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DISSEMINATION OF PLANT BIOTECHNOLOGY - AN AFRICAN PERSPECTIVE

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Introduction

The most important applications of plant biotechnology in Africa are those targeted at solving some of the continent's long-standing problems such as increased food production, poverty alleviation and improvement of the continent's public health services. Dissemination of plant biotechnology, on the other hand, requires that the tools of this novel technology are made available also to the low-scale farmers.

Genetic engineering techniques adopted in modern plant biotechnology effect transfers of genetic material between various organisms with the following aims:

- developing plant varieties with requisite properties to survive and thrive under the climatic conditions prevalent in the specific regions (resistance to heat, drought, acidity, salinity and pests);

- development of higher yielding plant varieties that guarantee the environmentally sustainable production of larger quantities of food and possibly, at lower production costs;

- production of plant varieties endowed with more nutritious constituents than the wild type species to boost the quality of the available food supply;

- development of fruit crop varieties with delayed ripening properties to reduce post-harvest loss due to fruit over-ripening;

- engineering novel plant varieties for the preservation and fostering of environmental biodiversity.

The need for plant biotechnology in Africa

In Africa, the objectives of plant biotechnology assume a higher degree of importance due to the continent's harsh climatic conditions and where, in some areas such as southern Africa, many years of drought have further dwindled the already poor farm yields thus, exacerbating the problem of food supply shortages. However, in order to assess the extent to which Africa needs biotechnologically improved crops and the dissemination of the requisite techniques to boost its food production capacity, it is important to review some statistical facts about the Continent and about its position in the arena of global food production.

- With a population of over 750 million, Africa holds 13% of the world's population in a total landmass corresponding to 20% of the world landmass. But 40% of Africa is desert land leaving only 12% of arable land for the African population, and only 6% of this arable and permanent cropland is irrigated compared to an average 33% for Asia.

- The rate of population growth in Africa out-balances the rate of increase in food production. In fact, according to a recent UN study, by 2020 the demand for cereals in Sub-Saharan Africa is forecast to outweigh the region's production by as much as 27 million metric tons.

- Farm work and the processes of food production in Africa remain predominantly manual. Furthermore, recurrent yearly poor harvests has fuelled the phenomenon of rural to urban youth migration, thus depleting rural farm work-force, and relegating the arduous task of food production to the uneducated elderly, women and children. It is thus not surprising that agriculture in Africa shows the lowest yield among all the developing regions of the world. Consequently, Sub-Saharan Africa is the only developing region where per capita food-grain output has effectively declined over the past four decades.

- Africa is the poorest continent with 40% of the population living on less than USD 1 a day, despite being one of the most richly endowed. In fact, the continent includes 25 of the world’s 30 poorest countries, and Sub-Saharan Africa is host to 32 of the 48 least developed countries.

- Health care services are most inadequate in Africa than anywhere else, making the Continent a fertile habitat for numerous illnesses. According to the United Nations Economic Commission for Africa (ECA) Executive Secretary, “on the major health problems of our time, Africa leads the world. Fully 80% of infectious diseases are found in Africa. Malaria alone kills two million people and reduces the GDP of Sub-Saharan Africa by one percent every year”(Amoako, K.Y. 2003). Certainly, the importance of efficient public health care services to adequate food production in any nation cannot be over-emphasized since the sick would produce very little food while the dead would produce none.

From the foregoing consideration, Africa desperately and urgently requires agricultural biotechnology in order to dramatically boost its capacity to produce abundant environmentally sustainable and nutritious food. More importantly, the tools of plant biotechnology and crop improvement should be made available to low-scale farmers. This would be effective dissemination of plant biotechnology. But notwithstanding this glaring necessity, agricultural biotechnology in Africa has fared rather poorly.

The principal cause for this poor performance of plant biotechnology in Africa is the persistent minimal investment in agricultural research and development by the governments of most African countries. In fact, as at the year 2001, only in the Republic of South Africa has agricultural biotechnology been practiced at the commercial level.

African countries depend heavily on foreign aid for agricultural research and development. In fact, many of the continent’s agro-biotech institutions are founded and funded essentially by international or donor organizations. Unfortunately, many indigenous food-crops that feed a large percentage of the African population (such as yams, millet, sorghum and cassava), represent little commercial interest to the multinational companies that invest in R&D. Thus, the extension of modern biotechnology tools to the improvement of these food crop species have been minimal, and in some cases, non-existent.

Agricultural biotechnology in Africa has also been hindered by the global debate on the safety of genetically modified foods. Many African countries have therefore, been resistant to adopting these technologies principally to protect their international trading interests.

In order to reverse this trend and participate more actively in agricultural research and development in Africa, the Executive Secretary of the ECA, Mr. Amoako has outlined the duties of national governments in Africa necessary to bring about success in biotechnology and enhance food production in the Continent. He wrote, "If Africa is not to miss the biotechnology revolution, then governments have to take the lead. Governments throughout Africa simply must refocus attention on agriculture".

Status of plant biotechnology in Africa

The most important successes in plant biotechnology in Africa include the development and commercial production of Bt crops (Bollgard^R cotton and YieldGard^R maize) in South Africa, and the development of new rice varieties dubbed NERICA (NEw RIce for AfriCA) at WARDA in Western Africa. WARDA is an intergovernmental research organization comprising 17 West African countries. Engineered by genetic crosses between African and Asian rice species, NERICA combines the high-yielding properties of Asian rice with the multiple stress resistance that characterize African rice varieties. Yield increases with this genetically improved rice range from 25% up to 250% (Monty, J. 2000).

Both Bollgard^R cotton and YieldGard^R maize are engineered for pest resistance, and farmers who planted these transgenic crops recorded substantial yield increases over those planting the non treated species (Bennet 2001). Planting Bt cotton in the Makhatini flats of northern Kwazulu Natal in South Africa helped to eliminate the need for insecticide sprays during the 2001 planting season. In an independent study in which 100 Makhathini farmers were interviewed, it was found that farmers who adopted and planted Bt cotton in 1998 and 1999 benefited from the new technology according to all the assessment measures used (Ismael *et al* 2001). Besides helping to reduce the overall number of hours spent in their farms, many small-scale cotton farmers in South Africa who planted transgenic cotton experienced an average 27% net income increase in the 2001 planting season. Thus, planting transgenic cotton contributed significantly to poverty alleviation through increased income earnings for the farmers in South Africa.

Important varieties of NERICA, developed at WARDA in Ivory Coast, include species suitable for cultivation in acid soils in which phosphate fertilizers are substituted with local rock phosphate. Others are low land varieties resistant to viruses, to drought and to iron toxicity, while other varieties carry resistance genes to rice blast fungus and to the yellow mottle virus. Some of these varieties are currently being distributed for large-scale cultivation. Two other NERICA varieties include the SAHEL 108, endowed with a short life cycle thereby allowing for annual double cropping, and the CISADANE resistant to the gall midge (a mosquito-like insect whose larvae bore rice shots). The CISADANE was a product of the International Institute for Tropical Agriculture (IITA) in Nigeria.

Scientists at the ISAAA and KARI both in Kenya have developed virus resistant sweet potatoes. Field trials for these transgenic sweet potato varieties started in 2001 (KARI 2001), and the commercial production would lead to substantial recovery of edible food in a zone where up to 50% of yearly farm yields are generally lost to degradation by the virus.

Other achievements in plant biotechnology in selected African countries, although essentially still at the laboratory level include the following:
(adapted from Brink, J.A. *et al*1998)

North Africa

Morocco
Micropropagation of forest trees, date palms. Development of disease-free and stress tolerant plants. Molecular biology of date palms and cereals. Field tests for transgenic tomatoes.

Tunisia
Abiotic stress tolerance and disease resistance. Genetic engineering of potatoes. Tissue culture of date palms, prunus rootstocks and citrus. DNA markers for disease resistance.

West Africa

Cameroon
Plant tissue culture of Theobroma cacao (cocoa tree), Hevea brasiliensis (rubber tree), Coffea arabica (coffee tree), Dioscorea sativa (yam) and Xanthosoma mafutta (cocoyam). Use of *in vitro* culture for propagation of banana, oil-palm, pineapple, cotton and tea.

Nigeria
Micropropagation of cassava, yam, banana and ginger. Long-term conservation of cassava, yam and banana, and medicinal plants. Embryo rescue for yam. Transformation and regeneration of cowpea, yam, cassava and banana. Genetic engineering of cowpea for virus and insect resistance. Marker assisted selection of maize and cassava. DNA fingerprinting of cassava, yams, banana, pests, and microbial pathogens. Genome linkage maps for cowpeas, cassava, yams and banana.

Senegal
Well established Microbial Resources Center (MIRCEN) programme that serves the region of West Africa in microbial-plant interaction. Production of rhizobial and mycorhizal-based biofertilizers for rural markets. Well established *in vitro* propagation of Faidherbia albida, Eucalyptus canaldulensis, Sesbania rostrate, Acacia senegal, in co-operation with several international agencies.

East & Central Africa

Burundi
In vitro production of ornamental plants - orchids, tissue culture of medicinal plants, micropropagation of potato, banana, cassava and yam.

Democratic Republic of Congo
In vitro propagation of potato, soybean, maize, rice and multipurpose trees, e.g. Acacia auriculiforius and Leucaena leucocefhala. Production of rhizobial-based biofertilizers in experimental stage. Tissue culture of medical plants, e.g. Nuclea latifolia, Phyllanthus niruroides.

Kenya
Production of disease-free plants and micro-propagation of pyrethrum, bananas, potatoes, strawberries, sweet potato, citrus, sugar cane. Micropropagation of ornamentals (carnation, alstromeria, gerbera, anthurium, leopard orchids) and forest trees. *In vitro* selection for salt

tolerance in finger millet. Transformation of tobacco, tomato and beans. Transformation of sweet potato with proteinase inhibitor gene. Transformation of sweet potato with Feathery Mottle Virus, Coat protein gene (Monsanto, ISAAA5, USAID6, ABSP7, KARI8). Tissue culture regeneration of papaya. *In vitro* long term storage of potato and sweet potato. Marker assisted selection in maize for drought tolerance and insect resistance. Well-established MIRCEN providing microbial biofertilizers to countries in the East African region.

Uganda
Micropropagation of banana, coffee, cassava, citrus, granadella, pineapple, sweet potato and potato. *In vitro* screening for disease resistance in banana. Production of disease-free plants of potato, sweet potato and banana.

Southern Africa

Madagascar
Tissue culture programme supporting conventional production of disease-free rice and maize plantlets, and medicinal plants. Production of biofertilizers to boost production of groundnut (Arachis hypogea), bambara groundnut (Vigna subterranea).

South Africa
Genetic engineering
-Cereals: maize, wheat, barley, sorghum, millet, soybean, lupins, sunflowers and sugarcane.
-Vegetables and ornamentals: potato, tomato, cucurbits, ornamental bulbs, cassava and sweet potato.
-Fruits: apricot, strawberry, peach, apple, table grapes, banana.
Molecular marker applications
- Cultivar identification – potatoes, sweet potato, ornamentals, cereals and cassava.
- Markers for disease resistance in wheat, forestry crops.
Tissue culture
-Production of disease free plants – potato, sweet potato, cassava, dry beans, banana and ornamental bulbs.
- Micropropagation of potato, ornamental bulbs, rose rootstocks.
- chrysanthemum, strawberry, apple rootstocks, endangered species, coffee, banana, avocado, blueberry and date palm.
-Embryo rescue of table grapes, sunflower and dry beans.
- Long term storage - potato, sweet potato, cassava and ornamental bulbs.
-Forest trees, medicinal plants and indigenous ornamental plants.

Zimbabwe
Genetic engineering of maize, sorghum and tobacco. Micropropagation of potato, cassava, tobacco, sweet potato, ornamental plants and coffee.

In all these countries as well as in other African countries, sustained public financial support will be required over the decades to move research in plant biotechnology from the laboratory or field trials to the commercial production of these transgenic crops. Only then will the benefits of crop improvement by genetic engineering be made available to those who need them most: the low-scale farmers.

Conclusions

Africa lags dramatically behind all other regions of the world in the overall application of agricultural biotechnology and food production. In order to avert the dangers posed by under-nutrition, governments of African countries must invest in agricultural R&D for crop improvement through genetic manipulation. The major tasks for achieving this goal lie on the collective hands of Africans in accordance with the African proverb that “the owner of the house sits where the roof leaks.”

Positive signals emerging in this direction include the creation of the African Centre for Crop Improvement (ACCI) at the University of Natal, South Africa to train African PhD’s in the breeding and biotechnology of African crop species adapted to the African environment, and in Nigeria where the government currently budgets several millions of US dollars for biotechnology development. If other African countries could adopt similar measures, according to their individual capabilities, then the future for the Continent would certainly shift from that of the present state of economic stagnation, social unrest and general strife to that of fulfilled promises of technological advancement, adequate and nutritious food security, economic prosperity and general welfare for the citizens.

I would like to conclude my presentation reminding those who campaign against the introduction of genetically improved crops in the food chain in Africa that one cannot rationally argue with the hungry on the potential health risks that may result from being overfed. If African countries fail to feed the present generation of their citizens due to fears of the potential future dangers deriving from GM foods, there would probably not be any future generations of Africans to protect from such dangers.

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