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REVIEW ARTICLE

GM FOODS OR NOT

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ABSTRACT

In the last decade, most of the developed countries had harvested the yields of GM crops and equally had opposed them in certain contexts. GM foods had reached the markets and are being utilized on daily basis in the developed countries. Cosumer awareness is the point of concern and there are confusions prevailing among consumers regarding GM crops. There are no clear policies regarding the marketability of GM products. Policies vary across the countries. Certain countries follow the labeling of GM products while some others do not, hence consumers are not clear regarding the usage of GM products. Oppositions for GM foods do exist in various fields including environmental concerns, animal feed and human consumables. Despite of the consequences, there are more prospects for GM technology. This potential technology had wide range of applications in various fields. Lifesaving therapeutics developed through recombinant DNA technology including insulin, thromboplastins etc. are genetically modified in one or the other organisms for the benefit of mankind. The need for genetic modification, development of GM crops, environmental concerns, environmental protection using GM technology, applicability of GM products for human needs, animal feeds, their cross contamination controversies, monopoly of certain companies, controversies faced by the developed counties, challenges targeted to developing countries, scientific solutions, marketability of GM products, labeling controversies, regulatory authorities, policy decision by various countries, consumer concerns and overall importance of GM crops is dealt in this review article.

INTRODUCTION

Need for Genetic modification

Gene pools of many crop species are limited; hence conventional plant breeding methods cannot provide solution for various kinds of stresses. Hence there is a need for transfer of genes across the species. Advances in biotechnology over the last few decades have paved way for molecular breeding. Today genetically modified crops developed through gene transfer technologies, are in cultivation in more than thirty countries. Transgenic technologies offer advantage as they provide gene transfer from any source of interest. Advanced high throughput sequencing techniques over last few years had made available genome sequencing of many species and the information generated can be used for genetic transformations in Crop Improvement.

Genetic modification methods verses conventional methods

It takes five to six generations to transfer a trait within a species/ into the high yielding locally adapted cultivars through conventional breeding and one has to screen a large number of progenies to select the plants with appropriate combination of traits. The improved lines developed, have to go through a set of multi-location tests, before a variety could be identified for cultivation by the farmers. This process takes minimum 7-10 years. Moreover, crop gene pools are limited. They may not contain genes to provide resistance to all the diseases. However, the transgenic approach not only provide access to genes from other species, but also helps in engineering and transfer of the genes to the target organism where it can express and exhibit its beneficial activity. The genes of interest can be transferred into the target cultivars in a single event, thereby improving the cultivars tolerant to various stresses. The lines thus produced can be released for cultivation by the farmers or used as donor parents in the conventional plant breeding. Genetic engineering offers plant breeders access to an infinitely wide array of novel genes and traits, which can be inserted through a single event into high-yielding and locally-adapted cultivars. This approach offers rapid introgression of novel genes and traits into elite agronomic backgrounds. Future impacts of biotechnology in crop production will be in the areas of: (i) developing new hybrid crops based on genetic male-sterility, (ii) exploit transgenic apomixes to fix hybrid vigor in inbred crops, (iii) increase resistance to insect pests,

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diseases, and abiotic stress factors, (iv) improve effectiveness of bio-control agents, (v) enhance nutritional value (vitamin A and iron) of crops and post-harvest quality, (vi) increase efficiency of soil phosphorus uptake and nitrogen fixation, (vii) improve adaptation to soil salinity and aluminum toxicity, (viii) understanding nature of gene action and metabolic pathways, (ix) increase photosynthetic activity, sugar and starch production, and (x) production of pharmaceuticals and vaccines. New crop cultivars with resistance to insect pests and diseases combined with bio-control agents should lead to a reduced reliance on pesticides, and thereby reduce farmers' crop protection costs, while benefiting both the environment and public health. Similarly, genetic modification for herbicide resistance to achieve efficient and cost effective weed control which can increase farm incomes, while reducing the labor demand for weeding and herbicide application. By increasing crop productivity, agricultural biotechnology can substitute for the need to cultivate new land and thereby conserve biodiversity in areas that are marginal for crop production. The potential of these technologies has been extensively tested in the model crop species of temperate and subtropical agriculture. However, there is an urgent need for an increased focus on crops relevant to the small farm holders and poor consumers in the developing countries of the humid and semi-arid tropics. The promise of biotechnology can be realized by utilizing the information and products generated through research on genomics and transgenics to increase the productivity of crops through enhanced resistance to biotic and abiotic stress factors and improved nutritional quality.

Genetic transformation offers direct access to a vast pool of useful genes not previously accessible to plant breeders. Current genetic engineering techniques allow the simultaneous use of several desirable genes in a single event, thus allowing coordinated approaches to the introduction of novel genes/traits into the elite background. The priorities for applied transgenic research are similar to those of conventional plant breeding, aiming to selectively alter, add or remove a specific character in order to address regional constraints to productivity. Genetic engineering also offers the possibility of introducing a desirable character from closely-related plants without associated deleterious genes from related species, which do not readily cross with the crop of interest or from completely unrelated species, even in other taxonomic phyla (Sharma 2000).

GM Crop Area, by Country, Crop and Trait

The global hectarage of biotech crops have increased more than 100-fold from 1.7 million hectares in 1996 to over 175 million hectares in 2013, this makes biotech crops the fastest adopted crop technology in recent history. This adoption rate speaks for itself in terms of its resilience and the benefits it delivers to farmers and consumers. The most compelling and credible testimony to biotech crops is that during the 18 year period 1996 to 2013, millions of farmers in approximately 30 countries worldwide, elected to make independent decisions to plant and replant an accumulated hectarage of more than 1.6 billion hectares. This is an enormous area equivalent to greater than 150% the size of the total land mass of the US or China. There is one principal and overwhelming reason that underpins the trust and confidence of risk-averse farmers in biotechnology is that biotech crops deliver substantial, sustainable, socio-economic and environmental benefits. A record 175.2 million hectares of biotech crops were grown globally in 2013, at an increased annual growth rate of 3% i.e., an increase of 5 million from 170 million hectares in 2012 and the year 2013, was the 18th year of commercialization, when growth continued after a remarkable 17 consecutive years of increases; notably 12 of the 17 years were double-digit growth rates. In 2013, a record 18 million farmers, compared with 17.3 million in 2012, grew biotech crops and remarkably, over 90%, or greater than 16.5 million, were risk-averse small, poor farmers in developing countries (James 2013).

Of the 27 countries which planted biotech crops in 2013, 19 were developing and 8 were industrial countries. Each of the top 10 countries, of which 8 were developing, grew more than 1 million hectares providing a broad-based foundation worldwide, for continued and diversified growth in the future. More than half the world's population, 60% or approximately 4 billion people, live in the 27 countries planting biotech crops. For the second consecutive year developing countries planted more biotech crops than industrial countries in 2013. In China, 7.5 million small farmers benefited from biotech cotton and in India there were 7.3 million beneficiary farmers. The latest economic data available for the period 1996 to 2012 indicates that farmers in China gained US$15.3 billion and in India US$14.6 billion. In addition to economic gains, farmers benefited enormously from at least a 50% reduction in the number of insecticide applications, thereby reducing farmer exposure to insecticides, and importantly contributed to a more sustainable environment and better quality of life (Brookes 2014). Bangladesh approved a biotech crop (Bt. eggplant) for the first time in 2013 to plant in the fields, whilst the situation in Egypt put planting on-hold, pending a government review. The approval by Bangladesh is important in that it serves as an exemplary model for other small poor countries. Very importantly, Bangladesh has broken the impasse experienced in trying to gain approval to commercialize Bt. eggplant in both India and the Philippines. It is noteworthy that two other developing countries, Panama and Indonesia, also approved cultivation of biotech crops in 2013 for commercialization in 2014. Latin American, Asian and African farmers collectively grew 94 million hectares or 54% of the global 175 million biotech hectares (versus 52% in 2012) compared with industrial countries at 81 million hectares or 46% (versus 48% in 2012) i.e., almost doubling the hectare gap from approximately 7 to 14 million hectares between 2012 to 2013 (James 2013).

The five leading biotech developing countries on the three continents of the South: Brazil and Argentina in Latin America, India and China in Asia, and South Africa on the continent of Africa, grew 47% of global biotech crops and have approximately 41% of world population. Brazil ranks second only to the USA in biotech crop hectarage in the world with 40.3 million hectares (up from 36.6 million in 2012) and is emerging as a strong global leader in biotech crops. The US continued to be the lead producer of biotech crops globally with 70.1 million hectares (40% of global), with an average adoption rate of approximately 90% across its principal biotech crops. Biotech canola in Canada still enjoyed a high adoption rate of 96% in 2013. India cultivated a record 11.0 million hectares of Bt. cotton with an adoption rate of 95%, whilst 7.5

million small resource poor farmers in China grew 4.2 million hectares of Bt. cotton with an adoption rate of 90%, cultivating on average, approximately 0.5 hectare per farm. Africa continued to make progress with Burkina Faso and Sudan increasing their Bt. cotton hectarage substantially, and South Africa with its biotech hectarage at marginally less but practically the same level as 2012. Five European Union countries planted a record 1,48,013 hectares of biotech Bt maize, up 15% from 2012.Spain was by far the largest adopter planting 94% of the total Bt maize hectarage in the European Union (James 2012).

Herbicide tolerance: Farmers in their regular agronomic practice spray herbicides to destroy weeds and small herbs in the crop fields so as to minimize the difficult procedures like manual weeding and tilling. These herbicides sometimes cause losses to the crop plants and also cause harm to collateral hosts and environment. An example for this is the Roundup (herbicide) tolerant soybeans, produced by Monsanto which makes their soybeans tolerant to Roundup, thus helping farmers to spray Roundup once and thus can prevent weeds in their fields (Monsanto 1999).

Table 1. Regulatory agents of GM foods in various countries

Country	Authority of Regulation	Functions
Japan	Ministry of Health and Welfare	Health testing of GM foods will be mandatory as of April 2001
Brazil	Brazilian Institute for the Defense of consumers along with Greenpeace	Filed a suit to prevent the importation of GM crops
Europe	European Commission (EC)	mandatory food labeling of GM foods
United States of America	EPA	Evaluates GM plants for environmental safety
	USDA	Evaluates whether the plant is safe to grow
	APHIS -Animal Health and Plant Inspection Service APHIS is a branch under USDA	
	FDA	Evaluates whether the plant is safe to eat.
India	Ministry of Environment and Forests, Ministry of Science and Technology, Ministry of Agriculture and Cooperation etc.	GM regulations, At present no GM food products in market.

Advantages of GM crops

Pest Resistance: The prospects of Bt. (*Bacillus thuringiensis*) had wide range of applications in different crop species. For instance against boll worm in cotton, leaf folder, stem borer in rice etc. Bt proteins are called as crystalline proteins, they target the midgut of the insects, act on the intestinal cell wall and finally kills the insect due to the leakage of cell wall (Bravo 2007).The genes responsible for these crystalline proteins were genetically transformed from the bacteria into the plants and thereby protect the plants from various insect pests (Schnepf 1998).The applications of Bt. genes thus avoids the usage of chemical pesticides, thereby protecting the environment and helping the farmers from the input costs of the pesticides (Mendez 2011)

Controversy: The Bt. genes which are intended to protect the crop species from various pests were equally harmful to collateral insects which are not harmful to plants like monarch butterflies etc. These butterflies were affected from the pollen produced by the GM plants (Losey 1999).

Gene flow

Pollen from the GM crops flows through a distance of about 200m into surrounding fields and this makes the non GM crops cross pollinated with GM crop's pollen thus carrying the gene into surrounding fields. This is of huge concern in the recent years in all the countries which adopted GM crops (Rao 2012).

Solution: These small controversies can be managed by planting distantly related crop species (Daniell 2002) surrounding GM crops and also by leaving buffer zones (Kareiva 2000) where GM crops are planted and by creation of male sterile plants (Daniell 1998) so that the pollen will not be fertile to cross prospects other plants.

Controversy: There are chances of gene flow from roundup tolerant soybeans into nearby weeds in neighboring fields and thereby making super weeds (Jonathan 1999) which can tolerate Round up.

***Solution*:** GM crops can be planted leaving some buffer zones nearby so as to prevent the gene flow into neighboring fields.

Abiotic stress tolerance

Crops plants were modified with genes from various sources to provide resistance for various stresses like drought (Jeffrey 2014) salinity (Hong-Xia 2001) submergence (Hattori 2009) cold tolerance (Kenward 1999), high temperature tolerance (Murakami 2000) etc.

Disease resistance

Crop plants were modified to provide resistance against various bacterial (Dahleen 2001), fungal (Fukuoka 2009) and viral (Scorza 2001) diseases to make the plants resistance to diseases.

Enhancement of nutrition

Food crops were fortified with iron (Goto 2000) and beta carotene (Ye 2000) in different trials to enrich the foods with these nutrients so that the people of the third world countries who cannot afford these nutrients additionally, can avail these nutrients by consumption of food grains. This helps people to overcome blindness, and also protects them from malnutrition as the bio-fortified foods would contain iron and zinc, the essential nutrients required for young children and women who are found to be deficient of these nutrients and most of the deaths worldwide are caused due to malnutrition. Examples include Golden rice enriched with beta carotene.

Vaccines

Keeping in view of the developing countries and third world countries which cannot afford for vaccines and therapeutics, vaccines are incorporated into fruits like banana (Mason 2002) and vegetables like tomatoes and potatoes (Arakawa 1998) so as to provide good health to the population by eradicating diseases with edible vaccines (Henry 2001). Edible banana vaccine is an example of this kind.

Phytoremediation

GM plants were used for phytoremediation to protect the environment. Soil and ground water pollution is a problem in several parts of the world. Tress like ‘popular’ are genetically modified to remove heavy metals (Bizily 2000) from the soil.

Other fields: Genetic modification is essential for experimental purposes to study the metabolism and physiological aspects of the functioning of various organs, enzymes etc. New findings can be possible only if modifications are done to study on comparison with controls (non modified ones). Several micro organisms are genetically modified for different purposes in different fields. Several recombinant proteins like insulin (Diane 2011) are life-saving. Genetically modified microbes are used in environmental protection; some of them are used to degrade oil spills (Chakrabarty 1975) in the oceans which cannot be done by any other natural means. Research is now focused even to create GM animals for high fat content and milk proteins (Sabikhi 2007).

Global value of biotech seed alone was approximately US$15.6 billion in 2013

Global value of biotech seed alone was ~US$15.6 billion in 2013. A 2011 study estimated that the cost of discovery, development and authorization of a new biotech crop/trait is approximately US$135 million. In 2013, the global market value of biotech crops, estimated by Cropnosis, a leading provider of market research and consultancy services in the crop protection and biotechnology sectors, was US$15.6 billion, (up from US$14.6 billion in 2012); this represents 22% of the US$71.5 billion global crop protection market in 2012, and 35% of the ~US$45 billion commercial seed market. The estimated global farm gate revenues of the harvested commercial ‘end product’ are more than ten times greater than the value of the biotech seed alone. It is estimated that India enhanced farm income from Bt. cotton by US$ 2.5 billion in 2010 alone (Brookes 2012).

Biotech crops contribution to Food Security, Sustainability and Climate Change

From 1996 to 2012, biotech crops contributed to Food Security, Sustainability and Climate Change by a) increasing crop production valued at US$116.9 billion b) providing a better environment, by saving 497 million kg annual income of pesticides; in 2012 alone reducing CO_2 emissions by 26.7 billion kg, equivalent to taking 11.8 million cars off the road for one year. c) conserving biodiversity in the period 1996-2012 by saving 123 million hectares of land; and helped alleviate poverty by helping approximately 16.5 million small farmers, and their families totaling approximately 65 million people, who are some of the poorest people in the world. Biotech crops can contribute to a ‘sustainable intensification’ strategy favored by many science academies worldwide, which allows productivity/production to be increased only on the current 1.5 billion hectares of global crop land, thereby saving forests and biodiversity. Biotech crops are essential but are not a panacea and adherence to good farming practices, such as rotations and resistance management which are also essential for biotech crops as they are for conventional crops.

Contribution of biotech crops to Sustainability

Biotech crops are contributing to sustainability in the following five ways:

- Contributing to food, feed and fiber security and self sufficiency, including more affordable food, by increasing productivity and economic benefits sustainably at the farmer level.
- Conserving biodiversity; biotech crops are a land saving technology.
- Contributing to the alleviation of poverty and hunger.
- Reducing agriculture’s environmental footprint.
- Helping mitigate climate change and reducing greenhouse gases.

Regulation of biotech crops and labeling

The lack of appropriate, science-based and cost/time-effective regulatory systems continues to be the major constraint to adoption. Responsible, rigorous but not onerous, regulation is needed, particularly for small and poor developing countries, which are “locked out” completely because of the high costs involved in developing and gaining approval of a biotech crop. It is noteworthy, that on 6th November 2012, in California, USA, voters defeated Proposition 37, the proposed state petition on “Mandatory Labeling of Genetically Engineered Food Initiative” the final result was No- 53.7% and Yes- 46.3% (James 2011). A similar poll in Washington State in November 2013 had a similar outcome except that the result had wider margins in favor of no labeling 55% -No and 45% -Yes.

Future Prospects

In the scientific community associated with biotechnology, there is cautious optimism that biotech crops, including both staple and orphan crops, will be increasingly adopted by society, particularly by the developing countries, where the task of feeding its own people is formidable, given that the global population, most of whom will be in the South, will exceed 10 billion by the turn of the century in 2100. We cannot feed the world of tomorrow with yesterday’s technology. Whereas rice is the most important food crop in China, and maize is the most important feed crop. Over 35 million hectares of maize is grown in China by an estimated 100 million maize-growing households. Other maize producing countries in Asia, including Indonesia and Vietnam, have field tested HT(Herbicide Tolerant)/Bt maize and are likely to commercialize in the near-term, possibly by 2015.Subject to regulation, another very important product for Asia is Golden Rice which should be ready for release to farmers by 2016 in the Philippines. Bangladesh has also assigned high priority to the product. Golden Rice is being developed to address Vitamin A Deficiency which results in approximately 2.5 million children a year dying with an additional 500,000 becoming permanently blind. Patrick More has opined that denying Golden Rice to malnourished dying children is *"a crime against humanity"* the moral imperative for Golden Rice is beyond question.

In the Americas the increased adoption of biotech drought tolerant maize and transfer of this technology to selected countries in Africa will be important, as well as the adoption of the virus resistant bean developed by Brazilian Agricultural Research Corporation (EMBRAPA) in Brazil and scheduled for deployment in 2015. In Africa there are three countries, South Africa, Burkina Faso and Sudan already successfully commercializing biotech crops and the hope is that several of the seven additional countries currently field testing biotech crops will graduate to commercialization. The early predominant products that will likely feature are the well-tested biotech cotton and maize, and subject to regulatory approval, the very important Water Efficient Maize for Africa (WEMA) and drought tolerant maize are scheduled for 2017. The following is the visionary counsel offered by Norman Borlaug on biotech crops in 2005 – it is as true today as it was in 2005. "Over the past decade, we have been witnessing the success of plant biotechnology. This technology is helping farmers throughout the world produce higher yield while reducing pesticide use and soil erosion. The benefits and safety of biotechnology has been proven over the past decade in countries with more than half the world's population. What we need is courage by the leaders of those countries, where farmers still have no choice but to use older and less effective methods. The Green Revolution and now plant biotechnology are helping meet the demand for food production, while preserving our environment for future".

Regulations on GM Crops

There are different regulatory authorities in different countries to regulate the GM crops. Brief description about the authorities in few countries along with their role in regulation of GM crops is described in Table 1.

Labeling of GM Foods

The customer should have an idea about source of the food products whether they are safe or not? In this direction marketing products are labeled and divided under different categories. For ex. GRAS (generally regarded as safe) etc. In order to make such variation companies should spend excess money to separate GM from non GM and the excess cost is burdened over customer (Mary Jane Angelo 2016).In the developed countries where GM is highly prevailed, there are incidences of cross contamination of GM soybean oil in the animal fodder, feed stock, corn flakes etc. European commission had agreed for the 1% adulteration of food materials with GM products (Hodgson 1999) but consumer societies demand for 0% adulteration. In countries like Brazil, farmers had smuggled (Ricardo 1999) the Bt. seeds for their crops to compete with the GM market as there is ban on GM products in Brazil. In Europe customers lost faith in the government's categorization as GM because of the huge scares created by bovine spongiform encephalopathy (mad cow disease). According to the act of US all the exporting countries should label the products as GM, but importing countries have their option to label or not, in such conditions there will be no transparency in the market and inequalities will prevail. There are no uniform policies and this creates imbalances; developing countries like India cannot label their products because they need the GM products to feed the ever growing population which cannot be met by conventional products alone and by now there are no GM food products in India (Jayaraman 1999). Customer awareness is highly important and who is going to educate them? What kind of labeling should be followed? How the monopoly of certain seed companies which use suicide gene technology to make farmers purchase seeds every season will be regulated? All the aforementioned questions should be properly addressed by the governments in implementing marketing laws. GM technology is adopted by all the countries, it is not a natural one, hence policies are to be amended as per the need of the situation.

Conclusion

GM technology is the need of the present day situation to meet the needs of ever-growing and burgeoning population. Conventional methods cannot provide food for the millions from the limited resources in the climate change scenario. Faster adoption of the farmers for GM crops all over the world clearly indicates the potential of the technology. Huge benefits are reaped from the GM crops. There is always a negative side of developing technology because it is newly emerged and different from natural process and hence people has to get used to the technology. Similarly government policies have to be modified keeping in view of the changed scenario. All the negative impacts raised by GM technologies can be effectively corrected. Few of the negative impacts and the solutions for them are as follows.

- Monopoly of some seed companies for instance in case of suicide gene technology and Roundup ready Soybean etc. These issues were severely dealt and laws were strictly imposed on the countries to stop those technologies.
- Any technology which is helpful to uplift the mankind should never be in the hands of few, hence such potential technologies should be made available to mankind and no such patents should be granted which creates disparities.
- Even though there are no proper evidences that Bt. technology could harm mankind, there was an unrest created among public, in this regard media should guide the people in scientific forefront and should not declare any news which doesn't has scientific support especially in case of GM technologies.
- Bt technology had created minor defects like affecting the collateral hosts like monarch butterflies etc. these issues can be avoided by enhancing the technology by creation of male sterile plants so that pollen would not be produced to contaminate the fields or to kill the butterflies.
- Gene flow is a potential concern and several remedies were suggested to maintain buffer zones along the side of GM plantation in eco-friendly approach.

- Regarding labeling of the GM food products, proper policies should be enacted by the governments to suite their demography and society.

By following all the proper government policies GM technology should be adopted by the mankind because this potential technology is the need of the present day situation to feed millions of people, addressing several diseases in crops and improving nutrients in foods and helping in perpetuation of life by providing nutritional food security worldwide.

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REFERENCES

Arakawa, T., Chong, D.K.X., Langridge, W.H.R. 1998. Efficacy of a food plant-based oral cholera toxin B subunit vaccine. *Nat Biotechnol* 16(3):292-297.

Bizily, P.S., Rugh, L.C. Meagher, B.R. 2000. Phytodetoxification of hazardous organomercurials by genetically engineered plants. *Nat Biotechnol* 18 (2): 213-217

Bravo, A., Gill, S.S., Soberon, M. 2007. Mode of action of Bacillus thuringiensis Cry and Cyt toxins and their potential for insect control. *Toxicon* 49: 423–435.

Brookes, G., Barfoot, P. 2012. GM crops: Global socio-economic and environmental impacts 1996–2010. In: Biotech crop impact: 1996-2010.PG Economics Ltd, Dorchester.

Brookes, G., Barfoot, P. 2014. Economic impact of GM crops. GM Crops & Food: Biotechnology in Agriculture and the Food Chain 5:165-75.

Chakrabarty, A.M., Mylroie, J.R., Friello, D.A., Vacca, J.G. 1975. "Transformation of Pseudomonas putida and Escherichia coli with plasmid-linked drug-resistance factor DNA". *Proc Natl Acad Sci* U S A. 72 (9): 3647–51.

Dahleen, S.L., Okubara, A.P., Blechl, E. A. 2001. Transgenic Approaches to Combat Fusarium Head Blight in Wheat and Barley. *Crop Science* 41 (3): 628-627

Daniell, H. 2002. Molecular strategies for gene containment in transgenic crops. Nat Biotechnol 20:581–586.

Daniell, H., Datta, R., Varma, S., Gray, S., Lee, S.B. 1998. Containment of herbicide resistance through genetic engineering of the chloroplast genome. *Nat Biotechnol* 16(4):345-348.

Diane, B., Henry, D. 2011. Low-cost production of proinsulin in tobacco and lettuce chloroplasts for injectable or oral delivery of functional insulin and C-peptide. *Plant Biotech J.*, 9:585–598.

Fukuoka, S., Saka, N., Koga, H., Ono, K., Shimizu, T., Ebana, K., Hayashi, N., Takahashi, A., Hirochika, H., Okuno, K., Yano, M. 2009. Loss of function of a proline-containing protein confers durable disease resistance in rice. *Science* 325: 998–1001.

Goto, F., Yoshihara, T., Saiki, H. 2000. Iron accumulation and enhanced growth in transgenic lettuce plants expressing the iron-binding protein ferritin. *Theor Appl Genet* 100: 658–664.

Hattori, Y., Nagai, K., Furukawa, S., Song, X.J., Kawano, R., Sakakibara, H., Wu, J., Matsumoto, T., Yoshimura, A., Kitano, H., Matsuoka, M., Mori, H., Ashikari, M. 2009. The ethylene response factors SNORKEL1 and SNORKEL2 allow rice to adapt to deep water. Nature 460(7258):1026-1030

Henry Daniell, 2001. Medical molecular farming: production of antibodies, biopharmaceuticals and edible vaccines in plants. *Trends Plant Sci* 6(5): 219-226.

Hodgson, J. 1999. EC says 1% is acceptable GMO contamination Nat Biotechnol 17: 1155-1156.

Hong-Xia, Z., Eduardo, B. 2001. Transgenic salt-tolerant tomato plants accumulate salt in foliage but not in fruit. *Nat Biotechnol* 19(8):765-768

James, C. 2012. Global Status of Commercialized Biotech/GM Crops: 2012. ISAAA Brief no.44. International Service for the Acquisition of Agri-Biotech Applications, *Ithaca NY,* USA.

James, C. 2013. Global Status of Commercialized Biotech/GM Crops: 2013. ISAAA Brief no. 46. ISAAA International Service for the Acquisition of Agri-Biotech Applications, Ithaca NY, USA.

James, C. 2011. Global Status of Commercialized Biotech/GM Crops: 2011. ISAAA Brief no.43. International Service for the Acquisition of Agri-Biotech Applications, Ithaca NY, USA.

Jayaraman, S.K. 1999. India intends to reap the full commercial benefits Nature 402:342-343.

Jeffrey, E.H., Xiaoming Bao, Nicholas, J.B., Jason, L.D., Dennis Dolan, Darren Hasegawa, Timothy GH, Renee HL, Nina Lovan, Hua Mo, Kellie Reimann Jeffrey, R.S. 2014. Transgenic alteration of ethylene biosynthesis increases grain yield in maize under field drought-stress conditions. *Plant Biotech J* 12: 685–693

Jonathan Gressel, 1999. Tandem constructs: preventing the rise of superweeds. *Trends Biotechnol* 17 (9): 361-366.

Kareiva, P., Marvier, M. 2000. Case study 3: Genetically modified organisms:An overview of risk assessment procedures applied to genetically engineered crops. Incorporating science, economics, and sociology in developing sanitary and phytosanitary standards in international trade. In: McGarraugh (ed) Incorporating Science, Economics, and Sociology in Developing Sanitary and Phytosanitary Standards in International Trade: Proceedings of a Conference: 231-246 January 1999;, National Academy Press, Irving, California.

Kenward, K.D., Brandle, J., McPherson, J., Davies, L.P. 1999. Type II fish antifreeze protein accumulation in transgenic tobacco does not confer frost resistance. Transgenic Res 8: 105.

Losey, E.J., Rayor, S.L., Carter, E.M. 1999. Transgenic pollen harms monarch larvae. Nature 399: 214.

Mary Jane Angelo, 2016. The Law and Ecology of Pesticides and Pest Management. Taylor and Francis group, London and New York.

Mason, H.S., Warzecha, H., Mor, T., Arntzen, C.J. 2002. Edible plant vaccines: applications for prophylactic and therapeutic molecular medicine, Trends Mol Med 8: 324-329.

Mendez, K.A., Chaparro, Giraldo, A., Moreno, G.R., Castro, C.S. 2011. Production cost analysis and use of pesticides in the transgenic and conventional corn crop [*Zea mays (L.)*] in the valley of San Juan, Tolima. GM Crops 2(3):163-168.

Monsanto, 1999. Residues in Roundup Ready soya lower than conventional soy.

http://www.monsanto.co.uk/news/99/june99/220699_residue.html. Accessed 24 April 2017

Murakami, Y., Tsuyama, M., Kobayashi, Y., Kodama, H., Iba, K. 2000. Trienoic fatty acids and plant tolerance of high temperature. Science 287: 476–479.

Rao, G. J. N., Dasarathi Swain, Rukmini Mishra, Prasad, D., Sai Krishna, R., Rao, R. N., Sahu, R.K. 2012. Marker based estimation of gene flow in tropical rice fields and its ecological consequences. *Trop Plant Biol* 5:277-285

Ricardo Bonalume Neto, 1999. Smugglers aim to circumvent GM court ban in Brazil Nature 402: 344-345.

Sabikhi, L. 2007. Designer milk. *Adv Food Nutr Res* 53:161-198.

Schnepf, E., Crickmore, N., van Rie, J., Lereclus, D., Baum, J., Feitelson, J., Zeigler, D.R., Dean, D.H. 1998. Bacillus thuringiensis and its pesticidal crystal proteins. *Microbiol. Mol. Biol. Rev.* 62:775–806.

Scorza, R., Callahan, A., Levy, L., Damsteegt, V., Webb, K., Ravelonandro, M. 2001. Post-transcriptional gene silencing in plum pox virus resistant transgenic European plum containing the plum pox poty virus coat protein gene. Transgenic Res 10 (3): 201-209

Sharma, K.K., Ortiz, R. 2000. Program for the application of genetic transformation for crop improvement in the semi-arid tropics. *In Vitro Cell Dev Biol Plant* 36: 83-92.

Ye, X.D., Al-Babili, S., Kloti, A., Zhang, J., Lucca, P., Beyer, P., Potrykus, I. 2000. Engineering the provitamin A (ß-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm.Science 287:303-305.

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