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Biosafety risk communication and a multidisciplinary approach: The key to adoption of agro-biotechnology applications in Sub-Saharan Africa

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ABSTRACT

The number of people lacking adequate food in the world is increasing, especially among the poor communities in Sub-Saharan Africa (SSA). Constraints to crop production in SSA are many including pests, diseases, weeds, environmental degradation and inadequate food processing facilities. Agro-biotechnology applications hold potential in solving some of the constraints. Two related challenges to the application of agro-biotechnology in SSA are inadequate capacity and public concerns. There are five main public concerns that have hampered adoption of agro-biotechnology in SSA: biosafety issues related to human health, concerns about detrimental environmental impacts, regulatory concerns, economic concerns and ethical concerns. This review will discuss the basis of these fears and concerns. We also identify risk communication as a major factor influencing public concerns and perceptions towards GM agriculture in SSA. We further suggest that scientists have a major role in clarifying issues about the adoption and use of genetically modified (GM) crops in agriculture.

Keywords: *Genetically Modified Crops, public concerns, safety issues*

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Introduction

The number of people lacking adequate food in the world is increasing, especially among the poor communities in Sub-Saharan Africa (SSA) (Dalgado, 1997). Constraints to crop production in SSA are many including pests, diseases, weeds, environmental degradation, soil nutrient depletion and inadequate food processing facilities (Scherr, 1999). Biotechnology tools like tissue culture, genetic transformation and molecular markers can improve efficiency in crop improvement efforts and overcome some of the challenges faced by conventional plant breeding strategies for improvement of food production (Machuka, 2001). The UN Human Development Report (HDR) "Making New Technologies Work for Development" (UN, 2001) identified biotechnology as a key avenue for the socio-economic advancement of the developing countries.

As a tool of biotechnology, genetic transformation is faster, and able to deliver genetic changes that would never occur through conventional methods (Kung and Wu, 1992). Genetic transformation is already being applied in the improvement of crops that are important in SSA. For instance, programs using genetic transformation to enhance nutritional content, to solve environmental constraints such as chilling, freezing, soil salinity, heat stress and biotic constraints such as weevils and viral diseases in sweetpotato have yielded promising results (Yamaguchi *et al.*, 2004; Kasukabe *et al.*, 2006).

Despite the documented potential of agro-biotechnology applications in transforming agricultural economies, its adoption has remained low in SSA (James, 2003). This contrasts with the increase in global area of agro-biotechnology. The global biotechnology crop area reached 250 million hectares in 2006, with more than 10 million farmers in 22 countries planting 102 million hectares of biotechnology crops, up from 90 million hectares planted by 8.5 million farmers in 21 countries in 2005 (James, 2006). The increase of 30 million acres between 2005 and 2006 was the second highest in five years and equivalent to an annual growth rate of 13% in 2006. Of the countries that grew biotechnology crops in 2006, South Africa was ranked eighth in terms of the hectarage devoted to growing biotechnology crops in the world. It is important to note that South Africa is the leading country in terms of GM commercialization in Africa (James, 2006).

Apart from inadequate capacity in terms of human resource and infrastructure, the dominating public concerns and fears towards agro-biotechnology applications threaten sustainable adoption of the technology in SSA. Other authors have shown that some perceptions have arisen due to a big failure to address concerns that currently fall outside scientific risk assessment; for example fears that agricultural economies will be changed fundamentally by the use of GM crops, leading to undesirable social or political change (Johnson *et al.*, 2006). In this review, we identify risk communication as a key to addressing public concerns and therefore speeding up the adoption of agro-biotechnology in SSA. We briefly review the concerns that have affected adoption of agro-biotechnology in SSA. With the aim of improving effectiveness in biosafety risk communication, we also highlight the historical basis of current perceptions towards genetically modified organisms (GMOs). We finally suggest how scientists can communicate risks and benefits of agro-biotechnology applications to influence opinions and perceptions by the public towards understanding GM agriculture. We also propose how scientists can handle sentiments from commentators who have opted to be denialists regarding GM agriculture.

The major concerns towards GM agriculture

There are five main public concerns that have hampered adoption of agro-biotechnology in SSA: safety issues related to human health, concerns about detrimental environmental impacts, regulatory concerns, economic concerns and ethical concerns. Some of these concerns are legitimate while others clearly result from lack of information and/or misinformation about the technology, whereas others are deliberately not genuine.

Commentators who argue that GM interferes with nature need to understand that GM is a development in a long line of plant breeding techniques. Older techniques shuffled the plant's genes, leading to lots of unintended changes, whereas GM is more precise. The comments that it is "unnatural" are just as true of plants generated through conventional plant breeding programs. It is also surprising that some commentators still talk about "releasing" or "freezing" GM as though it is a one-off decision yet to be taken (James, 2007). GM research and plant trials are on-going worldwide.

Loss of wildlife diversity on farm land is also not a problem specific to GM but of agriculture in general; the losses of habitat, use of fertiliser and pesticides, and changes in crop rotations have all reduced the number of plants, insects and birds (ABE 2002). Research into how GM maize crops influence non-target insects in the environment found that whether the maize is GM or not has much less of an impact than how much insecticide is used (USDA-ARS, 2002).

There are also food safety issues regarding GM agriculture. This still creates fear although in the US, foods containing GM ingredients have been eaten for over a decade. It is estimated that more than 80% of processed foods on US supermarket shelves contain GM traces and over a trillion meals containing GM ingredients have been consumed without revealing any adverse health effects (FSA, 2010)).

Some commentators, including scientists, go into an unfair comparison of the expected impact of GM on world food production in reference to the 'green revolution'. It is important to note that GM is simply a plant breeding technique while 'green revolution' resulted from many factors combined including use of new crop varieties, agrochemicals and improved irrigation. In addition it is necessary to note that the world population has grown from 3 billion in 1960 to 6.72 billion in 2008.

Commentators on the strictness of GM regulation will note that the original regulations on growing GM crops were instigated by scientists doing molecular biology research. The first published GM experiment was a paper in 1972 describing the insertion of bacteriophage genes into an animal virus DNA. It led scientists to raise questions about potential risk to human health and to organize the Asilomar Conference 1975, attended by scientists, lawyers and government officials to discuss the technology. They concluded that experiments could proceed under strict guidelines drawn up by the US National Institute of Health. Unfortunately this has led to regulations that cause most observers to get the impression that GM is dangerous, but it's rather the product of how the regulations developed to allay concerns. Therefore regulation for GM research and application operate proactively, anticipating possible risks. GM regulation is not developed after harm has already been experienced as it is with most existing regulations (Morris, 2007). This is demonstrated best in the regulation against the use of "terminator' technology also referred to as Genetic Use Restriction Technology (GURT).

GURT was previously proposed as a method for restricting the use of GM hybrid seeds by causing second generation seeds to be sterile. Companies thought of using this technology to protect their commercial interests and intellectual property rights in GM crops. This was seen as a violation of the rights of farmers to grow crops from saved seeds. A global moratorium on the testing and commercialization of the technology was established under the United Nations Convention on Biodiversity. It was reviewed in 2006 and still stands. This demonstrates that biosafety regulations are proactive and also shows that scientists are fully aware that multinationals' interests are financial rather than humanitarian. However to entirely refuse GM technology on that basis is throwing the baby out with the bathwater (Nuffield Council on Bioethics, 2003). There are many publicly funded GM schemes that have humanitarian, not financial aims. More productive public research on GM will soon be possible as regulation gets less restrictive.

A brief history of current perceptions towards GM agriculture

Opposition to transgenic crops has diverse origins. Some opposition may be our human tendency to want immediate solutions for perennially difficult problems. Therefore an understanding of the nature of objecting views and opinions is critical for clarifying what issue is actually part of the debate. For instance, one of the reasons for increased negative perception against agro-biotechnology among African smallholders and world consumers is that the first-generation transgenics involved a high cost to create (Stewart *et al* 2000). These were also produced with emphasis on the production traits (e.g. resistance to diseases and tolerance to herbicides) of the most economically important crops (e.g. wheat, cotton, rapeseed and soybean). These crops are grown in Africa but they are certainly not the most important crops in SSA (Bonny, 2003).

In addition, the early studies on risk assessment were scanty, sometimes statistically unsound, but, in hindsight, luckily enough showing the trends which were later asserted by better studies. At the same time firms involved in genetic engineering often initially underestimated the public's questions concerning GMOs. The industry even treated the questions with disdain, apparently considering them to be the result of irrational fears that would disappear gradually with better information and education (Marris *et al.*, 2001). Overall, the biotechnology industry did not seem to take the drawbacks of GMOs (whether real or perceived) seriously enough (Eichenwald *et al*., 2001).

More public suspicion about GMOs arose as the public authorities in Europe and Africa appeared hesitant to comment and often made inconsistent statements on the subject (Tripp, 2001). Scientists are still perceived as being divided on the issue, and the contradicting opinions given about GMOs worry many consumers. In addition, genetic engineering has had few allies or backers considered as credible by the public; whereas on the other side, it has had influential opponents supporting and strengthening the anti-GMO movement. More importantly, the contradictory information received on GMOs from experts compared with the clear message of environmental groups reinforces many people's worries on the subject (Bonny, 2003).

Another reason for the negative perceptions is that genetic engineering became a widespread and frequently reported topic shortly after a period during which various issues of public health, food safety, and pollution, among others, had arisen. Confidence in institutions, in industry, and in certain technological advances had been seriously undermined following the problems of contaminated blood, asbestos, and bovine spongiform encephalopathy (BSE) (Bonny, 2003).

Another factor that has played an important role in creating a negative perception of GMOs is that opposition to GMOs appears to be inherently attractive. Opponents put forward arguments calling upon values that a *priori* generate support, such as the need for caution and wisdom in the use of technology, care and concern for the environment, for public health, for the future of the planet, without forgetting citizen participation and involvement in technological choices (Bonny, 2003). Here, the GMO theme has proved to be an excellent platform for certain associations because it has credited them with a responsible attitude, thus conferring legitimacy upon them.

Various concerns with regard to the trends in techno-economic and socio-economic development nowadays may be added to these determinants of rejection. GMOs sometimes come to be considered as a symbol of changes that many people perceive as negative such as growing concentration in the agro-foods industry and increasing economic globalization. These linkages are bolstered by the fact that opposing organizations and activist groups use GMOs as a springboard for expressing their opinions on much broader related points (Bonny, 2003). Thus GMOs are accused of having negative characteristics which, in fact, are not specific to them e.g. the concentration of firms and difficulties of procurement by poor populations (Bové, 1998).

Risk communication: the key to addressing skepticism towards GMOs

The debate concerning genetically modified crops illustrates confusion between the role of scientists and that of wider society in regulatory decision making (Johnson *et al*., 2006). We identify risk communication as a helpful tool in promoting agro-biotechnology. We also assert that a multidisciplinary approach will speed up the adoption of agro-biotechnology since the challenge has shifted away from public ignorance to mistrust (AEBC, 2001). In this review we are concerned with the adequacy of information flow about GM crops. What type of information do farmers and consumers require in order to recognize and make decisions about GM crops? What type of information is required to assure the farmer that the GM seed for sale is of the traits they seek (Tripp, 2001)? What type of industry is required to deliver agro-biotechnology seed and the necessary information?

Factors that might possibly facilitate a positive change in perception include: companies providing credible answers to a range of GM issues; reliable actors highlighting the advantages of GMOs; changes in the general context such that people come to see GMOs in a different light; or the advantages of genetic engineering being highlighted in precise cases where other techniques were unsuccessful (Bonny, 2003). The way scientists have communicated risks associated with GM crops is blamed as one of the causes of rising fear towards agro-biotechnology (Stewart 2000). It seems scientists needed to be mindful that humans are risk averse by nature. It is possible that this problem comes from the way risk assessment studies are done (Johnson *et al.*, 2006). Scientific studies are frequently undertaken without a view as to how they will help to quantify risk: either there is no conceptual or theoretical model to link the data and the assessment endpoints or, worse, no assessment endpoints are defined (Poppy and Wilkinson, 2005). Scientists either set out to unearth potential intrinsic hazards associated with the stressor, or they focus on the potential for exposure to some component of the GM plant without demonstrating whether the component is hazardous (Johnson *et al.*, 2006). For risk to be properly estimated and communicated, both components, i.e. hazard and exposure, need to be quantified, if greater focus is on one then the risk assessment loses quantitative power (Poppy, 2004).

Scientists need to always remember that scientific risk assessment, as pure science, should test hypotheses and make predictions from the results of those tests (Johnson *et al.*, 2006). During interpretation of results, scientists need to consider that scientific risk assessment is only a part of wider risk analysis (Johnson *et al*., 2006). The public and opponents of GMO application need to feel that scientists are listening to them. Academic and public scientists have tended to make two mistakes with regard to the current controversy. The first is their reticence to speak directly to the public and the media for fear of being misunderstood. The second is their assumption that the public and the media will take their scientific data at face value (Stewart *et al.* 2000). Placing risk assessments in the wider context of risk analysis enables the wider 'non-scientific' questions to be considered in regulatory decision making (Johnson *et al.*, 2006). Such integration and understanding is urgently required for SSA because the challenges to regulation will escalate as scientific progress advances. This is also our justification for promoting a multidisciplinary approach in this review.

A multidisciplinary approach will improve public trust

It is important to bring together academia, government, and industry to work together towards a public policy (Arthur, 2001). It is also imperative to make the public aware of the importance of science in decision making by moving from "educating the public" to engaging with the public, through discussions with stakeholders such as the farmer, consumer and regulatory organizations (Rose, 2003). For a regulatory system to be successful it must inspire public confidence (Johnson *et al.*, 2006). Much regulation involves the evaluation of technical information by specialists, therefore, for non-specialists there needs to be a strong element of trust, not only in the regulations, but also in the people in charge. Opponents of the current regulations have proposed solutions, including broadening of the regulation to encompass a more holistic approach in assessing and addressing risks, so that not only human and environmental safety are evaluated, but also ethical and economic concerns. There are also calls for the widening of expert panels to include non-expert members to the committees who evaluate applications and advice on decisions for commercial release (Johnson *et al.*, 2006). A PABE report further recommends involving the public as far upstream in the innovation process as at the risk-assessment level through consensus conference, for example (Louët 2011).

Another way of gaining public trust in SSA is ensuring that trained scientists, technical experts, and policymakers from the region are actively involved in communicating agro-biotechnology issues (Bonny, 2003). If policy options regarding the safety of individual organisms and products are made by African scientists in trusted institutions there will be improved public acceptance of agro-biotechnology in SSA. In green revolution era both fundamental research and its application were mainly done by the public sector. Although GMO research is still carried out by public sector, its application largely takes place in the private sector where much of the intellectual property is controlled (Kuyek, 2002). Agricultural biotechnology research and development needs to be done wherever the products of biotechnology are intended to be used, whether in industrial or developing countries.

Suspicions towards GMOs are not a strange phenomenon

It is not our intention in this review to suggest that agro-biotechnology will be accepted in some prescribed period. Scientists communicating benefits of GMOs in SSA need to exercise patience. They need to understand the factors that influence public perception including culture, history, socio-economic conditions, religion, government policies and scientific uncertainty. Genetic engineering is a fairly recent technique, and numerous improvements can be envisaged to reduce risks or to develop innovations with more advantages than those of the very first transgenic plants. Numerous examples of this can be seen in the history of any technology (Bonny, 2003). Many innovations were initially extremely rough and dangerous but gained considerably in safety, usefulness, controllability and ease of use after years and decades of improvement and adaptation to conditions of use.

Conclusion

Biotechnology is a heavily discussed issue in almost every country, where opinions of the different parties vary considerably and sometimes are quite different. Consequently an understanding of the nature of objecting views and opinions is critical for clarifying what issue is actually part of the debate. Some of the negative perceptions towards GM are legitimate while others clearly result from lack of information and/or misinformation about the technology, whereas others are deliberately not genuine. Progress can be made if scientists discuss GM processes and products in comparison with their non-GM counterparts. Additionally such discussions should emphasize a risk-benefit analysis on a case by case basis. Scientists should note that genetic engineering and other areas of biotechnology form a new wave of innovation based on living material. These technologies promise better knowledge of the functioning of organisms and more accurate, finer and closer operation and intervention mechanisms than the empirical techniques used for decades, centuries or even millennia. However, GMOs have to do with food and nature, which have a special place in human culture. Strong societal questioning concerning this change seems logical and pertinent, because of the risks linked to great power used without sufficient wisdom. In addition, the frequent attitude of suspicion and rejection shown towards GMOs appears fairly logical with regard to the risk/benefit balance drawn up by many people.

Additionally, scientists have a duty not to communicate data in a way that implies that risk has been demonstrated, when all that has been done is that hazard or exposure, or some component of these parameters, has been studied. Importantly, all parties in the GM crop debate should be made aware that scientific risk assessment is one part of risk analysis; it is risk analysis that is used to make decisions and that reflects rational non-scientific concerns. Of course, decisions based on scientific and non-scientific arguments are not easy. One possible answer is to reformulate concerns that appear non-scientific into forms that are amenable to scientific analysis (Johnson *et al.*, 2006). Therefore a multi-disciplinary approach is recommended in this review.

In discussing GM agriculture in public, scientists should always note that the normal academic response of engaging in an opposing argument is not always applicable. It only works when both parties agree to look at evidence as a whole and to reject deliberate distortions and to accept the principles of logic (McKee, 2009). In this review, we argue that it is necessary to shift the debate from the subject under consideration, instead exposing to public scrutiny the tactics employed by anti-GM activists and identifying those tactics publicly for what they are. Denialsts like anti-GM activists use an approach that has the ultimate goal of rejecting a proposition on which scientific consensus exists. The five tactics deployed by denialists are identification of conspiracies or inversionism, use of fake experts, selectivity, creation of impossible expectations and the use of misrepresentation and logical fallacies (McKee, 2009). The controversy surrounding the application of GMOs in agriculture is complex biosafety risk communication and a multidisciplinary approach are alone are not enough to clear the issues discussed. As scientists, we must remain proactive in delivering accurate agro-biotechnology information using the most appropriate tools available (Stewart, 2000).

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References

A.B.E, 2002. Agricultural Biotechnology in Europe (2002). Economic Impacts of Crop Biotechnology Issue Paper 5 October

A.E.B.C. 2001. Agriculture and Environment Biotechnology Commission. Workplan (AEBC, London) <http://www.aebc.gov.uk>

Arthur, M.H. 2001. Research officers program urges science-based public policy. Food Technology Journal 55: 54.

Bennett, R. 2004. Reductions in insecticide use from adoption of Bt cotton in South Africa: impacts on economic performance and toxic load to the environment. Journal of Agricultural Science 143: 665–674

Bonny, S. 2003.Why are most Europeans opposed to GMOs? Factors Explaining rejection in France and Europe. Electronic Journal of Biotechnology [online]. 15 April, 2003. Vol. 6 -Issue no. 1 (cited 10 April 2011).

Bové, J. 1998. Speech at the Agen court, 12 February, translated by Greenpeace France, www.greenpeace.org.fr, www.cpefarmers.org

Dalgado, C.L. 1997. Africa's changing agricultural development strategies. International Food Policy Research Institute, 2020 Brief 42. http:/www.cgiar.org/2020/briefs/number42.htm.

Eichenwald, K., Kolata, G., Petersen, M. 2001. Biotechnology food: From the lab to a debacle. The New York Times, Jan. 25 (www.nytimes.com/2001/01/25/business/25FOOD.html).

F.S.A. 2010. GM food. Food Standards Agency. www.eatwell.gov.uk/healthissues/factsbehindissues/gmfood

James, C. 2007. Global Status of Commercialised Biotech/Gm Crops. ISAAA Briefs 37

James, C. 2003. Global review of commercialized transgenic crops. Current Science, 84

James, C. 2006. Global Status of Commercialized Biotech/GM Crops: 2006, ISAAA Brief 35-2006: Highlights.

Johnson K.L., Raybould A.F., Hudson M.D. and Poppy G.M. 2007 How does scientific risk assessment of GM crops fit within the wider risk analysis? Trends in Plant Science 12, 1-5

Kasukabe, Y., He, L., Watakabe, Y., Otani, M., Shimada, T., Tachibana, S. 2006. Improvement of environmental stress tolerance of sweet potato by introduction of genes for spermidine synthase. Plant Biotechnology 23: 75-83.

Kung, S. and Wu, R. E. (1992). Transgenic plants. *Volume 1*: Engineering and utilization. *Academic Press, Inc., 1250 Sixth Avenue, San Diego, California 92101-4311, USA*. pp 1-11

Kuyek, D. 2002. Genetically Modified Crops in Africa: Implications for Small Farmers. Published by Genetic Resources Action International (GRAIN): Girona 25, pral, Barcelona 08010, Spain. Web: www.grain.org

Machuka, J. 2001. Agricultural biotechnology for Africa: African scientists and farmers must feed their own people. Plant Physiology 126: 16-19.

McKee M. 2009. Denialism: what is it and how should scientists respond? European Journal of Public Health 19: 2-4.

Marris, C., Wynne, B., Simmons, P. and Weldon, S. 2001. Public Perceptions of Agricultural Biotechnologies in Europe. Final Report of the PABE Research Project commissioned by the EC, Published online at: http://www.pabe.net

Morris, S. H. 2007. EU biotech crop regulations and environmental risk: a case of the emperor's new clothes? TRENDS in Biotechnology Vol.25 No.1

Nuffield Council on Bioethics, 2003. The use of genetically modified crops in developing countries: a follow-up discussion paper.

Poppy, G.M. and Wilkinson, M.J. 2005 Risk assessment of GM crops – does the road ahead need to be long and winding? In Gene Flow from GM Plants (Poppy, G.M. and Wilkinson, M.J., eds), pp. 225–238, Blackwell Publishing, London, United Kingdom

Poppy, G.M. 2004. Gene flow from GM plants – towards a more quantitative risk assessment. Trends Biotechnology 22: 436–438.

Rose, S. 2003. How to (or not to) communicate science. Biochemical Society Transactions 32: 307–312

Sabine Louët (2001). EC study reveals an informed public. *Nature Biotechnology* 19: 15-16

Scherr, S.A. 1999. Soil degradation: a threat to developing country food security. International Food Policy Research Institute, 2020 Brief 58. http:/www.cgiar.org/2020/briefs/number58.htm.

Stewart C.N., Richards H. A. and Halfhill M. D. (2000). Transgenic Plants and Biosafety: Science, Misconceptions and Public Perceptions. *BioTechniques* 29:832-843

Thro A.M. 2004. Europe on Transgenic Crops: How Public Plant Breeding and Eco-Transgenics Can Help in the Transatlantic Debate. *AgBioForum*, 7(3): 142-148

Tripp, R. 2001. Can biotechnology reach the poor? The adequacy of information and seed delivery. Food Policy 26:249–264

U.N., 2001. Making new technologies work for human development, UNDP Human Development Report 2001, p.274; Oxford University Press, NC27513, New York, USA.

USDA-ARS. 2002. Other factors affecting monarchs. United States Department of Agriculture, Agricultural Research Services. www.ars.usda.gov/sites/monarch/sect3_2.html

Yamaguchi, K., Song, G. and Honda, H. 2004. Efficient Agrobacterium tumefaciens-mediated transformation of sweet potato (Ipomoea batatas (L.) Lam.) from stem explants using a two-step kanamycin-hygromycin selection method. In vitro Cell Development Biology - Plant 40: 359-365.