Challenges of Biotechnology and Genetically Modified Crops for Food Security in a Developing Economy

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ABSTRACT

Biotechnology is now recognized as an important tool for solving in a precise manner and in record time problems which have not been easily addressed by conventional breeding and genetics. Plant improvement began around 4000 BC with plant selection by Egyptian farmers who saved seeds from high yielding plants. From then on several actors have contributed to plant improvement and modern biotechnology and transgenic science as we know it today. Wheat (*Triticum aestivum*) was the first crop to be genetically modified by combining genes from three separate grasses. All crops have since gone through some form of genetic modification, through cross breeding, mutation and transgenic manipulation, to produce the high yielding, disease resistant species in cultivation today. Modern transgenic modification begins with the identification of the gene conditioning the desired trait. This gene is then modified to make it capable of being translated into proteins. Next it is linked to other pieces of DNA that serve as start and stop signals (promoter and terminator sequences, respectively) which function to read the desirable gene. The entire assembly - promoter, desirable trait gene and terminator - are then fed into an intermediate organism called a vector, usually a plasmid of the mammalian intestine bacterium, *Escherichia coli*. When the plasmid replicates, it makes several copies of the desirable gene. The vector, with the replicated gene, is then inserted into the plant with the assistance of another plasmid, the Ti plasmid of the bacterium, *Agrobacterium tumefaciens*, to complete the process of modification. Transgenic manipulation has been found useful in disease and pest resistance, herbicide tolerance and reduced pesticide use. Three field crops - soybean, maize and cotton - have undergone the most genetic modification (in descending order of importance). In these crops, biotechnology has been shown to offer tremendous potential for pest management and herbicide tolerance with significant positive environmental impacts compared to non-transgenic crops, along with minor improvements made on drought tolerance, adaptation to low soil fertility, provision of additional nutrients, good taste and good culinary qualities in plants. Biotechnology could be useful in addressing pressing problems in Cameroonian agriculture, such as the root rot of cocoyam, *Striga* and streak in maize, and black pod of cocoa. Biosafety concerns have, however, provoked serious concerns as to the suitability for introduction of transgenic plants developed elsewhere. The ideas lead to the conclusion that developing countries should instead be assisted in developing their national capacity (human resources and infrastructure) in producing genetically modified crops addressing their field constraints rather than rely on externally developed transgenic crops for direct introduction to Africa.

Key words: genetic modification, genetically modified organisms, transgenic plants

RÉSUME

La biotechnologie est maintenant considérée comme un outil important pour la résolution d'une manière précise et plus rapidement des problèmes qui n'ont pas pu être adressés par la génétique conventionnelle. Le début de l'amélioration des plantes date autour des années 4000 BC avec la sélection des plantes par des agriculteurs Egyptiens qui gardaient des graines obtenues des plantes hautement productives. A partir de ce moment beaucoup d'autres acteurs ont contribué au développement de la sélection, la biotechnologie moderne et la science transgénique. Le blé (*Triticum aestivum*) était la première plante de subir une modification génétique ayant obtenus des gènes de trois plantes herbiers différentes. Depuis ce temps, presque toutes plantes ont subi une forme de modification génétique pour produire les espèces hautement productives et résistantes aux maladies que nous connaissement aujourd'hui. La modification transgénique moderne commence avec l'identification du gène ou gènes conditionnant le caractère désiré. Ce gène est ainsi modifié pour le rendre capable d'être traduit en protéines. Puis, il est attaché aux autres sections de ADN qui servent comme interrupteurs de démarrages et arrêt (respectivement les séquences promoteurs et terminateurs) donc leur rôle principal est de lire le gène désiré. L'ensemble (promoteur, gène et terminateur) est en suite chargé dans un organisme intermédiaire appelé vecteur, soit un plasmide de la bactérie, *Escherichia coli*. Quand le plasmide se réplique, il fabrique plusieurs copies du gène désiré. Le vecteur, avec le gène répliqué, est en fin inséré dans la plante avec l'aide d'un autre plasmide, le plasmide Ti de la bactérie, *Agrobacterium tumefaciens*, pour compléter le processus de modification. Les manipulations transgéniques ont été trouvées utiles dans la résistance des maladies et insectes, tolérance aux herbicides et dans l'utilisation réduite des pesticides. Trois cultures - soja, maïs et coton – ont subi les plus grandes modifications génétiques. Dans ce cultures, la biotechnologie a démontré une grande potentialité pour la gestion des insectes et la tolérance aux herbicides, avec des impacts environnementaux positifs quand ont le compare avec les plantes non-transgéniques, ainsi qu'en leur application à la tolérance à la sécheresse, adaptation à la basse fertilité, amendement des nutriments, bons goût et bonnes qualités culinaires des plantes. La biotechnologie pourra être utile pour résoudre des problèmes majeurs dans l'agriculture camerounaise, telles que la pourriture racinaire du macabo, le *Striga* et streak de maïs, pourriture de cabosse de cacao. Les considérations de la biosécurité ont provoqués des discussions et doutes par rapport à la convenance de l'introduction des plants transgéniques développées ailleurs. Ces idées mènent à la conclusion que nous préférons plutôt l'aide pour développer notre capacité nationale (ressources humaines et infrastructures) pour pouvoir produire nos cultures génétiquement modifiées qui répondent à nos besoins de lutter contre les contraintes du champs au lieu de se pencher sur les cultures transgéniques développées ailleurs.

Mots clés : modification génétique, organismes génétiquement modifiés, plantes transgéniques

Introduction

It is often said that about one quarter of the 800 million people suffering from chronic hunger and malnutrition around the world come from Africa (Anon 2003). Predictions state that by the middle of the century, there will be at least 3 billion more people to feed.

Cameroon is said to be food self-sufficient but generally considered food insecure, because although there is much food produced, several people do not have access to it. The diversity of agro-ecological zones means that some regions produce more food than others. But because infrastructure is not properly developed in many zones, many mouths which need to be fed do not have the much needed food, and at the same time, there is glut in the producing areas. Cameroon's population grows at a rate of about 2.5 % every year. Providing enough food for this growing population presents an enormous challenge to scientists and policy makers. Plant biotechnology can assist farmers grow more food on less land, in drier climates, or on poor soils.

Plant Biotechnology, a process in which genetic information is manipulated to develop useful and beneficial crops, provides techniques for improving food and crops by giving to cultivars new traits and qualities such as high yields, disease and pest resistance, better nutritional value, more vitamins and minerals (AfroBio 2003). It is an extension of the traditional science of plant breeding and selection which started as far back as 4000 BC, and has led to the development of the crop varieties we cultivate today (Biotechnology Institute 2004)(Table 1).

Table 1. Strides made in genetic modification

No	Era	Biotechnology discovery	Country
1	4000 BC – 1600 AD	First evidence of plant selection: farmers saved seeds from high yielding plants	Egypt
2	1700–1720	Europe's first hybrid plant produced	Europe
3	1866	Gregor Mendel publishes work on heredity showing how characteristics are passed from generation to generation	Austria
4	1870-1890	High yielding cotton hybrids produced	-
5	1871-1900	Hybrid potato produced	-
6	1908	Hybrid corn produced through self pollination by Shull	USA
7	1919	The word 'Biotechnology' coined by Karl Ereky	Hungary
8	1930	US Congress authorizes the patenting of plant breeding products	USA
9	1933	Hybrid corn becomes available commercially	USA
10	1953	Double helix described by Watson and Crick	USA-UK
11	1960s	Dwarf wheat created by Norman Borlaug	USA
12	1973	Gene sliced and moved to another organism by Cohen and Boyer; modern biotechnology era launched	-
13	1978	Human insulin gene synthesized by Boyer's lab	-
14	1982	First biotech plant produced – tobacco resistant to an antibiotic; paved way for beneficial traits e.g. insect resistance	
15	1985	Field trials for biotech plants resistant to insects, viruses and bacteria conducted	USA
16	1986	EPA approves release of first crop produced by biotech – tobacco	USA
17	1991	Biotech tomato approved by EPA	USA
18	1995-1996	Biotech soybeans and maize approved by EPA	USA
19	1996	Biotech crops planted on 4.2 acres in six countries	USA etc.
20	1999	Golden rice developed	Germany and Switzerland
21	2000	Entire plant gene sequenced (*Arabadopsis thaliana*); provides insight into genes controlling specific traits in many crops	-
22	2001	Salt tolerant biotech tomato developed	USA-Canada
23	2001	Biotech products found to pose no risk to human and environment	EU
24	2001	EPA renews registration for *Bt* corn and cotton	USA
25	2002	Soybean, corn, cotton, papaya, squash and canola produce an additional 4 billion pounds of food and fiber; improved farm income by $1.5 billion; reduced pesticide use by 46 million pounds	USA

Table 2. Differences between traditional and biotechnological genetic modification

Traditional techniques	Modern techniques
1. Too slow (requires many years)	Fast (a matter of weeks)
2. Many genes transferred	One or few genes involved
3. Unwanted traits transferred along with desired traits (linked genes)	Only one desired characteristic is transferred
4. Modification not specific	Modification precise
5. Expensive in time and space	Expensive in terms of equipment
6. Training in conventional breeding	Requires high technology training

Genetic variability and crop modification

All crops grown by farmers have undergone some form of genetic modification. In fact, wheat (*Triticum aestivum*), one of the greatest grown cereal crops in the world, is a hybrid of three separate grasses (Council for Biotechnology Information 2003). Genetic modification in crop plants has been done either by nature or artificially by scientists making crosses between varieties of the same plants or between cultivated and wild relatives of crop species. Farmers (the first plant breeders) have done extensive selection over the years, manipulating crops by retaining for the future only those genotypes with high and promising yields, culinary qualities or field agronomic traits.

All genetic modification leads to the creation of variability. Variability is the major ingredient of selection. Variability in some crops with narrow gene bases has been created through mutation (Edge *et al* 2001).

The methods of generating variability are various: These are cross pollination (in traditional breeding or cross breeding), mutation, biotechnology. Plant breeding started with the domestication of wild plants. With conventional plant breeding, many traits from two parents are combined to give the offspring. Usually, thousands of genes are involved and are transferred. And it is only through time-consuming crossing and selection that the desired traits may be combined in the desired individual. The process is usually very long. Mutations (created by use of chemicals called mutagens) have also been used to create variability, but their advantages are limited because although the variability is created, you may never obtain a concentration of the desired traits. When you use modern plant biotechnology, only the desired characteristic is added to the plant variety, and this is done in a very precise manner. There are certainly many advantages with biotechnology (Table 2).

Steps in genetic modification

When a desirable gene (one for yield, disease or pest resistance, or culinary trait) has been discovered it is isolated from the source plant or bacterial cell. It is then modified so as to be able to be translated into proteins. To begin the process, the gene is linked to other pieces of DNA that serve as start and stop signals (promoter and terminator sequences, respectively) which serve to read the desirable gene. The entire assembly - promoter, desirable trait gene and terminator - are then fed into an intermediate organism called a vector. The most used gene vector is *Escherichia coli*, a bacterium that commonly inhabits the mammalian intestine. *E. coli*, like many other bacteria, contains in addition to its chromosomes, a small piece of double stranded, self-replicating piece of DNA known as a plasmid. When the plasmid replicates, it makes several copies of the desirable gene. The vector, with the replicated gene, is then inserted into the plant with the assistance of another plasmid, the Ti plasmid of another bacterium, *Agrobacterium tumefaciens*, to complete the process of modification.

Uses of genetic modification to combat crop production constraints

Disease resistance (especially viruses): Crops modified genetically are shielded from plant viruses and bacteria in a way similar to the protection that we humans have from diseases when we are given vaccines.

Insect pest resistance: Genetically modified crops carrying insect resistance usually contain a protein from the naturally occurring soil bacterium (*Bacillus thuringiensis*, now called *Bt*, for short) which kills economically destructive insects like the maize stem borer, and the cotton bollworm.

Herbicide tolerance and reduced pesticide use:
Crop species have long been known to be highly variable in their response to herbicides. Crop plants which are genetically modified are immune to some herbicides which are effective against harmful obnoxious weeds, but have no effect on the cultivated crops. Examples of crops which are resistant to a major herbicide called glyphosate ('round-up') are maize, cotton and soybean. Huge savings have been made in weed control on crops such as cotton (*Gossypium* spp).

Three mechanisms are responsible for pest resistance in crops. These are (a) increased ability to detoxify the pesticide; (b) altered biochemical site of interaction with the pesticide (also called 'target insensitivity'); and (c) lack of uptake (or penetration) and translocation of the pesticide (Kishore, Padgette and Fraley 1992; Preston and Mallory-Smith 2001). In the first two mechanisms, a protein or enzyme interacts with the pesticide. Genetically modified (or transgenic) maize, soybean and cotton (which are known to be resistant to herbicides) rely largely on resistance to the herbicide glyphosate (marketed as Roundup). The various genes conditioning tolerance to herbicides in field crops have been obtained from other crops or organisms (Table 2).

Herbicide-tolerant soybean is the most extensively planted biotechnology-derived crop in the world, accounting for 46% of total soybean acreage and 63% of total acreages of transgenic plants grown (James 2001ab, 2003).

Progress in transgenic field crops
The three field crops which have undergone the most genetic modification are soybean, maize and cotton (in descending order of importance).

Soybean: Herbicide-tolerant soybean (*Glycine max*) is the most extensively planted transgenic crop in the world. Soybean is one of the largest acreage crops in the world, grown on approximately 72 million hectares worldwide.

Traditional crop improvement techniques have been used in the development of soybean varieties that tolerate diseases such as *Phytophthora* root rot, downey mildew, bacterial pustule, target spot, and wildfire (Hartwig 1987; Hartwig, Musen, and Maxwell 1978) (Table 1). Modern biotechnology is addressing another important disease, bean pod mottle virus.

Weed control is one of the biggest challenges in soybean cultivation because poorly controlled weeds drastically decrease crop yield and quality. The most obnoxious weeds of soybean are common cocklebur, jimsonweed and velvetleaf. These weeds can result in soybean yield losses ranging from 12-80%. Farmers have resolved to use Glyphosate for controlling weeds because they just have to rely on one herbicide to control a broad spectrum of weeds without crop injury. Glyphosate is a highly effective, non-selective, broad-spectrum, post herbicide. It is effective against a wide spectrum of perennial grasses and broadleaf weeds. By planting glyphosate-tolerant soybean, farmers are able to apply glyphosate directly over the crop and take advantage of this wide spectrum of weed control. Furthermore, glyphosate has no crop rotation restrictions and may be used to control weeds that have developed resistance to other herbicides.

Transgenic soybean offers tremendous potential for pest management with significant positive environmental impacts compared to other soybean, thereby increasing the sustainability of soybean cultivation.

Maize: The corn (*Zea mays*) is the second most important transgenic plant in wide cultivation worldwide. Transgenic maize is tolerant to diseases, insect pests and weeds and selectivity for herbicides such as glyphosate. The European corn borer (*Ostrinia nubilalis*), the corn rootworm complex (western corn rootworm, *Diabrotica virgifera virgifera*, northern corn rootworm, *Diabrotica barberi*, and the southern corn rootworm, *Diabrotica undecimpunctata howardi*) are the most economically damaging insect species attacking maize in the USA (Table 3). In Cameroon, the stem borers (*Bussiola fusca* and *Eldana saccharina*) are the most important insect pests.

It is believed that the cultivated maize originated from teosinte (*Zea mays* spp. *parviglumis*). Since the domestication of corn, enormous research has been done on its improvement. The early work was done on yield, protein content and nutritional content. Later work, especially in Cameroon concentrated on high lysine hybrids, hybrids with good culinary qualities and the development of varieties for intercropping with cocoyams and other food crops (Ayuk-Takem 1981).

Table 3. Some major constraints addressed by transgenic plants

	Diseases and nematodes	Insects	Weeds
Soybean	Cyst nematode Root knot nematode Phytophthora root rot Downy mildew Bacterial pustule	Bean beetle Bean leaf beetle Blister beetle Sting bugs	Cocklebur Jimsonweed Velvetleaf
Maize	Southern corn blight Maize streak virus Rust	Corn stalk borer Rootworm complex Fall armyworm Southern corn borer Corn earworm	Horseweed Marestail
Cotton	Seed rot, root rot Damping off Fusarium wilt Boll rots, leaf spots Rhizoctonia, Pythium	Boll weevil Bollworm Tobacco budworm	Johnson grass Morning glory Pigweed

Transgenic *Bt* maize has traits common with other biotech-derived crops, such as herbicide tolerance, insect resistance and disease resistance. *Bt* maize covered 6% of total cultivated area of about 140 million hectares cultivated with maize in the year 2000 (James 2001a).

Transgenic maize continues to grow in developed countries where the benefits of this over traditional varieties are easily perceived. Cameroon's maize varieties are performing well, and it is unlikely that great strides will be obtained with the introduction of transgenic maize varieties which have been developed to overcome constraints alien to Cameroonian agriculture.

Cotton: Transgenic cotton (*Gossypium hirsutum*), with herbicide tolerance and insect resistance, is the third most extensively planted genetically engineered crop in the world. It accounts for 13% of total cotton acreage and 20% of total genetically modified crop acreage in the year 2001. Worldwide, cotton is an important component of the agricultural economies of some 80 countries. China and the USA are the largest cotton producers, supplying some 24 and 21% of the total world production, respectively. Cameroon produces about 0.45% of total world production.

Cotton is a high input crop, only second to rice in per hectare costs of production. The crop is grown in warm climates where insect pests thrive, and chemical pest control is predominant. The main insect pests are those that attack the bolls and flower buds, and thereby have a significant impact on fiber yields. The economically important insect pests are the boll weevil (*Anthonomous grandis grandis*), bollworm (*Helicoverpa zea*) and the tobacco budworm (*Heliothis virescens*). Other insects which are sporadic in occurrence are the beet armyworm (Spodoptera exigua), cotton fleahopper (*Pseudatomoscelis seriatus*), brown cotton leafworm (*Acontia dacia*), and the cotton aphid (*Aphis gossypii*).

Because of the huge economic losses and the increasing costs of pest control methods, pest-resistant plants had to be developed which now enable cotton growers to use biotechnology derived plant-incorporated protectants as part of their integrated pest management systems. This has allowed farmers to decrease negative environmental impacts substantially, increase profitability and enhance their quality of life (Edge *et al.* 2001).

Biotechnological approaches have aimed at inserting multiple genes that trigger the cotton plant to make proteins with different modes of pesticidal action (against both insects and weeds). The challenging part of the technique is locating promoter and terminator sequences which are more than ever obtained from entirely different species (Table 4). The most common cotton product expressing multiple (or stacked) traits is herbicide-tolerance and resistance to insect damage. Transgenic cotton varieties, stacked with insect resistance and herbicide

Table 4. Sources of 'on-off' genes for various traits in cultivated field crops

	Maize	Cotton	Soybean
Promoter sequence	Rice	Cauliflower mosaic virus	Cauliflower mosaic virus
Terminator sequence	*Agrobacterium tumefaciens*	Arabidopsis	Arabidopsis
Antibiotic resistance marker gene	Beta-lactamase (not expressed)	Neomycin phospho-transferase II (not expressed)	Neomycin phospho-transferase II (not expressed)

tolerance, are tolerant to glyphosate. Such cultivars have been available in commercial production in the USA since 1997. Commercial varieties in Cameroon still rely on chemical pest control. Transgenic cotton could salvage the situation of high costs of pest control chemicals if developed under Cameroonian conditions.

Drought tolerance: Cotton farming uses huge quantities of available water resources, presenting a significant environmental resource challenge. In Cameroon, cotton is grown in the Sudano-Sahelian region where fresh water is short supply. Extensive irrigation of cotton impacts the regional water resources, possibly contributing to surface and groundwater depletion. Using modern biotechnology, attempts have been made to produce cotton genotypes with tolerance to drought.

Adaptation to low soil fertility: With increasing peri-urban agriculture, several crops (especially home garden crops) are grown in soils of low fertility. To sustain productivity, the soils are heavily amended with chemical fertilizers. Fertilizers are expensive and sometimes unavailable. Transgenic crop genotypes adapted to low soil fertility could substantially increase productivity on marginal lands.

Additional nutrients: Golden rice fortified with beta carotene which stimulates the production of vitamin A in the human body is one of the major developments in cereal biotechnology. Vitamin A deficiency causes blindness and other diseases. Cassava could also be enhanced to contain about 40% more protein and essential amino acid.

Good taste: Seedless watermelon and grapes were produced by plant biotechnology. Culinary and organoleptic traits of our food crops could also benefit from transgenic approaches of this type. It is in this light that the strengthening of national capacity in biotechnology applications is vital.

Good culinary qualities: Local foods enhanced by plant biotechnology may offer health benefits. For instance, oils with less saturated fat and lettuce which lowers cholesterol will prevent many of the diseases we know today. Many high yielding cassava varieties do not cook. It takes several cycles of cross breeding and backcrossing to restore root quality – a process which takes several years. Modern biotechnology could provide the solutions now taking too long to achieve with conventional breeding.

Conservation tillage: Some of the new biotech crops have been genetically modified to help protect the environment by making it possible for farmers to do less ploughing and weeding.

Environmental stability: Transgenic plants are said to be environmentally friendly. Studies on transgenic soybean, maize and cotton have shown that such plants have the ability to alleviate problems with insect resistance to chemical pesticides, and at the same time maintain biodiversity. Whether this will be applicable to Cameroon which has a completely different ecological setting, is yet to be proven.

Challenges of genetic modification

Biosafety – The major challenges in transgenic plants is to demonstrate how safe these plants can be. In fact, policy makers in developing countries are reluctant to accept the introduction of these crops in their countries because of concerns on biosafely. Questions which keep coming up are (a) What effects will the introduction of these crops have on our local landraces? (b) What effects will these crops have on biodiversity? (c) How safe are these crops nutritionally? (d) What are the economic consequences of these crops? (e) Shall we have to depend on developed countries for our seed supply? (f)

Why the mad rush in the introduction of transgenic crops in developing countries? (g) Should the introduction of transgenic plants not be demand-driven? Until these questions can be answered clearly, the fears and challenges of genetically modified crops from developed to developing countries will continue to be enormous and embarrassing.

Economic constraints in Cameroon's agriculture requiring genetic modification

Some of major constraints hampering increased production of the major field crops grown in Cameroon involve diseases and pests, organoleptic qualities and plant nutrition. These constraints could very well be addressed in a timely fashion by approaches in biotechnology. For instance, pests like the maize streak virus and *Striga hermonthica*, have been responsible for huge yield losses in many production parts of the country. Cassava mosaic disease and the root scale (*Stictococcus vayssierei*) continue to cause havoc and appreciable yield losses in the country (Table 5). There are no known sources of resistance to the sweet potato weevil (*Cylas* spp.), and the late blight of potato (*Solanum tuberosum*). The root scale of cocoyam has completely eliminated cocoyam consumption from the diets of many indigenous tribes who depended wholly on this crop for their existence. The black pod of cocoa (*Theobroma cacao*) continues to be a major problem in cocoa production as resistance keeps building up from developed fungicides. These and other constraints could be well controlled by modern biotechnology.

Review of GM crops

A brief review of crop varieties which have been modified genetically shows benefits in yield, disease and pest resistance, and herbicide tolerance over non-transgenic types. The plants which have undergone modification for commercial purposes are:

- Maize (*Zea mays*) - high yields (yield increases upwards of 15% herbicide tolerance;
- Cotton (*Gossypium* spp) - herbicide tolerance, high yields (yield increases of over 10% in USA, and about 25% in South Africa

Table 5. Major agricultural constraints requiring genetic modification in Cameroon

Crop	Constraints	Remarks
Maize	Acidity, aluminium toxicity, striga, streak, aflatoxin, intercropping genotypes, high lysine content, yellow endosperm	Some improved genotypes have been developed which carry various levels of resistance to some of these constraints
Cassava	Mosaic, root scale, cooking quality	Many resistant genotypes also carry deleterious or unwanted traits
Cocoyam	Root rot, root scale, low oxalic acid	The narrow gene base (low variability) of this crop makes conventional genetic improvement worthless
Sweet potato	Weevils, virus complex, non-sweet types	These quantitative traits call for concerted work in both modern biotech and traditional breeding
Irish Potato	Late blight, bacterial wilt, tuber frying quality	All varieties appear to be susceptible, making biotech the only solution
Groundnut	Aflatoxin, rosette, pod filling	Biotech applications will be most handy in these circumstances
Cocoa	Black pod	Biotech applications will be most useful in a crop where chemical control has failed.

- Soybean (*Glycine max*) – higher yields of over 10 % when compared with conventional varieties; Roundup resistance.
- Pawpaw (*Carica papaya*) – good taste
- Squash (*Cucurbita* spp.) – Good taste, high yields
- Canola (*Canola* spp.) – High oil yields; More than 10% yield increases. Herbicide tolerance.
- Cantaloupe (*Cucumis melo cantalupensis*) – high yields
- Potato (*Solanum tuberosum*) – high yields; disease resistance
- Tomatoes (*Lycopersicon esculentus*) – high yields, disease resistance
- Sugar beets (*Beta vulgaris*) – high yields, disease resistance.

Problems with genetic modification

The merits and demerits of genetic modification are many. In Cameroon and other developing countries, fears about transgenic plants centre around the erosion of landraces, nutritional toxicity and environmental instability. Whether these concerns are founded or not is yet to be determined.

Cameroon perspectives on genetically modified crops

As a nation, it is important not to be left behind in the use of this technology. It has several advantages which should be exploited in fostering our agriculture. What we need to do to go further is to (a) develop a strong national capacity for generating genetically modified organisms (GMOs); (b) use the developed GMOs of our economic species in increasing productivity on marginal lands; (c) use GMOs to enhance production in harsh and dry climates; (d) use transgenic plants to increase productivity on poor soils, and (e) finally use biotechnology-derived crops for disease resistance, pest tolerance, herbicide tolerance and to improve culinary qualities.

Just accepting the introduction of exotic genetically modified crops (corn, soybean, cotton) may require caution until proper testing of their usefulness has been done.

Conclusions

The stakes with genetically modified crops are many. We need to:

- develop national capacity for genetic modification (training, infrastructure)
- use biotechnology wisely to develop GMOs to solve problems which have not been solved by conventional methods;
- accept exotic GMOs with extreme caution (after careful consideration has been given to the possibility of genetic erosion of landraces, environmental problems, biosafely and maintenance of biodiversity).

Despite these stakes and challenges, plant biotechnology continues to be the most rapidly adopted technology in agricultural history because of the economic and social benefits crops offer to growers, particularly those in developing countries. Biotechnology, if properly utilized, can contribute to sustainable food production, greater food security and alleviation of poverty, and at the same time protect the environment and enhance the production of better crops.

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