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Assessing the Prospects for the Adoption of Biofortified Crops in South Africa

Rosemary A. Wolson
Council for Scientific and Industrial Research (CSIR)

South Africa was an early adopter of GM crops and, more recently, introduced a national food-fortification program. This article discusses the country's experiences in developing an appropriate regulatory framework and the responses of key stakeholders. In addition, an assessment is presented of the prospects for the adoption of biofortified crops in South Africa.

Key words: biofortication, biofortified crops, genetically modified organisms, GMOs, South Africa.

The Response to GMOs in South Africa

Evolution of the Regulatory Framework

South Africa was one of the early adopters of genetically modified (GM) crops and remains the only African country to have approved commercial production of GM crops. The first field trials of transgenic crops on the African continent were initiated in 1989 with an application to the South African Department of Agriculture from the US seed company Delta and Pine Land, which used South Africa as an over-wintering haven for field trials of cotton. This application was approved according to guidelines established by the South African Committee for Genetic Experimentation (SAGENE), a scientific advisory committee set up in 1979 to monitor and advise on the development of genetically modified organisms (GMOs) in the country.

SAGENE guidelines continued to be the basis for approval of transgenic crop events until implementation of the Genetically Modified Organisms Act in 1999. Members of SAGENE participated in the drafting of the GMO Act. Because the process of introducing a biosafety regulatory framework began under the previous government, and because many of the same individuals continued to carry out roles when the legislation eventually took effect, GMO opponents have questioned the legitimacy of the process and the system. Others believe this continuity was necessary to ensure adequate technical capacity.

For several years, GMO applications moved through the system with ease, attracting little input via the available public participation mechanisms. The situation has changed in recent years as critics of GM technology have taken a more active approach and now routinely make submissions requesting information and objecting to applications. At the same time, the Executive Council (EC), the body established by the GMO Act with the responsibility of deciding whether or not to approve GM applications, also appears to be playing a more active role in questioning aspects of applications and calling for additional information before rendering a decision. For the most part, this seems to be *delaying* rather than *preventing* approval, but serves as a signal that applications will be subject to greater scrutiny than in the past.

Uptake of GM Crops

South Africa has the eighth highest acreage of GM crops in the world (James, 2005). Five GM crop traits, listed in Table 1, have been approved for commercial release. These are all based on imported technology, in some cases back-crossed into local varieties. While Bt yellow maize, which is used primarily for animal feed, was first grown commercially in 1998, South Africa became the first country to allow the introduction of a GM food staple when production of Bt white maize began in 2001. An advanced GM cotton variety containing stacked Bt and herbicide-resistance genes was approved in 2005.

A 2006 survey estimates that the area planted under GM crops now stands at 609,000 hectares (Van der Walt, 2006). According to this survey, the GM share of the soybean crop in South Africa stands at 59%, while GM maize holds a 29% market share of maize and GM cotton makes up about 90% of the area planted under cotton.

GM cotton was taken up very rapidly, not being hampered by the consumer-acceptance concerns that affect food crops, and adoption rates now appear to have stabilized. Farmers were initially fairly cautious in their uptake of Bt yellow maize. In the first few years, the available hybrids were not those most suited to local markets and the dry, windy climate, and the yield benefits were not considered sufficient to offset the technology fee since the stalk borer (the pest targeted by the

Table 1. Genetically modified crops approved for commercial release in South Africa.

Crop	Year first approved	Season first produced
Insect-resistant cotton	1997	1997/1998
Insect-resistant maize	1997	1998/1999 (yellow)
Herbicide-tolerant cotton	2000	2001/2002
Herbicide-tolerant soybeans	2001	2001/2002
Herbicide-tolerant maize	2002	2003/2004
Stacked-gene cotton **• insect resistance** **• herbicide tolerance**	2005	2005/2006

Note. Data from Republic of South Africa, Department of Agriculture (2005); Wolson and Gouse (2005).

GM technology) did not present a major problem during those seasons. But adoption increased as better varieties were introduced, and after farmers experienced serious borer pressure in the 2001/2002 growing season (Gouse, Pray, Kirsten & Schimmelpfennig, 2005). The uptake of GM white maize (white maize being the major food staple in South Africa and southern Africa) has been rapid. Acreage has increased from 6,000 hectares in 2001 (when first introduced commercially) to 84,000 ha in 2003 (James, 2003) and 155,000 ha in 2004 (James, 2004). South Africa was the second market, after the United States, in which Monsanto began selling its Roundup Ready maize. An industry study predicts that the uptake of GM maize will continue to rise rapidly, with that of white maize increasing from 3% of the harvest in 2003 to 8% in 2004 and 16% in 2005; in five years' time, more than half of the total maize harvest will be GM ("GM maize," 2004). There is no evidence of any illegal planting of GM seed having taken place in South Africa (Wolson, 2006).

South Africa is viewed to some extent as a testing ground for the adoption of GM products elsewhere in Africa, and many believe that without sustained success in South Africa, the prospect for GMO adoption in other African countries is far less likely. Such success is measured by factors such as a safe and predictable regulatory process, benefits experienced by farmers which exceed the additional seed costs, and consumer acceptance.

Adoption by Small-scale Farmers

The rapid adoption rate of Bt cotton early on by small-scale farmers in the Makhathini Flats of KwaZulu-Natal has been the focus of considerable international attention since it is one of the earliest examples of widespread planting of GM crops by resource-poor farmers. The experience with GM cotton brought benefits initially, and this story became frequently quoted as testimony that GM crops can indeed have a positive impact on small-scale farmers in developing countries. More recent studies, though, have shown that the optimism of the early days was premature. While the new technology continues to offer a strong advantage over conventional cotton, the overall benefits were not sustainable for small farmers when the institutional supports that had earlier been provided by the company Vunisa Cotton (as supplier of seeds, credit, inputs, and information on the one hand and the buyer of the crop on the other) were withdrawn, and the area planted under cotton in the region decreased significantly (Gouse et al., 2005).

Public Participation and Access to Information

Activists in South Africa for some time have highlighted the difficulties of obtaining access to adequate information to facilitate meaningful public participation. In 2002, Biowatch took legal action against the Registrar of Genetic Resources, the EC, and the Minister of Agriculture in order to compel them to make information available on the use, control, and release of GMOs, including details of all pending applications and issued permits as well as locations of field trials of GM crops. Biowatch took this course of action after four previous failed attempts to acquire information, as it believed that insufficient access to information was preventing the organization and the public from assessing whether genetic engineering in South Africa was safe and compliant with national legislation, the Constitution, and environmental standards. Seed companies, including Monsanto, subsequently joined the action as further respondents in order to protect their rights to confidentiality in their proprietary commercial information. The Open Democracy Advice Centre intervened as amicus curiae to highlight the importance of access to information in an open democratic society.

The case was heard in 2004. The judgment, delivered in 2005, found that Biowatch had established a clear right to some of its requested information but that access to certain records or parts thereof could be refused by the Registrar on justifiable grounds. The judgment considered each category of information requested by Biowatch and upheld most of the requests.

Arguably, the South African biosafety regulatory system would be better served if information were easier to access—subject, of course, to reasonable safeguards to protect the rights of private parties in their

proprietary information. Access to information is a necessary condition for enabling citizens to exercise and protect their rights. This is especially important for matters surrounded by controversy, such as GMOs. Difficulties experienced in obtaining information do not generate confidence in the regulatory process (Wolson, 2006).

Consumer Acceptance

Surveys and polls conducted over the years in an attempt to ascertain the extent of public knowledge and understanding of GM foods, as well as to assess public attitudes towards the technology, indicate that only a small proportion of the population has strong opinions either in favor of or in opposition to GMOs.[1]

The most comprehensive survey to date was released in 2005 (Rule & Langa, 2005). This was based on a sample of 7,000 adults, representative of the adult population. An overwhelming majority of respondents—almost 80%—was found to know very little or nothing about biotechnology, and more than two thirds had *never heard* of biotechnology before. Of those who expressed negative views about biotechnology, more than half were unable to supply any reasons for their feelings. Where reasons were given, health concerns were most common. Most people did not know whether they had ever eaten any foods containing GM ingredients, and respondents were generally not aware of which foods might be GM. Two thirds of respondents did not identify any GM foods, and of those who did, a significant proportion named fruit or vegetables, despite the fact that no GM fruit or vegetables are sold in South Africa yet.

Synovate, an international market research company, reported on a survey that compared attitudes to GM food in Greece, Indonesia, Poland, Singapore, and South Africa (Synovate, 2006). South Africans were the least likely of all respondents to believe that GM foods may be harmful or that GM crops should not be grown close to non-GM crops. In addition, South Africans are the least likely to check labels while grocery shopping in order to avoid buying GM food. At the same time, the percentage of South African consumers willing to buy GM products if they were cheaper than non-GM equivalents and of those who believe that anything that makes food taste better is acceptable was highest.

Regulations governing the labeling of foodstuffs obtained through certain techniques of genetic modification (e.g., Government Notice R. 25 of 2004) cover foods composed of, containing, or produced from GMOs. These include food additives and ingredients but exclude foods derived from a non-GM animal fed on GM feed. The non-discriminatory US approach of 'substantial equivalence' has been adopted. There are currently no GM foods on the market which must be labeled in terms of these regulations (Mayet, 2004).

While stakeholder groups have campaigned for labeling of GM food, there is not much evidence to show that this is an important issue for the public at large. This suggests that the introduction of more detailed labeling requirements—which might increase product costs—is not a high priority for most consumers and perhaps even less so for those from low-income groups. At the same time, though, the consumer's right to know must be upheld, and the value of labels in building awareness ought not to be dismissed (Wolson, 2006).

There are no clear indications as to what level of public acceptance of GMOs will ultimately develop in South Africa. As more GM food products start to enter the market and international debates on the topic intensify, it is expected that public awareness will increase. Whether this leads to greater *acceptance* or growing *rejection* will depend on the technologies in question, the nature and quality of information made available to the public, and how effectively it is communicated. All of the available survey evidence makes it clear that existing communication systems are inadequate, but there remains no consensus on how best to provide impartial information (and by whom) to a very heterogeneous society (Wolson, 2006).

Food Fortification in South Africa

Prior to 2003, compulsory fortification of margarine and iodization of salt was required by law in South Africa, while certain other products—including bread, maize meal, breakfast cereals, and fruit juices—were in some cases fortified on a voluntary basis (Food Advisory Consumer Service, 2004). A national food consumption survey conducted in the 1990s reported that 50% of South African children aged between one and nine years were receiving less than half of their daily recommended dietary intake for energy, Vitamin A, Vitamin C, riboflavin, niacin, Vitamin B6, folic acid, calcium, iron, and zinc. In response to this survey, a national food fortification program was implemented in October 2003

1. *Several of such surveys are listed at: http://www.pub.ac.za/resources/research.html.*

with the introduction of "Regulations Relating to the Fortification of Certain Foodstuffs" (Government Notice R. 504 of 2003), under the Foodstuffs, Cosmetics and Disinfectants Act No. 54 of 1972. The regulations mandated the fortification of maize meal and bread flour with Vitamin A, thiamine (Vitamin B1), riboflavin (Vitamin B2), niacin, folic acid, pyridoxine (Vitamin B6), iron, and zinc, according to stipulated formulations and standards for the various products. Maize meal and bread were selected because they are two of the most commonly eaten food items, particularly by people in lower income brackets.

Assistance has been received from the Global Alliance for Improved Nutrition (GAIN) in the form of a grant to support implementation. The South African government and private sector have contributed further investment to the initiative. While many of the large commercial milling concerns began to fortify the required products in anticipation of the regulations even before they came into force, implementation by medium-scale millers has not yet occurred across the board, and numerous issues must still be addressed to facilitate fortification by small-scale village millers. Such issues include economic feasibility and concerns about toxicity if the supplements are not properly mixed in the right proportions. It is estimated that up to 30% of maize meal nationally may not be fortified and a higher percentage of that consumed by poor rural populations (Meyers, 2006; H. Vermeulen, personal communication, 2006). Municipal environmental health practitioners are responsible for monitoring compliance and have been targeted to receive fast-track training. A national survey is in the process of being carried out to generate baseline data for assessment and monitoring of the impact of the program, but it remains too early to draw any conclusions in this regard (Roelf, 2006).

Stakeholders in the GMO Debate

Stakeholders who have weighed in on the GMO debate in South Africa include several government departments, non-governmental organizations (NGOs), scientists, local and multinational seed companies, retailers, farmers, consumers, trade unions, and church organizations.

South African Government

The South African Government's stance towards GMOs has been described as "guardedly positive" ("South Africa affirms," 2003). This is borne out, for example, by a 2004 public statement from the Directorate of Genetic Resources of the Department of Agriculture (DoA), which is responsible for administering the GMO Act and Regulations. The statement reiterated the belief that the use and application of GMOs can play an important role in poverty reduction, while at the same time it acknowledged the risks associated with application of the technology ("GMOs to eradicate," 2004; "Government reassures," 2004). While the DoA and Department of Science and Technology are generally regarded as GMO proponents, the Department of Environmental Affairs and Tourism and Department of Trade and Industry tend to take a more skeptical view.

Local Organizations Supportive of GMOs

Seed Companies

Multinational seed companies, among which Monsanto is the dominant player, are active players on the local GM seed market. Monsanto has licensed some of its GM technology to other multinational (including Pioneer Hi-Bred, Delta and Pine Land, and Stoneville) and domestic seed companies (e.g., Pannar) for incorporation into their proprietary hybrids. To some extent, these companies view South Africa as a testing ground for the promotion of GM products elsewhere in Africa.

Local seed companies have not yet developed their own GM traits, but there are examples of local companies in-licensing GM genes from Monsanto, which they have back-crossed into their own hybrids. Pannar, a local seed company, has a breeding program for maize varieties targeted at the needs of small-scale farmers, but they have yet to introduce GM traits into these varieties. Pannar supports collaborative academic R&D on GM maize, with an intent to commercialize viable events for both commercial and small-scale markets.

SANSOR

The South African National Seed Organization (SANSOR) was formed in 1989 as a result of the amalgamation of other trade and technical associations. It is a private, non-profit company operating as a secretariat with permanent staff and has a membership of about 100. It participated in the government working group responsible for drawing up the GMO Act. SANSOR is calling for harmonized biosafety legislation amongst Southern African Development Community (SADC) member states.[2] SANSOR has expressed support for GM crops in various public fora and has ties with AfricaBio. In a 2002 press release, the organization stated that GM technology "has come to stay as a valuable

additional tool in plant improvement." It stressed the importance of identity preservation with a documented audit trail to minimize the risks of fraudulent claims, unintentional mixing, and consequent legal disputes.

AfricaBio

AfricaBio is a leading "pro-GM" group, seeking to provide information to key stakeholders, the media, the general public, and international organizations and to lobby key stakeholders. Its membership includes representatives from industry, academia, and research organizations. While it holds itself out as an independent organization, it has drawn criticism as a result of the active support it receives from its industry stakeholders, and some believe that it is a "front" for industry and therefore more accurately described as an industry organization rather than the civil society organization it purports to be.[3] However, its stakeholder base is broader than industry alone and its activities extend beyond lobbying industry interests.

African Harvest Biotech Foundation International

African Harvest Biotech Foundation International is an NGO with offices in the United States, Kenya, and South Africa, whose Chief Executive Officer is a prominent Kenyan biotechnologist. The foundation champions the use of biotechnology to fight hunger, malnutrition and poverty in Africa and the developing world by increasing agricultural yields and incomes. It carries out its mission a) through technical programs to facilitate technology access; b) through a communications program, which aims to improve the quality of debate by supplying factual information to national stakeholders; and c) by representing Africa by effectively presenting the case for biotechnology in international fora. Its South African activities focus mainly on its communication program rather than on the provision of technology, although it is now collaborating with South African (and other) organizations in the Africa Biofortified Sorghum Project.

Academia and the Scientific Community

For the most part, scientists working in biotechnology tend to support GMOs, acknowledging there may be risks but believing that these can be managed. Biowatch critics have claimed that members of the scientific community with GM expertise are unwilling to give "honest and independent" opinions on the topic due to the financial support they receive from industry (Biowatch South Africa, 2004). However, the relatively small scale of such support is unlikely to justify allegations of widespread conflict of interest.

Local Organizations Opposed to GMOs

Biowatch

Biowatch is the most active and influential organization opposing GMOs in South Africa. It is a national organization whose work involves a) researching and monitoring the commercialization of biological resources; b) promoting sustainable livelihoods, sustainable agriculture and food security; c) monitoring the impacts of GMOs in South Africa; d) capacity-building; and e) raising public awareness on biodiversity issues to encourage informed participation in policymaking. Biowatch opposes GMOs on health, environmental, and socio-economic grounds. It is funded by a number of mainly European NGOs and GTZ, the German technical cooperation agency. It plays a strong lobbying role challenging the biosafety regulatory regime by invoking public participation and appealing provisions of the GMO Act.

Other Organizations

Other organizations that have taken a critical stance of GMOs at various stages include a) SAFeAGE (The South African Freeze Alliance on Genetic Engineering), an umbrella organization calling for a minimum five-year moratorium on field trials and commercial releases of GM crops, until the technology is proven to be safe, environmentally harmless, and in the interests of the people of South Africa; b) environmental NGOs and lobbyists such as the African Centre for Biosafety, the Environmental Justice Networking Forum, and Earthlife Africa; c) the National Consumer Forum; and d) the Organic Agricultural Association of South Africa.

Churches and Religious Communities

The Anglican Archbishop of Cape Town spoke out in May 2004 against GM crops, on the basis that they could compromise "the rights of future generations to a

2. *The SADC Member States are Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, United Republic of Tanzania, Zambia, and Zimbabwe. SADC headquarters are in Gaborone, Botswana.*
3. *For example, see http://lobbywatch.org/printprofile1.asp?PrId=170.*

safe, healthy and diverse environment," and that they could threaten rural livelihoods, food security, and local control over genetic resources as corporations gained ownership of life forms through the patenting of seeds and genes. He described the South African government's approach to GMOs as "cavalier" and argued that Africa ought not to adopt GM technology until the consequences were more certain (Mathys, 2004). A few days later, the South African Council of Churches (SACC) held a consultation on GMOs, out of which a statement was issued, entitled "Food is life: The right to food is not negotiable" (SACC, 2004). The document raised several concerns about GMOs, including the "purely technical" approach taken by proponents, which "delink(ed) science from ethics, values, economic and political ideology," as well as from "African communal spirituality about life and food" (SACC, 2004). Further concerns related to the role of GMOs in perpetuating unequal power relations.

The document calls on the SACC and its members to gather material and commission research to empower the church to pursue its position on GMOs. It also calls for government to acknowledge the risk of GM technology and to impose a moratorium on new GMO permits.

In March 2005, a national conference of religious communities (including Christian, Muslim, traditional African, Hindu, Buddhist, and Baha'i) was convened to establish the South African Faith Communities Environmental Institute, which aimed to facilitate greater involvement by faith communities in environmental issues. The meeting called for better public participation in decision-making on GMOs (Biowatch Bulletin, 2005).

Trade Unions

Trade unions, an important player in the struggle against apartheid, remain very influential in South Africa, with the Congress of South African Trade Unions (COSATU, an umbrella organization of trade unions) part of the ANC's tripartite coalition government.[4] At the COSATU Congress in 2003, a call was made for a moratorium on making GMOs available for human consumption in retail markets. Trade unions have also expressed fears that cheap imports of GM crops could affect the prices of local commodities and lead to job losses. They have concerns with the fact that control of GM technology is in the hands of multinational companies. The Food and Allied Workers Union, a COSATU member, has in the past threatened industrial action if a ban on GM food were not imposed, but did not follow through on this (Cook, 2002).

Assessment of Options for Local Acceptance

Selection of Crop: GM vs. Non-GM

In July 2006, an application under the GMO Act to carry out laboratory and greenhouse trials on biofortified sorghum—submitted by the Africa Biofortified Sorghum Project (ABS)—was turned down. ABS is a consortium of African and international public and private sector organizations funded by the Bill and Melinda Gates Foundation's Grand Challenges in Global Health initiative and aims to develop nutritionally-enhanced sorghum. The application was rejected because the containment levels at the relevant facilities were considered inadequate. The containment levels at the facilities concerned had in fact been upgraded but not registered. Registration may allow the deficiencies in the application to be corrected fairly easily and pave the way for the application to be reconsidered. However, because sorghum is indigenous to Africa, particular concern was expressed by the EC about the potential for contamination of wild varieties. So, even if the contained-use application goes ahead, serious doubts have been raised about the likelihood of any future applications for release into the environment being granted.

Small-scale farmers who have had positive experiences with GM crops are likely to be open to trying crops with new GM traits (depending on cost, yield, etc.). Ultimately, if GM crops are to be attractive to small-scale farmers in South Africa on a sustainable basis, seed companies will have to ensure that seed prices are set at a reasonable level and that the additional technology fee does not cancel out any positive income effects. Widespread uptake of any new crops is likely to depend at least to some extent on the incorporation of GM traits into those varieties preferred by small-scale farmers.

Consumer Acceptance

High-beta-carotene maize may face barriers to acceptance, bearing in mind that white maize is the staple food and yellow maize generally has been associated with animal feed. Results of a preliminary study designed to examine the impact of information on the preferences of rural consumers with respect to maize

4. *The third member of the coalition is the South African Communist Party.*

meal color indicate that by providing convincing information, it is possible to influence the choice of product. When faced with a choice between bowls labeled as containing white maize meal, yellow maize meal and 'golden' (beta-carotene-enhanced) maize meal respectively, an overwhelming majority of respondents initially expressed a strong color preference for white maize meal. However, after an information session covering the benefits of Vitamin A, natural food sources containing Vitamin A, the link between a yellow or orange color and Vitamin A content, and the relative content of Vitamin A in normal yellow maize, a high proportion of respondents changed their preference in favor of the golden maize (H. Vermeulen, personal communication, 2006).

Cost and Availability

The current program for fortification of maize meal and flour mandates the addition of eight micronutrients. It might be feasible to introduce some of these by biofortification instead (e.g. Vitamin A and iron, which are more expensive) in order to reduce costs to industry, and to increase coverage of affected populations.

Conclusion

While recognizing that the adoption of biofortified crops in South Africa will ultimately depend on a range of future technical, regulatory, economic, and social developments—which are difficult to predict—we can draw on the country's experience to date with the adoption of GM crops and food fortification in order to make a speculative preliminary assessment.

In principle, South Africa's initial early and rapid uptake of GM crops (including food crops, and a staple food at that) bodes well for the adoption of new GM crops. Experience to date would seem to indicate that GM technology remains a viable option to consider, as the risk is low that biofortification technology would be rejected, by either farmers or consumers, merely by virtue of being GM.

It must, however, be noted that the GM traits incorporated into the crops which are currently under cultivation provide benefits for farmers rather than for consumers. If biofortification traits were to affect yields adversely, without providing sufficient price advantages, uptake will be negatively affected.

Conversely, with regard to consumers, the fact that up to now there has been little consumer resistance in the marketplace to GM foods that confer no health benefits, there is no reason to expect any greater resistance to biofortified GM foods that offer tangible health advantages. In theory, one might even expect consumer preferences to favor biofortified foods over non-biofortified equivalents. However, this will by no means be an automatic consequence. Arguably, the current situation is the result of indifference toward and/or ignorance of GM foods rather than active acceptance. In order to cultivate preferences for biofortified foods, an effective marketing campaign would be necessary to inform the public of the benefits of biofortification. Anti-GM lobbyists would likely mount their own campaigns in response. This would raise public awareness of both perceived benefits and risks of GM foods in general, and it is difficult to predict whether better informed consumers would be more or less likely to embrace GM foods.

South Africa's well-established (albeit imperfect) biosafety regulatory framework is another positive factor for the adoption of biofortified GM crops. However, objections to applications are becoming more common, and there are signs that the EC is beginning to take a more cautionary approach before issuing approvals. Taken together, these factors indicate that new submissions are likely to undergo a tighter approval process.

A further positive feature is the acknowledgement by government of the importance of and the critical need for food fortification, which has been entrenched in explicit policy and legislation.

Bearing in mind that it is the poor who are most in need of food fortification, a successful adoption program will depend on ensuring that they are able to access the foods, as well as plant the crops (particularly in the case of subsistence farmers). The importance of white maize as a food staple makes this an obvious crop choice to target, but consumer acceptance will be difficult to win if alterations in color, taste, or texture are introduced via biofortification. Regarding uptake by small-scale farmers, the lessons derived from the experiences of the Makhatini Flats cotton farmers must be heeded. Appropriate institutional support will need to be provided, the cost of seed will have to be maintained at reasonable levels, and the relevant traits should be inserted into appropriate varieties.

The agents responsible for introducing biofortified crops are also likely to play a role in their adoption. The roles (and respective agendas) of government, private sector seed companies, development agencies, philanthropic organizations, and NGOs will need to be carefully considered, especially with respect to the responsibility of providing information and services. Partnerships between different stakeholders will probably be necessary.

Ultimately, the most important factor is one not unique to South Africa: the success of the technology itself. Stakeholders will have to be convinced that any biofortified crop is able to deliver sufficient nutrients to justify the costs that will be involved in developing the technology, obtaining regulatory approval, marketing the end-products, and providing appropriate support to ensure access and availability for the most vulnerable members of society for whom the technology potentially offers the greatest benefits.

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