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Review

The Role of Biotechnology in Solving Global Food Crisis

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Biotechnology is the formation of new heritable materials by insertion of nucleic acid molecules produced out side a cell by vector systems. The underlying principles involve dissection of desirable characters using restriction enzymes that protect host DNA by introducing methyl groups at recognition sites. These enzymes produce sticky ends that allow for ligation using phosphodiester bonds, and cloning vehicles (replicons) with high gene dosage allowing for modification in biotechnology. This second generation biotechnology premise give speed and precision, yet only compliments the traditional breeding programs, by re-invigorating life expectancy, productivity, growth in food and agricultural sustainability. USA (68%) Argentina (23%) Canada (7%) China (1%) and South Africa (1%) are fore runners in commercial GM –food production. Most modified crops are corn and soy bean (84%) rap seed (canola) cotton and potatoes (18%), reasons for modification include herbicide tolerance (74%), pest and disease resistance (19%) and biofortification (7%), between 109-120 million acres of land are used for cultivation of GM foods. As the world population quadruples, the only promising tool against global hunger is biotechnology. Nevertheless, are GM foods safe for us? Several criticism advanced are classed as environmental hazards, human health risks, economical and ethical reasons. Most regulatory agencies stance are GM foods are substantially safe, yet insist on mandatory labeling as 'GRAS' with 0% contamination, while importing countries have the right to accept or reject GM foods. We are optimistic that modified food aid will deal with the threatening starvation in sub-Saharan Africa with rampant civil unrest, political corruption and failed agricultural programmes. The only challenges are lack of infrastructures for storage, transportation, insecurity of aid workers and non acceptance. It would be unwise to believe that food insecurity can be eliminated without Agricultural biotechnology.

Keywords: Second generation biotechnology; genetically modified food; Global hunger and food insecurity; World Food Aid Programmes.

INTRODUCTION

Biotechnology allow for the identification and transfer of one or few genes that confer particular benefits with high precision. It is the formation of new heritable materials by the insertion of nucleic acid molecules produced outside a cell by vector systems (Replicon) (Chawla, 1998, NCBE, 2002). The DNA to be inserted into the host (bacterium, animals or plants) may come from prokaryotic cells, Eukaryotic cells or could be synthesized chemically. It enables the transfer of genes between completely unrelated organisms.

Principles and Mechanism of Gene Transfer

Genetic modification starts with the transfer of Deoxy-ribonucleic acids (DNA) the living materials of all organisms. They are made of phosphates and deoxyribose sugars bonded to Nitrogen bases like pyrimidines with Thymine (T) and Cytosine (C) in a single hexagonal ring; and purines with Adenine (A) and Guanine (G) forming a hexagonal ring attached to a pentagonal ring. The rung of DNA ladder is between pyrimidine and purine rings, in RNA, Uracil (U) replaces Thymine. (Garret and Grisham, 1999; Miesfeld, 1999).

DNA's are made of units called genes: These genes contain information that determines traits like amount of Vitamins, or Proteins in a plant or the colour of a fruit. To move these traits scientists must identify where they reside on the chromosomes, separate and purify using gel electrophoresis with high resolution and stain using intercalating fluorescent ethidium bromide (EtBr) stains; in an electrophoretic alkaline buffers like, Tris-acetate (TAE), Tris-borate (TBE) or Tris-phosphate (TPE) with P^H. 7.5 – 7.8; cut the genes for insertion into DNA of another organism; and the genes must express itself in the new organism (Gupta, 1996; Monsanto, 2002).

This principle involves dissecting specific portion (desirable characters) from the DNA of donor organisms by restriction endonucleases (RE). This nucleic acid splitting enzymes help host cells destroy, modify or restrict foreign DNA introduced into them by introducing methyl group at recognition sites to protect the host DNA (Old and Primrose, 1985; Kaul and Nimala, 1999).

Kingsman and Kingsman (1988) observed that RE's like Eco strains c/k differentiated by efficiency of plating on gel, or EcoR serotype, with I, II, III, etc denoting enzymes complex from a single origin are isolated from *Escherichia coli*, and break DNA molecules at non specific sites away from the recognition sequence i.e. 5´ G A¦A T T C 3´ or 3´C T T A A¦ G 5'; Hind III, isolated from *Haemophilus influenza*, break polynucleotide chains producing set of DNA fragments with define nucleotide sequence and length, 5´ A¦A G C T T 3´ or 3´ T T C G A¦A 5´; Hae III from *Haemophilus aegyptica* cut at distance from end of the sequence located on the recognition site, with an axis of rotational symmetry (palindromic sequence) meaning the sequence read the same in either directions in an opposite strands, i.e. 5´ G G ¦C C 3´ or 3´ C C¦ G G 5´; other RE's like Pvu 1 and II isolated from the bacterium *Proteus vulgaris* are nucleotide sequence specific in their cuttings i.e. Penta, Hexa, or Octa, nucleotide sequences. RE besides restricting foreign DNA to be inserted into a vector also cut open the vectors. For each phosphodiester cleavage by RE,>10,000 mol. ATP are hydrolyzed (Chawla, 2004).

Remarkably, RE produces single stranded ends (sticky/cohesive), which joins (anneals) with complimentary single stranded end of DNA from other sources. Rejoining usually occurs *in vivo* (Mantell et al., 1985; Kaul and Nimala, 1999). Three methods are applicable: DNA Ligase links sticky ends produced by RE; *E. coli*, produce DNA ligase infected by T_4 – bacteriophage which links blunt ended DNA fragments; Deoxynucleotidyl transferase introduces single stranded complementary tails to two different DNA populations, after which they anneal when mixed, both however differ in their cofactor requirements (GER,1984; Ignancimuthu, 1998). Chawla (1998) reported that ligases act on DNA substrates with 5´ terminal PO_4^{2+} groups and form the phosphodiester bond between two DNA sequence (vectors and the DNA to be cloned) a process called ligation.

The major cloning vehicles (Replicon) are plasmids, Lambda phage (phage) and Cosmids, with independent replication system from the host cells. Besides the genes for sexual transfer, replicons carry genes for antibiotics or heavy metal resistance, toxins and antibiotic production, but are not essential for the host cells survival (Pattanayak and Kumar, 2000;). A replicon amplify within its hosts DNA producing about 1000- 3000 copies per cell thereby forming DNA chimera (replicon + host DNA). This gene amplification (dosage) favors synthesis of several products useful in biotechnology (Gupta, 1996; Pattanayak and Kumar, 2000; Dubey and Grover 2001).

DNA chimera transfer involves, the spliced vector reforming into circular structures in presence of suitable fragments of foreign DNA's with complimentary sticky ends, forming large amount of foreign DNA digest (fragments). The hybrid DNA enter the host cell by transformation utilizing *Agrobacterium tumefasciens*, after treating host cells in calcium salts and washing in Magnesium (Monsanto, 2002; N C B E, 2003). Other biotechnology derived techniques used to transfer genes into host cells includes; microinjection, electroporation and microparticle bombardment (CFS 2008). Old and Primrose (1985), Kingsman and Kingsman (1988), Gibson and Summerville (1993) and Miesfeld (1999) both opined that recognition of transferred genes involves tissue culture in suitable medium containing antibiotics with specific resistance to the introduced foreign DNA. Growth should occur if desired genes were transferred.

To identify acquired genes (transformed genome) genomic sequencing using automated DNA sequencers. Thus markers to construct genetic linkage maps using restrictions fragment length polymorphism (RFLP) was developed with further innovations polymerase chain reactions (PCR), simple sequence repeat (SSR) and the amplified length polymorphism (AFLP). These advances led to DNA marker dense-maps (average distance of less than 10_cm (centimorgan) between markers) with defined centromeric location and each chromosome delimited with telomere associated markers (Devos and Gale, 2000, Barry, 2001, Rudd, 2003).

Table1 Some genetically modified plants registered by USDA.

PLANT VARIETIES	MODIFIED CHARACTER	PREVALENCE (%)	COUNTRY
Tomatoes and Cantalops	Ripening, drought, salt water tolerance and slow depreciation	68	UK, USA
Soybeans and Sugar beets	Herbicides resistance	74	UK.
Cotton and Corn	Insecticides resistance	19	USA
Rice and Fruits	Enriched with Vit. A	7	South Africa
Sweet Potatoes	Resistance to Fm –virus	19	UK, USA
Vegetables and melon	Increase beneficial vitamins and longer lasting.	15	USA, Asia
Bananas and Papayas	Vaccine administration, and lower allergenicity	10	China, France and Spain.
Canola	Altered fatty acid composition	10	USA
Plum	Virus resistance to Plum pox virus	8	USA, UK

Source: USDA; 2000

Table 2 Approximation (%) of GM-crop production in U. S. A.

YEAR	SOYBEANS	COTTON VARIETIES	CORN
1996	7	15	1.5
1998	42	45	26
2000	54	60	25
2002	58	76	30
2004	85	90	60

Premise of Biotechnology in the 21st Century

Biotechnology has been practiced for many centuries, through breeding and selection of superior plants and animals, use of yeast in bread, enzymes in cheese, brewing, Soy sauce and vinegar production (Kaul and Nimala, 1999). Infact, food biotechnology employs the tools of modern genetics in the age old process of improving food production. This technology helps to produce an abundant supply of better lasting and more nutritious foods (Wapples, 1991; Omar, 2004).

Over time, farmers developed techniques to improve their crops, through traditional methods with limitations of slowly breeding out tens of thousands of unwanted genes. These first generation innovations take up to 10 – 20 years. (Jensen, 1994; Kaul and Nimala, 1999). Today, modern biotechnology allows food producers achieve same feats with greater understanding and precision. Through these modern methods breeders can select and move specific traits into the genetic code of another plant. This forms the premise of second generation biotechnology'. Nevertheless, genetic modification does not replace traditional breeding. It complements it by shortening the time required to develop new varieties of "functional foods" (Deborah, 2000; Ann, 2001; Dubey and Grover, 2001).

Hoban and Kendell (1993), Omar (2004) reported that technological innovations has played important role in meeting human food needs since the down of agriculture. The 19th/20th century benefits of technological innovations like mechanization, hybridization, chemical fertilizer and pesticides are beginning to wane. However the 21st Century technologies biotechnology and information technology tend to re-invigorate life expectancy, productivity, growth in food and agricultural production, thus ensuring sustainability. (Tripathi, 2000).

Agricultural biotechnology in particular promises much, such as drought resistant crop varieties for Africa. It offers opportunity for economic self sufficiency to subsistence farmers in developing countries as in growing genetically enhanced cotton and golden rice enriched with Vitamin A in South Africa (Dubey and Grover, 2001), vaccines against cholera by dietary staples such as Maize and Bananas to combat problems with mass inoculation.

Objectives of the Review

i. Elucidate the potential dangers, basic criticisms, and role of governments in regulation of genetically modified food (GM – Food).

ii. Enumerate agricultural Biotechnology and 'World Food Aid programme of the UN, against shortages and starvation.

Genetically Modified Food

The term GM – Food refer to crop plants created for human or animal consumption using biotechnology. These laboratory modified plants enhances desired traits as increased resistance to herbicides or improved nutritional content (Bennetzen,, 2000; Dubey and Grover,2001). Conventional plant improvement programmes are expensive, time consuming and often in-accurate.

Genetic engineering however creates plants with exact desired traits very rapidly and accurately. Plant geneticist have isolated genes responsible for drought tolerance and inserted same into a different crop variety (01 Toole, 1989; Jensen, 1994). The hybrid is additionally drought resistant and high yielding. This gene transfer also occurs from non plant organisms (Wapples, 1991). Typically *Bacillus thuringiensis* (B.t) genes naturally produces crystal proteins lethal to insect larvae. When introduced into corn and other crops, enables production of self pesticides against insect pests. There are over forty (40) plant varieties modified and registered by the USDA (USDA, 2000).

Thirteen (13) countries produce genetically engineered crops commercially in 2000, out of which, 68%, 23%, 7% are in USA, Argentina, and Canada, while China and South Africa share 2% (USDA, 2000). It further reported that most widely grown GM-crops harvested in 2000 are; Corn and Soybeans (84%); Rapeseed (Canola), Cotton and Potatoes (18%). Reasons for modification includes, herbicide tolerance (74%), insect pests and disease resistance (19%) and nutritional enhancement (7%). Total land acreage devoted to GM-crops approximates at 4.3, 109 and 120 million acres in 1996, 2000 and 2004 respectively, Argentina and USA alone utilize over 99 million acres for commercial cultivation of GM –crops.

Pesticides, herbicides and fertilizer use on these GM-crop varieties were slashed, with attendant yield increase (USDA, 2000; 2004).

Current Advances and Prospects Of Biotechnology

Experts on population growth predicts the greatest challenge in the 21st Century as ' how to maintain an abundant and safe food supply' for the world population expected to double to over 10 billion by 2030, at 230,000 births per day. Biotechnology is the only promising tool to provide more food, check against acute global food shortage and starvation.

Increase crops ability to withstand environmental stress (ES) like heat or cold tolerance; frost destroys sensitive seedling, an anti-freeze gene from cold water fish introduced into tobacco, potatoes, straw berries and beets, confer tolerance to cold temperatures (-6.5°C). Drought and salinity tolerance, with land scarcity, previously unsuited land can be cultivated. Modified plants like cassava, potatoes and paw-paw can withstand long periods of drought or high salt content in soils (01 Toole, 1989; Wapple, 1991; Jensen, 1994).

Increase production by improvement in the agricultural gene pool conservation, and check against varieties lost as in several rice and Irish potatoes in India and Ireland respectively (Omar, 2004). Pest resistance escalates crop yield losses. Many tons of chemical pesticides and fertilizers applied annually poses potential health hazard, run offs contaminate water supply and the environment. GM-foods reduce cost of production, eliminate insect pest resistance, pesticide poisonings and increased ability to draw nitrogen from the soil. Herbicides tolerant GM crops show resistance to powerful herbicides, reduce usage and allow more effective "weed management" as in GM-Soybeans Round up® tolerance.

Production of safer food by lowering the amount of allergy causing proteins, identify and isolate toxins, pathogens or food contaminants. Improve products vital to functional food production such as enzymes, proteins and vitamins, e.g. improved rice with protein profile having high levels lysine and essential amino acids. Third world dietary crops like rice, cassava and corn lack adequate amount of nutrient. If genetically modified, additional vitamins and mineral salt, such as beta carotene (Vit.A) and increase protein enriched 'golden rice' against blindness and high nutritional content (Bennetzen, 2000, Dubey and Grover,2001; AFIC, 2003).

Better tasting tomatoes all year round which softens slowly (depreciation) with added flavor and color, hence applicable to other fruits like bananas, mangoes, cashew and papayas, with high levels of vitamins C, E and A, to reduce risk of chronic cardiac diseases, cancers and blindness. Modified and healthier cooking oils, with low fat content derived from corn, soybeans, canola and other plants; lower fat French fries and potato chips made from high starch potatoes which absorbs less oil when fried.

Non leguminous nitrogen fixation, crop yield potentials, food storage and enzyme value increased 1000 fold by gene amplification. Phyto-remediation of poplar trees, without soil and water to avoid pollution. Disease resistances to many viruses, fungi and bacteria have been engineered to produce genetic vaccines in papayas, squash melon, lettuce, Cucumber and bananas. Medicines and vaccines cost of production and need for special storage condition are lacking in most 'third world' countries. As such edible vaccines in bananas, tomatoes and potatoes for cholera, diabetes, typhoids and dwarfism which are easier to ship, store and administer than the traditional injectable vaccines characterized by allergens are produced. So also interferon (anti-viral and anti-tumor proteins) production to circumvent the difficulties of low yield and high cost of production. Lastly development and proliferation of biological weaponry (*B. anthracis).*

Criticism of BT and their Classification in a Scientifically Enlightened Word

Is GM food safe for use? Do the scientific techniques used pose any threat to the environment? Protesters in England opined that, our only objection to GM food is they are unsafe unwanted and unnecessary: BT has move at a comet speed that neither the law nor regulating agencies can keep pace with its advancement. Researchers warn that no long term large scale tests to prove safety of the GM-organisms. Environmentalists, religionist, governments and royalty sternly criticize agric-business for pursuing profit without concern for potential hazards (Hoban and Kendell, 1993; Hallerman, 1997; Deborah, 2000; AFIC, 2003).

Most criticisms are classified into

i. Environmental hazards: Un–intended harm to other organisms is envisaged. A study with B. t corn caused high mortality rate in Monarch butterfly Caterpillars fed Milk weed plants from neighboring field; unfortunately B. t, toxins additionally kill beneficial insects indiscriminately (van Emdem, 1996, Anup, 2000).

ii. Reduced effectiveness of pesticides; It is most likely that insects will become resistant to B.t or other crops genetically modified for pesticides, as in the resistance to DDT – by mosquitoes. Gene transfer to non target species is likely, as crop plants engineered for herbicide tolerance and weeds may cross breed. Therefore transfer herbicide resistance genes from crops to weeds. These' super weeds' would be herbicides tolerant. Other introduced genes may cross over into non-modified crops planted next to GM crops by interbreeding.

iii. Human health risks; as most children develop life threatening allergies to pea nuts and other foods. Introducing a gene into plants may create new allergens in susceptible individuals. Arapad (1999) reported significant difference in intestines of rats fed GM Potatoes and those fed unmodified potatoes. Along with modified genes are marker genes to determine if desired genes have been successfully embedded. These marker genes may result to wide spread antibiotic resistance.

iv. Economically, production and marketing of GM food is lengthy and costly process. Agric-biotechnology companies desire profitable returns, Labeling, Patentment and infringement rights are of concern to agric-business. These definitely raises the prices of seed, hence unaffordable for small farmers and 'third' world countries, making GM – crops in-accessible thereby widening the gap between wealthy and the poor nations, against the UN-millennium goals-2006.

v. Ethically, BT Crosses fundamental thresholds (biological boundaries) making species simply genetic information or fluid, hence changing the nature of life (Hallerman, 1997). Does life have intrinsic or just utility value, do we owe obligation to the generations unborn and other creatures we co-exist with (Mafe and Aminu, 2008).

Recommended solution to these criticisms

From the fore-going it is obvious; we need to genetically develop low risk GM-crops to non target organisms. Genes are exchanged between plants via pollen and seed, creating male sterile GM-plants (non pollen producing) or lacks introduced genes to check against cross pollination; create buffer zones 6 – 30 meters around GM crop fields to provide refuge for non target and beneficial insects.

With exception of allergenicity, scientist believed GM foods are not harmful to humans. Rocky feller foundation and other NGO's may offer financial succor in development of GM crops. Possible protection for patent-infringement is to introduce a suicide gene into GM – plants. Such seed will be viable only in one cropping season and would produce sterile seeds. Farmers may have to buy fresh supply of seeds and seedlings every cropping season. This would be financially disastrous to farmers in the developing countries.

Prince Charles of England argue that transfer of genes between unrelated species is exploring the realm of God, only time will tell, the danger inherent in this second generation technology to humans and the environment.

Edicts and regulatory measures of GM-Foods

Our palate could hardly distinguish GM foods from natural ones; there is need for proper labeling and acceptance. Governments around the world face the challenge of establishing bio-safety laws and regulatory process to monitor effects and approve new varieties of GM plants (Hallerman, 1997; Tripathi, 2000). For political, social and economic reasons, different governments respond in different ways. Japan insist on mandatory health testing of GM foods; India strongly support transgenic plant research, believing the benefits out weights the risks as a drastic measure to counteract its endemic poverty and feed its exploding population (Kaul and Nimala,1999, Chawla,2004). Brazil, Zambia and Niger have banned GM crops and had filed suits to prevent importation even as food aids. Nevertheless, smuggling GM soybeans tend to undermine these edicts.

In Europe, 1999 marked the turning point in Europeans attitudes to GM – foods. This unofficial bans may be short lived, the only choice then will be either to accept or reject GM- foods (Hoban and Kendell, 1993). Due to the bovine spongiform encephalopathy (mad cow disease) in

Europe and Great Britain, and Dioxin tainted food from Belgium, had undermine consumer confidence about European food supply. There is lack of trust in governments' information about the GM food. European commission (EC) has established 1% threshold contamination of unmodified food with GM food products. In the US, regulatory process is conflicting since three government agencies have jurisdiction over GM foods; EPA – evaluates environmental safety; USDA- evaluates safety of growing GM plants, and FDA-evaluates safety of consumption. Nevertheless, the FDA stance is GM-foods are substantially equivalent to un-modified 'natural' foods. By its risk assessment established tolerance, residue levels for pesticides and licensed farmers to plant 20% unmodified corn, and up to 50% in cotton fields. Animal and plants health inspection service (APHIS) unit of USDA issue permits for growing of GM plants only on meeting this six (6) criteria: (i) not likely to be a noxious weed; (ii) introduced gene is stably integrated into the plants own genome, (iii) function of introduced gene is known and would not cause plant diseases; (iv) the GM plant is not toxic to non target organisms, (v) introduced gene will not cause the creation of new plant pathogen (Viruses), (vi) the GM – plant cannot contain genetic materials from animals or human pathogens.

Genetically modified crop labeling

Hallerman, (1997) said people have the right to know what they eat. Most agric-business industries have proven unreliable at compliance with existing safety regulations. Safety monitoring agencies of the UN, gave acceptable label as 'GRAS' (Generally recognized as safe), with 0% contamination of unmodified products advocated. However, the available methodologies cannot detect even the EC acceptable 1% limit of cross contamination. Furthermore manufacturers commonly pledge compliance, but are not monitored, more so, what is the penalty for non compliance. In January, 2000, an International trade agreement for Labeling GM foods were established (Ann, 2001). Over 130 countries signed the agreement, 'That all exporters are required to label all GM foods, while importing countries have the right to judge for themselves the potential risk, to either accept or reject GM foods (Deborah,2000).

Role of Agricultural BT in world food aid

Biotechnology has the potentials to reduce chronic hunger, particularly in sub Saharan Africa where the 'Green Revolution' of the 70's never held. Food aid is a reliable global mechanism created to deal with hunger and food insecurity. This need varies with countries from specific responses to acute and episodic shortages to long term donations of food to abate chronic inability of some regions to become agriculturally self sufficient. Despite the worlds prosperity and technological advancement, over 800 – 850 million people are still malnourished, 20 million of these are children. Another 1.0-1.5 billion humans have marginal access to functional food, majority of these nutritionally at risk population live in developing countries. Poverty and hunger are strongly linked; family income is the single determinant of access to adequate food. The World Food Summit in 2002 reaffirmed a commitment of the international community five years earlier to halve number of hungry people by the year 2015. Attainment depends on increased agricultural productivity and personal income of the world's poorest regions.

Eliminating poverty is assumed more vital than producing more food, economists opined that surplus food is being produced, but adequate distribution poses a hindrance. Nevertheless, if the rural poor can produce surplus food sustainably, there will be adequate food supplies, increase income and opportunity for rural development. Mean while an adhoc approach to hunger is aid, although strongly politicized, skeptics assert it is simply an avenue for rich nations to eliminate the surpluses produced by their heavily subsidize farmers; it also robes local farmers of market and tend them to hunger also.

Eliminating chronic hunger through BT

The 'Green Revolution helped India, China and other Asian countries become agriculturally self sufficient and net exporters of food. This increased productivity is accompanied by increases in personal income and stimulates national economies. Quite contrary in sub-Saharan Africa, the 'Green Revolution' never happened, additionally civil unrest and political corruption have contributed greatly to lack of investment and adoption of technological innovations and management practices.

Agricultural production has not kept pace with expanding demand in the sub-Saharan Africa. Being the poorest with most depleted agricultural soils, only 4% of irrigate able land, significant land at risk of desert encroachment, high incidence of pests and diseases and weeds like *Striga* stifle yields, others like droughts, poor yields and 100% crop failures are endemic. Only BT has the potentials to develop crop varieties and management strategies that are more productive under these conditions (environmental stress tolerance),

Commercial application of agricultural BT gave more productive and profitable modified crops for the farmers, with major reduction in costs for labor, energy and chemicals, these crops are environmentally friendly with regard to bio diversity, reduction in soil and water contamination and decrease carcinogenicity in workers and communities exposed to chemicals. International consensus opined that BT crops are safe to eat as food and feed stuff.

Challenges Posed By Acute Food Shortage

Crop failures often lead to acute food shortages and hunger due to episodic events as flood, drought or civil wars. The UN, NG and assortment of NGO's often respond by mobilizing immediate food aid programs. However, distribution is hindered by lack of infrastructures for storage, transportation and often insecurity of aid workers. Most recent obstacle identified is non acceptance of GM-foods by recipient countries threatened with acute food shortage and starvation. Even when certified 'GRAS' in light of the global scare campaigns, nations like Zimbabwe, Zambia etc, lack regulatory and safety evaluation systems. Intensive international consultation and fact finding may alley such fears.

CONCLUSION

The Second generation biotechnology exploits speed and precision to create genetically modified food, grown in most developed nations. Despite serious criticisms, it is pertinent to note that combating chronic hunger and provision of functional food to the developing nations depends on this premise, along with adequate distribution system of the "World Food Aid Programme" of the United Nation.

REFERENCES

Ann MV (2001). Food and Agricultural Policy; Taking Stock for New Century. Agricultural Biotechnology, *USDA Report*. PP. 1 – 2.

Anup S (2000). Bio Safety Protocol: Global Issues. http://www.global issues.org/Envissues/Biodiversity/Biosafety 2000. asp.

Arapad P (1999). Rat Feeding Study with Lecithin Incorporated Potatoes. *The Lancet*. NCBE. U.K pp. 1 -3.

Asian Food Information Centre (AFIC) (2003). Intellectual Property Rights. Patentment of Innovations in Genetic Engineering. *AFIC News-Letter,* 6: 92-101

Barry GF (2001). The use of the Monsanto Draft rice genome sequence in research. *Plant physiol.125*:1164-1671

Bennetzen JL (2000). Transposable Element Contributions to Plant Gene and Genome Evolution. *Plant Molecular Biology*. 42: 251 – 269.

Bruce C (2003). Role of Agricultural Biotechnology in World Food Aid. B.C. Economic Publ. pp. 1 – 4.

Canadian Forest Service (CFS), (2006). Transgenic Trees. *Science.gc.ca*

Chawla HS (1998). Biotechnology in Crop Improvement. International Book Distributing Co. Lucknow.

Chawal HS (2004). Introduction to Plant Biotechnology 2nd Ed. Oxford & IBH, Publ. Co. LTD. New Delhi.

Deborah BW (2000). Genetically Modified Foods Harmful or Helpful. Cambridge Scientific Abstract, pp. 1 - 12.

Devos KM and Gale MD (2000). Genome relationships. The grass model in current research, *Plant cell 12*: 637-640

Dubey H and Grover A (2001). Current Initiatives in Proteomics Research. The Plant Perspective. *Current Science*. 80: 262 – 269.

Garret RH and Grisham CM (1999). Bio-chemistry, Saunders College Publ. Orlando Florida.

Genetic Engineering Report (GER), (1984). *Chemical Engineering News,* 2 (33): 110 – 165.

Gibson S and Summerville C (1993). Isolating Plant Genes: A review. *Trends in Biotechnology*, 2: 306 – 312

Gupta PK (1996). Elements of Biotechnology. Rastogi Publishing. Meerut-India.

Hallerman EM (1997). Bioethics and Biotechnology. NAGA. *The ICLARM Quarterly*. Jan- Mar. 13 – 17

Hoban TJ and Kendell PA (1993). Consumer Attitudes about Food Biotechnology. Dept. of Sociology and Anthropology. North Carolina State Univ. Raleigh. U.S.A.

Ignancimuthu S (1998). *Plant Biotechnology*. Oxford and IBH Publishing. Co. PVT LTD. New Delhi.

Jensen S (1994). Genetic Improvement of Maize for Drought Tolerance. In Jewell et al. (Eds) Maize Research for stress environments. Proc. Of 4th E & S Africa Regional Maize Conf. Harare.

Kaul MLH and Nimala C (1999). Biotechnology; Miracle or Mirage. In: Breeding in

Crop Plants Mutations and *In vitro* Breeding. Siddiqui, B.A, and S. Khan (Eds.) Kalyani Publ. India.

Kingsman SM and Kingsman AJ (1988). Genetic Engineering : An Introduction to gene

Analysis and Exploitation in Eukaryotes. Blackwell Scientific Publ. Oxford.

Mafe M and Aminu Y (2008). Biosafety Regulations and Bioethics: Internl. Workshop on Biotechnology, Yola. Pp 16.

Mantell SH, Mathew and Mckee RA (1985). Principles of Plant Biotechnology. An Introduction to Genetic Engineering in Plants. Blackwell Scientific Publ. Oxford.

Miesfeld RL (1999). Applied Molecular Genetics. Willy-Liss Publ. New York.

Monsanto (2002). Biotechnology Basics, National Centre for Biotechnology Education.6

National Centre for Biotechnology Education (NCBE) (2003). Genetically Modified Food. *Euro barometer Survey EU.*

Omar Salim Ahmed (2004). Biodiversity for Food Security. *UN (FAO) Report*, Nigeria. pp. 1 – 4.

Old RW and Primrose SB (1985). Principles of Gene Manipulation. An Introduction To Genetic Engineering. Blackwell Scientific Publ. Oxford.

Ol Toole JC (1989). Breeding for Drought Resistance in Cereals: Emerging New Technologies. In Baker, F.W.G (Ed). *Drought Resistance in Cereals*. Pp.81-94.

Pattanayak D and Kumar PA (2000). Plant Biotechnology: Current Advances and Future Perspectives. *Proc. Ind. Acad. Scie -13*. 6 : 266 – 310.

Rudd S (2003). Expressed sequence tags: Alternative or compliment to whole genome sequences. *Trends in Plant Science.8*: 1360-1385

Snustad DP, Simmons MJ and Jenkins JB (1997). *Principles of Genetics.* John Willey and Sons New York.

Tripathi KK (2000). Bioinformatics: The Foundation of Present and Future Biotechnology. *Curr. Sc*. 79: 570 – 575.

van Emdem HF (1996). Pest Control, 2nd Ed. ELPE, Australia.

United States Department of Agriculture (USDA) (2000). Regulatory measures on Biotechnology Research and Adoption. *Annual Report*, Pp. 28.

United States Department of Agriculture (USDA) (2004). Innovations on labeling and patentment of GMO's *Annual Report*, 2 Pp. 34.

Wapples RS (1991). Pacific Salmon *Oncorhyncus spp*, and the definition of "Species" Under the endangered species Act. *Mar. Fish Review*. 53 (3): 11 – 22.