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Prospective of agriculture biotechnology to minimize hunger and malnutrition

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Abstract
Over active nature of human being is affecting the environment of earth in adverse manner. This is leading a threat to global sustainable agriculture development and ultimately food security. The Food and Agriculture Organization of the United Nations (FAO) defines "food security" as a state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life. This means that in order to enjoy food security, there must be on the one hand a provision of safe, nutritious, and quantitatively and qualitatively adequate food and, on the other, rich and poor, male and female, old and young must have access to it. "Green Revolution "has been one of the greatest achievements since the Second World War. The phenomenal increase of research based agricultural productivity has fed millions and served as the basis of economic transformation in many poor countries, especially on the Indian subcontinent. This "Green Revolution" has avoided dire predictions of death and famine in world particularly in Asia. But in present scenario agriculture land is decreasing continually, due to vast industrialization, there is continuous degradation of soil health by improper agriculture practices, and simultaneously there is drastic shift in population from rural area to urban area. All this is creating problems of hunger and malnutrition in developing countries. As Biotechnology science has given us a new tool to maintain food security. Conventional breeding, widely used during the Green Revolution era, no longer provides needed breakthroughs in yield potentials, nor the solution to the complex problems of pests, diseases, and drought stress. On other hand various components of Biotechnology i.e. Plant Tissue Culture, Marker Assisted Breeding, Genetic Engineering, has enormous potential to achieve the goal of to minimize Hunger and malnutrition as well as make the complex agricultural systems of world more productive and sustainable.

Keywords: Agriculture biotechnology, hunger, malnutrition, plant tissue culture, marker assisted breeding, genetic engineering

Introduction
In last few years there is a great change in population in rural &urban area. A large population in developing world is shifting from rural to urban area. Within the next decade more than half of the world population, an estimated 3.9 billion will be living in urban area. As recently as 1975 just over 30-35% of world population lived in urban areas but by 2035 it will be almost 60-65%. The metro cities of future are taking shape in developing countries and will affect social& environmental aspect of concern countries and ultimately an alarm for food security. The Urban populations are not able to feed themselves by subsistence food production, and their eating patterns differ from those of rural folk. The amount of high-value, transportable, and storable grain (such as rice and wheat), animal protein, and vegetables in their diets is higher, with a corresponding decrease in the proportion of traditional foodstuffs. Probably in 2035 the 800 million subsistence farmers will not possibly be able to feed 4 billion city dwellers. Over active nature of human being is affecting the environment of earth in adverse manner. This is leading a threat to global sustainable agriculture development and ultimately food security. On the global level, major key indicators show that the physical condition of the earth is deteriorating, i.e. the earth is getting warmer. The deforestation of the planet continues unabated, reducing the capacity of soils and vegetation to absorb and store water, Soil erosion by water and wind, due to inappropriate agricultural techniques as well as overuse of scarce resources, particularly overuse of water resources, make every effort to improve food security and eliminate

poverty even more difficult task. Various sources suggest that 5 to 10 million hectares of land are being lost annually to severe degradation. The degradation of cropland appears to be most extensive in Africa, affecting 65 percent of the cropland area, compared with 51 percent in Latin America and 38 percent in Asia.

While the world has been changing over the last few years politically and economically in unexpected and remarkable ways, food security remains an unfulfilled dream for currently more than 800 million people about 10 percent less than in 1970. What seems to be a small improvement, should not go unappreciated, however, as about 1.5 billion people were added to the population of the developing countries since then. There has been progress on a global scale-but not for all. Poverty continues to limit access to food, leaving hundreds of millions of people undernourished in developing countries. Increased population and urbanization will drive sustained growth in food demand, with a doubling of food needs in developing countries possible over the next four decades. India is an agricultural dependent country, with having 13.8 per cent of Gross Domestic Product. Food security is broad area and various workers have contribution at different time in this. (Yogendra Singh, 2009, Yogendra Singh, 2022, Singh *et al*., 2013, Ratan and Singh, 2010) [40, 41, 14, 33].

Food security, Hunger and Malnutrition

The Food and Agriculture Organization of the United Nations (FAO) defines "food security" as a state of affairs where all people at all times have access to safe and nutritious food to maintain a healthy and active life. This means that in order to enjoy food security, there must be on the one hand a provision of safe, nutritious, and quantitatively and qualitatively adequate food and, on the other, rich and poor, male and female, old and young must have access to it.

Food security thus has two main dimensions

Availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports & Accessibility of food by households and individuals for appropriate and nutritious diet.

Hunger: Hunger is usually understood as an uncomfortable or painful sensation caused by insufficient food energy consumption. Scientifically, hunger is referred to as food deprivation. Simply put, all hungry people are food insecure, but not all food insecure people are hungry, as there are other causes of food insecurity, including those due to poor intake of micro-nutrients.

Malnutrition: Malnutrition refers to the condition of people whose dietary energy consumption is continuously below a minimum dietary energy requirement for maintaining a healthy life and carrying out a light physical activity with an acceptable minimum body-weight for attained-height. Malnutrition is determined from data about people's weight, height, and age.

Stark Reality of Hunger and Poverty Status

- Global hunger affects 1 in every 9 people.
- In 2018, 149 million children (under 5) were undernourished.
- Hunger has increased in many countries where the economy has slowed down or contracted, mostly in middle-income countries.
- Hunger is on the rise in almost all African subregions, making Africa the region with the highest prevalence of undernourishment, at almost 20 percent.
- Hunger is also slowly rising in Latin America and the Caribbean, although its prevalence is still below 7 percent.
- In Asia, Western Asia shows a continuous increase since 2010, with more than 12 percent of its population undernourished today.

In 2018, the number of chronically undernourished people in the world is estimated to have increased to 821.6 million, up from 811.7 million in 2017, according to the Food and Agriculture Organization of the United Nations (FAO).The 2030 Agenda for Sustainable Development and the UN Decade of Action on Nutrition 2016–2025 call on all countries and stakeholders to work as one to eliminate hunger and malnutrition by 2030.

No single approach will provide solutions to the declining agricultural productivity trends. Conventional crop improvement ALONE will not cause a dramatic "quantum jump" to bridge the huge food deficit and poverty globally. A successful strategy should have MULTIPLE APPROACHES that address principal factors in the food, feed, fiber and fuel availability MATRIX. These include: good governance, improved infrastructure, farmer education, improved seed quality and delivery systems, inputs, market access, fair trade and appropriate technologies that integrate proven indigenous knowledge practices with emerging technologies such as modern biotechnology.

Agriculture Biotechnology: For sustainable Food security

Against the background of the interdependence of continuing population growth, accelerated urbanization, increased pressure on the social fabric and the environment, the fight for elimination of hunger, malnutrition and poverty will have to be a fight on many fronts. The technological front e.g. "Agriculture Biotechnology" is most important among several technical options.

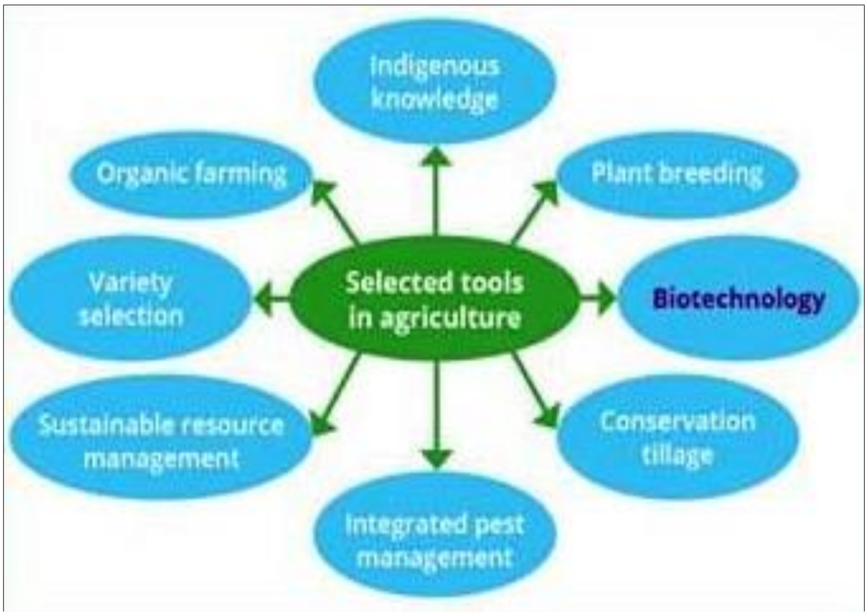
Main Branches of Agriculture Biotechnology

1. Plat Tissue Culture: Plant tissue culture is a collection of techniques used to maintain or grow plant cells, tissues, or organs under sterile conditions on a nutrient culture medium of known composition. It is widely used, to produce clones of a plant in a method known as Micropropagation. Different techniques in plant tissue culture may offer certain advantages over traditional methods of propagation including the production of exact copies of plants that produce particularly good flowers, fruits, or other desirable traits.

1. To quickly produce mature plants.
2. To produce a large number of plants in a reduced space.
3. The production of multiples of plants in the absence of seeds or necessary pollinators to produce seeds.
4. The regeneration of whole plants from plant cells that have been genetically modified.

5. The production of plants in sterile containers allows them to be moved with greatly reduced chances of transmitting diseases, pests, and pathogens.
6. Reproduce recalcitrant plants required for land restoration

Storage of genetic plant material to safeguard native plant species.



Source: ISAAA

Fig 1: Selected tools used to improve agricultural productivity, biotechnology is one among several tools available to complement but not to replace conventional agriculture

Plant tissue culture relies on the fact that many plant parts have the ability to regenerate into a whole plant (cells of those regenerative plant parts are called totipotent cells which can differentiate into various specialized cells). Single cells, plant cells without cell walls (protoplasts), pieces of leaves, stems or roots can often be used to generate a new plant on culture media given the required nutrients and plant hormones.

2. Marker Assisted Breeding: Marker-assisted breeding uses DNA markers associated with desirable traits to select a plant or animal for inclusion in a breeding program early in its development. This approach dramatically reduces the time required to identify varieties or breeds which express the desired trait in a breeding program. Marker assisted selection is the process of using the results of DNA testing in the selection of individuals to become parents for the next generations.

Types of Markers

The majority of MAS work in the present era uses DNA-based markers [5]. However, the first markers that allowed indirect selection of a trait of interest were morphological markers. In 1923, Karl Sax first reported association of a simply inherited genetic marker with a quantitative trait in plants when he observed segregation of seed size associated with segregation for a seed coat color marker in beans (*Phaseolus vulgaris* L.).

1. **Morphological:** These were the first markers loci available that have an obvious impact on the morphology of plants. These markers are often detectable by eye, by simple visual inspection. Examples of this type of marker include the presence or absence of an awn, leaf sheath coloration, height, grain color, aroma of rice etc. In well-characterized crops like maize, tomato, pea, barley or wheat, tens or hundreds of genes that determine morphological traits have been mapped to specific chromosome locations.
2. **Biochemical:** A protein that can be extracted and observed; for example, isozymes and storage proteins.
3. **Cytological:** Cytological markers are chromosomal features that can be identified through microscopy. These generally take the form of chromosome bands, regions of chromatin that become impregnated with specific dyes used in cytology. The presence or absence of a chromosome band can be correlated with a particular trait, indicating that the locus responsible for the trait is located within or near (tightly linked) to the banded region. Morphological and cytological markers formed the backbone of early genetic studies in crops such as wheat and maize
4. **DNA-based:** Including microsatellites (also known as short tandem repeats, STRs, or simple sequence repeats, SSRs), restriction fragment length polymorphism (RFLP), random amplification of polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), and single nucleotide polymorphisms (SNPs).

Molecular markers are also called DNA markers**.** It is a DNA sequence that is readily detected and whose inheritance can be easily monitored. The use of molecular markers is based on naturally occurring DNA polymorphism, which forms the basis for designing strategies to exploit applied purpose. A molecular marker has some desirable properties like

- It must be polymorphic
- Co-dominant inheritance
- Should be evenly and frequently distributed
- Should be reproducible

- Should be easy fast and cheap to detect.

No single marker me *et al*. l these requirements so there is need to develop a wide range of molecular markers

Classification of Molecular markers: (source: Singh and Upadhyay, 2016) [42]

Class	Marker system	Abbreviation	Remarks
First Generation Molecular Markers	Restriction Fragment Length Polymorphism	RFLP	Based on restriction digestion and hybridization with probe
	Sequence Tagged Sites	STS	RFLP probes sequenced and converted in to PCR based STS markers
	Random Amplified Polymorphic DNA	RAPD	Random primers for PCR amplification
	Arbitrary Primed PCR	AP-PCR	RAPD primers of 10-15 bases in length for discrete amplification
	Sequence Characterized Amplified Regions	SCAR	RAPD marker termini sequenced for designing longer primer
	DNA Amplification Fingerprinting	DAF	Single random primer of 5 bases short length
Second Generation Molecular Markers	Simple Sequence Length Polymorphism	SSLP	Based on tandem repeat flanking sequence
	Variable Number of Tandem Repeats	VNTRs	Based on tandem repeat sequence hybridization by probe
	Random Amplified Micro satellite Polymorphism	RAMPO	Random primers used for amplification and then hybridized with micro satellite oligonucleotides probe
	Cleaved Amplified Polymorphic Products	CAPs	PCR amplified products digested by restriction enzymes
	Inter Simple Sequence Repeat	ISSR	Single primer based on SSR motif
	Amplified Fragment Length Polymorphism	AFLP	Detection of genomic restriction fragment by PCR amplification
	Allele Specific Associated Primers	ASAP	Specific allele sequenced and primers designed for amplification
Third Generation Molecular Markers	Expressed Sequence Tag markers	ESTs	Sequencing of random DNA clones
	Single Nucleotide Polymorphism	SNP	Non-gel based marker system and DNA sequence differs by single base
	Miniature Inverted Repeat Transposable Elements	MITE	Non autonomous transposable elements with strong target site preference

3. Genetic Engineering

Genetically Modified (GM) crops are the products of introduction of one or better characterized genes in a crop plant using recombinant DNA technology. The inserted gene is known as transgene and the plants containing transgene are often called genetically modified (GM) crops or transgenic crops. The genetically modified crops are possible solution for the widely discussed current problems of food and nutritional security.

The first commercially grown genetically modified vegetable crop was Tomato (called Flavr Savr), modified to ripen without softening by a Californian company Calgene, which took the initiative to obtain approval for its release in 1994. Currently, a number of food crops such as soybean, corn, cotton, Hawaiian papaya, potatoes, rapeseed (canola), sugarcane, sugar beet, field corn as well as sweet corn and rice have been genetically modified to enhance their yield or durability, etc. Scientists are also working on oil yielding crops and medicinal plants for the cosmetics industry, crops with altered nutritional value, and even crops that produce pharmaceutical drugs.

The basis of Recombinant DNA Technology (RDT) is a key set of enzymes and techniques which allow DNA to be manipulated and modified precisely. The fundamentals of RDT includes

1. Cutting of DNA with sequence specific bacterial endonuclease (restriction endonuclease) to generate defined DNA Fragments and using the enzyme DNA Ligase to join theme
2. Separating nucleic acid on the basis of size by gel electrophoresis.
3. Detecting specific sequences in complex mixtures by nucleic acid hybridization
4. Introducing DNA in to cell
5. Amplification of specific DNA molecules either by molecular cloning or using Polymerase Chain Reaction (PCR). Molecular cloning is an *in vivo* technique for producing large quantities of a particular DNA molecule (recombinant DNA molecule). The cloning process involves:
6. Introduction of the recombinant vector in to a suitable host cell
7. Selective propagation of cells containing the vector
8. Extraction and purification of the cloned DNA molecule (recombinant DNA molecule).

The Expectations from Agriculture Biotechnology

The main objective of agriculture biotechnology research and development should be to develop improved crop varieties that enable reliable high yields at the same or lower tillage costs without compromising the quality. i.e.

- Resistance to plant diseases (fungi, bacteria, viruses).
- Resistance to animal pests (insects, mites, nematodes).
- Resistance to stress factors (climatic variation, poor soil quality).
- Transfer of genes with nitrogen-fixing capacity onto grains, and the improvement of food quality by overcoming vitamin or mineral deficiencies.

The achievements of Agriculture Biotechnology

A lot of work has been done by agriculture scientists throughout the world in last four decades, to increase yield of the major food grains. Yield levels of maize, rice and wheat nearly doubled over the 1960 to 1994 period. These yield increases are attributable largely to improved varieties, irrigation, fertilizers, and a range of improved crop and resource-management technologies. Much of this has been part of the Green Revolution. But now we cannot meet out efficiently increasing global food requirements without using Agriculture Biotechnology tools. In addition to producing more food, we have eliminate malnutrition and poverty from society by providing desired nutrition to growing Children in their diet, lowering the input costs in agriculture and increasing output. The following are some areas where Agriculture Biotechnology has worked towards global food security and elimination of malnutrition.

1. Developing high yielding varieties

Food is the most basic of human needs. Despite the "green revolution" between 1970 and 1990 almost half of the world's less developed countries suffer a decline in aggregate food supply, and more than a quarter suffer an increase in hunger. Malnutrition is a major barrier to economic and social development, leaving populations unable to maintain normal lives and to be economically and socially less productive (Conway, 1999) [12]. High-yielding varieties (HYVs) also known as modern varieties (MVs) of wheat and rice have spread more widely, more quickly, than any other technological innovation in the history of agriculture in the developing countries (DCs). First introduced in the mid-1960s, they occupied about half of that total wheat and rice area in the DCs by 1982-83. Their area has increased since that time avid will undoubtedly continue to grow in the future.in development of high yielding varieties genetic diversity analysis is a useful and important step (Singh and Singh., 2008, Singh *et al*., 2008) [34, 37].

The outcomes of the Green Revolution offer some guideposts for assessing the likely risks and benefits of agricultural biotechnology for developing countries. Risks and benefits may be inherent in a given technology, or they may transcend the technology (Leisinger 1999) [28]. The polic environment into which a technology is introduced is critical. For example, IFPRI research has found that in Tamil Nadu State in India, the adoption of high-yielding grain varieties meant not only increase yields and cheaper, more abundant food for consumers, but income gains for small and largerscale farmers alike, as well as for nonfarm poor rural households. Increased rural incomes contributed to nutrition gains for these households (Hazell and Ramasamy 1991) [18]. Because the Tamil Nadu state government has pursued active poverty alleviation strategies, including extensive social safety net programs and investment in agriculture, rural development, and a fair measure of equity in access to resources such as land and credit, the benefits were widely shared. Where increased inequality followed the adoption of Green Revolution technology, it was not because of factors inherent to the technology, but rather a result of policies that did not promote equitable access to resources. And even in these areas, rural landless laborers usually found new job opportunities as a consequence of increased agricultural productivity, particularly where appropriate physical infrastructure and markets developed. The International Rice Research Institute (IRRI) in the Philippines in 1960, and the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico in 1967. Three other international agricultural research centres (IARCs) were subsequently established which also worked on rice or wheat (CIAT in Colombia, IITA in Nigeria, and ICARDA in Syria). Short varieties of wheat and rice, the products of natural mutations, were first observed in Japan in the 1870s. As the availability of fertilizer increased in the late 1800s and in the early 1900s their use expanded. Shinriki rice was a particular example. Few short varieties, however, were what we now know as semi-dwarfs (which carry ore or two major genes for reduced height).

2. Prevention of post- harvest losses

Ministry of Food and Civil Supplies, Government of India estimated that the total preventable post-harvest losses of food grains at 10 per cent of the total production. It has been observed that losses of rice and wheat due to inefficient and inadequate storage and other post-harvest factors at the farm, village and commercial levels were up to 4 per cent (McFarlane, 1989; Abdullahi and Haile, 1991) [31, 1]. In another study, the storage losses at different stages have added up to about 36 per cent of the total post-harvest losses in rice and 33.5 per cent in wheat, while harvesting and threshing operations together account for about 17 per cent of total losses in both the crops. Transit losses at different levels have been an important component of post-harvest losses, contributing to about 20 per cent of the total losses. Several molecular techniques (RNAi) are used for prevents post-harvest losses. RNAi is involved in regulating many developmental processes in plants and pests, often through targeting transcription factor RNAs. They are also involved in processes as diverse as responses to stress (both biotic and abiotic), signaling and metabolism, and interestingly in regulating the miRNA pathways.

3. Pests and herbicide resistance management

Field studies of soya bean crops in northern and southern regions of USA reported by Scursoni *et al.* (2006) indicate that limited use of glyphosate has little long-term effect on weed diversity. Some of the new weed species found in the fields sprayed with glyphosate on no-till crops have shown a higher tolerance to glyphosate; in Missouri and farther south, long growing seasons allow weeds that emerge and grow late to escape single glyphosate treatments, and this may reduce crop yields substantially if not treated. In contrast, in Iowa and farther north, a single glyphosate application inhibits weeds sufficiently to maintain high soya bean yields obtained from transgenic crops modified to be resistant to glyphosate, but still permits expression of highly effective species richness. Thus, in northern temperate agro-ecosystems, one-pass glyphosate management systems in HT crops may serve agronomic and environmental needs simultaneously. The timing of pesticide application may have a bigger impact on biodiversity than the direct influence of the transgenic crops. For instance in North America, Bertram and Pedersen (2004) [6] found that the impact on the weed community is mainly because of the changes in the management system (i.e. rotations, tillage systems and herbicides strategies) than the transgenic trait.

The risk that weeds may become resistant to herbicide is well known. A collaborative monitoring study (Heap, 2010) [19] identified 194 herbicide-resistant species in 19 herbicide groups. Of the 194, 19 species show resistance to glycines, including glyphosate. Strategies have accordingly been developed to manage the cultivation of glyphosate tolerant transgenic crops so as to delay the emergence of resistant weeds. Hurley *et al.* (2009a, b, c) [20, 21, 22] described the weed management programmes, best management practices and the economic effects for growers of transgenic maize, cotton and soya beans. Based on farm surveys in USA, they reported that the emergence of resistant weeds reduced the economic benefit of growing these herbicide-tolerant crops by up to about one-third. The adoption of HT soya beans and no-tillage agriculture in Argentina has increased the use of glyphosate as the main tool to control weeds. This has helped to reduce the density of many weed species but has increased the density of some others that were previously not always part of the community. Overall, two weed management practices were considered effective: the use of a residual herbicide with glyphosate and the rotation of crops.

4. Quality (crop) improvement

New tools of molecular genetics and genetic engineering in particular help to increase the efficiency of crop improvement programs. Thus, biotechnology could boost global crop output in the future while promoting environmentally friendly agricultural production patterns (Serageldin, 1999) [32]. The adoption of genetically modified crops in agricultural practice followed an exponential profile during the last few years. In 1996, 2.8 million hectares were grown worldwide with transgenic crops; by 1999 this area had already multiplied to 39.9 million hectares (James, 1999) [23]. Most of the molecular genetics and genetic engineering technologies developed up till now involve soybeans, maize and cotton, which have been endowed with herbicide tolerance or insect resistance. But many other biotechnology products are already in the research pipeline. Techniques applied in genetic modification to improve crops quality, include mutation breeding, improved conventional breeding, transgenic modifications, DNA insertion, gene transfer and somatic hybridization (Bouis *et al.*, 2003; Christou, 1997; Mazur, 2001; Yan and Kerr, 2002) [7, 10, 30, 39].

Agricultural biotechnology played a role to improving the crop quality by introducing any desirable gene to the genome of particular crop, which is deficient in that particular crop for improved yields and perspective desirable trait. The production of increased levels of beta-carotene (the precursor to vitamin A) in plants is especially important, as its precursor, lycopene has been shown to have physiological chemo-preventive effects with regard to various cancers (Yan and Kerr, 2002) [39]. Furthermore, lycopene, commonly found in various carotenoid containing plants such as tomatoes and carrots, is an essential ingredient in maintaining eye health and vision. Modifications that have been targeted and developed by various biotechnology companies include improvement in the oil content and composition of oil seeds such as legumes (Mazur, 2001) [30]. Improvement in soybean oil quality includes stabilization of the unsaturated fatty acids by increasing levels of the antioxidant, vitamin E (Yan and Kerr, 2002) [39]. These successes indicate a relevant and important role for biotechnology in improving food quality and developing functional foods, particularly those targeted for needy populations in developing countries, such as children and pre-natal women.

5. Transgenic crops Invention and issues

The release of the first transgenic events with insect resistance (Bt) or HT (Bates *et al.*, 2005) [5] was not engineered to increase yield directly, but experience has shown that, by reducing losses from pests and weed competition, these varieties have in many cases delivered increased yields when compared with conventional crops. For Bt cotton, Fernandez-Cornejo and Caswell (2006) [15] reported that the increases in cotton yields in the Southeast United States were associated with the adoption of HT and Bt cotton in 1997. The same authors quote a 2001 US government survey data showing that maize yield was 9% higher for Bt maize than for conventional maize. Gianessi (2008) [16] reported the outcome of a study in Mississippi over 3 years, in which Bt cotton produced higher lint yields and had an economic advantage when compared with conventional cotton varieties. Although the transgenic varieties in years two and three had greater costs associated with insect control, the economic advantage associated with the transgenic cotton for the 3 years was \$82, \$24 and \$53 per acre, respectively, when compared with conventional cotton varieties. In China, Bt cotton was first approved in 1997 and by 2004 accounted for 69% of cotton grown in China, with 100% adoption in Shandong province, where pest pressure was greatest (James, 2008) [44]. Approval came later in India, in 2002, but as early as 2006, India's Bt cotton area exceeded that of China, and in 2008 accounted for 80% of India's cotton output (James, 2009) [25]. Karihaloo & Kumar (2009) [27] noted that between 2003–04 and 2006–07 cotton yields in India indicate a significant yield advantage of more than 30% with Bt cotton compared with conventional varieties with corresponding increase in farm income.

Yield enhancement varies depending on environment and the local intensity of pest and weed pressures. Commenting on yield increases obtained by Bt maize farmers in Spain, Gomez-Barbero *et al*. (2008) [17] observed regional differences in yield between Bt and conventional maize ranging from) 1.3% to +12.1%, with the yield advantage of Bt directly related to local pest pressure. They noted that Bt technology performed differently in the three regions studied, and this variability was explained by heterogeneity between farmers, differences in pest pressure, agro-ecological conditions and the fact that Bt technology may not yet have been introduced in varieties suitable for all regions.

Carpenter *et al*. 2002 [8] (CAST, 2002) found that the trend in soya bean yields was continually upward through to 2001, a year in which 68% of the total soya bean area was planted with HT soya bean varieties. The study of Fernadez-Cornejo and McBride (2002) [14] suggests that for HT soya bean, a 10% increase in adoption in the USA would lead to a 0.3% yield increase. At the same time, the yield effect seems to be compensated for by the higher seed prices as the authors found that a 10% increase in adoption would lead to no change in net returns on the farm, but the more recent data quoted above for the continuing increase in the numbers of farmers adopting HT soya bean suggest that farmers are finding sufficient benefits overall. Better results were obtained for HT corn where a 10% increase in adoption generated a 1.7% increase in yield and a 1.8% increase in net returns. Commercial planting of HT soya beans in Romania between 1999 and 2008 was associated with an average increase in yields of 31% because of improved weed control, especially of difficult-to-control established weeds such as Johnson grass. A recent report on the sustainability of soya bean production in the USA (CAST, 2009) [9] suggests that about 29 Mha of soya bean are grown each year in 31 states, covering about 22% of the total crop area of the United States. Of this, 92% is now glyphosate-resistant HT, and thus, it is essentially the 'conventional' growing system.

Soil erosion, desertification, climate change, water related issues and biodiversity are all of international importance in relation to sustainable development, and evidence suggests that transgenic crops can have positive impacts in many of these areas. For instance, transgenic crops have the potential to reduce soil erosion via association with lower levels of cultivation. Currently available transgenic events are all related to the modification of pesticide use, and this has the potential to reduce the environmental loading and in particular the movement of highly toxic pesticides into water. When combined with reductions in field operations associated with multiple pass spraying, this can lead to reductions in the amount of GHGs emitted. In these key areas, transgenic crops are already having benefits, and it is likely that these will continue to accumulate as the areas being grown expand. Biodiversity impacts related to transgenic crops are not as easy to quantify. Losey *et al.* (1999) [29] caused alarm with results of a test in which pollen from Bt maize was fed to monarch butterfly caterpillars, from which the caterpillars died; several independent investigations subsequently showed the risk of harm to those butterflies in the field to be vanishingly small (Conner *et al.*, 2003) [11]. The farm-scale evaluation in the United Kingdom illustrated some biodiversity benefits related to HT maize but some negative.

Challenges for Agricultural biotechnology

A main challenge for GMO advocates is stimulating research into technologies that would be benecial to third world countries. Little research is conducted on African crops such as sorghum and cassava. As so-called \orphan crops," they have received little attention for varietal development because of the lack of profit incentives (Takeshima, 2010) [38]. As the prices of these crops have risen, new research has led to better varieties of these crops. Recently introduced semidwarf sorghum produces 3 times the previous yield (Anonymous. 2011) [2]. More investment into African crops is needed, and greater distribution of high-grade seed needs to be available. Alliance for a Green Revolution in Africa (AGRA) has helped set up over 45 seed companies in Africa, and many more are needed to maximize utilization of new seed strands. Investment in local research centers would also be very productive, and it would help alleviate some of the potential problems of biopiracy from foreign farms.

Another issue with GMOs is simply whether or not they are effective. Utilizing herbicide resistant plants can lead to development of herbicide-resistant super-weeds. Roundup Ready crops (herbicide resistant) are shown to increase the level of plants with herbicide resistance, increasing herbicide requirements beyond what would be required without the genetic modification. Bt crops face similar criticism. Bt genes give plants a built-in insecticide, bacillus thuringiensis, effective at pest-control. However, recently Bt resistant varieties of insects have been emerging, actually increasing the required dosages of pesticides required. Similar to the case made against improper use of antibiotics, usage of herbicides and pesticides can lead to the evolution of resistant strains of plants and insects as the organisms develop field evolved resistance." Field evolved resistance occurs when exposure to a toxin increases the frequency of resistance alleles in the subsequent generations of a population, giving it immunity (Takeshima, 2010) [38]. In 2000, there were several reported cases of herbicide-tolerant canola plants cross-pollinating with related weeds, giving the weeds resistance.

However, although cases of resistances exist, studies show that they form a small minority. There are also several strategies that researchers have identified to limit and manage insect resistance. One strategy, known as the refuge strategy, can slow the evolution of resistance traits by increasing the chances that non-mutated insects will mate with the resistance-mutated insects, leading to non-resistant offspring. Bt crops are grown next to non-Bt crops to maximize crossbreeding of surviving insects. Another strategy is known as \pyramiding," where several Bt toxins are used in a crop, making it more difficult for insects to develop immunity (Takeshima, 2010) [38]. A comprehensive study examined 41 cases of Bt crops in several countries over a decade and found that despite a few documented cases of resistance, the vast majority of insect populations still remain susceptible (Takeshima, 2010) [38]. Incorporating the previously mentioned strategies can significantly limit the frequency of field-evolved resistance in future crops. If applied by caution Agriculture Biotechnology may be a weapon to fight hunger, malnutrition and poverty (Singh, Y., 2009a, 2009b.) [35, 36].

Future prospective and conclusion

Genetically-modified foods have the potential to solve many of the world's hunger and malnutrition problems and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides. Yet there are many challenges ahead for governments especially in the areas of safety testing, regulation, international policy and food labeling. Many people feel that genetic engineering is the inevitable wave of the future and that we cannot afford to ignore a technology that has such enormous potential benefits. It has been estimated that demand placed on world agricultural production by 2050 will double assuming moderately high income growth taken together with expected population growth. However, we must proceed with caution to avoid causing accidental harm to human health and the environment as a result of our passion for this powerful technology. Genetic modification has increased production in some horticultural crops but the evidence we have suggests that the technology has so far addressed too few challenges in few crops of relevance to production systems in many countries, even in developed countries a lack of perceived benefits for consumers and uncertainty about their safety have limited their adoption. It was evident that developed biotechnological approaches have the potential to enhance the yield, quality, and shelf-life of fruits and vegetables to meet the demands of the 21st century. However, the developed biotech approaches for fruits and vegetables were more of academic jargon than a commercial reality. To make sure that the current debates and complexities surrounding the registration and the commercialization of genetically modified fruits and vegetables are adequately addressed, various stakeholders in the industry (policy makers, private sectors, agriculturalists, biotechnologists, scientists, extension agents, farmers and the general public must be engaged in policy formulations, seed embodiments, and products development. The full benefit of the knowledge can be reaped if there are total commitment by all stakeholders regarding increased and sustained funding, increase agricultural R&D, and less cost and time for registration and commercialization of new traits.

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