Can Genetically Modified Crops Help the Poor? Options for Canada's Foreign Policy

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Editor's Preface

Launched in 2009, GPS: Where Genomics, Public Policy and Society Meet is a series hosted by Genome Canada to facilitate a dialogue between federal policymakers and researchers exploring issues at the interface of genomics and its ethical, environmental, economic, legal and social aspects (or GE^3LS).

Overarching themes for the series and specific topics are selected on the basis of their importance and timeliness, as well as the "ripeness" of the underlying scholarship. Accordingly, the series focused on "Genetic information," whereas in year two, attention shifted to "Translational Genomics". The third series, "The Innovation Continuum" broadens the discussion by casting the process of innovation in a broader societal context. The 2014 series focuses on the bioeconomy. The concept of the bioeconomy is meant to capture economic activities, and their related products and services, which result from new discoveries in the biosciences, including genomics.

At the core of these exchanges is the development of policy briefs that explore options to balance the promotion of science and technology while respecting the many other considerations that affect the cultural, social, or economic well-being of our society.

Co-authors of the briefs are leaders in their field and are commissioned by Genome Canada to synthesize and translate current academic scholarship and policy documentation into a range of policy options. The briefs also benefit from valuable input provided by invited commentators and other experts who participate in GPS events. Briefs are not intended to reflect the authors' personal views, nor those of Genome Canada. Rather than advocating a unique recommendation, briefs attempt to establish a broader evidence base that can inform various policymaking needs at a time when emerging genomic technologies across the life sciences stand to have a profound impact on Canada.

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Executive Summary

Genetically modified crops dominate agriculture in North and South America, have been met with much reticence in Europe, and are of increasing importance in emerging economies such as India, China and Brazil. Enthusiasm for using genetically modified organisms (GMOs) as an agricultural development tool is rising, spurred by significant investments by private corporations and international donors who promote GM crops as a means for improving yields and livelihoods. While the scientific research underpinning these new GM varieties is progressing rapidly, the social scientific evaluation of this new paradigm of agricultural development has struggled to keep pace. The socio-economic evaluation of these new breeding technologies for developing countries presents a range of possible policy options for donor nations. Some countries have invested heavily in scientific capacity and infrastructure to facilitate GMO commercialization, while others have been more reticent to endorse GMOs as a tool to help achieve broader goals of agricultural development.

This brief surveys the implications of this emerging debate for Canadian policy-makers in order to help the Canadian government to consider whether to support the adoption of GMOs as part of agricultural development strategies. It presents five policy options for consideration: an 'all in' approach robustly supporting GM crops; a partnership approach focussing on the needs of smallholder farmers; a 'precaution through experience' approach emphasizing context-specific systems, community engagement and risk management; a participatory farmer-led approach based on a demand-driven model of experimentation; and a holistic approach focussing on underlying causes of food insecurity rather than technological solutions.

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I. Context

Genetically modified (GM) crops are plants in which laboratory techniques have been used to engineer the plant's DNA to express beneficial traits. These agricultural innovations have spread unevenly across the globe: they form a dominant part of agriculture in North and South America, have been met with much reticence in Europe, and are of increasing importance in emerging economies such as India, China and Brazil, which now account for over 30% of all GM crops grown worldwide (James 2014). Most of the current expansion of GM crops is rooted in developing countries: in 2012 the acreage planted in developing countries exceeded that of developed countries for the first time, and this gap increased by more than 10% within two years. Of the 28 countries that planted biotech crops in 2014, 20 were developing and 8 were developed. According to one report, nearly 90% of the 18 million farmers growing GM crops in 2014 were smallholder farmers from developing countries (James 2014).

Enthusiasm for using genetically modified organisms (GMOs) as an agricultural development tool is rising, spurred by significant investments by private corporations and international donors who promote GM crops as a means for improving yields and livelihoods. These investments have coalesced into a new paradigm of agricultural development in which GMO technologies are given license-free for use in crops that matter to subsistence farmers. These public-private partnerships (P3s) bring together the technology developer and developing country research scientists as partners in creating GM versions of 'orphan' crops that have largely been ignored by innovation and investment. Examples currently under experimentation include water-efficient maize for drought-prone parts of East and Southern Africa, virus-resistant cassava in East Africa, insect-resistant cowpea in West Africa, and bio-fortified Golden rice in South Asia. These second-generation GM crops are being trumpeted as a technology that can combat poverty and reduce food insecurity: both the World Bank (2007) and the United Nations' Food and Agriculture Organization (Ruane et al. 2013) have endorsed GM crops as a win-win strategy for agricultural development, serving the interests of both donor countries and small landholder farmers.

While the scientific research underpinning these new GM varieties is progressing rapidly, the social scientific evaluation of this new paradigm of agricultural development has struggled to keep pace. Much of the scholarship examining the socio-economic dimensions has focused on quantifying potential benefits that GM crops offer to poor farmers via increased yields, better nutrition, and labour savings, which have been estimated to be as high as US$3 billion (Qaim 2010; Park et al. 2011). Other social scientists are more cautious, emphasizing political and economic variables that play a significant role in determining whether GM crops can help improve livelihoods for poor, rural farmers (Stone 2011; Fitting 2011; Akram-Lodhi 2013).

The socio-economic evaluation of these new breeding technologies for developing countries presents a range of possible policy options for donor nations. Some countries (such as the United States, Canada and Australia) have invested heavily in scientific capacity and infrastructure to facilitate GMO commercialization, while others (such as France and Germany) have been more reticent to endorse GMOs as a tool to help achieve broader goals of agricultural development. This brief surveys the implications of this emerging debate for Canadian policy-makers.

Specifically, the question this brief will address is this: Should the Canadian government support the adoption of GMOs as part of agricultural development strategies?

II. Background: The International Policy Landscape

The most useful start for examining the various policy options available to donor countries such as Canada is the long-standing divide between the American approach to GMOs (rooted in the principle of substantial equivalence) and the European approach (rooted in the precautionary principle).

The American policy approach towards GMOs has emphasized similarities in product between conventional and GM breeding (as opposed to differences in process, as emphasized in Europe). The US approach is rooted in the principle of substantial equivalence, in which GMOs are viewed as comparable to the products of conventional farming; as such, there is no need to create new institutions or new regulations to oversee them (Lieberman and Gray 2008). In practical terms, this means that GM crops and foods are treated the same as conventional products, a dynamic that has created debates both domestically (in the form of continuing disputes over state-level GMO labeling laws) and internationally (in terms of rejected trade shipments due to the low level presence of unapproved GM events).

The United States supports the use of GMOs as part of the strategy to achieve its agricultural development goals. In 2002 the U.S. Agency for International Development (USAID) launched the Collaborative Agricultural Biotechnology Initiative (CABIO) "to promote developing country access to and management of new scientific tools such as biotechnology for improving agriculture productivity, environmental sustainability and nutrition" (U.S. Department of State and USAID 2005: 191). CABIO led to the establishment of a suite of programs dedicated to building infrastructure, developing capacity and sharing information around the potential for agricultural biotechnology (including GMOs) to help alleviate poverty and hunger around the world.

One of the most visible programs to emerge from this policy was the Agricultural Biotechnology for Sustainable Productivity Project (ABSP). ABSP is a consortium of private and public organizations designed to promote biotechnology in three regional centres (south Asia, southeast Asia and east Africa), with the overarching aims of increasing access to technical expertise and encouraging the transfer of biotechnology tools (Cohen 1999). During the past twelve years, ABSP has focused primarily on infrastructure development (i.e. construction of laboratories, greenhouses and confined field trials) and capacity building (funding graduate students in the areas of molecular biology, plant breeding and biosafety management). The Program for Biosafety Systems (PBS) is a second important project, managed by the International Food Policy Research Institute (IFRPI), whose mandate includes supporting policy development, creating awareness and facilitating regulatory approval. PBS aspires to create an enabling environment to advance the safe use of biotechnology into new markets.

Additionally, the United States has played a crucial role in establishing the African Agricultural Technology Foundation (AATF). The AATF is a key intermediary facilitating public-private partnerships (P3s) technology transfers to national research scientists for humanitarian purposes. This emerging model challenges many of the most entrenched preconceptions around GM crops. First, the AATF negotiates with patent holders to donate proprietary technologies license-free, so they are available to farmers at no cost. Second, the traits being prioritized move beyond the narrowly focused insect- and herbicide-tolerance towards addressing a range of issues that matter to small landholder farmers, such as drought-tolerance, disease-resistance and nutritional enhancement. Third, the crops being prioritized are major carbohydrate staples across the continent (sorghum, cowpea, cassava and *matooke* banana) that have not been targets of genetic modification because biotech companies have traditionally emphasized varieties that have broader adoption potential.

European doubts around GMOs stem from a broader interpretation of the precautionary principle (Principle 15 of the 1992 Rio Declaration), in which GMOs are viewed as foundationally different from previous techniques of selective and mutagenic breeding. This focus on the exceptional nature of GMOs leads to an approach that is fundamentally risk-averse, in which novel biotechnological techniques must be subjected to rigorous tests including the identification of any and all potential harms to human health or the environment, evaluating different types and levels of uncertainty involved, and mitigating any potential risk that could emerge from the new biotechnology (Myhr 2010; Ludlow et al. 2014).

This more conservative approach to risk assessment and management of GMOs among European nations has led to policies at home and abroad that are relatively comprehensive and onerous, including strict measures for approval, monitoring and liability. France, long considered to espouse one of the continent's most reticent views towards GMOs, remains sceptical regarding their possibilities both inside and outside its borders. While there is no formal stance on the role of GMOs in foreign policy, current debates within France revolve around the role GMOs play in exacerbating inequality, and the need for stronger regulations to limit off-farm migration, soil erosion and increased food-price volatility (Tait and Barker 2011). Such principles have become formalized in Norway under the Norwegian Gene Technology Act, which stipulates that any new GMO introduced in the country must undergo an impact assessment that includes consideration of sustainability and societal utility. Within this act the assessment of non-safety concerns is mandatory, and "can include any health and environmental consequences in the countries in which the crops are grown—notably developing countries—as well as in the countries in which they are consumed" (Marcoux et al. 2013: 662).

Adherence to and application of the precautionary principle has not been uniform across Europe. The government of the United Kingdom, for example, has produced a series of recent reports identifying GM technology as one component in a wider approach to food security and food production (Dibden et al. 2013). Specifically, the concept of sustainable intensification has been put forth as a necessity for both meeting the increasing global demand for food and for attempting to bridge the divide between the "agri-industrial/biotech and agro-ecological paradigms by drawing on aspects of both" (Dibden et al. 2013: 65). Indeed, one UK Foresight report identifies investment in transgenic technologies as essential, and stresses the need to keep open policy options pertaining to such technology (Tait and Barker 2011). This view is espoused by former Secretary of State for Environment, Food and Rural Affairs Owen Paterson, who remains a vocal proponent of using GMOs as a pillar of Britain's efforts to alleviate poverty and hunger (Paterson 2015).

III. Issues: Can GMOs Help The Poor?

Proponents argue that GMOs are an important tool in the global fight against poverty and hunger, one that donor nations such as Canada should support both politically and financially (Smyth et al. 2015). Harvard's Robert Paarlberg (2009: 84) argues passionately that donor countries have a responsibility to invest in low-income agricultural systems, which have a reduced opportunity of benefiting from 'spillover' effects of beneficial technologies operated elsewhere. What is needed, he argues, is a concerted push to introduce and evaluate the potential for GM crops to help farmers in the poorest parts of the world. He suggests that Africa is particularly well-suited for this investment in GM technology because farmers tend to be land-secure, thus increasing their chances of benefiting from a technological upgrade. According to Paarlberg, the problem in Africa is not inadequate pay-off of GM technology but rather adequate pay-in on the part of development donors: "Africa's agricultural science deficit will thus have to be corrected through supportive interventions from international donors…restoring this external support should now be an urgent priority" (Paarlberg 2009: 195).

Jennifer Thompson is another proponent of the potential for GM crops to help African farmers. She emphasizes that GM crops are but one tool in the struggle for sustainable agriculture, but one that deserves more investment from donors because of its ease of use and the dramatic benefits GMOs can offer to poor farmers. She believes that it would be "a major injustice if prejudices against this technology, expressed by those with enough food, were to deny the use of GM crops to the poor and hungry in other parts of the world" (Thompson 2015: 158).

However, this new wave of second-generation GM ventures has also been subjected to critique. First, there are concerns about the power relations that frame these interventions, and questions about the degree to which such projects truly reflect farmer needs and priorities (Schnurr 2013). Second, critics argue that that the narrative of progress underpinning science-based risk assessments works to depoliticize GM technology and reposition it as a moral imperative (Dibden et al. 2013). Within this view, framing GMOs as a technology that can 'feed the world' is a clever public relations strategy that could crowd out other promising approaches such as agro-ecology. Other critics view the new wave of GM in developing countries as a Trojan horse that serves to establish collaborations between private biotech companies and Southern research countries, cultivate good public relations for private sector donors, and facilitate the advancement of more permissive GM regulations (Lieberman and Gray 2008: 407).

IV. Background: a GMO policy dichotomy in Canada

As in many other areas, Canada's position within this debate lies somewhere between the more extreme poles of the United States and Europe (Andree 2006). When it comes to the regulation of new GM crop varieties, Canada parallels the U.S. in the use of a science-based risk assessment protocol. But when it comes to adopting these innovative technologies into foreign policy, Canada's approach aligns more with Europe.

Canadian policy towards GMOs has remained broadly consistent across the changing Progressive Conservative/Liberal/Conservative governments of the past three decades. Canada's domestic approach has, by and large, synched with the substantial equivalence approach adopted by the United States. In 1993, the federal government introduced the Federal Regulatory Framework for Biotechnology, with the goal of minimizing environmental risks while fostering competitiveness (Abergel and Barrett 2002; MacDonald 2014). This framework provided guidelines for the environmental assessment of unconfined release, which, by the end of 1994, signaled the beginning of Canada's product-based regulatory regime. In 1998, the federal government introduced the new Canadian Biotechnology Strategy (CBS), which established the Canadian Biotechnology Advisory Committee (CBAC) in 1999 to advise on science and social policy issues (Marcoux and Letourneau 2013; Skogstad 2008).

CBAC was an arm's length expert group that undertook in-depth assessment of emerging genomic-related issues, ranging from patenting of higher life forms to labelling of GMO products. On occasion, CBAC reports were critical of the government's biotechnology policy and the regulatory regime, arguing that the system needed more transparency and accountability. Measures introduced early in the new millennium developed guiding principles for applying precaution to science-based decision-making within the regulatory regime that identified health, safety, and the environment as key areas of concern, before CBAC was disbanded in 2007 (Skogstad 2008).

Another critical moment that shaped the trajectory of this country's regulatory path was the government's response to the 2001 Royal Society of Canada's Expert Panel on the Future of Food Biotechnology. This report was largely critical of the government's regulatory processes and capacities, recommending that both needed to be substantially beefed up. The RSC panel also offered a sharp rebuke to the government's emphasis on substantial equivalence, which the panel regarded as too poorly defined and overly superficial. The report called for a plethora of more stringent regulations, including more comprehensive environmental and food safety assessment, enhanced post-release monitoring and evaluation, and increased public transparency in all decision-making. Within one year of its publication, the Liberal government produced a detailed action plan to address these recommendations, though Peter Andree argues that while the RSC panel's original recommendations were designed to tilt the Canadian approach more towards the precautionary principle, they had relatively little impact on real-world policy or process (Andree 2006).

Assessments of the effectiveness of the Canadian policy approach to GMOs vary widely. The system has many champions who laud the approach as being largely free from the influence of industry actors and committed to the rigorous evaluation of 'sound science' (Montpetit 2005; MacDonald 2014: 341). Critics argue that Canada's regulatory system is structured around ensuring public and investor confidence in Canada's business climate and in recombinant DNA technology itself, and does a woeful job of incorporating public consultations (Abergel and Barrett 2002: 155). Others contend that the development of Canadian policy has unfolded within a narrow network of biotechnology developers, representatives, government officials and scientific experts, and that the Canadian approach remains preoccupied with minimizing discrepancies with the US for fear of creating trade barriers (Skogstad 2008).

With respect to foreign policy, Canada has been much more reluctant to act as an advocate for investment in agricultural technology. The recent emphasis on enhanced food security as a thematic priority for international development assistance has led to a broad investment in technological development and market expansion that has included an emphasis on GM alongside other breeding programs (DFATD 2014a). Agricultural biotechnology has also emerged as a key sector within efforts aimed at increasing ties with emerging economies such as India, China and Brazil (Government of Canada 2012; Government of Canada 2013; DFATD 2014b).

Canada also boasts a long history of investing in science and technology as a means of enhancing food security and nutrition, with long-standing programs dedicated to improved cassava breeding in Latin America (Aerni 2006), biotechnology applications to improve livestock management in Kenya (Hall 2005), fortifying foods with micro-nutrients in the Philippines (IDRC 2015c), strengthening seed systems in Afghanistan (IDRC 2015a), and expanding the use of DNA barcoding around the world (IDRC 2015b). Most significantly, Canada's recent investment in the IDRC-led Canadian International Food Security Research Fund has supported partnerships in the broader areas of agricultural innovation and technology transfer (though it is important to note that none of the current funded projects utilize GM technology).

Overall, Canada's foreign policy towards GMOs has been considerably more hesitant than its domestic policy. GM crops have been mainstays of the nation's agricultural production systems for twenty years, yet remain virtually invisible within the country's international development agenda. Broader commitments to technology transfer, capacity building and the potential for scientific technology to help achieve agricultural development goals abound, but there are virtually no specific references to the role GM crops can play in achieving these objectives within existing Canadian foreign policy.

V. Policy Options

1. The 'all in' approach

Canadian foreign policy-makers embrace GM crops as a breeding technology that can contribute to improving global food security. Canadian support, combined with ongoing U.S. initiatives, includes political and financial backing for the inclusion of GM breeding techniques as critical elements of a broader investment in science and technology infrastructure. One concrete example for how to go about this is offered by Smyth et al. 2013, who suggest that the most effective means of encouraging the commercialization of GMOs in Africa is to combat fears around potential harm to African exports to Europe. They propose that donor nations such as Canada establish a compensation fund with credible commitments to meet potential export losses. By providing just-in-time compensation for countries negatively impacted by the commercialization of GMOs, this liability fund would help overcome one of the major hurdles to the widespread disseminations of GMOs in Africa.

One potential avenue for accomplishing this would be for Global Affairs Canada (GAC) to adopt a mandate similar to that of the United States Agency for International Development, whereby support for existing Canadian agriculture technologies and practices becomes a key aspect of Canada's international activities. GAC would support the public plant breeders and private agriculture technology development companies that have commercialized technologies and crop varieties providing significant benefits in terms of yield and sustainability. To make a contribution to improving global food security, support for proven technologies would underpin Canadian international development programs.

Within this view, Canada's role would transform into a global ambassador for agricultural innovations more generally and GMOs specifically, working towards educating and informing scientists and regulators on how new technologies can help to achieve broader goals of agricultural development. Adopting such an enthusiastic approach would likely be welcomed by Canadian industry, which would be excited about potential opportunities to parlay existing knowledge and products in ways that could benefit both trade and development. Conversely, the approach would likely be significantly criticized by the NGO community, who would be concerned that such a narrow focus on technologies has the potential to preclude broader conversations around the nature of poverty and hunger.

2. The partnership approach

Canadian policy-makers embrace a model that uses partnerships between relevant sectors, in order to create GMOs with the traits and varieties that matter to smallholder farmers. Within this approach, Canada's role would be that of a facilitator, focused on brokering partnerships among multi-sectoral partners, securing access to proprietary technology for use in not-for-profit endeavors, and helping to guide negotiations around some of the more polarizing issues. Canada would advocate for the central role played by the private sector within such initiatives, which is often best positioned to provide the expertise and technology needed to create GM varieties that are well-suited to the needs of smallholder farmers. Canadian interventions would focus on emphasizing potential gains associated with bringing the private sector into partnerships (i.e. facilitating access to technology, enhanced capacity building, and increased expertise related to downstream activities such as commercialization and marketing for public sector partners, as well as benefits to the private sector in the form of building future markets and enhancing corporate image).

Some promising examples exist for how the private sector can be successfully integrated into initiatives designed to target the needs of smallholder farmers. Agricultural 'pull mechanisms', for example, provide results-based payments to incentivize innovation in areas with little existing profit potential. These financial incentives are designed to overcome market failures and encourage the creation of new innovations with high development impacts by strengthening the demand for such socially desirable projects. Using the G20's newly established AgResults program as a model, Canada could mobilize such mechanisms as a means of encouraging the development of new GM technologies that are not currently available through traditional market mechanisms (AgResults 2015).

Existing P3s could serve as viable templates for future initiatives. P3s are designed to accomplish synergistic goals that none of the individual partners could achieve on their own, offering promising vehicles for joint technological innovation and commercialization of new GM technologies. A number of P3s are already underway experimenting with GM versions of African carbohydrate staple crops addressing traits (such as disease or pest resistance) that resonate with poor farmers. For example, an existing P3 has produced a banana that is genetically modified to resist Banana Bacterial Wilt, one of the most pernicious diseases affecting growers in Uganda. This partnership brings together Ugandan research scientists, the United States Agency for International Development, the Bill and Melinda Gates Foundation and the African Agricultural Technology Foundation, which facilitated access to proprietary technology in order to develop an end product that is license-free. In a second example, GM versions of cassava are being bred to resist cassava mosaic disease and brown streak disease, again through a grouping of development donors, African scientists and private sector partners. P3s offer a means of overcoming some of the most entrenched obstacles blocking more sustained application of biotechnology to the needs of poor farmers, including limited profit potential and under-developed or under-enforced regulatory regimes that have limited effectiveness in protection intellectual property rights.

Embracing this policy approach could also involve moving beyond existing partnership models to innovate novel strategies. The partnerships noted above have been criticized for prioritizing the needs of donors over those of producers, and for failing to include producers as meaningful partners in every stage of the partnership process. Canada has the opportunity to play a crucial role in transforming these P3s into P4s by recognizing that the 'producer' (that is, the proposed beneficiary) should play a central role in shaping and delivering new agricultural technologies. Canada is already a world leader in agriculture-based P4s, with a number of domestic initiatives—such as the Saskatchewan Pulse Growers and the Western Grain Research Foundation—providing important models of how such producer-led projects can stimulate innovation (Boland 2014). The Canadian government could play the role of broker or enabler, ensuring that partnerships for agricultural development are created and implemented based on shared values and inclusivity, and that producer priorities are at the centre of all partnership activities (Thrope and Maestre 2015).

3. The 'precaution through experience' approach

Canadian policy-makers embrace a middle-of-the-road strategy that seeks to balance European adherence to the precautionary principle with American notions of substantial equivalence by incorporating greater public participation in an 'evidence-informed' framework. Such an approach would move the unit of analysis away from both the process (the focus of European regulations) and the product (the focus of American regulations) towards an emphasis on context-specific systems, including a robust system of risk management that incorporates “both scientific and socio-economic perspectives of risk in deepened deliberative settings.” (Clark 2013: 480). According to Clark “[i]dentifying the sources of complexity within governance frameworks can help to better understand what influences decision-making within multi-level risk governance” (p.486). By bringing both science-based and non-scientist perspectives of risk under the same umbrella, Canadian policy-makers would widen the scope of issues considered by the regulatory process.

At the core of the ‘precaution through experience’ approach is a commitment to robust and deliberatively democratic practices that incorporate the full range of benefits and risks by emphasizing the principles of transparency, participation and accountability. Zahabi-Bekdash and Lavery (2010) refer to the role of community engagement early on as a means of satisfying some of the aims of precaution without undermining the development of new technologies. Hibbert and Clark (2014) agree, stressing the need for “negotiated rulemaking” that allows stakeholders to participate in the regulation drafting phases as one of the best strategies for making the debate over new GM technologies more inclusive and democratic. They offer the Norwegian Gene Technology Act as a viable model that incorporates a wide range of socioeconomic and sustainability criteria within its risk assessment, including impacts on biodiversity, global justice, inter-generational justice, greenhouse gas emissions and potential benefits to local communities.

There are several potential benefits to such an approach. Including a wider range of consultations in the decision-making process could access unique knowledge to help improve the product itself, and/or the social pathways leading to successful experimentation and implementation (Zahabi-Bekdash and Lavery 2010). Others see the primary benefit stemming from the democratic legitimacy gained by engaging in such a consultative process, creating a space where critics and supporters of controversial technologies can coexist (Hibbert and Clark 2014).

This model incorporates social learning by drawing on lessons from previous experiences with GM crops. Such a model would, for instance, see Canadian policy encouraging recipient nations to fast-track some GM varieties based on previous experience elsewhere with similar technologies in conjunction with the development of participatory governance systems. This is similar to the current model initiated by the Common Market for Eastern and Southern Africa (COMESA), which adopted a centralized regional framework and a harmonized risk assessment mechanism. These were designed to allow technologies that are vetted, tested and approved in one member country to be approved in another country without unnecessary delay. However, the outcome of regulatory expediency is open to critique; first, on the grounds that the rhetoric of inclusivity and participation outweigh the reality, and second, that such efforts towards regulatory harmonization are strategies to circumvent the complications that can plague the release of controversial technologies at the national scale (Schnurr 2013).

4. The participatory, farmer-led approach

At the core of this approach is a commitment to a demand-driven model of experimentation that incorporates producers as equals at every project stage. Existing examples of such farmer-led breeding programs could serve as models for future GM ventures. Since 2009 the Canadian International Development Agency (now Global Affairs Canada) has provided funding to Unitarian Service Committee (USC) Canada, which works with a Honduran NGO supporting farmer-led participatory research on improving local varieties of maize and beans. FIPAH (Foundation for Participatory Research with Honduran Farmers) is made up of agronomists/farmer leaders who reside in the communities and provide technical assistance to communities, training local farmers to execute, evaluate and analyze formal agricultural experiments. FIPAH initiates a Community-Based Agricultural Research Team (CIAL) in a community, and subsequently brainstorms with the community which crops deserve priority focus. The CIAL is then responsible for deciding what problems to tackle, what kind of research to undertake, and how to use this information to help other communities. Farmers are trained to evaluate for their specific research objective on their own farm, and when the experiments are complete, the CIAL formalizes the research through a report and presentation. Results are presented to their own and nearby communities in a way that emphasizes the local issues. For example, a group of Santa Cruz farmers successfully developed a variety of shorter stalked corn with large cobs that would withstand more frequent hurricanes. Culinary traditions are often taken into account when breeding for traits in these communities (USC Canada, 2009).

The Swiss Agency for Development and Cooperation (SDC) and the Rockefeller Foundation fund the Southern African Drought and Low Soil Fertility Project (SADLF), run by the International Maize and Wheat Improvement Center (CIMMYT). This program shares geographic information systems (GIS) data with maize researchers so varieties can be bred to support local conditions. SADLF runs across countries by testing at several different sites, allowing researchers to investigate how different maize cultivars perform under the stress conditions facing smallholder farmers. Maize is evaluated pre-release for desirable traits, drought and nitrogen stress, responsiveness to favourable conditions, resistance to disease, tolerance of acidic soils and resistance to storage pests. SADLF uses mother/baby trials to open a forum for smallholder farmer communication: ‘mother’ trials are researcher-managed experiments, and six to twelve ‘baby’ trials are farmer-managed in the same community, all within walking or bicycling distance.

A local counterpart, normally within the centre of a farming community, manages the mother trials. Baby trials contain a subset of the cultivars included in the mother trial and are planted and managed exclusively by the farmer. The farmer will use the information from the mother/baby trials to buy seeds in following years. Information on farmers' opinions of the trials and performance thereby flows back to researchers and seed companies, increasing the prospect of seed companies providing farmers with appropriate seeds (CIMMYT, 2003).

There are significant drawbacks to this approach. First, these models are slow, expensive and time-consuming. Wettasinha et al. (2014) emphasizes that truly participatory models require donors to allocate longer than typical time frames in order to ensure successful partnerships that are able to engage in significant reflection. To institutionalize farmer-led approaches, donors would need to be persuaded to become more flexible in allowing for "differentiated funding arrangements" that would permit a more decentralized model of technological development (Wettasinha et al., 2014). Second, participatory approaches have been criticized for not being effective at targeting the very poor. It is often easier to target less remote and relatively more privileged groups than extremely poor, remote or excluded minority groups. Even when these communities are effectively targeted, elite actors frequently dominate projects. The power differentials at play are extremely important but can be minimized when farm 'leaders' are residents of the community and farmers themselves (Classen et al. 2008).

5. The holistic approach

Instead of focusing efforts on technological solutions to systemic problems of poverty and hunger, Canadian policy shifts towards a more holistic approach that seeks to address the underlying causes of food insecurity in terms of access, control and justice. A new policy agenda emerges that prioritizes discussion of structural factors including global trade deficits, agricultural subsidies, and smaller-scale technology transfer that are demand- rather than supply-driven.

In this scenario, the foundational question of GM's potential to help poor farmers is replaced with a more holistic, critical view of agricultural development that begins with the needs of farmers themselves. A narrow focus on technologies has the potential to preclude broader conversations around the nature of poverty and hunger, and the potential political dimensions of such interventions. An alternative starting point would be a wider focus that does not preclude any technological or political possibilities for effecting meaningful change for the world's most vulnerable farmers.

Within this view, the foundational question could be broadened to 'Under what conditions should the Canadian government support the adoption of certain GMOs as part of its agricultural development strategies?' or even 'What approaches to agricultural development should Canada support?' Shifting the starting point for this conversation would facilitate a broader conversation about how Canada could best support the needs of poor farmers, and might lead to more political interventions such as renegotiating terms of trade and removing agricultural subsidies, as opposed to the development of new technologies such as GM.

VI. Practical considerations

Canadian policy makers face a number of challenges on this controversial file. First, they will need to establish a model that successfully integrates the perspectives of natural scientists (who tend to be more bullish on the prospects for GM crops to improve livelihoods for poor farmers) and social scientists (who tend to be more cautious about potential benefits). Successful experimental programs and development interventions will benefit from both perspectives, even though the discussion about which variables and parameters will form the basis of an agreement may be challenging and at times frustrating.

The second practical consideration relates to the technology itself. Advances in new breeding techniques are expanding at a breakneck pace, with new technologies such as gene editing, CRISPR and synthetic biology offering possibilities that were unimaginable even five years earlier. These will radically challenge the slow moving regulatory and policy debate, which is still discussing issues (such as gene flow and transgenic contamination) that new technologies have moved beyond.

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