

Title >> **The Role of Agricultural Biotechnology in
Alleviating Food Insecurity in Ethiopia**

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Date of Publication >> 2009



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This paper is published as part of the KDSC series 'Research and Perspectives on Development Practice'. The opinions expressed in this paper are those of the author and do not necessarily reflect the views of the Kimmage Development Studies Centre.

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Abstract

This paper summarizes my MA thesis examining the role of Agricultural Biotechnology in alleviating food insecurity in Ethiopia. Agricultural biotechnology, and in particular Genetically Modified Organisms (GMOs), is considered by the biotech industries as a potential means to tackle food insecurity. Other views run counter to this position. This paper analyzes the role of agricultural biotechnology in alleviating food insecurity and its implications for smallholding farmers and biodiversity, as perceived by key stakeholders in Ethiopia. Data was collected in 2007 from fourteen key respondents including government, non-governmental and public sector representatives as well as three organic farmers.

Three groups of opinion strongly emerged from the findings. The first and largest group expressed skepticism about the role of agricultural biotechnology in alleviating food insecurity. The second and smaller group of respondents held the middle ground and shared the opinion that if it is applied with proper caution under biosafety guidelines, it could be beneficial. The third and smallest group of respondents saw agricultural biotechnology as the only way to alleviate Ethiopian food insecurity. Although the weight of concern differed within the three groups, concerns were raised that biotechnology could have negative implications for smallholder farmers and biodiversity. The findings showed a general consensus in their concern over international governance policies and the inadequate contribution to supporting efforts of the 'countries of the global South' in achieving food security. The paper highlights the need to address the diverse causes of food insecurity and argues that the potential of agricultural biotechnology to address food insecurity is highly questionable and it may even intensify such problems.



1. Introduction to the Topic

Agricultural biotechnology is at the center of an increasingly heated debate in relation to solving the problem of food insecurity, particularly in so-called 'developing countries'. Pray et al. (2001) note that proponents of agricultural biotechnology such as Monsanto and other seed companies see this technology as a tool to solve the problem of food insecurity. On the other hand, opponents such as Altieri and Rosset (2000) argue that it will not solve the problem and could cause adverse effects on human health and the environment. The most noticeable effects highlighted by the above writers are the impoverishment of small farmers due to Intellectual Property Rights (IPRs), the increased use of pesticides and reduced biodiversity, with increased profits for seed companies.

Degefe et al (2001) note that the Ethiopian economy is fundamentally rural and that it relies heavily on the agriculture sector, which contributes nearly half of the GDP and 85% of total employment. A report from the Environmental Protection Authority argues that the surplus from the agricultural sector is quite limited and annual production is strongly correlated to rainfall (EPA, 2006). The Ethiopian Agriculture Research Organization (EARO, 2000) highlights that the food insecurity situation in Ethiopia is complicated by poverty, a rapidly growing population and an agriculture sector that has low productivity.

This research assesses the social dimension of agricultural biotechnology and aims to bridge the knowledge gap by providing information about perceptions of the potential role of agricultural biotechnology in alleviating food insecurity in Ethiopia, and its consequences.



2. Key Concepts and Definitions

In this section, I will discuss key concepts and definitions that are relevant for the research topic. In the Ethiopian context, biodiversity plays a major role in national food security as the diversity of crops gives better elasticity to adjust to adverse climatic changes and diseases. On the other hand issues relating to biopatenting and IPRs go hand in hand with agricultural biotechnology and consequently they affect food security in a different manner.

2.1 Biodiversity

For a country like Ethiopia with rich genetic but poor technological capacity, maintaining biodiversity is vital. Reinforcing this, a report from EARO (2000) concludes that Ethiopia is a centre of origin/diversity for many cultivated plants and has also an immense wealth of wild plant and animal genetic resources. The loss of Ethiopian biodiversity is not desirable for food security and also catalyses the extinction of some native crops in Ethiopia. In line with this, Vavilov (1929) quoted in Messele (2001 p.14) notes that "Ethiopia is a centre of diversity for several economically important cereals such as wheat, barley, coffee, teff, sorghum and chat". Asfaw further illustrates that "the diversity of some crops in Ethiopia depends on the gene pool that exists in the natural ecosystems" (1997 p. 9).

Biggs (1998) in Downes (2003 p.4) defines the term biodiversity as "all living organisms, their genetic make-up and the communities they form". The loss of biodiversity is not only intrinsically undesirable but also a threat to human welfare because of the reduced ability of ecosystems to provide key services and products (ibid).

Genetic erosion is one of the major causes of agricultural biotechnology through monoculture which further threatens diverse ecosystems. G/ Egziabher, heading the Environmental Protection Agency of Ethiopia, emphasizes the use of self-reliance in food production and genetic diversity as follows:

Ethiopia shows diverse ecologically and culturally adapted food production systems. This is generated and controlled by millions of smallholding farmers to provide food security and protect the people and the country from foreign and commercial control of food. Self-reliance in food at the household and country level is the foundation on which democracies can be built (1999 p.30).



2.2 Food Security

There are different understandings of food security, each carrying different emphases. These have changed over time as the debate has been framed in different ways. Most recently, food security is perceived as the adequate availability of foodstuffs globally, to sustain the steady demand for food consumption and to be able to adjust for price fluctuations (UNDP, 2001). The Food and Agriculture Organization (FAO, 2006 p.8) estimates that “854 million people in the world lack sufficient food for an active and healthy life”. In the course of the research I have undertaken, a number of respondents have raised the issue of the link between food production and distribution. While this has to be acknowledged as an important factor, it is not a key focus of this particular research. In line with debates around food production versus distribution, Nikki van der Gaag has argued that “hunger is about distribution, not just about quantity...biotechnology goes hand-in-hand with intensive agriculture, with single crops grown in huge fields... resulting in reduction of the world’s biodiversity by promoting certain species over others” (1997 p.8-9).

2.3 Agricultural Biotechnology

Agricultural biotechnology is a highly contested term and a broad concept. For the purpose of this research, I am referring specifically to Genetically Modified Organisms (GMOs) when discussing the concept of agricultural biotechnology. Bio-Earn’s report informs us that the Convention of Bio-diversity (CBD), 1992 Article 2 defines biotechnology as, “any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific uses” (2001 p.9). Some of the key debates and concerns of agricultural biotechnology are its potential threats to human health and the environment through gene contamination and genetic erosion. Another major debate concerning this issue is patenting and IPRs (G/Egziabher 1999) and the potential establishment of seed monopolies through commercial organizations. On the other hand, proponents of this science believe that this technology could enhance food production as well as biodiversity.

Zilberman et al. (2006 p.1430) argue that the “application of biotechnology can increase food output and improve nutritional quality”. In line with this, Kydd et al (2000 p.1135) also note the dual benefits of GMOs as “production cost reductions and positive environmental externalities (from reduced chemicals and tillage). Additional features of GM crops may be insect resistance, as is seen currently with *Bacillus thuringiensis* (Bt) cotton and Bt maize, which has been transformed to include insecticidal protein from the bacterium Bt” (ibid).



The issue of health and environmental safety in agricultural biotechnology has become a global issue for international debate. This debate is particularly important for a country like Ethiopia that has not yet decided on the introduction of GMOs or put a biosafety regulatory framework in place.

2.4 Biopatenting

Apart from the potential health and environmental hazards of GMOs, biopatenting is seen as a major threat to impoverishing poor farmers by transferring seed ownership from them to the seed companies. Mengiste (2001) quoted in Bio-Earn defines patents as “a legally enforceable right granted by law to a person to exclude others from certain acts related to described inventions for a limited period of time” (2001 p.78). Arguing for the rights of the farmer to save, re-sow and exchange seeds, G/Egziabher highlights that “patents are for inventions derived by intellectual activity of the human mind...no living thing or part of a living thing, even a gene, has ever been invented, only discovered” (1999 p.22).

2.5 Intellectual Property Rights (IPRs)

The World Intellectual Property Organization (WIPO, 2005) handbook defines IPRs as a legal right over a creative work of human intellect that includes patents, trademarks, registration, certification and copyright. Commenting on the North-South technology divide, Downes (2003 p.5) asserts that the IPRs' agreements could be viewed as a means of protecting the technologies of the North from the South.

This exploration of key concepts highlights diverging views on the effects of biotechnology on food security, with proponents arguing the benefits of increased food production and the opposing view highlighting concerns about the negative environmental consequences and the constraints imposed on small farmers by IPRs and biopatenting.



3. Research Outline

In order to explore the perceptions of key stakeholders on the role of agricultural biotechnology in alleviating food insecurity in Ethiopia, primary research was undertaken in Ethiopia in 2007. A qualitative research approach was applied, based on fourteen interviews with key informants with expertise and prior knowledge of the research topic. 'X' were representatives of government or other public sector organisations, 'Y' were from NGOs and 3 others were organic farmers. A purposive sampling technique was employed throughout the research.

Taking into consideration that the development of agricultural biotechnology is still very much at the policy formation stage and remains a contested issue in Ethiopia, a combination of data collection methods was used so as to overcome the deficiencies of a single method study. This was intended to achieve a higher degree of validity and reliability of data collected. A semi-structured interview technique was applied throughout the research. Data was gathered from both primary (key informants) and secondary (documents) sources.



4. Summary of Finding and Analysis

To introduce the topic of the research, a general question concerning the causes of food insecurity was put to all respondents. More specific questions relating to the role of agricultural biotechnology, the consequences of biodiversity and the implications of biopatenting then followed. They also addressed forces driving or shaping the debate and international governance policy supports for alleviating food insecurity. The findings were based on a semi-structured interview designed to focus on the key issues of the research, especially the role of agricultural biotechnology. Clearly the responses given were based on assumptions rather than facts and were mostly related to experiences from other countries since there is no evidence to-date showing the introduction of GMOs into Ethiopian agriculture¹.

4.1 Causes of Food Insecurity in Ethiopia

When asked about the causes of food insecurity in Ethiopia, respondents identified a combination of complex issues. These ranged from historical, technical and environmental factors to political and institutional problems at local, national and global levels. Institutional problems such as government pressure to grow high input seeds, unfair loan repayment systems and the land tenure system were also major contributory causes identified. The lack of locally improved seeds was mentioned as another factor. Other environmental and economic factors were also mentioned, e.g., land degradation, population pressure, low productivity, lack of market access and information, limited economic ventures and genetic erosion.

One concern that was repeatedly mentioned by most respondents was the displacement of native by high input seeds. One genetic resource person stated that:

for poorer countries in general rather than creating displacement of local varieties with hybrid or GM crops that use alien genes through genetic engineering, we have to look at the problems of distribution because increased food production does not necessarily mean that a country is food secured.

The same respondent added, “we should also look at the issue of nutritional security - as to what type of crops we are growing or the spectrum of the crop varieties”. Another respondent also commented that “promoting the use of indigenous seeds enhances productivity without sacrificing the diversity inherent in this material, which is very crucial for securing the food resource of Ethiopia”. This concurs with Downes’s (2003) view that despite the promotion of high yield varieties,

1. I have established through my research that the EARO biotechnology R&D that is under construction in HOLETA at Addis Ababa has not to-date undertaken field tests with GMOs.



the Green Revolution has raised dependency on seed companies and chemical inputs which have resulted in a loss of crop diversity. In my research one interviewee argued that since Ethiopia is still paying the price for the Green Revolution, welcoming new technology seeds from abroad removes ownership of seeds from farmers and replaces them with seeds that do not consider the agro-biodiversity of Ethiopia.

The issue of inefficient distribution as opposed to production problems was discussed as a contributory factor to food insecurity in Ethiopia. Most respondents seemed to think that food insecurity was more an issue of food distribution rather than production. Nikki van der Gaag (1997) also confirms the same. In line with this one biotechnologist working for a government organization said that *“in most cases, there is sufficient food production in the country...however, problems of distribution remain an impediment due to high transport costs and poor market and road infrastructure”*.

4.2 The Role of Agricultural Biotechnology in Alleviating Food Insecurity

When asked about the role of agricultural biotechnology in alleviating food insecurity, the respondents analysed the complexity of Ethiopian food insecurity and conveyed that the solution does not lie solely in the use of GMOs. Most respondents acknowledged a part for such technology but only if it is developed in the right context and handled with caution. Questions around ownership of the technology, who controls and manages the debate, supply and control of the seed and affordability of GMO related packages raised concerns. A genetic resource person suggested, for example, that:

The technology is in the hands of Monsanto and other multinational giants, which originate in the developed countries. The natural resources are based in the developing countries with very little knowledge on how to make the best and safest use of this technology.

Bekele, quoted in Bio-Earn (2001) affirms that addressing the social dimension of biotechnology means addressing the issue of social injustice, the issue being ownership and application of the technology. He argues that science and technology are not neutral. They are working in the current changing environmental, social, political, economic and cultural spheres of the world and he suggests that *“to meaningfully solve social and environmental problems, the hidden agenda of science and technology have to be unmasked”* (2001 p.27).

Similar examples of resistance and pessimism from experts and farmer groups were evident in my research. Some pessimistic views were



based on a perception of policy and institutional inefficiencies that are not conducive to the establishment of an enabling market environment. The other pessimistic views referred to the potential environmental risk of GMOs through monoculture and the issue of IPRs and biopatenting.

In contrast, very few respondents overwhelmingly endorsed the potential of agricultural biotechnology for boosting productivity. Nonetheless, they cautioned about associated risks with the implementation of GMOs and questioned Ethiopia's risk assessment and management capacity. Fear of transgenic gene transfer resulting in contamination of non-GM crops was cited in particular.

4.3 The Consequences of Agricultural Biotechnology for Biodiversity

The general consensus among respondents in terms of the consequences of agricultural biotechnology was a fear of the irretrievable loss of biodiversity in Ethiopia. Further aspects of biodiversity such as the genetic pool and traditional knowledge were also mentioned as being under threat. In the current debate, the Department for International Development (DFID) (2001 p.4) also affirms the importance of diversity and traditional knowledge as it argues that "diversification helps to protect rural families from biological, climatic and other shocks or stresses".

Use of monoculture as opposed to conventional diverse cropping was another major concern expressed by participants. This was because with monoculture techniques, a very limited number of crops are introduced to the environment which exhibits little or no plasticity to evolve with it. The respondents suggested that there is greater plasticity and lesser probability of crop failure through the use of conventional seeds. This concern about biodiversity is also addressed by Ekpere who underlines that:

local communities have always 'hedged their bets' by planting a wide range of species and varieties in order to ensure food security... in Ethiopia, a recent survey has shown that farmers have already identified climatic instability as a serious problem and consequently are widening the range of crops and varieties they plant (2001 p.3).

Kydd et al have also raised ecological concerns with regard to the possibility of GM crops and weeds out-breeding as "loss of biodiversity, through...the reduction of weeds affecting species in the ecological chain which depend on these, or the direct effects of breeding insecticidal properties into plants" (2000 p.1136).



In contrast with these types of concerns, a small number of respondents noted that agricultural biotechnology enriches the environment by developing improved varieties of seeds. This reflects Zilberman et al's-view that "application of biotechnology can increase food output, improve nutritional quality and raise health status" (2006 p.1430). Nonetheless, the same respondents acknowledged associated threats such as the dominance of GMOs over conventional seeds, the likelihood of transgenics escaping to the wild, production of super weeds, the potential for pests to evolve resistance to toxins and the potential to create antibiotic resistant microbes. As such, there seems to be confusion and contradiction amongst different experts working in the area. While some acknowledge GMO potential, they highlight the negative aspects associated with these crops without taking a clear stance on the issue.

4.4 Implications of Biopatenting and IPRs for Smallholder Farmers and Food Security

Most respondents considered biopatenting and IPRs to hold negative implications for smallholder farmers and food security. Issues relating to biopatenting and IPRs for breeders rights, farmer's rights, exchange of seeds and patenting of whole organisms were identified.

The current requirement of GMO free corridors² for biosafety reasons were viewed by some respondents as impractical since Ethiopia is a country of smallholder farmers with many land holdings less than a hectare in size. It was clear to respondents that this would intensify the chance of contamination and pose the risk of non-GM growers, most of whom are poor farmers, getting prosecuted by GM companies. Most respondents condemned the extension of IPR to a seed as a breach of farmer and human rights. One farmer from Were Illu stressed the importance of local landraces³ by quoting a traditional saying. "*Nebar zer be dukete yelewetale*⁴, meaning that a local landrace has more value than flour that takes a lot of effort and energy in preparation. An NGO activist working in organic farming also expressed concern: "*IPRs are where the industrial coalitions dominate over human rights because they never meet the needs of poor people*".

4.5 Forces Driving the Debate and Policies Around Biotechnology and Food Security

The research conducted indicated that the Ethiopian government and some donor organizations such as the United States Agency for International Development (USAID), the World Bank (WB), the International Monetary Fund (IMF) and the Consultative Group on International Agricultural Research (CGIAR) are the major forces

2 GMO free corridors are areas left in between GM and non GM cropping to avoid GM contamination

3 "Landraces are defined as a mixture of morphotypes evolved through human and natural selection" (Messele, 2001, p.9)

4 Roughly translates as: Local landrace can be exchanged with flour.



shaping and driving the debate on the use of agricultural biotechnology. The impact of donor driven research and development is noted by Yibrah and Demessie (1998) as lacking a focus on solving national problems. There was a mixed response among research participants to the Ethiopian government's position. Some respondents noted that the government is welcoming the introduction of GMOs while others conveyed an unclear position.

Research participants also saw large corporations as a driving force through their funding of international R&D institutions. At national level some hybrid seed companies were reported as forces behind the debate but not to the extent of shaping policy.

The findings also outlined key organizations that have been involved in public debates (through radio and television) and policy formation in this area. The Environmental Protection Authority (EPA), Ethiopian Agricultural Research Organization (EARO), Ethiopian Science and Technology Commission (ESTC) and African Biodiversity Network were some of the organizations repeatedly mentioned by most respondents.

4.6 The Role of International Governance Policy in Supporting the National Efforts of Ethiopia to Address Food Security Concerns

The role of international governance policy in supporting the national efforts of Ethiopia and other Southern countries to address food security concerns was viewed critically. Research respondents suggested that these policies had little or no impact mainly due to the negative impact of agreements on agriculture, including TRIPs. The TRIPs⁵ (Trade Related Intellectual Property rights) agreement is one of the three pillars of the WTO (World Trade Organization), the others being trade in goods and services. These concerns about TRIPs reflect current criticism where it is viewed that TRIPs could jeopardise farmers' rights to save and exchange seeds, and encourage misappropriation of genetic resources, thus eroding biodiversity, undermining traditional knowledge, fostering a dependency on foreign corporations and ultimately endangering food security (ActionAid-Ethiopia, 2005).

In general, respondents cited the inefficient role of international governance policies and their impacts on aggravating global food insecurity. Most respondents mentioned food aid as intensifying problems of food insecurity by suppressing local production and creating dependency. This concurs with a report from the Organization for Economic Cooperation and Development (OECD), which argues that "food aid has been criticized as a wasteful means of transferring resources to needy people, not least because almost one-third of all

5 "TRIPs was negotiated during the Uruguay Round of trade talks that took place from 1986-1994...The agreement was framed with the intention of protecting intellectual property on a global scale by means such as patents, copyrights and plant breeder's rights" (Downes, 2003, p.5).



food aid resources are captured by domestic food processors, shipping firms and other intermediaries in the donor country” (2006, p.3).

International governance policies and contributions towards ‘poverty-alleviation’ were generally acknowledged by research respondents as having a double-edged role. Newell and Mackenzie agree:

global governance currently active on the issue of biotechnology are failing adequately to address the needs of the poor, at least in terms of their ability to address food security concerns...the dumping of their products on developing country markets is permitted by subsidies to farmers in the North, which continue to be a bone of contention in global trade talks (2004 p.83).

Conflicts between international agreements were also noted in the findings as contributory factors. The TRIPs agreement was cited as one in conflict with other international agreements such as the Convention of Biodiversity (CBD). This concurs with Ekpere’s argument that while the CBD recognizes traditional knowledge and the importance of biodiversity, “the TRIPs agreement is in direct conflict with the basic tenets of the CBD, in that it formalises the trend in which IPRs confer private, individual and exclusive ownership of life forms” (2001 p. 2).



5. Conclusions and Recommendations

The research showed a general agreement around concerns regarding international governance policies and their inadequate and sometimes aggravating contribution to the cause of food insecurity. The respondents generally believed that GM is about mass production of cheap food, controlled by large corporations for urban masses. Most concluded that GM is not a pro-poor technology; it is a pro-cheap food technology enabled by agricultural research. Given that biotechnology is focused on food production and that there are serious questions about its effects on food distribution, its contribution to alleviating food insecurity is highly questionable.

5.1 Conclusions

This research examined the potential role of agricultural biotechnology in addressing food insecurity in Ethiopia and various stakeholders were consulted for their views on the matter. As indicated earlier, there were many different views and they were not always shared by those people in similar organisations or groups. For this reason, I have classified them by their opinion.

The first and largest group comprised of the majority of the respondents who acknowledged a positive role for technology in general but nevertheless, were sceptical as to the potential of agricultural biotechnology to alleviate food insecurity. The respondents expressed fear that the technology may become subservient to industrial coalitions and profit motives. They also expressed fear of the unpredictable effect of the technology on biodiversity and its social and economic implications in conjunction with Ethiopia's capacity to assess and manage risks.

The second and smaller group of respondents held the middle ground and shared the opinion that if agricultural biotechnology is applied with proper caution under biosafety guidelines, it could be beneficial for alleviating food insecurity problems. Nonetheless, this group of people held the same opinion as the first group in relation to IPR and biopatenting. In general they were cautiously optimistic about the potential of agricultural biotechnology.

The third and smallest group consisted of a very small number of respondents who saw agricultural biotechnology as the only way to alleviate Ethiopian food insecurity. This group endorsed the potential of agricultural biotechnology to 'feed the world' and enhance biodiversity. Nonetheless, they cautioned on the risks associated with GMO



implementation. I feel that despite the positive outlook on the benefits of GMOs held by this group, the many negatives given must surely outweigh them. Surprisingly, these respondents further contradicted their optimistic view of GMOs by expressing concern regarding high costs, the commercialised nature of the business, contamination and use of antibiotic genes and their potential to create resistant microbes. In general, it seems that the pro-agricultural biotechnology respondents are focused on the potential of GMOs to boost production leaving other causes of food insecurity and issues of food distribution aside.

While the purpose of this research was to assess the role and consequences of agricultural biotechnology for food insecurity in Ethiopia, it raised interesting questions on other related issues. These included areas such as productivity versus distribution as a root cause of food insecurity and the conflicts between international agreements such as the CBD and TRIPs. It also raised questions on the possibility of international governance policies such as the CBD being undermined by bilateral and trade agreements that prioritise the interests of corporations rather than addressing the root causes of food insecurity. Last but not least, a minor concern was raised regarding ownership of Ethiopian germ plasms since their duplicates are kept in Germany.

5.2 Recommendations

In order to address food insecurity in Ethiopia, research participants made very useful recommendations. They argued for the need to explore the potential of Ethiopia's existing wide diversity of crops to improve aspects such as yield, resistance and adaptability. Another recommendation was to diversify crop varieties with resulting diversification of sources of nutrition. A further suggestion was the establishment of a biosafety regulatory regime and the need to build the capacity of government institutions for risk assessment and management prior to GMO introduction. Some suggestions related to policy and institutional issues were the establishment of an efficient input and commodity market and a mechanism to adjust market price at national level.

Using simple techniques of biotechnology such as plant breeding and tissue culture instead of genetic engineering (GE) was highly recommended. Zeweldu (2000) cited in EARO (2000) also affirms this: "before adopting genetic engineering, Ethiopia needs biosafety guidelines, a regulatory system and a clear system of IPRs. GE is an expensive technology to set up and implement and may not meet local needs. Currently there is no need for GE, we need to exhaust the simplest technologies" (2000 p.9-11).



Numerous suggestions were made regarding re-distribution of local produce rather than accepting subsidized food. The need for closer examination of the agendas of international governance bodies partaking in the funding of biotechnology research and development was also recommended.

In the light of these recommendations from stakeholders, it would appear that the establishment of an open forum for discussion and dialogue between government organisations, farmers, non-governmental organisations, civil society and the public sector, along with the establishment of non-partisan advisory committees to analyse the opportunities and risks of agricultural biotechnology is also vital.

Reviewing the literature and analyzing the findings from primary research conducted, I would tentatively suggest that the balance of effort in reaching a solution needs to focus on the diversity of causes of food insecurity. Most revealing of all was that all farmers taking part in the research overwhelmingly endorsed their preference for their local landraces over GMOs or improved varieties despite the fact that they are the people who face the challenges of food insecurity. I think it is worth sharing the following quote from Pat Roy Mooney which endorses the value of biodiversity in the global South and our food interdependence:

When you settle down to dinner tonight, there will be nothing on your plate that does not come to you directly, and/or indirectly, from the Third World. Our food system is vastly more interdependent than most of us would have imagined. Should anything happen to severely reduce the genetic diversity of the Third World, or make it impossible for the First world to obtain vital germ plasm, the potential for a world-wide food crisis would be very real. It is apparent that the 'gene-poor' nations outside the Vavilov Centres must continue to look to the Third World for genetic support (1980 p.8-9).



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