intrinsic part of local diets, are medicinal treasure chests and quell hunger when trouble sets in. Yet this kind of diversity is overlooked by the reductionist agenda pushing a few biofortified commodity crops. (Photo: Larousse de la cocina Mexicana)

biofortified crops to fight cancer, obesity, heart disease and diabetes in the region.

In 2018, Guatemala released the world’s first hybrid maize that is biofortified with zinc. Its promoters claim that it has improved forms of protein, almost equal in quality to that found in milk, as well as 15 per cent more zinc than non-fortified varieties. The seeds are being produced by the government as well as local seed producers, raising serious concerns about how it may replace local varieties in a country that is part of the centre of origin of maize. In other countries like Panama and Colombia, non-hybrid and non-GM forms of biofortified maize rich in provitamin A, protein and/or zinc are being promoted.

In February 2019, the first biofortified rice, with 30 per cent more zinc than ordinary varieties, was released in Latin America, after years of work by CIAT in Bolivia.⁵⁰ A GM version that has zinc and iron is under development too, through joint research between CIAT and other researchers.⁵¹

50. “Bolivia ya produce arroz biofortificado con zinc”, El Deber, 18 February 2019, <https://www.eldeber.com.bo/rural/Santa-Cruz-ya-produce-arroz-biofortificado-con-zinc-20190218-7017.html>

51. “Desarrollan arroz transgénico biofortificado en hierro y zinc para combatir la desnutrición”, Chile Bio, 23 August 2016, <https://www.chilebio.cl/2016/08/23/desarrollan-arroz-transgenico-biofortificado-en-hierro-y-zinc-para-combatir-la-desnutricion/>

Brazil probably has the strongest national programme on biofortification. It’s called BioFORT and is funded by the Bill and Melinda Gates Foundation and World Bank, among others. It basically pulls together all work on biofortified crops under the coordination of Embrapa, Brazil’s national agricultural research agency. And while it focuses on the same trio of zinc, iron and provitamin A, BioFORT is committed to only produce conventional biofortified seeds.⁵² Many crops have already been fortified and found their way into people’s diets. For example, a new sweet potato variety called Beauregard contains 10 times more provitamin A than the popular commercial one.⁵³ The same has been done with cassava, generating varieties with ten times more betacarotene, the precursor of vitamin A.⁵⁴

Private companies are also getting involved. PepsiCo, one of the world’s biggest manufacturers of junk food

52. See Rede BioFORT, <https://biofort.com.br/rede-biofort/>: “No Brasil, a biofortificação vem consistindo em melhoramento genético convencional, ou seja, por meio de seleção e cruzamento de plantas da mesma espécie, gerando cultivares mais nutritivos, excluindo assim ações transgênicas.” Of course in future this could change.

53. “Embrapa apresenta o potencial da batata-doce biofortificada para a merenda escolar”, Embrapa, 18 April 2018, <https://www.embrapa.br/busca-de-noticias/-/noticia/33490417/embrapa-apresenta-o-potencial-da-batata-doce-biofortificada-para-a-merenda-escolar>.

54. BioFORT, “Resultados”, <https://biofort.com.br/resultados/>

like chips and sugary drinks, has been financing research on biofortified maize for many years. This takes the form of direct grants to CIMMYT in Mexico as well as financial support for researchers in universities and laboratories all over the world. In Brazil, PepsiCo South America Foods is partnering with Embrapa to develop snacks based on biofortified ingredients rich in provitamin A, iron and zinc.⁵⁵

In Brazil, part of BioFORT's work is also funded by a longterm contract with Monsanto (now owned by Bayer), including the royalties generated from their joint work producing GM soybean seeds.⁵⁶ Monsanto, Nestlé and PepsiCo are also funding conferences on biofortification in Brazil.

Emerging critiques: One of the major concerns of social movements in the region is the very fact that a lot of the crops being transformed through biofortification—such as maize, potatoes and beans—originate in Latin America. The concern is that new varieties will replace indigenous and traditional seeds, which were developed and are protected particularly by women. The strongest feelings concern maize, which has deep cultural and spiritual significance in the region. Hybrid forms of biofortified maize, which can quickly displace peasant varieties, are an immediate threat to local food systems.

Linked to this is the role of private corporations like Nestlé, PepsiCo and Monsanto. They are aggressively pushing a model of food production and consumption that revolves around land grabbing, soil and water pollution, agrochemical use, deforestation, ultra-processing, ultra-packaging and global markets. This model is destroying local food systems, harming workers, eroding public health and driving the climate breakdown. Yet this is hardly discussed in the promotion of biofortification as a strategy to fight malnutrition in Latin America or elsewhere.

Another critique is that biofortified crops are the wrong approach to improving health. Social movements in Brazil, for instance, looked at the push for biofortification there and concluded that diverse diets and diversified crops and livestock are far better solutions than

55. PepsiCo, "2011/2012 GRI Report", https://www.unglobalcompact.org/system/attachments/60421/original/PEP_RPT12_GRI_Report_%2824%29.pdf?1390321746

56. Convênio Embrapa-Monsanto coloca mais de R\$ 1 milhão no projeto Biofort, Suino Cultura Industrial, 3 de junho de 2009, <https://www.suinoindustr.com.br/imprensa/convenio-embrapa-monsanto-coloca-mais-de-r-1-milhao-no-projeto-biofort/20090603-141907-u605>

boosting the micronutrients of just a few starchy staples.⁵⁷ The real solution—not only to malnutrition but also poverty and social and environmental injustice—lies in promoting diversity in Latin American diets and farming systems under the control of indigenous and local communities. Otherwise, these schemes will only expand corporate control over local farming systems and eclipse local food cultures.

In Mexico, the culture of producing, gathering, cooking and conserving local greens, called "quelites", is very important for people's health and nutrition.⁵⁸ Quelites—which may be weedy or wild amaranths, goosefoot, all sorts of shoots, buds and flowers—form an intrinsic part of local diets. They are also a medicinal treasure chest and quell hunger when drought or other troubles set in. Many cultures across the world have a similar reliance on local greens for nutrition and health. Yet this kind of diversity is completely overlooked by the reductionist agenda pushing a few biofortified commodity crops.

As in other regions, people in Latin America are concerned that biofortified seeds could be a trojan horse for the spread of GMOs. The nutritional angle is hard to argue against, and even if institutes like Embrapa claim to use only conventional breeding techniques to develop biofortified crops, researchers and the companies behind them have a vested interest in biotechnology.⁵⁹

A call to action

The international scientific establishment is increasingly funded by unaccountable private interests from the Gates Foundation to Pepsico to Bayer and DuPont. Together, these are the actors most stridently pushing for biofortification. Beyond the hype around golden rice or the super banana, there is a corporate agenda to deepen the privatisation of food and agriculture by exploiting the emotionally-charged issue of hunger and using women as leverage.

While the first wave of biofortified crops have not been genetically modified, the acceptance of biofortified crops paves the way for the next wave of

57. Brazilian Forum on Food and Nutrition Security and Sovereignty, "Biofortification: a threat to food security and sovereignty?", 2017, <https://fbssan.org.br/2017/05/boletim-sobre-biofortificacao-em-espanhol-e-ingles/>

58. See UNAM, "Quelites. Historia de sabores y saberes", 12 January 2018, <https://youtu.be/e62KVDS05hl>.

59. "Estudio: La edición genética se usa principalmente para desarrollar cultivos de alto rendimiento, más saludables y resistentes", Chilebio, 29 November 2017, <https://www.chilebio.cl/2017/11/29/estudio-la-edicion-genetica-se-usa-principalmente-para-desarrollar-cultivos-de-alto-rendimiento-mas-saludables-y-resistentes/>.



Community facilitator supporting an enquiry into traditional food systems in Sikandelapur Village, Sangareddy District, Telangana State, India, in 2018. (Photo: Food Sovereignty Alliance India)

biofortified GM crops to be marketed to farmers and consumers.

GRAIN issues a call to action, inviting women's groups and peasant organisations to examine the issue of biofortification—locally, regionally, nationally or globally. We think there is enough information and experience to justify a boycott of all biofortified crops and foods, coupled with demands for investment in a different approach to agricultural research based on agroecology, local culture and food sovereignty.

We propose that alternative approaches to address hunger and malnutrition should be based on the five following principles:

- 1 Sharing information and education about healthy diets and living, with an emphasis on women and gender equality;
- 2 Strengthening women's leadership in food policy decision-making and food systems research;
- 3 Promoting diversity in farming and in diets, not monocultures or single foods. This includes valuing local plants and animals, food cultures, seeds and local knowledge that sustain health and keep communities strong;
- 4 Lowering the cost and increasing the availability of fruits and vegetables in part by redirecting subsidies and other public funds currently promoting industrial commodities and processed foods; and
- 5 Resisting the neoliberal takeover of food and agriculture that treats food and crops as commodities and patentable intellectual property to facilitate corporate profits. Addressing the root causes of poverty and hunger requires keeping food and agriculture under public and community control.

Going further:

📖 The Brazilian food sovereignty forum's 2017 report, "Biofortification: A threat to food security and sovereignty?" is available in Portuguese, Spanish and English: <https://fbssan.org.br/2017/05/boletim-sobre-biofortificacao-em-espanhol-e-ingles/>

📖 Aya Hirata Kimura, "Hidden hunger: Gender and the politics of smarter foods", Cornell University Press, 2013, <http://www.cornellpress.cornell.edu/book/?GCOI=80140100834350>

📖 Sheila Rao, "Sweet success? Interrogating nutritionism in biofortified sweet potato promotion in Mwasongwe, Tanzania", 2018, https://curve.carleton.ca/system/files/etd/a7ded06b-6df1-428f-94a5-85ca7e4bdec8/etd_pdf/fde32c889036a0e6aaf98e358fe47470/rao-sweetsuccessinterrogatingnutritionismminbiofortified.pdf.

📖 Food Sovereignty Alliance India and Catholic Health Association of India, "Exploring the potential of diversified traditional food systems to contribute to a healthy diet", 2018, <https://foodsovereigntyalliance.files.wordpress.com/2018/12/Report-1.pdf>

📖 GRAIN, "Engineering solutions to malnutrition", 2000, <https://grain.org/e/54>

Summary of emerging critiques of biofortified crops

1. The main underlying problem with biofortified crops is the belief that health can be reduced to a few nutrients. Malnutrition cannot be isolated from poverty and inequality. Since biofortification doesn't address the root causes of poverty and malnutrition, it risks blindly reinforcing it.
2. The second major problem is the belief that adding nutrients to a few staple crops that are supposedly most accessible to the poor is better than promoting a diet rich in diverse foods. This strategy promotes dangerous farming practices like monocultures and monotonous diets.
3. Biofortified crops are part of a Western and white male-dominated approach to what food and agriculture should look like: capitalist markets serviced by formal (and often corporate sponsored) scientific research.
4. Women and children suffer many forms of discrimination and malnutrition, but they should not be used as pretext for pushing a technological fix that risks deepening social injustices. There is a lack of meaningful and inclusive consultation and dialogue with women prior to these research projects and their evaluation.
5. Biofortified crops are a top-down solution. They are not aimed at strengthening local farming and food systems, but replacing them with supposedly superior crops.
6. While many biofortification programmes are presented as using ordinary breeding techniques, they are a trojan horse for bringing in GMOs. Scientists use a number of biotechnology tools to pack nutrients into staple foods including transgenesis, mutagenesis and genome editing. These serve to create patented GMOs which pose significant threats to food sovereignty.
7. The role of agribusiness and food corporations like PepsiCo, Nestlé, Bayer and DuPont in promoting biofortification is worrisome. These companies are part of an industrial food system based on monocultures that destroy biodiverse farming systems and processed foods that are a major cause of global malnutrition and diet-related disease.



GRAIN is a small international non-profit organisation that works to support small farmers and social movements in their struggles for community-controlled and biodiversity-based food systems. GRAIN produces several reports each year. They are substantial research documents providing in-depth background information and analysis on a given topic.

The complete collection of GRAIN reports can be found on our website at <http://www.grain.org>

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