"For your own good!"

The chicanery behind GM non-commercial 'orphan crops' and rice for Africa

March 2016

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Contents

On 7 April 2015 the African Centre for Biosafety officially changed its name to the African Centre for Biodiversity (ACB). This name change was agreed by consultation within the ACB to reflect the expanded scope of our work over the past few years. All ACB publications prior to this date will remain under our old name of African Centre for Biosafety and should continue to be referenced as such.

We remain committed to dismantling inequalities in the food and agriculture systems in Africa and our belief in peoples' right to healthy and culturally appropriate food, produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems.

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Design and layout: Adam Rumball, Sharkbouys Designs, Johannesburg
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Acknowledgements

The ACB acknowledges the generous support of the Swift Foundation and Bread for the World. It is also extremely grateful to Mariam Mayet, Sasha Mentz-Lagrange and Zakiyya Ismail for their research efforts and contributions.

Acronyms and Abbreviations

AATF	African Agricultural Technology Foundation
ABNE	African Biosafety Network of Expertise
ABS	Africa Biofortified Sorghum Project
ABSP	Agricultural Biotechnology Support Program
ACB	African Centre for Biodiversity (formerly African Centre for Biosafety)
ACMV	African cassava mosaic virus
AGRA	Alliance for a Green Revolution in Africa
AHBFI	The Africa Harvest Biotech Foundation International (Africa Harvest)
AOCC	The African Orphan Crops Consortium
ARIPO	African Regional Intellectual Property Organisation
ARO	Agricultural Research Organisation [Uganda]
AU-NEPAD	African Union- New Partnership for Africa's Development
BC Plus	BioCassava Plus
BecA-ILRI	Biosciences Eastern and Central Africa International Livestock Research Institute
BC Plus	BioCassava Plus project
BMGF	Bill & Melinda Gates Foundation
CBSD	Cassava brown streak disease
CFTs	Confined Field Trials
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CIRAD	International Cooperation Centre in Agronomic Research for Development
CMD	Cassava mosaic disease
CRI	Cooperative Resources International
CRI	Crop Research Institute [Nigeria and Ghana]
CSIR	Council for Scientific and Industrial Research [South Africa and Ghana]
CSIS	Center for Strategic and International Studies
DDPSC	Donald Danforth Plant Science Center
DFID	Department for International Development (United Kingdom)
EU	European Union
FAO	Food and Agriculture Organisation
FtF	Feed the Future
GCP21	Global Cassava Partnership for the 21st Century
GE	Genetic Engineering
GH	Green House
GHC	Green House Containment
GM	Genetically Modified
GMO	Genetically modified organism
GNAFF	Ghana National Association of Farmers and Fishermen
IAR	Institute of Agricultural research [Nigeria]

ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid-Tropics
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Environmental and Agricultural Research Institute (Burkina Faso)
IPM	Integrated Pest Management
ISAAA	The International Service for the Acquisition of Agribiotech Applications
JT	Japan Tobacco
KALRO	Kenya Agriculture and Livestock Research Organisation
KBCH	Kenya Biosafety Clearing House
MNCs	Multinational Corporations
NACCRI	National Crops Resources Research Institute [Uganda]
NARO	National Agriculture Research Organisation [Uganda]
NARS	National Agricultural Research Systems
NBC	National Biosafety Committee
NaCRRI	National Crops Resources Research Institute
NEPAD	New Partnership for Africa's Development
NEWEST	Nitrogen Efficient Water Efficient and Salt Tolerant
NUE	Nitrogen Use Efficiency
PBS	Program for Biosafety Systems
PIPRA	Public Intellectual Property Resource for Agriculture
PPPs	Public-private partnerships
R&D	Research and development
SCIFODE	Science Foundation for Livelihoods and Development
SPCSV	Sweet potato chlorotic stunt virus
SPFMV	Sweet potato feathery mottle virus
SPMMV	Sweet potato mild mottle virus
SPVG	Sweet potato virus G (SPVG)
SSA	Sub-Saharan Africa
USAID	United States Agency for International Development
VIRCA	Virus Resistant Cassava for Africa
WEMA	Water Efficient Maize for Africa
WWF	World Wildlife Fund

Use of terms

In this report we use the term genetic engineering (GE) and genetic modification (GM) interchangeably, to denote the application of transgenic techniques.

About this paper and research challenges

This paper focuses on research and development (R&D) relevant to non-commercial so-called 'orphan crops'[1] in Africa—cassava, sorghum, sweet potato, pigeon pea and millet[2] —as well as one commercial crop, rice. This paper should be read in conjunction with work already produced on GM banana (Schnurr, 2014)[3] and GM cowpea (ACB, 2015).[4] These non- commercial crops as well as rice are mainly carbohydrate crops that constitute staple food for African populations. The intention of this paper is to place information and new knowledge in the public domain. However, because of the dearth of publicly available sources, it has proven very challenging to source reliable information on the topic. Compounding the apparent limited interest on the part of academia is the fact that research on these GM crops is so secretive. As a consequence, people involved in this research generally declined our requests for interviews. A particularly challenging aspect of the study was our attempts to obtain information about the sums of money invested in research concerned with genetic engineering.

1. Orphan crops are defined by Naylor et al. as: "(crops that are) not produced widely around the world, [that] are not traded to any significant extent in international markets, and [that] receive considerably less attention than the major crops from international or regional crop research organizations.... Nevertheless, orphan crops are valued culturally, often adapted to harsh environments, nutritious, and diverse in terms of their genetic, agro climatic, and economic niches." (2004:16).
2. Yams would also qualify as a non-commercial crop for which GM research is underway. An application to carry out genetic modification of yams (Dioscorea spp.) for nematode resistance in laboratory and greenhouse conditions in Kenya was approved in 2011 (Kenya Biosafety Clearing House, 2016).
3. http://acbio.org.za/tag/gm-banana/.
4. Although cowpea qualifies as an orphan crop it is not covered in this report as it was subject to a detailed investigation published in 2015 (ACB 2015a).

Executive Summary

Agricultural GE investments have for the most part focussed on internationally traded staple crops (maize, rice, wheat, cotton, soybeans, and rapeseed). There has been only marginal investment from the public and private sectors in non-commercial crops because these cover smaller areas and have more limited markets (i.e. they are essentially subsistence related) (Naylor et al., 2004). This investment climate has changed significantly over the past decade and several national and international players are now actively involved in the genetic engineering of non-commercial crops such as cassava, cowpea, pigeon pea, sorghum and sweet potato, as well as rice and bananas.[5]

These GE crops are reductionist solutions proposed by the biotech machinery for a myriad of agronomic and nutritional diversity challenges. They are intent on prying open Africa's food and farming systems to GM based agriculture, by giving the highly contested and failed technology a humanitarian face.

To date, seven African countries—Egypt, Burkina Faso, Ghana, Kenya, Nigeria, South Africa and Uganda[6]—have conducted or are still conducting field trials on the following broad range of non-commercial crops: cassava, pigeon pea, sorghum, sweet potato and rice (the International Service for the Acquisition of Agribiotech Applications (ISAAA), 2014).[7,8] (If we included cowpea then Malawi could be added to this list of countries.) Research is currently underway on millet but this crop has not been the object of reported trials in any of the countries under research.[9]

For each country, the crops being researched are as follows:

- Burkina Faso (rice and sorghum);
- Egypt (rice and sorghum);
- Ghana (cassava, sweet potato, rice);
- Kenya (cassava, pigeon pea, sweet potato, sorghum, [millet was not verified]);
- Nigeria (cassava, rice, sorghum);
- Uganda (cassava, rice, sweet potato).

In all countries research is currently at the stage of either Green House Containment (GHC) or Confined Field Trials (CFTs). Prospects for commercialisation are highly dependent on the outcome of these trials, how biosafety regulations evolve (as in the case of Uganda) and whether existing moratoriums will be lifted (as in the case of Egypt which, in 2012, halted the commercialisation of GM crops). There is very limited information on the anticipated environmental releases of these crops once CFTs have been completed, let alone about the potential commercialisation of these crops.

The genesis of GE research in these crops can be found in royalty-free donations of various patented GE traits, by MNCs to experimental programmes undertaken by African scientists employed by government ministries. These donations are intended to give a humanitarian face to the real involvement, vested interests and expanding influence of these MNCs in Africa.

These technology donations for 'philanthropic' reasons include, for instance, the Cry1Ab (Bt) gene and the antibiotic gene marker *nptll*, developed by Monsanto and donated to the

6. Zimbabwe also conducted CFTs for some of these orphan crops but research in this country, to date, has been discontinued. R&D on GM cassava and sweet potatoes was left at laboratory stage.
7. The ISAAA does not mention pigeon pea and limited information is available for this crop.
8. http://isaaa.org/resources/publications/briefs/49/executivesummary/default.asp.
9. The extent of the application of the research driven by the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT) on GM pearl millet to Africa is unclear. Field trials on GM pearl millet reportedly have been conducted in Kenya and in South Africa, but no further evidence could be found. The Kansas-State University houses the Feed the Future Innovation Lab for Collaborative Research in Sorghum and Millet, and is reported to focus on Ethiopia, Senegal and Niger, as well as Mali and Burkina Faso.

Cowpea Project, ostensibly on a 'humanitarian basis' (ACB, 2015a).[10] Further charitable technology donations include those made by the DuPont Business Foundation, which is the principal technology donor of the African Biofortified Sorghum (ABS) project; Pioneer Hi-Bred, which is involved in R&D on GM sorghum in Kenya and Burkina Faso; and Arcadia Biosciences which gave the African Agricultural Technology Foundation (AATF) a cost-free license granting access to Arcadia's Nitrogen Use Efficiency (NUE), Water Efficiency and Salt Tolerance technologies, to develop NEWEST rice. Complementing these property rights donations, GM research into these crops is primarily funded by foundations (Naylor et al., 2004).

The main players in this respect include the AATF—which is on the receiving end of many of the technological property right donations—the Agricultural Biotechnology Support Program (ABSP) and the Program for Biosafety Systems (PBS). The latter two organisations are funded, essentially, by the Bill & Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID) (Schnurr & Gore, 2015). USA-based research institutions such as the Donald Danforth Plant Science Center (DDPSC) (for cassava) and universities (notably the Michigan State University and the Kansas State University) play a major role in this 'philanthropic' research.

GM research on non-commercial crops in Africa is thus typically driven by three-pronged partnerships. These include MNCs, which 'benevolently' donate technology to large not-for-profit platforms, such as the AATF, to drive this research, which is then locally anchored in national research institutes. Not-for-profit US-based research firms, such as DDPSC, and universities are also part of these partnerships, often spearheading the technological research. This system is backed by a complex web of support structures (such as the PBS and the African Biosafety Network of Expertise (ABNE) that engage in strong advocacy campaigns to ensure the development of biosafety legislation, which is a pre-requisite for the commercialisation of any GM crop.

Organisations involved in supporting research on GM non-commercial crops are shrewdly creating large amounts of propaganda that celebrate the 'breakthroughs' achieved in this field. Annual reports produced by the International Service for the Acquisition of Agribiotech Applications (ISAAA) are replete with glossy illustrations that portray the successful promotion of GE technology throughout the world, how new GE events are supposedly benefitting small farmers with spectacular yield increases, and how these are being embraced in an uncontested manner (James, 2014). These and similar claims are vigorously disputed by opponents of genetic engineering, particularly as this relates to small-scale farming in Africa (ACB, 2015b).

Most of the on-going trials are focused on drought and salt tolerance, nitrogen use efficiency, and resistance to tropical pests and diseases. An important dimension of this GE research pertains to nutritional enhancement (biofortification).

The dearth of literature that critically addresses biosafety and the socio economic aspects relevant to the biofortification of indigenous crops through GE, to improve nutrition for poor people and nutrient deficient populations, is both striking and worrying. The present strong focus on biofortification through GE is especially remarkable, given the need to move from an over-emphasis on food fortification strategies, including biofortification, toward a permanent solution, i.e. diet diversification through locally available foods, which was recognised as early as 1992 by the UN International Conference on Nutrition. In this regard, agroecology and, in particular, home gardens have been singled out as the most successful strategies to combat micronutrient

10. Note that the much criticised GM organisation, Water Efficient Maize for Africa (WEMA), was also developed on the basis of maize germplasm donated by each of the organisations involved in its development, namely Monsanto, the International Maize and Wheat Improvement Centre (CIMMYT) and the five participating National Agricultural Research Systems (NARS) (ACB, 2015b).

deficiencies in developing countries (Lopez Villar, 2015). There are also viable alternatives that address the biotic and abiotic (i.e. the living and non-living components, respectively, of an ecosystem) stresses and challenges, which confront some of these crops.

The time is long overdue for Africa to shift to developing and implementing key strategies for food and dietary diversification at the community and household levels. As already stated, it was 24 years ago that the Food and Agriculture Organisation (FAO) supported this approach, including the promotion of under-exploited traditional foods and home gardens and the raising of small livestock; improved preservation processes and storage facilities for fruits and vegetables, to reduce waste, post-harvest losses and effects on seasonality; the strengthening of small-scale agro-processing and food industries; and nutrition and education to encourage the consumption of a healthy and nutritious diet (FAO, 1997; Lopez Villar, 2015). Africa must shift its agriculture paradigm to agroecology, which can provide enough food for all in a sustainable manner (De Schutter, 2010; 2014), by building on traditional agriculture, which is extremely rich in biodiversity and the diversity of ecosystems.

Overview of value of non commercial crops to African farmers

Sorghum

Sorghum is native to Africa and has become a major food crop the world over. African farmers domesticated sorghum from wild grasses, and they and other farmers worldwide continue to grow the crop, and to develop and nurture its genetic diversity. In Africa, most sorghum seed is open pollinated and is saved by farmers and replanted, or is shared between farmers or farmers' groups or farming communities.

Sorghum was eaten in Egypt some 4,000 years ago, and today it is Africa's second most important cereal. Ethiopia is the center of the crop's diversity, and sorghum is still an important staple food for most of the Horn of Africa. Sorghum is an extremely versatile crop. It can be cooked like rice, made into porridge, malted for beer, baked into flatbreads, and popped like popcorn. The sorghum plant is often used as hay, and the stems are used for buildings, fences, and firewood. The seeds are commonly used as livestock feed. The sorghum kernel is about 70 percent carbohydrate and 12 percent protein—very much like wheat and maize—but the grain has more vitamin B than maize. Sorghum is highly drought tolerant and requires little inputs – especially water. Sorghum can withstand water logging from heavy rain, and can grow in both temperate and tropical zones. Sorghum thrives in many marginal and difficult croplands and can produce up to three harvests a year. It is an important mainstay in sub Saharan Africa's most food insecure communities.
Historically, it has received less attention from commercial plant breeders than maize and other plants, in part because it has been perceived as "poor man's food".[11]

Millet

Millet has been cultivated for thousands of years and is a staple grain for much of the world's population, particularly in South Asia and East Africa. The African native variety, finger millet, likely originated in the highlands of Ethiopia and Uganda and is one of the most nutritious of the world's major cereal crops. It can be used to make porridge, bread, malt, animal feed, popped millet (like popcorn), an Ethiopian liquor and even beer.

Finger millet is high in starch and is considered to be "superior" to wheat because its proteins are more easily digested. It has the third highest iron content of any grain, after amaranth and quinoa. Some varieties, such as those in Uganda and southern Sudan, have high levels of methionine, an amino acid that

11. http://www.worldwatch.org/system/files/NtP-Africa's-Indigenous-Crops.pdf
http://acbio.org.za/wp-content/uploads/2015/02/Sorghum_genome_grab.pdf
http://acbio.org.za/wp-content/uploads/2015/02/ACB-Briefing_African-sorghum-for-agrofuels_March-2010.pdf

is lacking in the diets of hundreds of millions of poor people who eat primarily starchy foods such as cassava. The millet grain is generally ground into flour for making flatbreads and porridge. Finger millet can be an ideal crop in dry areas because it can lie dormant for weeks. Once the rains come, the grain springs to life and can be ready to harvest in just 45 days. The grain is resistant to rot and insects and keeps well in storage, making it an important staple when no other food is available. If kept dry, it can store for as long as five years.

Globally, pearl millet is less widely sown than sorghum, yet it is a key food and feed crop in arid and semi-arid parts of Africa and Asia (particularly India). Like sorghum, one reason pearl millet is of interest to the markets, is its' tolerance of dry, even desert-like conditions, and of low fertility soils. These characteristics are likely to be increasingly important in Africa and elsewhere as a result of climate change. Pearl millet is typically inexpensive to grow and may be sown on land where more water-intensive plants, like maize, would perish without irrigation. These advantages have stimulated interest and attracted the attention of foreign players to millet.[12]

Cassava

The Portuguese introduced cassava, which originated in South America, to Africa in the 16th and 17th centuries. Today, it is considered the most important tropical root crop in the world, as its starchy roots are major sources of dietary energy for more than 500 million people worldwide. Though grown mainly as a food crop, Cassava also has applications as animal feed and for certain industrial products, as starch. In South Africa, what little cultivation takes place (predominantly by small holders) is for commercial and food grade starch, which is about 20,000 tons annually. The global starch industry is said to be worth around $20 billion annually.[13]

Pigeonpea

Pigeonpea is a small legume grown by small holder farmers in warm semi-arid and sub-humid tropics, often in poor soils with little-to-no chemical inputs thanks to the pea's hardiness and drought-tolerance. Historians believe that the pigeonpea originated in India and then traveled to East Africa and up the Nile Valley to West Africa. Today, the food is a dietary staple in India, southern and eastern Africa, and Central America.

Pigeonpea is extremely nutritious and has hardy qualities. It is a nitrogen-fixing legume, which gives it great potential to improve soil quality by fixing nitrogen in the soil.[14]

Sweet Potato

Sweet potato is native to tropical America and is commonly called a yam in parts of the United States. Sweet potato is a crop plant whose large, starchy sweet tasting tuberous roots are an important root vegetable. The edible tuberous root is long and tapered, with a smooth skin whose colour ranges from white through yellow, orange and purple. Although the leaves are also edible, the starchy tuberous roots are by far the most important product.[15]

Sweet potato is an extremely important food crop for several Southern, Eastern and Central African countries – often outranking cassava and maize.

Sweet potato requires fewer inputs and less labor than other staple crops. It tolerates marginal growing conditions, such as dry spells or poor soil. Sweet potato provides more edible energy per hectare per day than wheat, rice, or cassava. Its ability to produce better yields in poor conditions with less labor makes sweet potato particularly suitable as a crop for households.[16]

12. http://www.worldwatch.org/system/files/NtP-Africa's-Indigenous-Crops.pdf
http://acbio.org.za/wp-content/uploads/2015/02/African-Millet.pdf
13. http://acbio.org.za/wp-content/uploads/2015/02/Hazardous-Harvest-May2012.pdf
14. http://www.worldwatch.org/system/files/NtP-Africa's-Indigenous-Crops.pdf
15. (http://www.nda.agric.za/doaDev/sideMenu/Marketing/Annual%20Publications/Commodity%20Profiles/field%20crops/SWEET%20POTATO%20MARKET%20VALUE%20CHAIN%20PROFILE%202014.pdf)

Current research and development initiatives in Africa, with respect to GM cassava, sorghum, pigeon pea, rice, millet and sweet potato

1.1 A research agenda driven by 'charitable' organisations

Generally speaking, experimental programs on GE non commercial] crops are heavily donor-driven" (Schnurr, 2013:11), with not-for profit research institutions playing a significant role in advancing the research. The 'charitable' approach that prevails in GE research on non-commercial crops is driven by multinational corporations that own proprietary rights on technologies and that 'donate' the technology for 'philanthropic' reasons.

This includes, for instance, the Cry1Ab Bt gene and the antibiotic gene marker *nptII*, developed by Monsanto and donated to the Cowpea Project, ostensibly on a 'humanitarian basis' (ACB, 2015); the DuPont Business Foundation, which is the principal 'technology donor' of African Biofortified Sorghum (ABS); Pioneer Hi-Bred, which is involved in R&D on GM sorghum in Kenya and Burkina Faso; and Arcadia Biosciences, which gave the AATF a cost-free license granting access to Arcadia's Nitrogen Use Efficiency (NUE) trait, plus its Water Efficiency and Salt Tolerance technologies, in order to develop the Nitrogen Efficient Water Efficient and Salt Tolerant (NEWEST) rice project. This was followed by the signing of a licence agreement between AATF and Japan Tobacco (JT) in 2012, which, in addition, allowed AATF to use JT's technology for NEWEST rice. Complementing these intellectual property rights donations, GM research on these crops is primarily funded by foundations (Naylor *et al*., 2004).

Organisations presently driving GE research on these crops—cassava, sorghum, sweet potato, pigeon pea, millet and rice—include the AATF, ABSP and PBS. The latter two organisations are funded, essentially, by the BMGF and USAID (Schnurr and Gore, 2015).

- The AATF is a not-for-profit organisation that plays a cornerstone role in setting up public-private partnerships (PPPs) in order to promote "appropriate[17] agricultural technologies" (AATF, 2014) for use by smallholder farmers in sub-Saharan Africa (SSA). Typically, it liaises with national research institutes that form part of the Consultative Group for International Agricultural Research (CGIAR), which then drive the research into local lines of the selected crops.[18] The AATF is taking a lead role on the NEWEST rice project in Africa.
- The ABSP is USAID's 'research arm' and typically funds research infrastructure (laboratories, greenhouses, fencing and disposal equipment), in target countries. It provides scientific training with a strong focus on agricultural biotech research.
- The PBS acts as USAID's 'policy arm' by exposing stakeholders to technology through numerous site visits and active lobbying in favour of biotechnology to convince the leadership and general public of the 'benefits' of GM crops (Schnurr, 2013:17).
- The BMGF has a US$ 40 billion endowment and is one of the world's major donors to agricultural research and development. It is tremendously influential in shaping Africa's agricultural sector, particularly through financing the Alliance for a Green Revolution in Africa (AGRA), which it co-launched with the Rockefeller Foundation in 2006–07. The BMGF is one of the main funders of GM research on some of the orphan crops (cassava, sweet potato) mainly through funding the ABSP and PBS (Schnurr and Gore, 2015). The BMGF funds crop-specific research initiatives including, among others, the BioCassava Plus (BC Plus) project, the

17. By 'appropriate' the AATF effectively means Green Revolution inputs such as fertilisers, herbicides and seeds and a strong emphasis on genetically modified organisms (GMOs).
18. www.feedthefuture.gov

Virus Resistant Cassava for Africa (VIRCA) project and the ABS.

Complementing these partnerships are USA-based research institutions and universities[19] that play a major role in this 'philanthropic' research and therefore in "GM's expansion across the continent [by enabling] access to proprietary technology [and channelling] funds to construct the significant infrastructure needed for domestic experimentation ... training [and engineering] campaigns of "demystification and "sensibilization", designed to cultivate domestic support for GM" (Naylor et al., 2004). Notoriously, these include:

- The Donald Danforth Plant Science Center (DDPSC), a non-profit research institute with a mission "to improve the human condition through plant science [via] project management, biosafety and biotechnology expertise" (Danforth Centre, 2015b). The DDPSC is the lead institution for two critical projects focused on transgenic cassava, which form part of the VIRCA and BC Plus projects and which are financed by USAID (Danforth Centre, 2015a).
- The Feed the Future Innovation Lab for Collaborative Research in Sorghum and Millet, at Kansas State University, one of the 15 'innovation labs' established within universities across the USA, on which the Feed the Future (FtF) programme rests. The Innovation Lab for Collaborative Research on Sorghum and Millet was established in 2013 and started its research on African countries with a grant from USAID.

Other important institutional players include:

- The Africa Harvest Foundation International (Africa Harvest or AHFI), which spearheads the ABS (ACB, 2010a).
- The ISAAA, a "not-for-profit organisation that shares the benefits of crop biotechnology to various stakeholders, particularly resource-poor farmers in developing countries, through global sharing of knowledge and technology development support" (NameISAAA, 2014a:2). Through its AfriCenter, ISAAA has been entrusted with communication and outreach activities for one of the major cassava research projects—VIRCA (ISAAA, 2014).
- The New Partnership for Africa's Development (NEPAD) which, through ABNE, has been involved actively in the development and/or implementation of biosafety regulatory systems in selected countries in Africa: Burkina Faso, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Tanzania, Togo and Uganda. ABNE's services include: "information resources; training and education in the form of training workshops, short courses, online biosafety courses, internships and study tours; technical support and consultations; and networking and linkages" (ABNE, 2014).

In terms of private corporations, the main firms involved in GM research on orphan crops and rice are:

- USA-based Arcadia Biosciences, which in 2008 donated to the AATF the intellectual property rights to its Nitrogen, Water Efficiency and Salt Tolerance technologies, to generate improved rice varieties as part of the NEWEST rice project. The company emphasises that "as part of Arcadia's stated commitment to agricultural and environmental improvement in the developing world, the company received no monetary compensation for the licenses granted to AATF".
- Japan Tobacco, which also has signed several licence agreements, effectively donating access to its technology for the development of GM crops. Such was the case with a 'humanitarian license agreement' with the DDPSC, which donated JT's technology for GM cassava research (ACB, 2010b); and with the agreement signed in 2012 with the AATF, enabling it to use JT's transformation

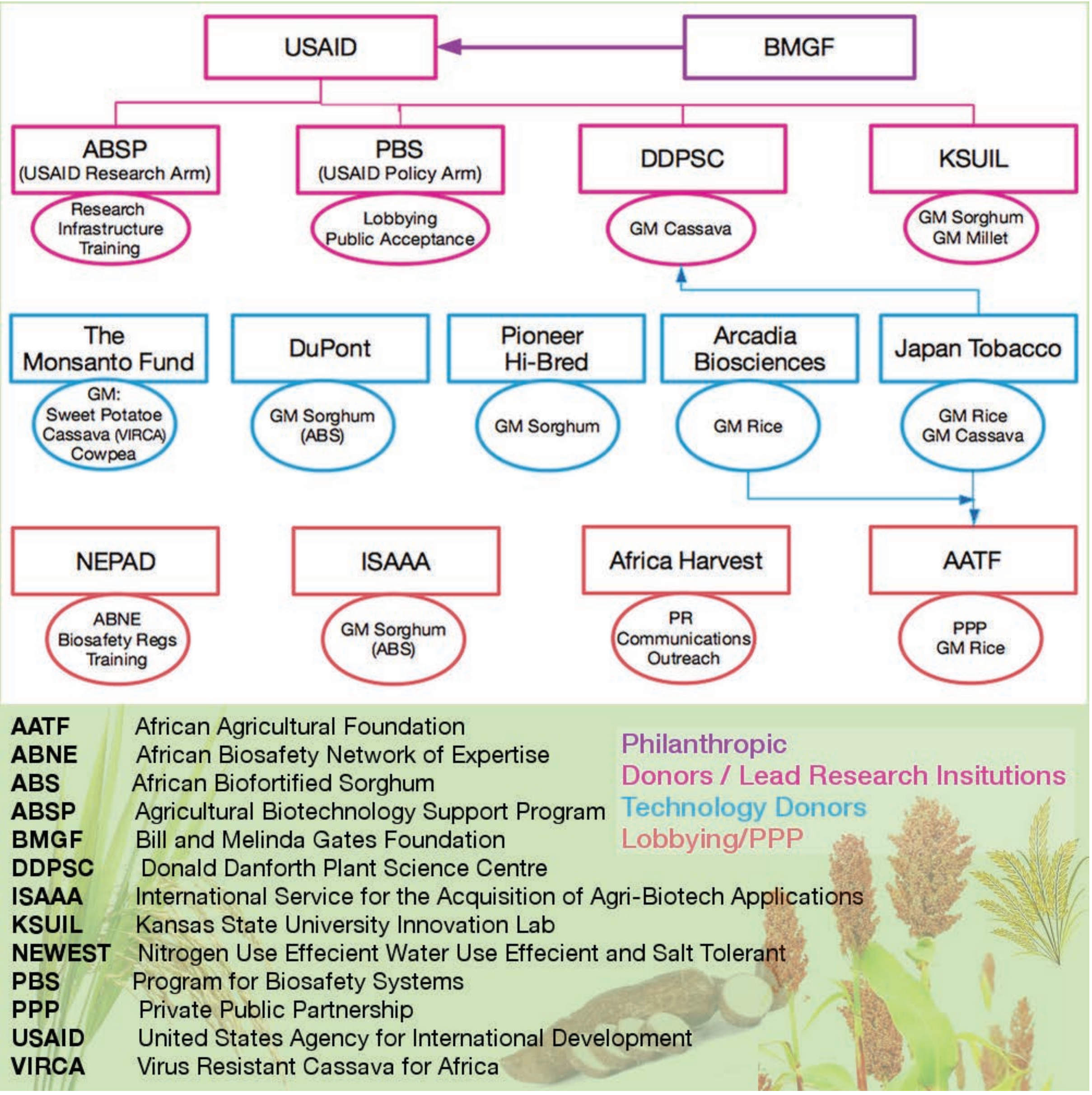
19. Schnurr usefully describes "the standard *modus operandi*" adopted to drive these GM experimental programmes (notably, Uganda's GM matoke banana programme) as consisting of "training and funding junior scientists who, after having completed their PhD on a specific crop, then go on to fill key positions as national researchers, driving GM's expansion. These scientists become enrolled in this process as their professional well-being" (Schnurr, 2013).

technology for the NEWEST rice project (AATF, 2012).

- DuPont Business Foundation, the principal technology donor of the African Biofortified Sorghum (ABS) project, together with other researchers in the US and Africa, reported a 'breakthrough' in 2014[20] regarding the development of biofortified sorghum.
- The Monsanto Fund, which is involved in funding GM research in some of the orphan crops (cassava, under the VIRCA project, and sweet potato) (Schnurr and Gore, 2015; Danforth Centre, 2015a).
- Pioneer Hi-Bred, which is involved in research on GM sorghum in Kenya and in Burkina Faso.

1.2 Crop focused partnerships and the funding involved

The BMGF and USAID are the main funders of PPP research initiatives that focus on the development of transgenic crops, particularly through the funding they grant to the AATF, the ABSP and the PBS (Schnurr and Gore, 2015), as well as the research grants given to



20. http://www.gongnews.net/dupont-scientists-make-breakthrough-in-crop-biofortification/

research centres such as the DDPRC. In 2015 the BMGF granted close to US$ 6 million to the International Food Policy Research Institute (IFPRI) for research focusing on "support to African governments' efforts to design and implement policies and regulations that facilitate and sustain smallholder farmer adoption of biotech crops (such as maize, rice, cassava, banana, and sweet potato, among others) to improve their food security, nutrition, and economic status".[21] Cassava, rice and sorghum are especially subject to such 'crop-focused' PPPs.

Cassava

As in the case of the other crops, there has been no private and limited public investment in the breeding of cassava. In addition, research on cassava breeding has focused mainly on developing widely adapted disease-resistant clones (Legg *et al*., 2014).

A key initiative focusing on cassava is the Global Cassava Partnership for the 21st Century (GCP21), established in 2003 at the Rockefeller Foundation Centre, Bellagio, Italy. The Global Alliance was created to develop a strategic action plan to "declare war on cassava viruses in Africa" with the primary aim of containing the spread of the disease[22] and to ensure that Cassava brown streak disease (CBSD) does not spread from East to West Africa (Legg *et al*., 2014). The Global Alliance includes a mixed basket of strategic initiatives, ranging from Integrated Pest Management (IPM), biological control, and "developing whitefly-resistant cassava, using conventional and transgenic approaches" and deploying whitefly-resistant transgenic varieties (Legg *et al*., 2014).

Another critical cassava-focused initiative that entails transgenic research is the VIRCA project. This collaborative project is spearheaded by the Donald Danforth Centre, the National Crops Resources Research Institute (NaCRRI) in Namulonge (Uganda), the Kenya Agricultural and Livestock Research Organisation (KALRO) in Nairobi, and the IITA at BecA in Nairobi, Kenya.[23] The project is supported by funding from the BMGF, the USAID the Monsanto Fund (Danforth Centre, 2015a).[24] This programme was optimistic that it could achieve commercialisation by 2015 (Monsanto, 2014b as cited in Schnurr, 2015a).

The DDPSC is also leading research for the BioCassava Plus project (BC Plus), which it describes as "an innovative research project that aims to reduce micronutrient malnutrition by increasing the nutritional value of cassava" (Danforth Centre, 2015b). The project is funded by the BMGF, the National Root Crop Research Institute of Nigeria and the DDPSC. The countries targeted by the research are primarily Nigeria and Kenya, while Uganda is considered an additional focus country. The research under BC Plus will lead to the development of two products:

1. The product earmarked for West Africa (with Nigeria as the primary target) is focused on biofortified cassava (B-carotene and iron); and
2. the product earmarked for East Africa is a biofortified (B-carotene) CMD and CBSD resistant cassava (with Kenya and Uganda as the primary target countries).

The limited financial information available relevant to GM R&D is as follows:

- Between 2009 and 2012, the BMGF supported the DDPSC on cassava- related research to the tune of US$ 21.5 million.[25]
- In 2015 the BMGF granted US$ 4.5 million to the University of California, Los Angeles for

21. http://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database/Grants/2015/11/OPP1131119.
22. The three primary objectives of the strategy are: to prevent CBSD from reaching Central and West Africa (the largest cassava regions in Africa); to mitigate the effects of these constraints on cassava in parts of Africa already affected; and to prevent the spread of CMD and CBSD to the rest of the world (Legg *et al*., 2014).
23. ISAAA (2015) also mentions the involvement of the Science Foundation for Livelihoods and Development (SCIFODE) in this partnership and cites NARO and not NCRI as the partnership research institution in Uganda.
24. https://www.danforthcenter.org/scientists-research/research-institutes/institute-for-international-crop-improvement/crop-improvement-projects/virca.
25. http://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database#q/k=cassava%20danforth.

research on virus resistant cassava.

- In 2014 the BMGF granted US$ 472 857 to the Crops Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR), Ghana, to develop new high beta-carotene (Vitamin A enriched) varieties of cassava.
- In South Africa, the starch enhanced cassava project was funded by USAID/South Africa to the tune of US$ 800 000 over two years. This project has long since been abandoned.

Rice

The Nitrogen-Use Efficient (NUE), Water-Use Efficient (WUE) and Salt Tolerant (ST) rice project (NEWEST) targets four countries in Africa, namely: Burkina Faso, Ghana, Nigeria and Uganda (AATF, 2015).

The AATF plays a key role in this initiative, coordinating activities across the partnership and easing the processes of intellectual property transfer and biosafety regulations. The Public Intellectual Property Resource for Agriculture (PIPRA) is donating the enabling technologies for plant transformation (AATF, n.d.). Initial funding to support conceptualisation and implementation of the NEWEST project came from the Department for International Development (DFID) in the United Kingdom, and from USAID. NEWEST project activities are essentially funded by the USAID (AATF, n.d.).

Two private firms were involved in the development of NEWEST rice, namely:

1. California-based Arcadia Biosciences, which in 2008 'donated' the trait technologies for nitrogen-use efficiency, water-use efficiency and salt tolerance (AATF, 2014) and introduced the new traits into NERICA rice, an African variety. These initial lines were then handed over to the International Center for Tropical Agriculture (CIAT) in Colombia, where preliminary field evaluations were conducted and seed stocks of the most promising varieties were generated. These same seeds were then shipped to national research institutions within Ghana's Crop Research Institute (CRI) and Uganda's National Agricultural Research Organisation (NARO), who planted their confined field trials in 2013 (Powell, 2013). Later, Nigeria's CRI became involved; and
2. Japan Tobacco, which granted a 'royalty-free non-exclusive license' to AATF that allows access to its *Agrobacterium*-mediated plant transformation technology (known as *PureIntro*) (AATF, 2012).

Sorghum

The project known as Nutritionally Enhanced Sorghum for the Arid and Semi-Arid Tropical Areas of Africa falls within a programme known as African Biofortified Sorghum (ABS). The programme was developed under the technical leadership of DuPont Pioneer, whilst African Harvest and national partners in Kenya and Nigeria focused on the technological development aspects of the crop, as well as capacity building. Several American universities have been associated with the research.

The research is focused on the development of "a transgenic sorghum that contains increased levels of essential nutrients, especially lysine, Vitamin A, iron and zinc. The nutrition-enhanced sorghum will be used by the product development team for introgression of the nutritional traits into high-yielding, African and farmer-preferred varieties".[26] The programme attributes the success of the initiative to the introgression of the ABS trait into improved sorghum varieties. (AHBFI, 2014).

Phase I of the project (2005–2010) was funded by a grant from BMGF under the Grand Challenges in Global Health Initiative (the total grant allocated to AHFI in 2005 amounted to over US$ 20 million).[27,28] In addition, Pioneer has donated about US$ 5 million[29] in patented sorghum genetics, seeds and know-how to the project (Anderson, research director for grain end-use improvement at Pioneer, as cited in

26. http://biosorghum.org/.
27. http://www.gatesfoundation.org/How-We-Work/Quick-Links/Grants-Database/Grants/2005/07/OPP37877.
28. Although a different source mentions a five-year, US$ 18.6 million grant from the BMFG (Perkins, 2008).
29. ACB (2010a) mentions that the initial technology donation was worth US$ 4.8 million.

Perkins, 2008). According to the project team, ABS thus produced the world's first golden sorghum with increased levels of Vitamin A.[30] Known as 'ABS#2', this transgenic variety has undergone four separate trials in Puerto Rico (ACB, 2010a). Phase II will be/is funded by a multi-donor strategy.[31]

Other research initiatives focusing on sorghum (and millet) that need further investigation to ascertain whether they include a focus on genetic modification include:

1. the partnership between the University of Georgia's Plant Genome Mapping Laboratory and the International Crops Research Institute for the Semi-Arid-Tropics (ICRISAT), which is focused on the sustainable intensification (drought resistance) of sorghum production (US$ 4.98million funding from USAID) (ICRISAT, 2013); and
2. the US$ 8.5 million FtF partnership for sorghum and millet, established in 2014, under the Kansas State University research programme (Kansas State University *et al*., 2014).

Sweet potato

GM Sweet research was much acclaimed during the early 2000s, championed by Dr Florence Wambugu,[32] a Kenyan scientist trained by Monsanto. Monsanto had donated, royalty free, the technology developed for sweet potato virus resistance to Kenya's lead agricultural research institute, the Kenya Agriculture and Livestock Research Organisation (KALRO), then known as KARI, for its sweet potato improvement programme (Gathura, 2004). In 2002 Wambugu claimed that the yields from the new transgenic variety were "double that of the regular plant" (Cook, 2002) and was at the centre of enormous media hype around this supposed breakthrough.[33] However the three-year trial failed spectacularly when reports claimed there was no improvement to the crop in Kenya and that, in fact, "the trials of non-transgenic crops used as control yielded much more tuber compared to the transgenics" (Gathura, 2004). This project was reported to have cost a total of US$ 6 million.[34]

Additional information on sweet potato research, which is assumed to be GM focused, includes:

- In 2014, the BMGF granted over US$ 21 million to the International Potato Centre for research to focus on "high-yielding and disease-resistant varieties of sweet potato as well as tools for improved seed systems for farming families in sub-Saharan Africa".
- Prior to this, the BMFG had allocated over US$ 22 million to the International Potato Centre for the production of "high-yielding, stress-tolerant varieties of sweet potato".

1.3 Traits developed in GM non-commercial crops [sub]

These transgenic crops are being developed primarily for farmers and consumers (Schnurr, 2015a). 'Farmer-oriented traits' refer to improving the agronomic resilience of these crops that are deemed most relevant for vulnerable farmers, especially resistance to insects and viruses; tolerance to herbicides, nitrogen efficiency, and tolerance to drought and salinity. The genetic engineering (GE) of these orphan crops is consumer-oriented and pertains essentially to nutrient enhancement, also known as Biofortification.

30. http://biosorghum.org/timeline.php.
31. http://www.dupont.com/corporate-functions/our-approach/global-challenges/food/articles/global-food-security.html.
32. Interestingly, a recent media report, broadcast on BBC World news (GMWatch, 2015) showcased the very same Dr Wambugu, referred to as "CEO and founder, Africa Harvest" as a partner of the DuPont Pioneer-driven ABS (sorghum) programme.
33. As reported by GMWatch on http://gmwatch.org/index.php/millions-served-the-gm-sweet-potato#5.
34. http://gmwatch.org/index.php/millions-served-the-gm-sweet-potato#5.

Cassava

The viruses threatening cassava are the cassava mosaic disease (CMD) and cassava brown streak disease (CBSD).[35] CMD and CBSD are reported to be "the two worst biological constraints to cassava production in Africa—both pandemics are being driven by unusually high populations of the whitefly vector" (Legg *et al*., 2014), which is likely to be exacerbated by climate change. The crop is also being researched for nutrition-enhancement, notably through the BioCassava+ project, which originally targeted Kenya and Nigeria, with some consideration given to Uganda (ABNE, 2013). The Danforth Center is also the leading research institution in this project. Their biofortification work focuses on increasing levels of iron and zinc in the tuber.

Pigeon pea

Pigeon pea is being researched for insect resistance in Kenya. According to the European Union (EU) funded GMO Compass website, field trials of GM pigeon pea have been conducted in the USA and India.

Pearl millet

HarvestPlus, in collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), is conducting extensive work on increasing iron and zinc concentrations in pearl millet, with a specific focus on South Asia.[36] ICRISAT is reported to have released a "high-iron pearl millet variety known as *Dhanshakti*" and this variety is said to be "the first mineral biofortified crop cultivar to be officially released and reaching farmers' fields in India".[37] Field trials on GM pearl millet have reportedly been conducted in Kenya and South Africa, but the outcome of the research conducted and the current status thereof could not be established.

Rice

The first GM rice that was developed and commercially released (only in the USA) was the herbicide tolerant LibertyLink601 (LLRICE62) (Glufosinate herbicide tolerance) (GAIN, 2015e:23).[38] In 2011 the South African regulator approved its importation into South Africa despite the critical concerns raised by civil society about biosafety issues,[39] especially that GM rice imported into SA could contaminate non-GM rice varieties (ACB, 2011). However, LL rice, to date, has not been imported into South Africa as it is not yet being produced commercially.

Another GM strain of rice is the so-called 'Golden Rice', developed by the International Rice Research Institute in Asia. Golden Rice contains β-carotene (which gives it a golden colour) but it has not yet been authorised for cultivation, to the 'dismay' of scientists (Potrykus, 2010, as cited in Baulcombe *et al*., 2014). The Golden Rice research and development project has been underway for more than 20 years and has gobbled up an obscene amount of resources.

Technology adopted for the NEWEST rice project was developed following the signing of a licence agreement between AATF and Arcadia Bio Science in 2008, followed by another agreement with JT in May 2012. These agreements allow AATF to use, free-of-charge, the transformation technologies of these two companies (AATF, 2012; Arcadia Bio, 2013). Clearly evoked by the project name, this rice product has focused on the following traits:

35. CMD is triggered by germ mini viruses carried by whiteflies and is disseminated through infected cuttings. The most recent outbreak was reported in Uganda in the 1980s and by 2012 had affected 12 countries in Africa. CBSD is triggered by ipomoviruses transmitted by whiteflies and propagated through infected cuttings. The disease has been reported in East Africa and the Great Lakes region as from 2003 and can render entire crops unusable (Legg *et al*., 2014).
36. http://www.harvestplus.org/content/new-technology-speed-pearl-millet-breeding
37. http://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=11181.
38. In 2006 the discovery of this illegal variety in food aid and commercial imports of rice from the USA, in Ghana and Sierra Leone, provoked a huge scandal. At the time of the shipments the rice had not been approved by the USA. Subsequently it was given approval for commercial release in the USA. By 2011 the USA remains the only LL62 growing country in the world.
39. See Objections to the Application made by Bayer Cropscience Gmbh in respect of commodity clearance of event LL rice 62, 3 June 2006.

Nitrogen-Use Efficiency (NUE), Water-Use Efficiency (WUE) and Salt Tolerance (ST).

Sorghum

The lead event that researchers have been targeting within the scope of the ABS project is called the 203 event and attempts to stabilise pro-vitamin A with vitamin E. Other ABS events were developed with higher levels of B-Carotene (ABS 235 and ABS 239) (AHBFI, 2014).[40] ABS is being rolled out in Kenya and Nigeria; with a focus on enhanced Vitamin A levels and bio-available zinc and iron (ABNE, 2013). In South Africa, research relating to biofortified sorghum relates to the following traits: pro-Vitamin A, iron and zinc, as well as protein digestibility (James, 12). To the best of our knowledge this project has been abandoned.

Sweet potato

Sweet potato is being researched for nutrient-enhancement in Ghana (ABNE, 2013)—although this research has currently been stalled due to the lack of funding—and for virus resistance in Kenya (SPFMV-Maruca-resistant sweet potato). Research has also been conducted in Zimbabwe (laboratory stage) (Chambers *et al*. 2014) and research for weevil resistance was initiated in 2010 in Uganda (Schnurr & Gore: 2015:61), for which contained GH trials are on-going (JAMES 2012; Chambers *et al*. 2014). Applications for SPFMV and SPCSV resistant sweet potato have also been made (JAMES 2012).

The sweet potato feathery mottle virus (SPFMV), sweet potato chlorotic stunt virus (SPCSV), sweet potato virus G (SPVG) and sweet potato mild mottle virus (SPMMV) have caused a synergistic disease complex that has devastated sweet potato in South Africa (Sivparsad and Gubba, 2014).[41] Following Monsanto's first failure the transgenic sweet potato (*Ipomoea batatas* Lam.) is now being developed. It is a sweet potato with broad virus resistance (ISAAA, 2014). There is little information in the public domain regarding progress on this research.

1.4 Countries targeted for research on GM crops and stages of research

Once GM crops have been approved for testing they are assessed under contained conditions, and thereafter they are testedwhich includes testing under Green House (GH) or Confined Field Trials (CFT) conditions. CFTs are small-scale field experiments conducted in a confined environment to evaluate the performance of genetically modified (GM) plants. The confinement supposedly is aimed at ensuring that there should be no "gene spread to higher organisms, the soil and airborne pests or organisms" (Prabhu, 2009:172). CFTs are supposed to be surrounded by fencing and around-the-clock security to avoid any accidental release of materials or theft, and all transgenic material is burned at the conclusion of every study. (Schnurr and Gore, 2015). As shown in this section, which discusses the current stage of research involving non-commercial crops, most of the crops are still at nascent experimental phases.

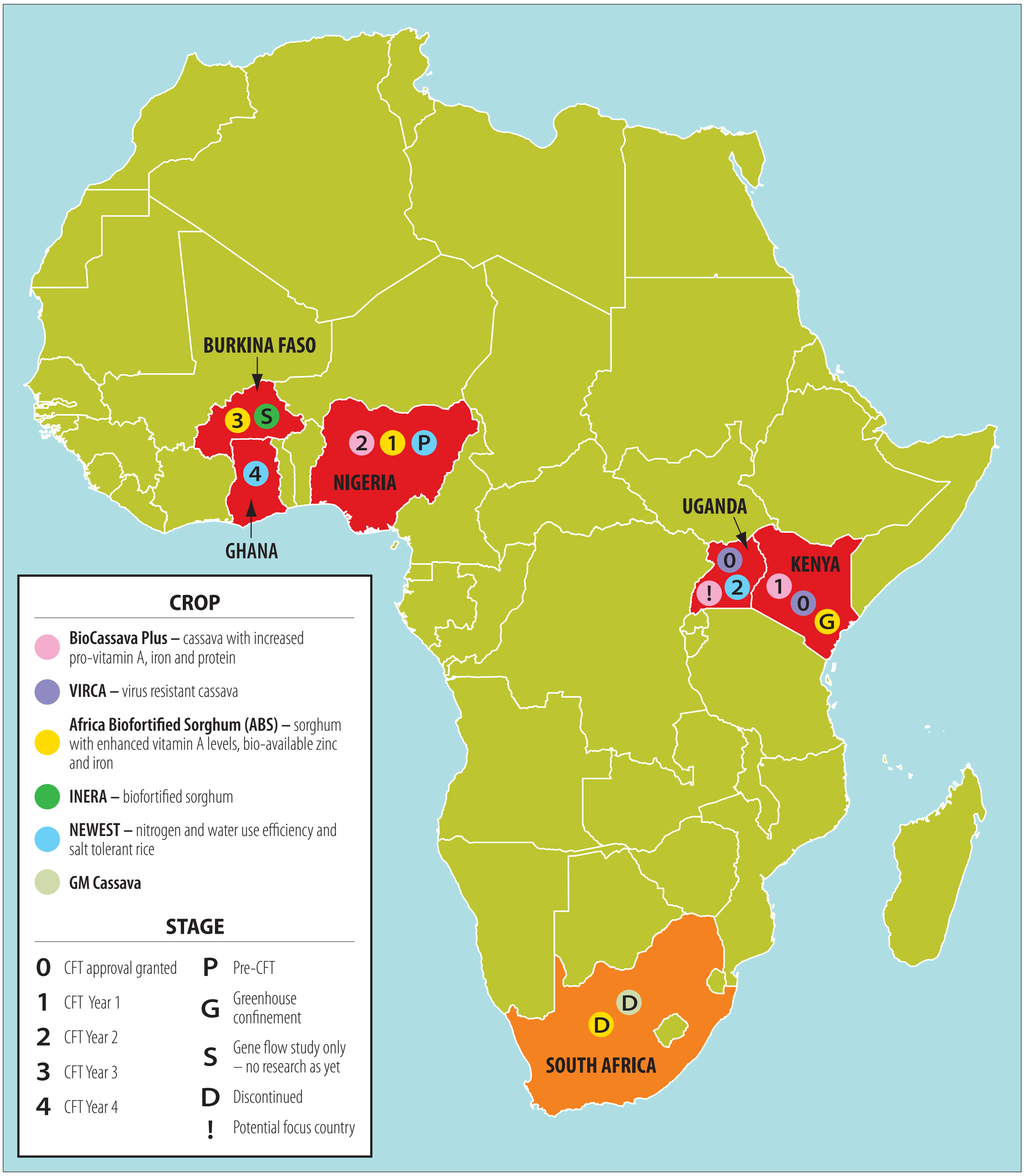
The countries targeted by GM research on orphan crops (and rice) include: Burkina Faso (rice and sorghum); Egypt (rice and sorghum),[42] Ghana (cassava, sweet potato,[43] rice); Kenya (cassava, pigeon pea (transformation and green house stage), sweet potato (transformation), sorghum, millet—although information pertaining to GM research for this crop in the country is scarce;[44] Nigeria (cassava, rice,

40. DuPont has mentioned the development of a second generation of transgenic sorghum seeds, known as 'ABS#2', as part of the ABS project (Perkins, 2008).
41. http://www.isaaa.org/kc/cropbiotechupdate/article/default.asp?ID=12255; April 30, 2014 Issue of Crop Biotech Update. See http://link.springer.com/article/10.1007/s11248-013-9759-7?no-access=true
42. The current status of trials for this research could not be verified because in 2012 Egypt halted the commercialisation of GM crops.
43. However, a shortage of funding has impeded the conducting of trials for this crop (GAIN, 2015b) and, according to the ABNE (2015:11) trials are "yet to commence".
44. Mention of GM millet research was found only on the GMO Compass website: http://www.gmo-compass.org/eng/database/plants/301.millet.html—no other sources make any mention of millet.

sorghum); South Africa (cassava—this research has been discontinued—and sorghum, for which the state of research uncertain); and Uganda (cassava, sweet potato—at the green house stage—and rice).

International partnerships already in place to research these GM crops, specifically regarding various phases of GE experimentation per country, include the following:

- Cassava with increased pro-vitamin A, iron and proteins through the BC Plus project in Kenya (CFT stage) and Nigeria (CFT stage) and Uganda (CFT stage);
- Virus Resistant Cassava through VIRCA, targeting primarily Nigeria and Kenya;
- The ABS project, with enhanced Vitamin A levels, bio-available zinc and iron, currently targets Burkina Faso (3rd year CFT), Kenya (green house confinement stage), and Nigeria (CFT stage), although the ABS has



been trying to introduce GM sorghum to South Africa since 2006;
- In Burkina Faso, the Environmental and Agricultural Research Institute (INERA) has conducted a gene flow study on biofortified sorghum, but GM research has not started yet (USDA Gain, 2014); and

Nitrogen and water use efficiency and salt tolerant (NEWEST) rice is currently being rolled out in Burkina Faso (pre-CFT stage), Ghana (4th CFT season in 2015) (GAIN 2015b), Nigeria (pre-CFT stage) and Uganda (2nd1rst CFT season in 20XX2013).

There is limited information on the anticipated environmental releases of these crops after CFTs are completed, let alone on the potential commercialisation of these crops. There is a paucity of available information and data pertaining to these crops, particularly data relating to health and environmental impacts. Some of the primary ecological concerns relate to the fact that many countries in Africa are 'centres of diversity' and these crops risk the flow of genes from GM strains to wild species—a risk that is both very high and ethically unacceptable. Experts have demonstrated this in the case of cowpea (ACB, 2015). A study of pollinator behaviour and a population genetic analysis of natural West African wild cowpea populations showed that the Bt-gene used in GM cowpea will escape as soon as Bt-cowpea is grown within the pollinator range of wild cowpea (Pasquet, 2012). The transgene could move from the genetically modified lines to non-modified lines of both cultivated and wild cross compatible relatives (Fatokun et al., 2012). The escape of the Bt-gene is a major concern as this will cause weediness (other plants will acquire a resistance trait that causes an alteration in the ecological balance) and pose unacceptable and adverse ecological effects (ACB, 2015). Another example of this is sorghum: researchers conducting a risk assessment found a wide range of gene flow from sorghum, as well as strong evidence of introgression of GM sorghum into crops and wild relatives, as soon as it is released into the environment (Schmidt and Bothma, 2006).

Nevertheless the roadmap for commercialisation reveals the following:

- According to the lead researcher at the BC Plus project, product development work and obtaining regulatory approval will take five years (i.e. up to 2020) (Anderson, pers. comm.);
- In 2011 HarvestPLus was cited as saying that "by the middle of 2014, more than 150 000 households in Nigeria are expected to be eating vitamin A fortified yellow cassava" (IITA, 11).[45] We are now well into 2016 with no GM biofortified cassava in sight;
- A media source states that the NEWEST rice variety is likely to be made available to farmers by 2018 (Oryza.com);[46]
- According to the CSIR's principal investigator, the fourth harvest of rice in Ghana had revealed a 'lead event'. This will be recommended to the Biosafety Committee to allow it to be grown, after testing, by farmers in Ghana. Further, he is reported to have indicated that commercialisation of GM rice would take between three to five years (CSIR, 2015);[47] and
- According to the EU-funded GMO Compass, the commercial utilisation of genetically modified millet cannot be expected in the near future.

45. http://www.iita.org/search/-/journal_content/56/25357/881871.
46. http://oryza.com/news/rice-news-africa/african-farmers-get-newest-rice-variety-2018.
47. http://www.cropsresearch.org/index.php?option=com_content&view=article&id=112:csir-harvests-fourth-batch-of-genetically-modified-rice&catid=48:cri-in-the-news&Itemid=263.

Conclusion

This scoping study on the current status of GM research in Africa for a few non-commercial crops—cassava, sorghum, sweet potato, pigeon pea and millet, as well as for rice—shows that the GM industry appears to be expanding its grasp over traditional subsistence crops which had, until recently, been disregarded. This indicates that the GM industry, under the veil of technology donations and public financing, is effectively managing to make further inroads into promoting GM on the African continent. By focusing the research on traits meant to 'benefit' farmers and malnourished populations, through biofortification, the industry is bent on winning the hearts and minds of Africans regarding genetically modified crops.

The hype around the current wave of GM research into non- commercial crops in Africa is purposefully ahistorical and deceitful. It does not mention past failures involving the demise of Wambugu's/Monsanto's GM sweet potato research in Kenya (DeGrassi, 2003; GMWatch, 2015), or the quiet recognition by the Danforth Research Centre in 2006 that the GM cassava it had developed had lost resistance to African cassava mosaic virus (ACMV) (ACB and GRAIN, 2006). The recent case of Burkina Faso's reversal on GM cotton, due to the Bt cotton crop's declining quality, is instructive for Africa. Burkina Faso's cotton companies have committed to phasing out Bt cotton and returning to the exclusive use of conventional cotton, by the 2017/18 seasons. The sector is seeking compensation from Monsanto for the losses incurred and this is also extremely telling (Dowd-Uribe and Schnurr, 2016).

Crucially, as is the case with the Golden Rice research and development project (which has devoured an unconscionable quantity of available resources) these GM projects are diverting both financial and human resources, policies and practices, away from implementing the real solutions which can be found within the diversity of natural foods and farming. This is also where real cures can be found to address vitamin and mineral deficiencies. Typically, poor people and those living in environments that may be degraded, or who have little by way of access to public health systems, sanitation and proper education, and who may be socially marginalised, are also suffering from various nutritional deficiencies including zinc, vitamin C and D, folate, riboflavin, selenium and calcium. GM crops will not address these multiple nutritional challenges.

Further, on going R&D into these GM crops is obstructing sustainable solutions to the multiple challenges faced by Africans regarding nutrition. These include ecological farming and traditional kitchen and home gardens, both of which can better contribute to healthy and diverse diets and empower people to access and produce their own healthy and varied food. These are sustainable solutions and they will move us closer to achieving our demand for food sovereignty, which, in turn, will increase access to healthy and varied diets to address a range of vitamin and nutrient deficiencies.

Smallholder farmers in Africa must be given the right to choose their means of production and survival. We do not believe that these GM projects are enabling small-scale farmers in this way. Rather, it appears as if decisions as to what is best for smallholder farmers and consumers in Africa have been made in the North, which is a tragic throwback to our colonial past. These decisions encompass more exploitation of hunger and malnutrition and more promotion of the interests of the rich and powerful. GM based technology is costly. Even if gene sequences and constructs are donated, the accompanying requisite GM inputs will be expensive for farmers. GM crops are highly likely to increase the costs of production for farmers and lead them into indebtedness and dependency. It is also highly likely that breeding material will be subject to plant breeders' rights, and that certified seed will be sold to farmers by local seed companies who will expect a profit or royalty payments from farmers. There is no such thing as a free lunch for poor farmers. And to add insult to

48. http://www.gmo-compass.org/eng/database/plants/301.millet.html.

injury, these farmers will be precluded from saving any farm-saved propagating material. In this way, they will be expected to give away their age old farmers' rights to freely reuse, exchange and sell seed and propagating materials in their farming and seed systems.

These GM crops threaten the genetic diversity that exists among traditional plant varieties and which can be found under the control of smallholder farmers. The trajectory of these GM crops is taking the future of farming in Africa away from the control of farmers and directing it to those who will benefit from the huge profits to be made from GM seed (including vegetatively propagated material) and other related chemical inputs.

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