The Nexus Between Horticultural Farming, Biotechnology and Food Security in Ghana

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Abstract

Horticultural exports contribute immensely to Ghanaian agriculture and rural development, by generating pro-poor growth and developing non-traditional exports. With appropriate policies and technologies like biotechnology, horticulture increases the incomes of smallholder farmers, enhancing rural development and increasing foreign exchange earnings. However, Ghana's major handicap is her inability to sustain export growth on the open market. Currently, only about 40,000MT out of the 100,000MT of pineapples demanded by markets across Europe from Ghana can be produced. Although conventional plant breeding techniques have made considerable progress in the development of improved varieties, they have not been able to keep pace with the increasing demand for vegetables and fruits in developing countries. There is the need to integrate biotechnology to speed up crop improvement programmes. Biotechnological tools have revolutionized the entire crop improvement programs by providing new strains of plants, supply of planting material, more efficient and selective pesticides and improved fertilizers. This study examined the link and interrelationship between horticultural farming, biotechnology and food security. The impact of biotechnology on the welfare of smallholder farmers was also analyzed. The paper concludes that the role of biotechnology in food security in Ghana cannot be overemphasized but still has a long way to go. Agricultural production and productivity problems in developing countries like Ghana go beyond technological solutions alone; already existing challenges of smallholder farmers should be addressed first.. Biotechnology could however contribute to sustainable development by increasing agricultural productivity using new breeding techniques. It can also increase the revenues in agricultural production.

Key Words: Biotechnology, Food Security, Horticulture and Smallholder Farming

1. Introduction

Insecurity of food is prevalent in most parts of Africa. The chronic food insecurity in SSA is because about 85 % of agricultural production is rain-dependent and according to the World Bank, this accounts for about 35% of Sub-Saharan Africa's GNP, and about 40% of exports and 70% of employment. Also, domestic food production makes up for about 80% of consumption. It is estimated that about 40% of people in SSA are living below the poverty line (IFAD, 2012). With the introduction of economic reforms notwithstanding, economic development in many SSA countries slow, adversely affecting the wellbeing of the rural poor in particular. Also, natural disasters have worsened this situation. There is the need to address these issues to ensure

poverty reduction, food security, and sustainable development.

Food production is done predominantly in Ghana by smallholder farmers; as many as about 70 per cent of farmers are smallholders (Afari-Sefa, 2008). These farmers are challenged in their way of farming as they are faced with many production constraints. These include limited access to land, labour, high yielding seed varieties, credit, markets, limited access to and adoption of technology among others. These challenges have greatly affected their efficiency, productivity and yields dramatically. In developing countries like Ghana, most farmers own small lands that are only able to or in some cases scarcely feed one household and generate very small income. The issue of low soil fertility and crop losses from pests and droughts has also reduced harvests to very low levels.

As agriculture and food security have become more and more of a priority, it has been observed that more attention has been focused on supporting research and capacity development in this area. There has also been an increase in donor-supported interventions in agricultural development and the improvement of the welfare of smallholder farmers especially. More attention and funds are also being allocated to the improvement of scientific discoveries and innovations to produce quality, high yielding and disease resistant seeds to combat hunger and poverty. This is where biotechnology comes in very handy. When farmers grow more food and earn more income, they are better positioned to feed their households and send their children to school, see to their family's health needs and are also able to invest in their farms. Biotechnology is expected to help them achieve these. The current state of agricultural technology in Ghana is not capable of bracing with the production challenges ahead. Innovative technologies like biotechnology have to be exploited to guarantee sufficient availability of food in the future. Since land and water for agriculture continue to become diminishing resources, it has become necessary to research further into the use of biotechnology to boost agricultural productivity to ensure enough food for all.

Biotechnology is now considered as a potential means to improve food security. These technologies can be used to speed up traditional ways of plant breeding for instance. Biotechnology can be used as a major tool to boost crop yields and reduce production costs for smallholder farmers. Biotechnology can help in researching drought-resistant varieties of crops that will adapt well to the harsh environmental conditions under which they are grown. It can also help solve land issues by maximizing the use of the limited land available to cultivate and get many returns from the land. It is however not clear how biotechnology affects food production in Ghana. A study of this nature is therefore desirable to x-ray the extent of biotechnology adoption with the aid of exploring how food security in Ghana can be advanced through biotechnology. Hence the need for this study.

Objectives of the Study

The overall objective of the study is to draw the link between horticultural farming in Ghana and biotechnology and how this impacts food security. The specific objectives are to:

(i) review horticultural farming in Ghana

(ii) discuss the perceived risks and benefits of biotechnology adoption

(iii) determine the potential of biotechnology in increasing the productivity of horticultural farming in Ghana.

2. Horticultural Farming in Ghana

There has been an increase in the share of high value products in world agricultural trade especially from developing countries (Maertens & Swinnen, 2006).. However, Africa's exports are still dominated by traditional commodities, and the share of agriculture in Sub-Saharan Africa's (SSA) total exports has decreased in the past few decades (Webber & Labaste, 2010). Only a few SSA countries such as South Africa, Zimbabwe and Kenya have achieved some significant diversification of their exports over the years. Despite those trends, agriculture remains the largest source of export revenue for most SSA countries and the largest income generator for their populations. Production and trade of agricultural commodities continue to play a major economic role in many African countries. About 70% of the population in Sub-Saharan Africa is largely dependent on the production and export of agricultural commodities including horticulture (Gioe, 2006).

Horticulture is the production and marketing of crops (such as fruits and vegetables) that have with a relatively high value per unit or high perishable character, produced under intensive use of labour, land, and other inputs (Afari-Sefa, 2008). They are usually produced with the export market in mind. The growth of horticultural exports plays an important role in agriculture and rural development, in generating pro-poor growth and in developing non-traditional exports. Through the implementation of relevant policies, horticultural production can significantly contribute towards increasing the incomes of farmers especially smallholder farmers, expanding employment opportunities, enhancing rural development and contributing towards foreign exchange earnings (USAID, 2005). Horticultural products may offer substantial prospects for export growth in Sub-Saharan Africa in view of its comparative advantage due to Sub-Saharan Africa's relative proximity to the growing European market (Gioe, 2006). The main competitive advantage of Ghana relative to probably the most important horticultural exporter to Europe; Costa Rica, is her location. Additionally, Ghana's political stability, business environment and travel costs compare favorably with her neighbor, Cote d'Ivoire.

However, low-productivity supply chains may result from the low unit of agricultural production in Sub-Saharan Africa. It may also be that a majority of producers of agricultural products in Africa are smallholders. According to Maertens & Swinnen (2006), in Africa, majority of fruit and vegetable cultivation for both domestic consumption and for export continues to be dominated by small-scale farms. In Ghana, smallholder farmers account for about 70 per cent of horticultural producers (GEPA, 2010). In spite of the successes of many African exporters in selling on new markets, if there are no advancements to their executions of businesses on the export market, many risk being trapped by producing low-skill, low-value products and services. This means they would struggle to obtain a significant value-added share in the world market. The efficient operations of agricultural supply chains are important for the success of the SSA rural poor in terms of their income. Ghana's horticulture has potential. This is evidenced by the fact that many donors have focused on and invested in activities in this agricultural sub-sector. Some of these donors include GIZ, USAID, ACDI/VOCA, among others. The government of Ghana has also shown keen interest in developing the horticultural sector. This, according to GEPA (2010), is because about 15% of the population of Ghana depends on horticultural export-related production and/or marketing for their livelihood. The Ministry of Food and Agriculture has therefore put in place the Horticulture Export Industry Initiative (HEII) to see to the development of horticulture in Ghana. The Ministry of Trade and Industry has also formulated a national export strategy focusing on increasing revenue from non-traditional exports.. In view of this, the Trade Ministry has implemented the Private Sector Development Strategy (PSDS II) that is aimed at developing a thriving sector to improve the wellbeing of Ghanaians. It is hoped that the PSDS II will boost the country's GDP by a minimum of 10% per annum (GEPA, 2010). This notwithstanding, the positioning of Ghanaian products in the European markets is still weak. Even though horticultural exports have grown dramatically over the last ten years, these have yet to fulfill their potential. For instance, currently, only about 40,000 MT out of the 100,000 MT of pineapples demanded by markets across Europe can be produced.

3. Welfare Implications of Horticultural Farming in Ghana

Developing countries have been advised to change the way food is produced and traded. Improvements in horticultural production have been advocated for in the past decades because of its benefits. Horticulture has important welfare implications for rural households. The effects may be in various ways, through product and labour markets, and through direct and indirect mechanisms. The continual growth in horticulture has led to debates among academics, policy-makers and the development partners on horticulture's overall welfare implications. Some have seen

this as an engine for rural income mobility and poverty reduction, while others argue that it exacerbates existing inequalities and fails to create direct gains for the rural poor. In order to understand the overall welfare implications of the growth in modern food supply chains for rural households, it is necessary to take into account and distinguish between several different effects. The growth in horticulture in developing countries can bring about important positive welfare effects for rural development and poverty reduction. These effects can come in various ways through product effects on income and contribute immensely towards welfare and development. This implies a need for supporting the development of horticulture especially smallholder horticultural farmers in poor countries.

4. Biotechnology and Horticultural Farming in Ghana

Agriculture, especially horticultural crop farming has been the mainstay of the rural economy. The sector is however plagued with a myriad of challenges ranging from drought, floods, limited access to labour and capital inputs, low levels of irrigation, prevalence of weeds, pests and diseases, and limited access to credit facilities among others. These problems have placed huge limitations on the scale of farm production and also leads to low crop yields, and low farmer incomes, consequently. Since farmlands are the major natural resources in rural Ghana, households continue to produce in the midst of these devastating conditions over the years that seem to confine them to abject poverty.

The application of biotechnology in other parts of the world seem to provide solution to the bulk of the production bottlenecks associated with horticultural farming in Ghana. Studies over the years show that application of biotechnologies in the field of GMOs for instance has been beneficial to farmers in some developing countries. The first GMOs became commercially available in the mid-1990s; and since then, their relevance to the agricultural production sector has not waned. Consequently, the number of GM crop varieties has increased significantly and the area sown to GM crops has also seen appreciable increases. Adoption across countries has however not been even, with almost the entire expansion taking place in developed countries. Also, in spite of the increasing availability of various varieties of GM products, commercial success has been concentrated on a few varieties or traits.

In those countries where GM crops are applied, principal benefits reported include productivity gains, cheaper and improved food quality, minimized pests and disease infestation, and the ability to save and improve land resources among others. These benefits notwithstanding, the adoption of such technologies appears not widespread among Ghanaian horticultural farmers, especially the rural smallholder farmers. Limitations to the adaptation of these biotechnologies may be due to inability to meet the initial costs of such

technologies, especially by poor rural farm households. There are also debates over the safety and the long term impacts of the adoption of such technologies thereby leaving farmers in a state of dilemma, whether to adopt these technologies or not.

The role of research, and relevant policy tools combined with some financial assistance to farmers willing to adopt these technologies would be useful if the expected gains from the adoption of these technologies are to be realized by farmers in Ghana.

5. Benefits of Biotechnology

The potential socio-economic benefits of the applications of biotechnology abounds in the extant literature. Enhanced food production via insect, disease, insect and weed resistant seeds; nutritional enhancement are strongly proposed as potentials likely to follow the application of biotechnology (Mackey, 2003). Overall, biotechnology is being considered globally as a potential means to improved food security, especially in drought and disease prone regions of developing countries. These technologies are expected to improve traditional ways of plant breeding for instance. Biotechnology can be used as a major tool to boost crop yields and reduce production costs for smallholder farmers. Biotechnology can also help in researching drought-resistant varieties of crops that will adapt well to the harsh environmental conditions. It can also help solve land issues by maximizing the use of the limited land available to cultivate and derive the maximum returns from a given piece of land; thus further inuring to environmental conservation gains. The crucial role of biotechnology in the economic transformation and sustainable development of the developing world has assumed increased significance as a result of a variety of factors involving fast technological advances, increasing commercialization of genetically engineered foods, increasing food insecurity, and increasing food prices.

James (2007) enumerated the following as the most compelling case for biotechnology, especially in the case for genetically engineered (GE) crops in their capability to contribute to: (i) increase in productivity, and thus contributing to global food, feed, fiber and fuel security, with benefits for producers, consumers and society at large; (ii) conserving biodiversity, as a way of saving land (iii) lowering the environmental effects of agriculture and adopting more sustainable agriculture systems; (iv) mitigating climate change and reducing greenhouse gases by using biotech applications (v) increasing stability of productivity and production to lessen suffering during famines due to biotic and abiotic stresses, particularly drought which is the major constraint to increased productivity on the 1.5 billion hectares of arable land in the world; (vi) the improvement of economic, health and social benefits, food, feed and fiber security and the alleviation of abject poverty and malnutrition for the rural population dependent on agriculture in developing countries; (vii) the cost-effective production of

renewable resource-based biofuels, which will reduce dependency on fossil fuels, and, therefore, contribute to a cleaner and safer environment with lower levels of greenhouse gases that will mitigate global warming; and (viii) as a result, provide significant and important multiple and mutual benefits to producers, consumers and global society. James further suggests that the most promising technological option for increasing global food, feed and fiber production is the integration of the best of conventional technology and the best of biotechnology applications in the production process.

6. Risks of Biotechnology

There has been expression of fears and uncertainties about the risks associated with the use of biotechnology in agricultural production. There have been concerns about the adverse effects on the environment and on human health due to the direct manipulation of the genetic makeup of plants for instance. These may be environmental, such as the threat that crops may develop into weeds or transfer genes to other plants thus creating super weeds (John Innes Centre, 1998). It is also possible that pests could in the long-run overcome the resistance presented by GM crops, and hence the variety will only be protected for a short while (Tabashnik et al., 2000). There is another risk dimension similar to those involved in studying the adoption of agro-technologies by farmers in the developing world. Research has shown that are potential socio-economic problems responsible for the differentiation between those who can afford the technology and those who cannot (Morse, 1995). For instance, the adoption of biotechnology in Asia has over the years provided some evidence (Lipton, 1989; Freebairn, 1995).

Further, it is observed that though the applications of biotechnology, especially in the field of GM crops has been widely explored in terms of its contribution to overall global food security, some studies argue that it may not be the optimal option available to developing countries in the long-run. It is has been argued time and again that biodiversity is crucial for sustainable food production, because agricultural diversity can help in reducing the impact of climate change. Food security will therefore depend on agricultural production systems that are resilient, sustainable and which produce benefits that are equitably shared.

Similar to the debate on the socio-economic impacts of GM crops adoption, there have been various schools of thoughts on the potential risks of the cultivation of GM crops for the environment and, in particular, biodiversity. While some judge the environmental risks of GM adoption as severe, others argue that the benefits of GM crops compared to conventional crops prevail and the risks are rather limited. Carpenter (2011) however asserts that GM crops have contributed to increasing agricultural sustainability resulting in yield increase, and the less use of chemicals.

Even beyond the assertion of Carpenter (2011), the precise impact of GM crops on biodiversity continues to remain a risk area that future research is expected to clarify in the long-run.

Studying the long-term effects of GM crops on the environment and health, De Coppi et al (2007) identifies different potential environmental risks of GM adoption from the literature. Although the study points out that it is not yet possible to quantify long-term risks of GM crops adoption as quantitative evidence is lacking, it warns over potential future environmental risks, which are differentiated in four major priorities areas: (i) potential adverse effects due to changes in cultivation and agricultural management of HT crops, mainly by the use of complementary herbicides, (ii) resistance development in pests targeted mainly by Bt crops followed by an even higher use of pesticides, (iii) potential gene flow to wild relatives with consequences for species conservation and biodiversity, (iv) potential impacts on soil and soil organisms with a high degree of uncertainty due to a limited number of studies available.

Further, a recent assessment of the impacts of genetically engineered crops on pesticide use in the U.S. in the last 16 years (Benbrooke, 2012) has shown that the overall pesticide use has increased by an estimated 183 million kg or about 7 per cent since the adoption of GM crops. Benbrooke (2012) further observes that the use of HR crops and the emergence and spread of glyphosate-resistant weeds are some of the endearing reasons for promoting the use of herbicide on land where herbicide-resistant varieties are grown. Herbicide-resistant weeds are forcing farmers to respond by increasing their herbicide application rates, resulting in multiple applications of herbicides, which exerts negative impacts on biodiversity .For Bt crops such as cotton and maize, Benbrooke (2012) shows that the application of insecticides can be significantly reduced, at least in short-terms. However, this advantage potentially poses a threat to growers of genetically modified crops. The use of genetically modified cotton for instance and the associated lower levels of conventional insecticide spraying create a safer environment for other, non-bollworm insects (Wang et al, 2009), which are not targeted by the modified traits. That in turn can lead to yet another compensating increase of pesticide use for combating secondary insect infestations as happened for example in China (Wang et al, 2009).

Additionally, some concerns have also been raised in terms of the gene flow of GM crops to wild relatives. A respective study for the HR transgene concluded that there is no evidence that its presence in wild plants is inherently problematic (Warwick et al. 2008). The study suggests that wild hybrids containing the transgene are expected to be present in large quantities in agricultural areas where herbicides are applied frequently as they can outcompete plants with no resistance against the herbicide. As in many developing countries a frequent use of herbicides is rather

exceptional, it can be tentatively concluded, that gene flow is of rather minor significance in these areas.

These potential risks notwithstanding, it is noteworthy, that the potential danger of living modified organisms (LMOs) on global biodiversity was the greatest concern and underlying mandate for adoption of the Cartagena Protocol on Biosafety under the Convention of Biological Diversity (CBD) in 2000 (Warwick et al, 2008). In order to minimize these potential risks from GM seeds and other organisms, the Protocol requires exporters to seek consent from importing countries before the initial introduction of an LMO into the environment and provides the necessary guidance for risk assessment.

7. Potential of Biotechnology in Increasing Productivity of Horticultural Farming

There is no aspect of plant production that will not undergo profound changes as a result of the application of biotechnology, nonetheless in horticulture. Commercial applications of plant genetic engineering have not yet occurred. Presently, many traditional aspects of biotechnology such as tissue culture have been of major importance, especially in the acceleration of the breeding process for new varieties and in the multiplication of disease-free seed material.

Biotechnology can be used in many ways to achieve higher yields; for example by improving flowering capacity and increasing photosynthesis or the intake of nutritive elements. Breeding of horticultural plant species has been enhanced considerably by in vitro development of improved varieties that tend to be better adapted to particular environments. The application of tissue culture attributed to this in many ways such as: (i) the rapid reproduction and multiplication of cultivars (produced by selective breeding); (ii) the production of healthy cultivars, free of viruses and pathogenic agents; (iii) the rapid adaptation and selection of cultivars that are resistant to specific stress factors (for instance, salinity and acid soils); (iv) the availability of seed material throughout the year (rather than seeds which are subject to the seasonal cycle); (v) the possibilities to produce species that are difficult to reproduce or that reproduce and grow slowly; and (vi) improved possibilities for the storage and transportation of germplasm. The application of tissue culture does not require very expensive equipment, thus technology can be applied easily in developing countries that in turn helps to improve other varieties of horticultural crops.

Biotechnology aids in the reduction of the need for agro-chemicals that small farmers in developing countries often cannot afford. A reduction in the use of agrochemicals implies fewer residues in the final product. Worldwide, nitrogen-fixing bacteria are being used increasingly to inoculate the soil, thus allowing reduced inputs of fertilizer that is expensive and often presents a heavy drain on the scarce foreign exchange resources of developing

countries. Biotechnology helps to identify the strains of bacteria most suitable for specific crops and soils and to multiply them for large-scale use. There are about a hundred fungus species with insecticidal effects known today. Biotechnology can facilitate the mass production of these fungi in a storable form and the use of these products may be less expensive than that of agrochemicals. As living organisms, they will multiply under favorable conditions depending on the intensity of the pests to be controlled. In addition, improved screening techniques at an early stage may reduce the amount of agrochemicals needed to fight specific diseases.

The potential of biotechnology for increasing horticulture productivity is vast indeed. The fact that such a capability exists, however, does not assure that it will be realized. Obstacles frequently stand in the way of the application of new technologies in horticultural farming. Some of these obstacles are: (i) weak linkages between international and national research institutions; (ii) poor communication between national research institutions and farmers; (iii) a lack of support measures (credit schemes, regular provision of improved seeds, demonstration plots and marketing outlets); and (iv) landholding structures which dampen the interest of landlords and tenants in introducing new technologies. Biotechnology has tremendous potential for promoting horticultural farming. However, where the application of this new technology aims to increase productivity in the export sectors, the successes in this area could be at the expense of the market position of others. In such cases, international competition may endanger cooperation between other fields of farming and could impact other technologies that seem necessary for the application of biotechnologies that are specifically suited to their interests.

8. Conclusion

From the arguments made so far, it is evident that the role of biotechnology in food security in Ghana and other developing countries remain one of the greatest developmental concerns over the years. Agricultural production and productivity problems in developing countries like Ghana go beyond technological solutions alone. It could however contribute to sustainable development by increasing agricultural productivity using new breeding techniques. It can also increase the revenues of agricultural production. This notwithstanding, the application of agricultural biotechnology in developing countries is not without debate. Potential challenges are expected to follow the application of such technologies with potential harmful effects especially on smallholder farmers. Irrespective of these potential fears highly publicized by civil society groups and researchers in the developing world, sustainable alternatives to biotechnology applications to not appear handy and their potential abilities compared to those likely to be derived from biotechnology applications do not appear superior.

From a human welfare standpoint, the greatest benefits of plant biotechnology will surely be derived from the adoption of improved crop varieties in the developing countries of the world where billions of people still depend on agriculture for their livelihoods. Finally, the paper generally agrees with Makinde et al (2009) that agricultural biotechnology alone is certainly not a panacea to the multitude of problems that farmers in Africa face; however, it has the potential to make crop breeding and crop management systems more efficient thereby generating improved crop varieties and higher yields.

Based on the conclusions made, some recommendations are suggested. Firstly, for biotechnology to have the desired effect on productivity and thus food security, there is the need to first of all tackle the myriad of challenges faced by smallholder farmers in Ghana. Secondly, it is necessary to build the required capacity to generate plant biotechnologies and then incorporate these into our national crop improvement programs. Thirdly, it will also be important for Ghana to establish the required intellectual property rights and regulatory policies that will assure safety and encourage the private sector to develop and market these new crop varieties. Finally, both public and private sector research institutions in Ghana should be empowered to continue producing and delivering products and research that are targeted towards the needs of poor farmers and consumers.

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