Biotechnology in Organic Agriculture in Africa: Myth or Oversight?

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Biotechnology refers to scientific methods and practices that are based on biological systems or components. Its applications vary from simple system to amino acids (i.e. DNA and RNA) based applications and are relevant to many stages of commodity value chains. Whereas the simple applications are well understood, contemporary advancements into these applications have gone to deeper levels of innovation, dealing with cells, chromosomes, nucleotides and genes. Since these determine the cellular functions that influence behaviour and inheritance, any biotechnological method applied at this level is very sensitive, because it might result into undesirable alterations in the traits and behaviour of organisms. Notwithstanding its likely contributions, therefore, this level of innovation raises scepticism against biotechnology among the organic agriculture community in Africa. Thus, this paper examines the applicability of these innovations in the development of organic agriculture on the continent.

Key words: Attitude; Indigenous Knowledge; Technology Adoption; Genetics

Introduction

Biotechnology refers to a range of methods that are used to manipulate organic matter to meet human needs. It involves the application of indigenous and scientific knowledge to the management of micro and macro-organisms, organs, tissues, cells or their organelles to supply commodities to human beings (Bunders et al., 1996). Biotechnology may be looked at as occurring on a continuum of technologies, ranging from simple to sophisticated and from traditional to modern. This conceptualization concurs with that of the Convention for Biological Diversity, Cartagena Protocol and International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) (Beintema et al., 2008). On the other hand, the International Federation for Organic Agriculture Movements defines biotechnology as a set of molecular biology techniques by which the genetic materials of plants, animals, micro organisms, cells and other biological units may be altered in ways, or with results, that could not be obtained by methods of natural reproduction or recombination (Rundgren, 2004). On top of its consonance with the definitions advanced by the Convention for Biological Diversity, Cartagena Protocol and IAASTD, this definition characterizes all manipulations of biological units using unnatural methods as genetic engineering. It is widely agreed that whereas traditional technologies have a wider application, and may not require specialization, genetically engineered technologies are highly advanced and, therefore, applied by well trained specialists. Genetic engineering deals with a cell, chromosome, nucleotide and Deoxyribonucleic acid (DNA) or Ribonucleic acid (RNA) or a segment of the chromosome encoding

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for particular genes. Since genes determine cellular functions that influence organism behaviour and inheritance, any biotechnological method applied at this level could be very sensitive because it might result into alterations in organism characteristics and behaviour. Fortunately, many biotechnologies do not involve genetic engineering and could, therefore, be applied to organic farming.

Status of Biotechnology

The proponents of organic agriculture consider biotechnology to embrace the genetic engineering of Genetically Modified Organisms (GMOs). This, as discussed above, includes any unnatural method used to manipulate biological parts of organisms and may be applied in seed production, animal breeding or the production of agricultural inputs. Rundgren (2004) reports that the proponents of organic agriculture discourage these methods, citing the synthetic nature of their products, since they are not naturally occurring; the 'precautionary principle', under whose auspices they seek to avoid wide-scale application of untested technologies; potential health risks, since it is unclear as to whether the consumption of genetically modified materials may pose health risks; environmental risks, since genetically modified crops may pollinate neighbouring crops and weeds let alone damage non-target insects; dependency, since genetically modified crops might increase the farmers' dependency on seed companies; and destruction of alternative methods, since genetically modified crops might induce pest resistance.

Nonetheless, some of these arguments may be grounded on oversight. For example, sheer dislike for unnatural techniques might obstruct farmers from tapping into the diversity of biotechnological innovations that are environment-friendly and adoptable in organic agriculture. In this regard, biopesticides, which are emitted by cells of infected tissues but are extracted using modern techniques, are a case in point. Likewise, even though some technologies involve the changing of the genetic codes of organisms, which is widely feared, there are other technologies like *in vitro* production of Solanum Potato Micro-Tubers, Meristem Tissue Culture, bio-prospecting in traditional medicine (Twarog and Kapoor, 2004) and Marker Assisted Breeding (Witcombe et al., 1998). Besides, measures are being put in place to regulate genetic engineering. For example, several African countries are implementing, or putting in place, biosafety laws and the African Union, together with the Institute for Sustainable Development, have come up with African Model Laws on safety in biotechnology.

Conversely, conventional biotechnologies are well understood (Markwei et al., 2008). Over the years, for example, *new* crop and animal breeds have been generated using open pollinated varieties selection and assisted cross-breeding. In the 1980s, improved maize (*Zea mays*) varieties were widely adopted by smallholders in many African countries. Biotechnological techniques, involving the use of cuttings and meristem tissue culture, have been applied to bulk cassava planting materials, making them widely available and, thus, surmounting the scarcity of cassava caused by *Cassava mosaic virus*. New Rice (*Oryza sativa*) for Africa--combining the high-yielding potential of Asian rice with the stress resistance of African rice--was released in 1996, making rice growing common and cost effective in many parts of Sub-Saharan Africa. In East, Central and Southern Africa, nearly ten million farmers are growing new bean varieties (*Phaseolus vulgaris*), availed through selection, Marker Assisted Breeding and farmer seed multiplication and, therefore, have multiple stress resistances. The use of cuttings has been traditional for plants that are propagated in a vegetative way, such as sweet potatoes (*Ipomea batatas*), cassava (*Manihot esculenta*) and vanilla (*Vanilla fragrans*) and, of late, coffee (*Coffea arabica/robusta*) and passion fruit (*Passiflora edulis*) are also widely multiplied using this technique. In Uganda, for example, the planting of coffee clones from cuttings sustained the country's coffee industry despite the incidence Coffee Wilt Disease while in the COMESA region passion fruit production increased by over 50% due to the grafting of cuttings on resistant rootstocks, to control Collar Rot Disease (Ssekyewa et al., 1999). Indeed, relative to seeds, budding produces the desired quality of fruits in a short period of time (Hartmann *et al.*, 1990). Tissue culture, which involves the separation of biological components of a system and high sanitation quality control in the *in vitro* environment to maximize the number of propagules produced (Hartman et al., 1990), is as old as 1934 (White, 1963). The method is well developed for Solanum potatoes (*Solanum tuberosum*) and, of late, it has been applied to bananas, to produce disease free planting materials; many nurseries apply it on citrus, passion fruits and pineapples; attempts have been made to use it to preserve and multiply endangered tree species (e.g. Muvule); and, in Sri Lanka, banana powder, coconut milk and charcoal are used in the tissue culturing of Anthriums and Orchids. In East and Central Africa, a phytoseiid (*Typhlodromalus aripo*) natural predator was used to control the Cassava Green Mite (IITA, 1999). Likewise, Citrus woolly whitefly, aphids, white egret and cats have provided biological control. Pheromone traps, male sterility, plant oil extracts and mycorrhiza associations have also been utilized (Stoll, 1998).

Causes of the Biotechnology Revolution

There is need to improve farming methods in favour of a greener environment (United Nations Environment Programme, 2008) and, to this end, biotechnology has potential for significantly impacting various aspects of crop and animal productivity, yield stability, environmental sustainability and consumer traits that are important to the poor. First-generation biotechnologies include plant tissue culture, for micro-propagation and production of virus-free planting materials; molecular diagnostics of crop and livestock diseases; and embryo transfer in livestock. Fairly cheap and easy to apply, these technologies have been adopted in many countries. For instance, disease-free sweet potatoes that are based on tissue culture have been adopted on 500,000 hectares in Shandong Province of China, with yield increases of 30 to 40%. Advanced biotechnology-based diagnostic tests also helped in the eradication of Rinder Pest Virus in cattle. Based on molecular biology, on the other hand, second-generation biotechnologies use genomics to generate information on genes that are important for particular traits, thereby enabling the development of molecular markers to select improved lines in conventional breeding (i.e. Marker-Assisted Selection). This has led to downy, mildew–resistant, millet in India; cattle that is tolerant to African sleeping sickness; and bacterial leaf blight-resistant rice in the Philippines among others. And as the cost of Marker-Assisted Selection continues to fall, the technique is likely to become a standard part of the breeder's toolkit, thereby improving the efficiency of conventional breeding in a substantial way.

Besides, in the recent years, various pests and diseases, including Coffee wilt (*Fusarium* spp), Banana wilt (*Xanthomonas* spp), Maize Grey Leaf Spot, Citrus Woolly White Flies and Tomato Leaf Curl have emerged. Incidentally, due to environmental breakdown; stagnation of cereal yields coupled with increases in the proportion of the yields expended on feeding livestock; and reductions in the availability of fish, due to increasing stress on the marine environment and harvest- and post-harvest fish spoilage, food prices might increase by 30 to 50% within a few decades. This would have critical consequences for those living in extreme poverty and, therefore, spend up to 90% of their income on food. Furthermore, through causing water scarcity and the rise and spread of pests, weeds and diseases, climatic changes are foiling efforts to feed the world population (projected to exceed nine billion by 2050). Increasing agricultural productivity is one of the best ways of offsetting these constraints (World Bank, 2008), hence the need for technologically advanced techniques of which customized application of biotechnology has been recommended (Bientema et al., 2008).

With the exception of genetic engineering, therefore, biotechnology is applicable to organic agriculture and is, thus, relevant to Africa. Nonetheless, its juxtaposition with genetic engineering (by proponents of organic agriculture that misunderstand it) (Paul et al., 2003), is impinging on its adoption on the continent. This is especially on the understanding that IFOAM (2005)'s standards explicitly refuse the use of genetic engineering, stating that;

> "…The deliberate use or negligent introduction of genetically engineered organisms or their derivatives to organic farming systems or products is prohibited. This shall include animals, seeds, propagation materials and farm inputs such as fertilizers, soil conditioners, vaccines or crop protection materials…the use of genetically engineered seeds, pollen, transgenic plants or plant material is not allowed. Organically processed products shall not use ingredients, additives or processing aids derived from GMOs. Inputs, processing aids and ingredients shall be traced back one step in the biological chain to the direct source organism from which they are produced to verify that they are not derived from GMOs…the use of GMOs is not permitted in any production activity on the farm."

Moreover, these standards do not refuse the application of *other* biotechnological techniques, including molecular methods, for understanding new pests and diseases and beneficial plant and animal biodiversity. In this case, DNA or RNA is extracted, isolated, bulked, specific gene markers are identified and the existence of desired genes in different varieties/breeds is understood (through comparison studies). Thereafter, the information generated from each of these activities can be applied in natural breeding programmes. For instance, the problems of Coffee Wilt and Banana Wilt might require investigation into resistant land races that could be used in natural pedigree breeding for resistance. Meristem tissue culture is also applicable to organic agriculture. Artificial insemination may also be used, since it employs appropriate methods to tap, conserve and administer semen from elite animal breeds to generate new off-springs, thereby reducing breeding costs and disease transmission. Many more biotechnological techniques are similar to these methods in applicability to organic agriculture; however, their alignment with genetic engineering and IFOAM (2005)'s standards is not well understood by many organic farmers and extension workers in Africa.

Discussion, Conclusions and Recommendations

The low adoption of modern biotechnology in Africa is blameable on oversight, consequent upon which biotechnology is juxtaposed with genetic engineering and farmers are incognizant of the full range of biotechnological techniques that are applicable to organic agriculture and the advantages that they offer. Moreover, accounting for up to 85%, smallholder farmers, who are usually risk averse and conservative (Ssekyewa, 2008) and assume that organic agriculture is akin to traditional farming and negates the application of modern techniques, comprise the majority of the farmers in Sub-Saharan Africa. Likewise, many extension officers are not sufficiently knowledgeable about organic agriculture and biotechnology let alone the regulations governing the application of the latter in the former. Therefore, the adoption of biotechnology requires that stakeholders change their attitudes towards it, which, in turn, requires that they, and their extension officers, are sensitized on the full range of biotechnological techniques that are applicable to organic agriculture and the advantages that they offer. It is, therefore, recommended that awareness about biotechnology be promoted among relevant stakeholders. This could be achieved through education and training. Given its potential, and integration with organic agriculture, biotechnology could transform Agriculture in Africa. Nonetheless, current investment in its development is largely by the for-profit sector and, thus, driven by commercial interests that may not focus on the needs of the poor, despite the fact that the poor comprise up to 85% of the farmers on the continent. This means that there is need to increase public investment in pro-poor farmer traits and crops. There is also need to develop capacity to evaluate and regulate the risks associated with biotechnology, so as to inspire public confidence in it. Whereas this necessitates participatory research into the technology, the organic agriculture research funding situation in Africa is appalling. Hence, it is recommended that more resources are availed for research into biotechnology on the continent.

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