TAILORING BIOTECHNOLOGIES
Vol. 2, Issue 1, Spring-Summer 2006, pp: 51-62

Tailoring Biotechnology in Ghana: Implications for Genomics Development

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Introduction

Modern scientific and technological breakthroughs have great potentials to raise agriculture levels to produce food to meet the needs of the teeming population of the world. However, there has been a sharp contrast in the application of these breakthroughs to agriculture in the developed and developing countries. Most developed countries have been able to achieve food self-sufficiency through intensive application of the scientific breakthroughs. However, in developing countries, especially the Sub Saharan Africa, achieving self-sufficiency in food production has become a daunting task.

Agriculture in African continues to be plagued with poor planting materials, crops with poor genetic characteristics (low yielding, poor in food nutrients, long gestation periods etc. poor and degraded soils, erratic rainfall patterns, high post harvest losses and poor distributive channels. Other militating factors include small holder farming (subsistence farming), poor agronomic practices and continuous dependence on hoe and cutlass (as the main farm implements). These factors have hindered increased food production and in effect have limited access to food in those countries.

However, the situation can be improved through a focused application of science and technology. Technologies such as biotechnology potentially can address the problems facing agriculture and food production in the developing countries. But controversies surrounding its development, increased focus on industrial crops, perceived dependency syndrome on few multinational seed companies among others have limited its widespread application.

Genomics technology is gradually becoming one of the critical technologies with a lot of prospects. It has been argued that it is likely to be less controversial and might have wider acceptance. Genomics development has concentrated in the developed countries whose orientation is different from those of developing countries. The question is how can genomics meet the needs of the South. This paper provides some reflections on tailoring genomics to meet the needs of the South drawing lessons from biotechnology tailoring in Ghana.

Potential of Genomics

One of the new scientific feats which has emerged is genomics and is expanding the thresholds of scientific, technological and economic activities. It has opened a new door for innovations in life sciences, industries, agriculture and food production.

Genomics has been defined as the technology that maps out all genetic information of human, animals, plants and micro-organisms.[1] It provides access to critical genetic information that governs life. For example, it enables scientists to find out why certain plants are drought tolerant, high yielding, disease resistant etc and this information could help in breeding processes for specific characteristics in plants.

It has been argued that genomics may not generate much public controversies like genetic modified organism technology and therefore, might enjoy wider public acceptance. Instead of modifying the genetic constitution of a plant or animal through insertion or removal of genes to promote desirable traits, with genomics technology, scientists can easily probe the numerous genes in a genome to see which genes are at work. These genes depending on their characteristics can be selected for the breeding process.

According to Goodman (2001), the key asset of the genomic technology is its ability to enable scientists to identify genes that are exhibiting desirable characteristics and also focus on lots of genes at once. Goodman further argued, that this has underlined the work of breeders for many years. Breeders over the years have painstakingly developed plant varieties with desirable traits through selection and crossing and this process was long. With the modern technology and knowledge, breeders can make more progress on many traits than in the past.

1 See www.genomics.nl/homepage/genomics/all_about/

In agriculture, it has the potential of revolutionalizing food production. Through genomics technology, many genes can be combed and identify new combinations based on their characteristics. And this can increase the speed of the development of new plant cultivars of certain desired qualities. Scientists need not graft or cross plants in the field and wait to see if the supposed desired traits would be evident in the growing plant. The trait of interest may be related to crop protection, reduce or eliminate the use of pesticides, improve disease resistance, improve stress tolerance and improve grain quality among others (Phillips and Freeding (1998). This will invariably meet the goal of every agricultural endeavor - improving food production, crop quality, and the maintenance of the environment.

Phillips and Freeding (1998) further argued that plant genomics information has great potential for maintaining biodiversity. It can increase knowledge of anchor crop species which may create the potential to garner exotic and useful genes which have already been engineered by natural selection.

The contributions of genomics are being drummed harder. From the editor of nlpwessex's GM News Service (2002), society is on the threshold of moving to a more sophisticated, more appropriate, more integrated form of genetics, based on applying gene mapping to conventional breeding which clearly eminent voices in the biotechnology industry consider have great potentials…and if we have a good debate we have a reasonable chance of finding best solutions to creating a viable and sustainable agriculture in the future[2]

The technology has been identified as having great potential in addressing many problems in different segments of life sciences. The critical issue is in which directions this technology with great potential should follow. Who should be the beneficiaries and how should this technology be developed so as to serve interest of society?

It is instructive to discuss the development path of biotechnology and its consequences in providing increased access to the benefits of the technology so as to provide guidelines that will facilitate the development of genomic technology for the benefit of the human race.

2 (www.btinternet.com/~nlpwessex/Documents/monsantoMASpossibilities.htm)

Biotechnology Development Path

The application of modern biotechnology has led to the development of crop varieties which are tolerable to environmental stress, early maturing, high yielding and improved nutritional qualities among others. These potential of biotechnology have generated interest in agriculture by the industrial sector and are gradually transforming the agricultural sector into a relatively new agro-industrial sector. For example, the traditional chemical industries have taken keen interest in seed development. With this development, the major players are the multinational biotechnology companies who are capitalizing on the potential of biotechnology to increase their economic performance. his has increased the remote control of the agricultural sector by the industrial companies through the introduction of new inputs, for example, seeds, pest-control methods and breeding material (Ruivenkamp, 1992). These new inputs create the problem of dependence on the companies for additional inputs, for example, fertilizers and other agro-chemicals.

The industrial transformation of agriculture, according to Ruivenkamp (1992, 2002) has a number of consequences and these are:

- Farmers, no longer have to depend solely on their ingenuity but also on multinational companies for the supply of inputs for their economic activities. The dependence on the multinational companies, as argued by Ruivenkamp (1992), do not only diminish the farmers participation in the development and application of farm inputs but also impose specific way of farming. In that case, farmers do not decide on how, when or what to do but the new inputs direct the processes to be adopted.
- Most biotechnology applications are only pursued within a narrow social frame of the new industrial development leaving diversity in agricultural development. Biotechnology is applied to few selected crops that are of critical industrial interest to companies in the North and leave out many others which are equally important for the sustenance of biodiversity as well as meeting the needs of the South. Therefore, agriculture in the South has not benefited greatly from biotechnology applications. Because, most of the crops improved by biotechnology have little relevance to the situation in those countries.
- Biotechnology is primarily considered and used as an exogenous instrument for the on going modernization of agriculture and rural development because farmers do not have a hand in the development of the technology. It is a technology developed exclusively by scientists and handed over as quick fixes to the problems of the farmers.

The application of modern biotechnology by the industrial companies has also resulted in the interchangeability in food processing. For example, animal fat is being replaced by vegetable fat in the preparation of certain types of cheese. Cane sugar is also being replaced by maize fructose in soft drinks production. These have come about due to increased applications and improvements in enzyme technology. This is also strengthening the arms of the industrial sector as the farm is no longer the main source of inputs for food processing.

The result of this biotechnology development path spearheaded by industrial concerns has led to the dislocation and marginalization of critical actors in agriculture - farmers. The contributions of farmers with rich repertoire of knowledge gained from long experience become secondary to the scientists who have limited knowledge about agriculture but because of the agro-industrialization have become important actors.

These developments have called for a reordering of biotechnology development to take care of the interest of all social actors. In the new biotechnology program, the social actors can negotiate for space in the development process and integrate their social economic perspectives and requirements into the process. In that case the results are tailored to their needs. Tailoring as a process recognizes different farming styles and reinforces the heterogeneity of agricultural system. What it means is that biotechnology development should be tailored to meet diverse needs of a social system specific to a country or locality. In that sense, the tailoring should lead to a situation where the process of applying a technology to a problem in Ghana should be different from that of India or Brazil.

The tailoring process also recognizes the farmer as an active participant in the research process, acknowledges indigenous knowledge and supports interactions between the farmer and the scientist as a new model for biotechnology development.

In the next section, Ghana's experience in the tailoring process is discussed to make a case for the adoption of a tailoring process in genomics technology development.

Biotechnology Tailoring Process in Ghana

A case study on maize[3] is illustrated here to show how tailoring took place in Ghana, those involved and the results achieved. The lessons learnt from the case studies can inform the genomics development path.

Maize is one of the major cereal crops cultivated in the country. Smallholder farmers mostly cultivate the crop basically for subsistence but the excess is sold for money to meet other social commitments of the farmers. Indeed, there are farmers who cultivate maize as cash crop.

The need for improving the quality of the local varieties of maize was borne out of two basic problems facing farmers i.e. poor traits of the local varieties and the lack of two important food nutrients. Traditionally, farmers in Ghana mostly use farm saved seeds of known maize varieties for continuous cropping of maize over the years. However, the local varieties were mostly low yielding, susceptible to diseases and late maturing (Sallah et.al 2001). They also had relatively long stalks, which were easily destroyed during windstorms or heavy down pours.

The other problem of the local maize varieties was the absence of two essential amino acids (i.e. lysine and tryptophan). The problems associated with the local varieties of maize have resulted in low productivity, low incomes to farmers, and invariably affected their standard of living as well as their access to food, and other necessities of life. Consequently, there was the need for research to be conducted to address the negative straits of the local varieties, especially the nutritional deficiency so as to improve the health status of Ghanaian children.

This was critical because health demographic surveys conducted in the country revealed low health status of Ghanaian children. For example, the Health Demographic survey of 1993 showed that, 26 percent of Ghanaian children under the age of three years were stunted for their age, 11percent was wasted (below the expected weight relative to their height and 27 percent underweight (Statistical Service, 1994). Therefore, improving the nutritional quality of the maize crop which was the main supplement and weaning food for children would go a long way to improve the health status of the Ghanaian children

3 This is part of a case report presented as part of the preliminary phase of the activities of the TMBT Network.

The desire to improve upon the nutritional content of maize began in the 1960s when opaque 2 and other mutant varieties with appreciable levels of lysine and tryptophan were discovered. However, in the 1970s the Crops Research Institute (CRI) collaborating with a number of local (Kwame Nkrumah University of Science and Technology) and international institutions (notably International Maize and Wheat Improvement Centre (CIMMYT) based in Mexico and West Africa Maize Network) initiated serious work on the development of new lines of maize varieties rich in the two amino acids. This was under the Ghana Grains Development Project (GGDP), a collaborative project between the government of Ghana and the Canadian International Development Agency.

CIMMYT provided a large pool of germplasm with modified opaque-2 endosperm. A series of breeding processes involving combined process of crossing, selection and evaluation for varieties with the desired properties were carried out at the research farms and farmers' fields, and this culminated in the development of a maize variety "GH8363 -SR" which was enriched with protein. This variety has a maturing period between 105 - 110 days, resistant to maize streak virus and high protein content. After successful trials and release in 1992, a hybrid development program was also initiated to develop several inbred lines by employing the technique of self-pollination and early generation testing through topcross evaluation.

Results of Tailoring Process

The development of the quality protein maize (QPM) had been successful. The QPM has gained much acceptance and CRI has co-ordinated international varietal trials in over 20 countries in Africa, Central America, South America and Asia in 1995 and 1996. A number of factors accounted for the successful development, trial and release of the QPM. Some of these factors are discussed in this section.

Indigenous Knowledge

A critical aspect of the tailoring process was the recognition and use of indigenous knowledge on the breeding process for new maize varieties. Indigenous knowledge contributes towards developing crops that meet the socio-cultural needs of farmers as well as towards the advancement of science

(Frempong et. al, 2003). Scientists benefited from the experiences of farmers and contribute to their stock of knowledge.

The importance of indigenous knowledge is altering the modus operandi of agricultural research in the country. Scientists recognized the importance of such knowledge and efforts were made to bolster interaction with farmers either indirectly through extension officers or directly with them. Farmers were directly involved in on-farm trials and thereby were able to relate their perceptions to scientists for incorporation into the crop improvement program.

Indeed the involvement of the farmers was not just cosmetic or for political expediency but a critical one.[4] Scientists require the indigenous knowledge and experiences of farmers in every crop improvement program. Their non-involvement may seriously affect the crop's adoption rate and/or may not address the critical problems facing the farmers.

The farmer/scientist interaction has been institutionalized through the formation of the Research Extension Liaison Committees (RELCs).[5] The RELCs were formed to continuously collate views from all stakeholders on agriculture and feed them into research policy-making mechanism of the country. The committees are composed of all stakeholders and provide the farmers with the chance to contribute to the scientific development of agriculture in the country. Five RELCs have been established to cover each of the ecological zones of the country, namely; Transition, Guinea Savannah, Coastal Savannah, Sudan Savannah and Rainforest.

New Partnership

Farmers played a dominant role in the development of QPM. Farmers through long period of cultivating the crop had gathered much information on maize. This information or experience was critical for any scientific work on the crop but may be exclusively known to the farmer. Their involvements were through constant interactions with the research scientists. These interactions helped to demystify science and enabled them to appreciate science better. The interactions also helped the scientist to gain the confidence of the farmers and this led to a situation where the farmers readily shared their indigenous knowledge with the scientists. In effect, the maize farmers were no longer passive

4 An interview with the Director of the Ghana Grains and Legumes Development Board

5 RELC was one of the institutions established under the National Agricultural Research Project which was funded by the World Bank and the Ghana government.

recipients of scientific findings but active participants in the whole scientific process. As a result a new partnership had been formed between farmers and scientists in Ghana and this emphasises the recognition of the importance of both parties in research activities.

Acceptability of Crop

The new partnership established between the scientists and farmers greatly influenced rapid diffusion of the new maize variety. The farmers saw themselves as part of the research and therefore, had no hesitations in adopting the crop. Impact assessment studies conducted over the years on the improved maize varieties gave encouraging results. A survey was conducted by GGDP in 1990 on the improved maize varieties, revealed that about 48% of the maize growing areas in the country had utilized improved varieties released by CRI. Another survey in 1997 showed that about 58% of the sampled farmers were planting at least one improved variety in their fields. This showed the level of acceptance of the new maize varieties by the farmers who traditionally are slow in shifting from a known crop to a new one.

The tailoring process and its institutionalization under the World Bank's sponsored project emphasize the importance of tailoring process in agricultural research. Results achieved have been encouraging and had provided the basis for replication under genomic research.

Implications for Genomics Development

The tailoring exercise in Ghana provides some experiences which can guide the development and diffusion of genomics technologies but who should be the critical actors? The next session provides a reflection of how genomics should be developed to benefit everybody.

Endogenizing Genomic Technology

To prevent genomics technology classified as exogenous technology, it should be endogenously developed. Endogenous development mean a process whereby local resources - local ecology, labor force, knowledge and local patterns are used to link production to consumption.[6]

By this process, the local environment is taken into consideration in the

6 The working definition used by the Network of TailorMade Biotechnology for Endogenous Development

process of developing the technology. The local environment may include indigenous knowledge and the specific needs of the people. In the maize development, indigenous knowledge of farmers was taken into serious consideration. Consequently, the varieties that were developed met the needs of the farmers. Genomics technology will be beneficial and acceptable when it is founded on the existing knowledge, skills and practices. For example, farmers used the knowledge acquired over the years in crop production, adapting and developing huge range of varieties and resources available in their specific local environments. They also draw upon indigenous knowledge existing in the community in their farm management practices and these make them 'experts', or 'scientists' in food production.

Consequently, the inculcation of indigenous knowledge and involvement of these 'scientist' in genomics development are critical for the development and acceptance of genomics technologies which will be tailored to their needs. In that case, acceptability levels will be high as well as reducing suspicions about the products. This is because farmers / adopters will see themselves in the product and the process would not dislocate the critical actors but make them partners of the development process.

In a broader sense, the development of genomic technologies should not be at the exclusion of actors in the South. The knowledge of actors (farmers and scientists) from the south will enable specific conditions in the South, needs, and perceptions to be integrated in the technologies. Genomics technology should not be a gift from the North to the South but a technology which the South has made great inputs into its development.

New Partnership Between North and South

The tailoring process in Ghana resulted in a new partnership between scientists and farmers. This experience can be translated into a global level in terms of new partnership between the North and the South in genomics research. Definitely the north has been in the lead in science and technology research, development and application. And most of the investment had come from the private sector.

To ensure the development of genomics technologies which will be beneficial to everybody (North and South) requires a new partnership. The new partnership should be between multinational life science private organizations and research institutions in the South. Statistics indicate that the private sector organizations have been leaders in investing in scientific research activities,

especially biotechnology and it is most likely that these organizations will increase their investments in genomics research. Further, genomics research is capital intensive and many developing countries, especially those in Africa do not have the financial capacity to adequately fund the research.

The new partnership could provide agenda for cross fertilization of ideas which could be mutually beneficial to both parties. Genomics technologies developed out of this new partnership could have been tailored to specific conditions in both North and South. This is because the conditions in both areas would have been taken into consideration during the research formulation process

In line with this new partnership idea, is the formation of the TailorMade Biotechnology for Endogenous Development (TMBT) Network. The general aim of the Network is to use the concept of tailoring to provide a new direction for biotechnology development, especially for developing countries. At present, six countries are participating in the network; these are Ghana, Kenya, India, Brazil, Cuba and the Netherlands. Membership of the network (drawn from the North and South) provides a platform for sharing of experiences and expertise through joint projects. This network can provide a pedestal for launching into genomics research which will be tailored to the needs of the members. Due to the enormous potential benefits of genomics, the Network should make genomic research one of its priority research agenda to cradle its members especially those from the south to join the mainstream research in genomics technology.

Strengthening Capacity and Development of a New Professionalism

Related to the development of a new partnership is the need for the development of new professionals who could link up with all actors in the genomics research. In the tailoring process, there was a recognition of the central role farmers play and this led to the development of new scientists who could work with all actors in the development process. Genomics research is a science-intensive discipline and requires well-trained personnel to understand the intricacies of the technology as well as apply it to their research and development activities.

For the South to enter into partnership with the North requires the build up of capabilities which could be utilised in the research collaboration. Most developing countries have established research centres to undertake research and development activities that will address technology and socio-economic problems.

What is required is for the government to adequately resource these institutions to enable them play meaningful roles in the socio-economic and technological development activities of the country. Well-resourced institutions will enable them to participate in the capital and science intensive research programs that have great benefits to the people.

The importance of tailoring process has been shown with the experience of Ghana in the development of quality protein maize varieties. The process of tailoring can be applied to genomics research so that its benefits may be not alien to the conditions in the South. The scientists and farmers in the south have indigenous knowledge and skills to contribute to make genomics research very successful. Therefore, operators in the North should open up to include partners from the South for the development of genomics technologies which could address the problems of the human race.

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