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Policy Brief

POLICY BRIEF N° 3

ENVIRONMENTAL ISSUES RELATED TO GENETICALLY MODIFIED CROPS IN AFRICA

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Introduction

The continued growth of agricultural biotechnology demonstrates that biotechnology is playing a positive role in agricultural production and genetically modified (GM) crops are adopted by farmers around the world. As a matter of fact, the total area planted of GM crops in 2011 reached 169 million hectares over 29 countries.

In Africa, while the adoption of modern biotechnology is relatively slow, noticeable progress has been made in a few countries including South Africa, Burkina Faso and Egypt where farmers are commercially growing GM crops including Bt cotton and Bt maize. In other countries like Kenya, Uganda, Nigeria and Ghana national legislative frameworks are being developed to facilitate the regulation and use of agricultural biotechnology. Transgenic events with crops such as maize, cassava, cowpea, banana, potato, sweet potato and cotton are under field trials in several African countries. Specifically, transgenic drought tolerant maize, nutritionally enhanced sorghum, cassava, and banana and N-Use Efficient rice, amongst others are in the development pipeline for Africa, all aimed at reducing food insecurity, poverty and malnutrition.

One of the major factors slowing down the adoption of agricultural biotechnology in Africa is the precautionary attitude taken by regulators to protect the continent's rich biological diversity. Many believe that the

high level of biodiversity found in Africa makes the assessment of the potential environmental risks associated with GM crops more complex in Africa than in less biodiverse areas. This assumption is incorrect as risk assessment procedures have been developed that can be utilized in all regions of the world.

This policy brief summarizes the logical principles and steps that need to be taken to assess the potential risks that genetically modified crops could pose to the environment, and explains how these methodological procedures are valid and applicable on a case-by-case basis, regardless of the location or level of biodiversity

The issue of biodiversity loss in Africa

It is well known that Africa is endowed with rich and varied biological resources that are important not only for African's social and economic development but also for regulating the global climate as well as providing materials for the global industry. While hosting a very rich animal and plant biodiversity, the African continent is also the centre of origin and the centre of diversity for a number of agricultural plant species. As such, local species serve as an important genetic storehouse for indigenous farmers and plant breeders engaged in plant domestication and crop improvement.

Biodiversity in Africa and at the global level is in decline. The need to prevent or reduce this

loss of biodiversity has become an urgent issue. The international community through the United Nations agreed in 2002 to consider the reduction of biodiversity loss as a target under the Millennium Development Goals. It was expected that a significant reduction in the rate of biodiversity loss would be achieved by 2010, at the global, regional and national levels. Unfortunately, African Governments have not been able to achieve this target.

The major drivers of biodiversity loss have been identified by the Millennium Ecosystem Assessment as habitat change, urban expansion, overexploitation, climate change, pollution and the impact of invasive alien species. Unsustainable agricultural practices, deforestation, conversion of forest to farmland are considered important factors that threaten biodiversity and ecosystems in Africa.

The cultivation of GM crops has also been viewed by some as a possible source of biodiversity change, mainly through potential impacts on the environment. The reality is that approved GM crops are no greater threat to biodiversity than conventional crops. Reliable scientific approaches and guidelines have been developed to evaluate potential risks before decisions are taken to release GM crops.

Key principles of Environmental Risk Assessment of GM crops

Extensive scientific research has led to systematic protocols to measure the potential risks posed by GM crops to the environment. Assessment of these risks is based on the logical definition of risk being a function of hazard and exposure. This follows the same fundamental principles as other risk assessment schemes. Unfortunately, people frequently assume that hazard is the whole risk, but unless exposure is taken into consideration, hazard is a poor assessment of risk.

The typical logical framework designed for risk assessment entails the following key steps: 1) identification of hazards, 2) evaluation of the magnitude and duration of identified hazards, 3) estimation of the likelihood of occurrence of identified hazards, 4) account for the nature and importance of the scientific uncertainty in each phase of the process. Thus for each concern raised about a genetically modified organism (GMO), scientists identify the hazard at the root of the concern; the likelihood that this hazard will materialize; the consequences should it materialize; and whether risk management measures can be applied to reduce any identified risk. When the level of risk is known for all the identified hazards the decision makers determine whether this total risk is acceptable for local communities. Biosafety reviewers around the world rigorously follow these logical steps to arrive at credible estimates of risk and to define management measures. African scientists are a part of this network and African decision makers need to trust their national scientists who are working in partnership to achieve international safety standards.

There is consensus that three fundamental questions must be addressed in conducting risk assessments, regardless of where the GM crop will be grown and the local levels of biodiversity. These are: 1) whether GM technology will increase plant invasiveness or weediness and cause the transgenes to exhibit competitive advantage over the natural forms and disturb local ecosystems; 2) whether GM crops or derived plants will negatively impact on non-target species present in the environment; 3) whether GM crops will negatively impact on the non-living components of the environment, damaging or polluting the air, soil or water.

In addressing these concerns there is also consensus that a science-based environmental safety evaluation must focus on: 1) the nature of the crop plant, 2) the characteristics of the introduced trait, 3) the

characteristics of the environment where the GM crop will be released and 4) the interactions among these components. Gene movement from GM crops to non-GM relatives, wild or cultivated, is an important consideration, taking into account that the level of gene flow is influenced by the proximity of sexually compatible relatives and the pollination of the GM crop, especially the degree of outcrossing and the level of viable seed and progeny. This information is known for most of the major crop species grown in Africa.

In addition to concerns expressed about the natural environment, GM crop cultivation has also raised issues about coexistence between GM and non-GM crops and about pest-management. As with pollen flow, guidelines have been developed to address these issues. These topics on stewardship of approved GM crops will be discussed in more detail in future briefs.

Critical information needed to assess environmental risks associated with GM crops in Africa

It is important to note that GM crops being cultivated or under development in Africa are not new to African scientists and farmers. These are African crops in which specific traits are incorporated to improve their tolerance to pests or abiotic stress, or to enhance their nutrient content. Only three or four of the thousands of genes in a GM crop are modified. Wide knowledge and familiarity with these local crops makes it possible to conduct science-based risk assessment focusing on the characteristics of the crops species, the introduced traits and the local environment in which the GM crop will be cultivated.

Each crop species may have compatible relatives in the growing area with which hybridization can occur. Developers including African scientists provide information on the potential for outcrossing from a GM crop via

pollen flow to other plants of the same species or to wild species in African release environments. Cultivation of GM crops that do not have wild relatives in Africa does not pose environmental threats associated with gene flow to wild species. Further risk analysis of the impact of pollen flow is only needed to understand gene flow to the same crop species in the release area. For example, the wild relatives of maize are not found in Africa; therefore, pollen flow from GM maize to wild relatives is not an issue in Africa. However, Africa is the centre of origin for sorghum, so the impact of pollen flow from GM crops to wild species needs to be addressed wherever wild species are present in growing areas and are sexually compatible.

The mode of pollination, the levels of self-fertilization and the viability of seed from outcrossing are important considerations. Sorghum for instance, a predominantly self-pollinated species, outcrosses readily with its sexually compatible wild and weedy relatives when grown in close proximity, have overlapping flowering times and share a common pollination mechanism. This would imply that genes from GM sorghum would most likely escape into the native populations. The overarching question here, therefore, would be the consequences or the fate of such transgenic trait in the wild and not whether gene flow would actually occur. On the contrary, other self-pollinated crops such as cotton and cowpea have a very low probability of hybridizing with neighbouring relatives, so isolation distances of less than 100m should effectively prevent pollen-mediated gene flow from GM cowpea. Other species such as banana and many sweet potato varieties are predominantly sterile, making hybridization with relatives highly unlikely. Levels of self-fertilization and the viability of hybrid seed are particularly important issues to consider when developing strategies for managing coexistence of GM and non-GM crops.

In performing safety evaluations, newly introduced traits are assessed for their potential to increase plant fitness or produce substances that could be toxic to non-target organisms. Pest resistance traits such as those conferred by Bt genes can only have an environment impact if the populations of the wild relatives are controlled by the same pests in the natural environment. Nevertheless, it has been recently proved that the widespread adoption of Bt cotton and the subsequent reduction of the usage of broad spectrum insecticides have significantly promoted the biological control services in ecosystems in Northern China. Herbicide tolerance traits generally do not increase the fitness of progeny from cross pollination with wild species since herbicides are not applied in unmanaged environments. Abiotic stress tolerance traits such as drought tolerance or salt tolerance may have an environmental impact since they allow crops to grow where they might otherwise have been restricted by the abiotic stress. Typically, nutritionally enhanced traits providing for example increased levels of micro nutrients like iron, zinc or pro-vitamin A are not known to produce toxic substances and are therefore not expected to have any negative effect on the environment.

Table I below shows some of the main African crops that have been genetically modified and are under trial or have been approved for commercial cultivation in few countries in Africa, with a summary of the relevant information needed to assess the potential for outcrossing prior to their deployment.

Pest management issues associated with GM crops in Africa

Evolution of resistance in target pest populations is a concern for all methods of crop pest management. Resistance to chemical pesticides is well known. The cotton bollworm, *Helicoverpa armigera* (*Noctuidae-Lepidoptera*), for instance, is the insect species with the highest number of resistance

cases reported around the world. Resistance of this insect to chemicals badly affected the cotton sector in Burkina Faso in the 1990s and encouraged the Government of Burkina Faso to explore the use of Bt cotton. Farmers in Mali, Chad, Cameroon and Togo are still facing these resistance issues with chemical pesticides.

Even in GM pest protected crops, resistance to Bt toxins has been reported in a number of countries including South Africa. This indicates that even with products of agricultural biotechnology resistance can arise; but this situation has been successfully managed using different means including high dose, refugia and gene stacking strategies as well as adoption of integrated pest management. This is discussed in the environmental safety section of the ABNE web site and will be discussed in more details in future publications of ABNE.

Coexistence issues associated with GM crops in Africa

The issue of coexistence of GM crops with conventional and organic agricultural production is not a safety issue. It is market driven and directly related to enabling choice by consumers and agricultural producers.

The accidental mixing of GM materials with non-GM products, also referred as “adventitious presence”, occurs through physical mixing of seed and pollen flow. Many countries, including the European Union, have defined acceptable levels of adventitious presence and have determined segregation measures that enable cultivation of GM crops while protecting farmers from adverse economic consequences of accidental mixing of GM materials.

In Africa, coexistence with GM crops could become an issue mainly for high value cash crops exported to countries where the

threshold for adventitious presence has been defined and standards need to be met. However, segregation measures including isolation distance can be efficiently applied to meet different thresholds. For each crop species, isolation distances have been defined based on their reproductive biology. This will be discussed in more detail in other publications from ABNE.





Conclusion






Adoption and cultivation of GM crops are growing worldwide with the advent of efficient regulatory systems that are able to properly evaluate the inherent risks and set up appropriate measures to manage those risks. Concerns raised with respect to the safety of the environment are the same all over the world. These concerns centre around whether GM crops and any derived progeny will become more invasive and outcompete other species in the environment or whether they will produce substances that could be toxic to non-target organisms. Biosafety guidelines and methodologies have been developed, based on rigorous scientific approaches that carefully assess the identified risks. Knowledge of crop biology

and the geographical distribution of wild relatives are key to properly conducting the environmental risks assessments. African scientists and farmers have a strong knowledge base having worked with these crops plants for many decades.

It has been argued that because of the large biological diversity in Africa, assessing potential risks of GMOs would be more complex and the scientific uncertainty higher. As a consequence, more precaution has been taken in African countries to deal with any potential risk associated with GMOs. This overly precautionary attitude has denied most African countries access to safe and potentially beneficial modern biotechnology. The risk assessment strategies being used outside of Africa are applicable to this continent and risk assessment can be used effectively for countries with any level of biodiversity. The right question then is whether it makes sense that Africa is denied modern technology simply because of safety concerns that can be addressed. What would be the value of biodiversity if it is not protected by sustainable agriculture and used sustainably to support economic and social growth for local communities?

Table 1: Summary of information required for environmental risk assessment of the potential for outcrossing from selected GM crops in Africa.

<i>Crop species</i>		<i>Center of origin and diversity</i>	<i>Reproductive biology</i>	<i>Degree of outcrossing</i>	<i>Presence of wild relatives in Africa</i>	<i>Likelihood of pollen flow into native relatives</i>
<i>Banana (Musa sp.)</i>		<i>South Asia</i>	<i>Cross pollinated by insects, but sterile</i>	<i>None / sterile</i>	<i>No</i>	<i>Highly unlikely due to sterility issues and absence of wild relatives</i>
<i>Cassava (manihot esculenta)</i>		<i>South America</i>	<i>Cross pollinated by insects</i>	<i>variable</i>	<i>Yes</i>	<i>Highly unlikely due to nature of propagation and incompatibility issues</i>
<i>Cotton (Gossypium hirsutum)</i>		<i>Central America</i>	<i>5-40% cross pollination</i>	<i>Extremely low</i>	<i>Yes</i>	<i>Low into wild relatives and local varieties</i>
<i>Cowpea (Vigna Unguiculata)</i>		<i>East, West and Southern Africa</i>	<i>Self pollinated with some outcrossing by insects</i>	<i>Extremely low</i>	<i>Yes</i>	<i>Extremely low into wild and local varieties</i>

<p><i>Maize (Zea mays)</i></p>		<p><i>Mexico</i></p>	<p><i>Cross-pollinated by Wind</i></p>	<p><i>High</i></p>	<p><i>No</i></p>	<p><i>Highly unlikely due to absence of wild relatives</i></p>
<p><i>Potato (Solanum tuberosum)</i></p>		<p><i>South America</i></p>	<p><i>Either self-pollinated or cross-pollinated by insects</i></p>	<p><i>Variable</i></p>	<p><i>No</i></p>	<p><i>Highly unlikely</i></p>
<p><i>Rice (Oryza sativa and Oryza glaberrima)</i></p>		<p><i>West Africa</i></p>	<p><i>Self pollinated (some outcrossing by wind)</i></p>	<p><i>Extremely low</i></p>	<p><i>Yes</i></p>	<p><i>Extremely low into wild relatives; low into local varieties</i></p>
<p><i>Sorghum (Sorghum bicolor)</i></p>		<p><i>Various regions in Africa</i></p>	<p><i>Self-pollinated but some degree of outcrossing by wind</i></p>	<p><i>High</i></p>	<p><i>Yes</i></p>	<p><i>Highly likely due to sympatric occurrence of cultivated, wild and weedy forms</i></p>
<p><i>Sweet potato (Ipomea batata)</i></p>		<p><i>South America</i></p>	<p><i>Cross pollinated / insect</i></p>	<p><i>Variable</i></p>	<p><i>Yes</i></p>	<p><i>Highly unlikely due to nature of propagation</i></p>

Suggested further reading

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This is the third of a series of policy briefs to be developed by the NEPAD Agency - African Biosafety Network of Expertise (ABNE) addressing environmental safety aspects of modern biotechnology. This policy brief is targeted for regulators and decision makers.

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