

## REVIEW ARTICLE

## CROSS-SECTIONAL VIEW OF GENETICALLY MODIFIED ORGANISMS (GMOs) IN AFRICA

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## ABSTRACT

Modern technology and its applications continue to touch every aspect of our daily lives. The advent and advancement of biotechnology have brought immeasurable improvements in the agriculture and food science industries, medical faculty, and pharmaceutical industry of the world. The biotech industry has developed several products including GMOs, which have set the pace for transforming various sectors of the global economy and salvaging many countries from the several emerging problems of the 21st century. This paper reviewed some of the evidenced-based importance and potentials of GMOs as highlighted by several researchers and authors. It particularly took a brief critical view of the profile of GMOs in Africa and their potential to transform lives on the continent. This review also discussed some mixed reactions hinged on fear, belief, speculation and other influences surrounding GMOs on the continent. A brief background of the steps taken by some countries across the continent towards the use of GM resources, including several trials of GMOs at different stages. However, based on the critical assessment of the reactions, feelings and low interest towards GMOs in Africa, this article has suggested a critical country-based assessment of institutional efficiency, continuous commitment to research, sectorial collaboration and consolidation of country-specific allied industries, before allowing wholesale introduction and application of GMOs.

## KEYWORDS

Acceptance, Concern, Biotechnology, Genetic, Modification, Organism, Risk.

### 1. INTRODUCTION

The practical application of technology in biological processes to modify, improve and transform outputs for the satisfaction of man can be described as biotechnology. Biotechnology is an aged-long technology that is traditionally familiar to the brewery industry through yeast application in making bread, beer and other assorted food products. However, the application of modern biotechnology became very famous at the discovery and advent of Deoxyribonucleic acid (DNA) in the 1950s (Kyei et al., 2017). Some important branches of biotechnology like micropropagation, genetic engineering, plant tissue culture, In vitro production, DNA fingerprinting, genome mapping and marker-assisted breeding are in application across many agriculture fraternities in Africa (Kyei et al., 2017). The application of biotechnology in Africa has made huge positive progress in changing the falling values, particularly in agriculture. For instance, in the past two decades, production of crops like soybean and corn in South Africa, Africa's country at the forefront of biotechnology has recorded about 100% and 200% increments, respectively (Danielson and Watters, 2021).

The packages of biotechnology used in agriculture encompass various techniques such as molecular breeding (use of markers), tissue culture, genetic engineering, molecular diagnosis, bio-based vaccines, etc. Other advanced and sophisticated derivatives of biotechnology include but are not limited to gene editing, recombinant DNA technique and genetic modification. The applications of these latest refined technology products are providing wonderful answers and solutions to some of the aged-long

developmental questions and emerging problems respectively. Some of the impacts of this technology are seen in crop production as improved yield, resistance to drought and flood, resistance to pest and disease, early maturity, improved storability, etc. However, the widely divided views about the potential of biotechnology in Africa's developmental outlook revolve around the adoption and use of genetic modification techniques (Chambers et al., 2014). Meanwhile, Munaweera et al. have reported that biotechnology, through the application of genomics and gene-sequencing approaches in improving crops can best help to arrest global food insecurity (Munaweera et al., 2022).

#### 1.1 Prospects of GM technology

GM technology is touted as an emerging biological tool with the technological wherewithal for fostering higher productivity, and sustainability and above all it comes with a breakthrough for leveraging positive agricultural transformation (FAO, 2017). The application of the GM technique has led to the development of transgenic crops with very high water-use-efficiencies, most particularly the gene FRI has been biotechnologically maximized for the enhancement of resistance to water stress in several plants (Chandler and Tanaka, 2018). Moreover, the commercial application of GM technology in agriculture is improving productivity, promoting good economic outlooks and ensuring food security, because it has birthed several food crops with higher potentials

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in curtailing biotic and abiotic stresses which have always hamper crop production (Askari-Khorasgani et al., 2018). Again, another legacy of GM in the area of crop protection is the development of Bt corn which is very rich in proteins (*B. thuringiensis*) and possesses Bt toxin that is toxically capable of killing members of the insect pest groups such as Diptera, Coleoptera and Lepidoptera (Trapero et al., 2016).

Also, the advent of GM tools is seeing major progressive gains in the health and disease-fighting spaces of the world through the utilization of plant-based food such as bananas, lettuce and tomatoes in the development of antigens and eatable vaccines to serve as boosters for the immune system (Gebretsadik and Kiflu 2018; Ankita et al., 2016). It is also worth knowing that gene technology has achieved another milestone of good fortunes in the field of nutritional science, through the development of "golden rice", which is highly fortified with vitamin A. The study which spans about 25 years in the laboratory finally saw a breakthrough by successfully engineering a rice well blessed with beta-carotenoid, a precursor of vitamin A to help curb the growing vitamin A deficiency problem among many children across the globe. This gallant scientific revolution can also reduce the higher financial burdens on several second and third-world countries that do not have the enabling systems to develop vitamin A vaccines but largely procure such vaccines from producer countries or through donations from partner countries (Zhang et al., 2016). It is becoming increasingly obvious that GMOs have the potential for rapid advancement with vast prospects to fulfil the nutritional needs of about 828 million people languishing in malnourishment as of 2021 and satisfy the industrial food materials demand of the world (FAO et al., 2022).

## 1.2 Concerns and Opposition toward GMOs

There have been growing emotional feelings among the citizens of many states in Africa towards GMOs, which are mostly built upon suspicions and anxiety they have regarding the speculated dangers linked to GM and its products (Cusimano et al., 2018). This unhealthy emotional feeling for GMOs is the driving force behind the anti-GMO campaign marches and activism in the continent, forming the genesis of the divergent conceptions, perceptions and divided opinions of people about GMOs and their products (Mallinson et al. 2018). Some common concerns raised by many of these anti-GMOs activists include; "GMOs and related products are unnatural", "GMOs and their products could have potential threats on the unborn generations", "GMOs are not morally fit", "GMOs can endanger the natural environment", "application of GM-techniques in food production will mainly profit GMOs-affiliate multinational companies", "GMOs are alien" (Mallinson et al., 2018).

Interestingly, these concerns have won and continue to win the hearts of many from the academia, social, religious, economic and political classes around the region, making the issues of policy and decision on GMOs very complex. The Religious anti-GMO activists in secular African settings also perceive the application of GM tools and GMOs as criminal attempts to interfere with the natural protocols and designs of processes for lives. Hence, they perceive the GM package as unfit on moral grounds. The belief of possible risks associated with GMOs has been the key factor of influence dictating the acceptability of the restrictions on GMOs against their publicized benefits (Scott et al., 2016). There are continuous debates regarding the interference and influence of policy-formulators on biotechnology and agricultural markets, which were staged by the recent development of interest in Africa for the green revolution (Kwade et al., 2019). Some laws and policies which have been put in place by several states in the continent to bring the conflicts surrounding GMOs to rest, at times also turn up to be the breeding germ for new disputes about the same (Friedrich, 2020).

However, it has been well established that most of the anti-GMO advocates are not moved by evidence, and as such their wills and motives are not determined by the ongoing debates about the gains versus the risks of GMOs (Scott et al., 2016). The feeding of the public with incredible reports and misinformation about GMOs continues to split up the behaviours of consumers into fractions, perhaps, some of these unverified truths are proceeded from the domains of major anti-GMO groups which are close to the biotech industry. This situation leaves the divided consumer community that is not privy to credible information on GMOs in a state of confusion over whom to entrust (Siegnier, 2019).

One school of thought is of the view that all attempts to change views and how consumers perceive GMOs must as a matter of urgency sufficiently deal with the factors that triggered the perception of risks associated with GMOs. Again, efforts should also be put in place to advance the preaching of the positivity of bioengineered plants. In addition, some sections of the public also argue that the procrastination of regulatory procedures and the cost of commercializing the application of recombinant-DNA

techniques are very onerous, and the required commitments and efforts continue to outweigh the perceived risks. Thus, the best alternative forgone for the expenses and delays in regulating GMOs is redoubtable (Holman, 2019). The commercial producers of GM products of agricultural importance must not just demonstrate to the public and consumers that their produce is off-risk and danger-free to nature and the environment. They must also back their claims with verifiable proof, affirming that these genetically modified products pose no danger to humans and animals (Nuryanti, 2018). The introduction of GMO-containing products is being regulated by several nations across the world at given percentages, and this strictly calls for proper and adequate labelling of packages of all GM foods for ease of identification (Kolodinsky and Lusk, 2018).

The certified and approved genetically engineered products are hardly distinguished from the possible uncertified and counterfeit ones. Therefore, it could be very catastrophic in the likely event of a possible release of the latter as biological weapons to rain havoc on the global community under the shadow of GM technology and products. Most particularly at this age when assessment, evaluation and regulation of GMOs are yet to gain feet in many countries of the continent and other parts of the world. Notwithstanding the large amount of GM crops such as corn and soybeans that have gained prominence on the international trade front, GMOs have still not been accredited as wholesome commodities with no side effects on the well-being of man. The oppositionists of GMOs are of the view that their release and commercialization can destabilize the natural ecosystem and render the agriculture system GMO-dependent, which will welcome a high influx of GMOs against the native crops and cropping systems, placing high implications on sustainability (Friedrich, 2020).

Many anti-GMO campaigners and activists whose actions contribute significantly to the political will against GM crops in Africa have launched aggressive criticisms, describing GMOs and associated techniques as criminal acts against lives, and accused such as efforts to "take food off the plates of the hungry masses" (Brandon, 2015). Some recent studies have revealed socio-economic, environmental and health risks perceived by the anti-GMO community as the main driving forces behind the stern opposition of the public against GM foods, influencing the decisions and policies of international and national governments around the world. According to Rzymiski and Królczyk the non-scientific identifiable oppositions against GM foods are primarily dependent on purported risks and threats people believe are associated with them (Rzymiski and Królczyk 2016).

## 1.3 Perceived risks of GMOs

According to studies in the recent past, several direct and indirect negative implications of using GMOs and related products have continued to emerge, since the inception of the technology and its allied products about 20 years ago (Tsatsakisa et al., 2017). In addition to the unintended danger of a potential loss of nutritional quality and the negative implications associated with marker genes, GMOs also have the potency to trigger many allergies. There could be a possible consumption of counterfeit products if sensitization is not intensified to provide adequate information on the nature and type of GM foods available at the consumers' disposal (Lee et al., 2017). For instance, if a desired allele of a fish is accidentally inserted into maize, any person who is allergic to that fish will develop an allergy to that particular maize, having no idea of the common gene shared by the fish and the maize (Gatew and Mengistu, 2019). There have been greater efforts towards public education on the benefits and promotion of GMOs; however, very little emphasis has over the years been placed on their relative consequences on the sustainability of food and agriculture (Chagwena et al., 2019). Some of these unidentified GM dangers are long-term and will not be manifested in a short period, perhaps, their effects on man and animals may not be acute but chronic. For example, when a GM maize (NK603) of Monsanto Biotech Company was fed to rats over two years, it left them with a couple of damages to the liver, and kidneys, interfered with the function of the pituitary gland and disrupted the hormones (Bernillon et al., 2018).

Many promoters of GMOs have also always asserted that in as much as there may be some risks ascribed to GMOs, such risks purportedly ascribed to the technology and procedures used in developing GMOs are not so dangerous and highly dreadful as the risks associated with other conventional breeding approaches employed in developing crop varieties and cultivars. For instance, the United States Development Agency (USDA) is of the view that GM crops do not pose any danger of being higher pests or noxious weeds to crop production than crop varieties developed through traditional and mutation breeding procedures (Holman, 2019). Furthermore, a group researcher also believe that the risk which may come with the gaps and lapses in the regulatory processes of GMOs will be

the difficult task of distinguishing GMOs from products developed through conventional breeding technologies at the major markets of international trade (Wallace, et al., 2018). The recent approach of culturing tissues employed by GM technology can fundamentally result in negative changes and modifications of biochemical reactions, proteins and the DNA of GMOs that may pose harm to lives (Eriksson, 2018).

## 2. STATUS AND PROSPECTS OF GMOS IN AFRICA

Amid the strong opposition and slow-paced approvals for GMOs in the African continent, quite several countries in the continent such as Kenya, Egypt, South Africa, Sudan, Burkina Faso and Nigeria have broken grounds in commercial approval of some GM commodities like Bt cotton, Bt maize, and pod borer resistant cowpea, which cultivations are gaining feet (Ongu et al., 2023). In Kenya, strict trials of several GM crops like maize, cassava, sweet potato, banana, cotton, cowpea, and soybeans with desirable traits such as pests and disease resistance, drought tolerance, and high nutrition capacity started in 2010 and it is ongoing. In the same vein, insect pest-resistant maize, cotton and virus-resistant cassava were given cultivation permits in the country in 2015, 2016 and 2021 respectively (Ongu et al., 2023). Again, cassava was subjected to controlled field evaluations for characteristics like mosaic disease resistance and enhanced nutritional contents in Nigeria in 2019, while potato and maize had their turn in 2022.

In addition, the country approved commercial cultivation of GM cotton and GM cowpea in 2018 and 2019 respectively (Ongu et al., 2023). Nigeria has also successfully established and operationalized national agencies to regulate the development of biotechnology and biosafety since 2001 and 2015 respectively. Again, the country has approved the importation of genetically engineered wheat, making it the first nation in Africa to allow the application of genetically engineered wheat in the feed and food industries. Nigeria in West Africa has also made another giant step ahead by giving permits for her scientists to use gene-editing techniques to better lives (USDA, 2022).

In Ghana, GMOs and their products have not been adopted, but they are under strict regulation, enclosed testing and scientific evaluations at institutional and research levels. For example, some native scientists at the Council for Scientific and Industrial Research (CSIR) of Ghana have engaged in a series of strict field evaluations of GM cotton, rice and cowpea for nitrogen use efficiency and pod-borer resistance, and these were obtained from the African Agricultural Technology Foundation (Rock et al., 2023; ISAAA, 2017; Rosegrant et al., 2014).

Just like in Ghana, Uganda has also engaged in the assessment of some GM crops, viz; Black Sigatoka and Bacterial wilt resistant GM bananas in 2006 and 2010, insect pests and herbicides tolerant GM cotton in 2007, Drought and insect pests tolerant GM maize in 2010 and 2012, Brown Streak virus-resistant GM cassava in 2010, Virus resistant sweet potato in 2013, Late Blight resistant potato in 2015, Herbicides tolerant Soybean in 2016, etc. (Zawedde, et al., 2018). To Add to the list, other countries like Ethiopia, Sudan, Malawi and Eswatini have in recent times adopted and released some GM crops; cotton, maize, cassava and cowpea for cultivation and utilization. Meanwhile, GM cotton, maize and soybeans have long been commercially adopted and given cultivation and utilization approval in South Africa since the 1990s, this has made South Africa the foundation GMO country in the continent (Turnbull et al., 2021). South Africa remains the leader in GMOs with the oldest and most robust regulatory policy in Africa, which has its feet legally firm on the GMOs Act legislation enacted in 1997 (Danielson and Watters, 2021).

According to Rock, an open public contention over GMOs in Ghana, has thrown the country into a state of dilemma over the adoption of the technology and consumption of GM products, since the year 2013 (Rock, 2019). In light of this, the government of Ghana monitors evaluates and regulates the use and activities of plant varieties and associated GMOs in the country and has enacted the "Plant Variety Protection" law in 2020. A law that seeks to ensure intellectual property rights and gives exclusive oversight rights to plant breeders and associates in the country (ParliamentofGhana, 2020). Before that law, there was an act of the legislature on biosafety in Ghana, thus, the "Biosafety Act, 2011, (Act, 831)" which saw the establishment of the National Biosafety Authority. Also, the country ratified and became a recognized member of the Cartagena Protocol of Biosafety in 2004, with a primary mandate of regulating the safer use, movement and keeping of GMOs in the country (NBA, 2019).

Agro-industrial activity in Ethiopia is expected to receive a massive boost and rapid expansions due to the rising drive for cultivation and supply of cotton. This has forced the country to resort to the importation of GM hybrid cotton from GM-cotton-producing countries, and also a plan is far in advance for the country to adopt the commercial growing of Bt cotton

(Bob, 2016). There are urgent scientific and social needs for the African continent to adopt and commercialize the application of modern GM tools in the advancement of the agriculture sector. This will be a giant step to swiftly salvage the overwhelming fall in food production posed by climate change (Gebretsadik and Kiflu, 2018). The continent's food production sector is heavily challenged by several evolving factors such as ownership of lands, pests and diseases, rapid encroachments of arable lands by urbanization and irresponsible exploitation of natural resources, intermittent rainfall patterns, depletion of soil nutrients, and inadequate desire for adoption and little use of improved technologies. These are making it nearly impossible to adequately feed its outburst population and move on an industrialization drive. However, GM has the proven potential to resuscitate the declining wealth of agriculture and set a brighter fortune for the sector to augment the individual and collective governments' efforts towards the attainment of food security and poverty alleviation in Africa (Maina, 2021).

The exploding population and unpredictable climate of the continent have always left significant deficits in agricultural outputs, households' food demands and industrial raw material needs. These critical gaps are the founding elements underlying the issues militating against Africa's continental drive for industrialization and economic self-sufficiency. In all these, GM and its allied products present the best, most affordable and efficient opportunities for doubling the agricultural net output and providing the needed solutions to these challenges (Kamle et al., 2017). Moreover, it has been reported that a very significant sum of about 63,500,000 106,100,000 and 19,600,000 of the populations of 6 countries in the Eastern bloc, 7 countries in the Western sub-region and 4 countries in the Southern part of the African continent respectively are living in food insecurity situations as at the second quarter of the year 2022 (FoodSecurityMonitor, 2022). And in addressing this aged-long and perennial situation, GMOs stand the imaginable chance of being one of the measures needed to bring the situation under control.

### 2.1 Challenges to the Acceptance of GMOs in Africa

The quest to harness the numerous agricultural potentials and the desire to transform the post-harvest and agro-processing fronts in Africa through the magic of GM are still hanging in the balance. This refined technology and its associated tools are heavily contested by several individuals and recognized groups of diverse backgrounds. These oppositions based on their understanding and beliefs have developed untoward feelings for the technology and all its derivatives. Their concerns and persistent campaigns have charged the academic and scientific micro-climates, and the social and governance agencies, and have successfully bred heated debates among key stakeholders on the prospects and values of GM against its perceived threats and dangers in Africa. These ongoing mixed reactions towards GM have formed the object of centrality for the low patronage, slow adoption and poor acceptability of GMOs in many countries of the African continent. At the back of this, only a few countries; Burkina Faso, South Africa, Sudan, Kenya and Egypt have adopted and commercialized the cultivation of some GM crops, which occupy about 0.54% of total cultivated areas (Mathur et al., 2017).

The reluctant and sluggy adoption, and in extreme cases the placing of the total band on the commercialization, cultivation, marketing, distribution and consumption of GMOs and their products in Africa, do not mean African farmers believe that the indigenous crops have better production advantages over the GM crops. It is due to strong opposition against GMOs in many parts of the region alongside the influences from major international markets and the European Union (EU) as well as some Non-Governmental Organizations affiliated to the EU, in a bid to keep trade tides with them. These faceless forces turn to control the will of many countries in the continent through trade and aid, a typical example is the suspension of GM maize cultivation in 2012 Egypt by a government decree due to trade tide concerns with the EU (Zawedde et al., 2018; Mathur et al., 2017). The acceptance and moves towards the application of GMOs in the future of Africa are not certain as the status and roadmaps towards general approval for GMOs in many countries in the region are not well-defined (Ardekani and Shirzad, 2019).

Some civil society groups have strongly registered opposition against some attempts by the Ghana government to adopt and give commercial permits for the importation, production and marketing of GMOs and their allied foods in Ghana (Kwade et al., 2019). There are mixed feelings among Ghanaians toward GMOs, with the majority of them having negative perceptions and bad reactions about GMOs, indicating their unreadiness for the adoption and commercialization of GM foods (Kwade et al., 2018). The regulation of GMOs and detection of counterfeits can be seriously hampered in Africa when introduced and commercialized. The market systems of several states in the continent are not well structured and

therefore, the marketing and activities of internal and external traders cannot be well coordinated for auditing. Almost every country in the continent has porous borders with several opened unapproved routes at the rural border communities. This situation can pose a major challenge to the monitoring and regulation of GMOs, plus checking the influx of possible counterfeits from the neighbouring countries or states, most especially in the rural markets of border communities in African countries.

## 2.2 The way forward

As it stands now, out of the 20 countries in the African continent which have some level of legislation on biosafety; Algeria, Burkina Faso, Cameroon, Egypt, Ghana, Kenya, Mali, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Zambia, Sudan, Swaziland, Tanzania, Togo, Uganda and Zimbabwe, about half of the number have conducted some amount of restricted field trials on GMOs. These include Burkina Faso, Cameroon, Egypt, Ghana, Kenya, Nigeria, South Africa, Uganda, Sudan and Zimbabwe. However, about 6 of these 10 countries (Burkina Faso, Egypt, Kenya, South Africa, Sudan and Nigeria) have operational biosafety policies and have approved the general release and production of some GMOs in their domains (Ardekani and Shirzad 2019; Ongu et al., 2023). These progressive but slow-paced steps taken by the individual countries are good indications of readiness and preparations towards the general adoption and commercialization of GMOs in the continent.

However, there are inconsistent policies and poor political will toward GMOs in many African countries. Members of many research and academia communities have heavily decried the poor levels of commitment of several governments of Africa towards science and research. When it comes to policy formulations, maximum attention and adequate considerations are not fairly given to that area which mostly results in poor budgetary allocations and inconsistent funding for science and research activities in the countries around the continent. Many countries in the region might have the institutional and structural requirements to adopt, pilot and commercialize GMOs. Nevertheless, the political will and needed commitments of governments to ensure adequate and consistent retooling and funding of these institutions of practice to ensure sustainable availability of GMO materials to the farming masses at affordable cost at all times remains the fear for tomorrow. Many institutional oppositions of GMOs in Africa have always centred their intellectual debate on this unreliable nature of African governments and policymakers.

If Africa opens its doors and widely adopts GMOs for commercial production, the continent's agricultural sector in particular can become strictly GMO-dependent in the foreseeable future. When this happens with no workable sustainable policy framework to ensure continuous synchronization of governments' devotion and research efforts, Africa may have to rely on multinational GMO companies outside its shores to secure basic plant and animal resources for cultivation and production (Mbabazi et al., 2021). This situation can potentially put the protruding agrarian populations of many nations in the continent on the path of "reformed opened and hidden hunger". The high influx and patronage of GMOs can lead to a potential loss of the indigenous stabled varieties and breeds as well as cause depletion of the elite local genetic stocks if policy and attitude towards sustainability are not well checked before granting permits for commercial application of GMOs in the continent. Going forward, countries in Africa which intend to commercially embrace GMOs should as a matter of urgency put in place very stringent and coordinated assessment measures and consolidates research and seed systems fronts before approval. Despite the enormous gains of GMOs, it will not be worth adopting them unprepared. The systems and structural demands must be met to ensure sustainability.

## 3. CONCLUSION

Genetic modification is a refined sophisticated technology with several advantages across all spheres of life around the globe. It is arguably becoming the light that has the greater intensity to brighten the worlds of many nations; most particularly the least developed regions of the globe including Africa, where many countries are swimming in perennial struggles in a bid to materialize their everyday dreams of achieving food security and improved livelihoods. Though the continent has sufficient evidence-based information regarding the prospects of GMOs, the calls and moves to embrace them for commercial use and production have not been very satisfactory. The delay in their adoption and use is heavily hinged on the raging debates and opposition going on in many states of the continent. In as much as some of these oppositions may be based on mere fear, feelings and speculations, some are found on facts, data-driven and can be substantiated. In all these, for the adoption of GMOs to be in the best interest of the general masses, policymakers should do wider stakeholder

consultations, and sensitizations, arrive at a collective agreement and set up the appropriate structures to build confidence of sustainability.

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