BIOTECHNOLOGY: A BOON OR A CURSE?

Manjula V. Guru & James E. Horne[1].

ABSTRACT

Crop genetic diversity is not just a raw material for industrial agriculture; it is the key to food security, and sustainable agriculture because it enables farmer=s to adapt crops suited to their own site specific ecological needs and cultural traditions. Without this diversity, options for long term sustainability and agricultural self - reliance is lost. The type of seed sown to a large extent determines the farmers need for fertilizers, pesticides and irrigation. Communities that lose community bred varieties and indigenous knowledge about them, risk losing control of their farming systems B thereby restricting their markets - and becoming dependent on outside sources to satisfy those needs, and for the inputs needed to grow and protect them. Without an agricultural system adapted to a community and its environment, self - reliance in agriculture is impossible. In this paper the advantages, disadvantages, and concerns associated with the loss of biodiversity and the advent of the biotechnological age are explored.

KEY WORDS: Biotechnology; Diversity; Genetic; Sustainability.

1. INTRODUCTION

1.1 Background.

One of the newest developments in US agriculture is the advent of biotechnology, which seems to be leading us into a sudden new biological revolution. It has brought us to the brink of a world of "engineered" products that are derived from the natural world rather than on chemical and industrial processes. The term "biotechnology" was coined in 1919 by Karl Ereky, a Hungarian engineer. At that time, the term meant all the lines of work by which products are produced from raw materials with the aid of living organisms. Ereky envisioned a biochemical age similar to the stone and iron ages.

1.2 Objective of this paper.

Genetic engineering is now bringing to agriculture novel varieties of crops, animals, and microorganisms. It offers many potential benefits in medicine, industry and

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[1] Manjula V. Guru & James E. Horne, The Kerr Center for Sustainable Agriculture, Inc., P.O. Box 588, Hwy. 271 South, Poteau, Oklahoma, USA B 74953, manjula@kerrcenter.com, jhorne@kerrcenter.com

agriculture. The biotechnology industry touts these products as a major contribution toward sustainable agriculture, but it is not clear whether agriculture will in fact benefit. This paper therefore looks into the risks as well as benefits of biotechnology.

2. A BOON OR A CURSE?

2.1 The two sides of the same coin.

Biotechnology has been described as "Janus-faced." This implies that there are two sides. On one, techniques allow DNA to be manipulated to move genes from one organism to another. On the other, it involves relatively new technologies whose consequences are untested and should be met with caution. Many traditional biotechnologies are uncontroversial, such as the fermentation of microorganisms to produce wine, beer, and cheese. But genetic engineering, a powerful new technology that involves the artificial transfer of genes across species lines, has provoked intense public interest and scrutiny. Despite its many benefits, genetic engineering has caused concern among some people. Some oppose genetic engineering because they fear that harmful, uncontrollable bacteria might be produced accidentally. Others worry about possible environmental damage by the deliberate introduction of organisms whose heredity has been altered.[2] In addition, some people question the morality of manipulating the genetic material of living creatures.

2.2 Environmental and ecological consequences.

Thousands of different and genetically distinct varieties of our major food crops owe their existence to thousands of years of evolution and to careful selection and improvement by our farmer ancestors. This diversity protects the crop and helps it adapt to different environments and human needs. The potato, for instance, originated in the Andes, but can be found today growing below sea level behind Dutch dikes, or high in the Himalayan mountains. One variety of rice grows in 7.5 meters of water, while another survives on just 60 centimeters of annual rainfall. Today, much of this diversity is being lost.

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[2] http://www.fao.org/sd/EPdirect/EPre0040.htm.

Many unique varieties are disappearing and becoming extinct. The FAO estimates that since the beginning of this century, about 75% of the genetic diversity of agricultural crops have been lost.[3] Maintaining distinct strains of agricultural crops is important because these strains may contain genes useful in the continuing fight against pests and diseases, even those strains with overall characteristics that may not be attractive economically.[4]

Industrialized agriculture favors genetic uniformity. Vast areas are typically planted to a single, high-yielding variety or a handful of genetically similar cultivars using capital intensive inputs like irrigation, fertilizer and pesticides to maximize production. A uniform crop is a breeding ground for disaster because it is more vulnerable to epidemics of pests and diseases. A pest or disease that strikes one plant spreads quickly thoughout the crop. The Irish Potato Famine of the 1840s is a dramatic example of the dangers of genetic uniformity. Potatoes originated in the Andes mountains of South America. In the 1500s, when New World potatoes were introduced into Europe, none of the introduced varieties were resistant to a fungus that struck Ireland's potato crop in the 1840s. When the disease struck, the potato crop was wiped-out. Over 1.5 million people died in the famine. The potato blight is not merely an historical footnote in a long list of crop epidemics. The same fungus, in new and more virulent forms, today poses a grave threat to food security. In 1970, genetic uniformity in the United States maize crop was responsible for destroying almost $1 billion worth of US maize, and reducing yields by as much as 50%. The problem was that over 80% of the commercial maize varieties being grown in the United States at that time carried a gene that made them genetically susceptible to a virulent disease known as southern leaf blight. Further catastrophe in maize was averted due to intensive breeding programs.[5]

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[3] In China, for example, nearly 10,000 wheat varieties were cultivated in 1949. By the 1970s, only about 1,000 varieties were in use. In Mexico, genetic erosion of maize is well documented. Only 20% of the maize varieties reported in 1930 are now known in Mexico. [http://www.fao.org/sd/Epdirect/Epre0040.htm].

[4] http://cnas.ucr.edu/~cnas/facilities/germplasm.html

[5] http://www.fao.org/sd/Epdirect/Epre0040.htm

The epidemic and its consequences for food security drew worldwide attention to the problem of genetic vulnerability in major food crops. For this reason, scientists involved in genetic engineering have developed safety guidelines to guard against accidental release of such organisms.[6] It should be borne in mind that bioengineered crops could have unpredictable social, economic, and ecological consequences. Traditional crop breeding programs have relied on the time element to determine if a cultivar will be useful under various environmental conditions such as drought, high rainfall and pest challenges. Biotechnology and the companies pursuing the life sciences are in a race for profits without adequate testing and again the time element prevails. There is a strong possibility that genetically engineered crops could be important to the sustainability of agriculture if they are developed ethically, for the public good, and we understand ramifications. But that may not be the case if the technology is primarily promoted for short-term economic gain. There are two issues that need consideration in this aspect: (1) Who is profiting from the current wave of "biogenic" crops? (2) Are there unintended ecological impacts?[7]

Problems can arise, as in 1997, when thousands of acres of supposedly Roundup-resistant cotton were killed in Mississippi by the herbicide. Monsanto says it has reached settlements with two dozen farmers. Furthermore, glyphosate drift could affect plants outside fields. And the advent of Roundup-resistant poplar trees has raised the specter of vast tracts of diverse northern forests being converted to huge monocultures. To some extent, plants can transfer pollen B and genes -- to related plants. That creates the potential for transferring inserted genes from the crop to other plants. The idea got a boost when Norman Ellstrand, a professor of genetics at the University of California, Riverside, showed that weeds hybridized with radish plants in 1994. The problem traits could include herbicide and insect resistance, and tolerance to cold, drought or salinity.[8]

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[6] 1999 World Book. Multimedia Encyclopedia.

[7] http://www.leopold.iastate.edu/centers/leopold/sum98scistew.html

[8] Id.

Among the problems that researchers and regulators face with regard to bioengineered seeds is that continual exposure to Bt proteins in bio-engineered crops will result in selection for new strains of insects that can withstand the bacteria's toxic proteins. To counteract this problem, seed companies are asking farmers to plant a small portion of their fields, sometimes as little as 4%, with standard seeds to create a refuge for Bt-susceptible insects. The hope is that the rare Bt-resistant insects that survive feeding on Bt crops will mate with Bt-susceptible insects in the refuge and that the Bt susceptibility trait will predominate in their offspring. Computer models predict that, without such refuges, Bt resistance will be widespread within ten years. If refuges are used, however, more than 50 years might pass before Bt resistance becomes a major problem.[9]

Another issue is that genes for Bt or for herbicide resistance could be passed, via cross-pollination, to related weed species. Such cross-pollination is a normal mechanism in plant evolution. Many plant species produce fertile hybrids, and genes have regularly moved between crops and their wild and weedy relatives. Thus resistance to a particular herbicide may appear in some strains of weeds. Furthermore, an engineered organism may produce unanticipated harmful impacts on other species in its new environment.

A group of scientists at Oregon State University, for example, engineered a variety of Klebsiella planticola, a bacteria known to reside in the soil and contribute to the decomposition of plant material. Their goal was to engineer a product that would efficiently convert agricultural wastes to ethanol fuel. Although the project was successful in meeting this goal, the scientists discovered in late stages of testing that the new product also destroyed much of a beneficial mycorrhizal fungus essential to the recycling of nitrogen through plant roots -- which could lead to desertification throughout the range of use of the product. [10]

2.3 Possible human impact.

Biodiversity and species integrity is inextricably linked. Transgenic technology transgresses both species integrity and species boundaries, leading to unexpected, systemic effects on the physiology of the transgenic organisms produced as well as the ecological

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[9] http://www4.nas.edu/beyond/beyonddiscovery.nsf/DocumentFrameset?OpenForm&DesignerSeeds

community into which the transgenic organism is introduced. Allergenic and toxic products have arisen in transgenic organisms and recent evidence suggests that transgenic resistance to pests and diseases may be associated with increased allergenicity.

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[10] http://www.leopold.iastate.edu/centers/leopold/sum98scistew.html

Recent evidence also suggests that vectors carrying transgenes may spread horizontally via microorganisms, animals and human beings in an uncontrolled and uncontrollable manner. The teeming microbial populations in the terrestrial and aquatic environments serving as a horizontal gene transfer highway and reservoir, facilitate the multiplication and recombination of vectors and infection of all plant and animals species.[11] It has already been seen that genetic engineering of crops can backfire. For example, an effort to insert a protein-producing gene from a Brazil nut into soybeans was short-circuited when people who were allergic to the nuts showed an allergic reaction to the beans in skin and blood tests.

Pioneer Hi-Bred International[12], the seed company which had sponsored the tests as a way to create a high-protein soy feed for animals, decided not to proceed with further development of this product since there was no easy way to completely exclude these soybeans from human food processing and distribution system, according to Rod Townsend, the company's director of regulatory affairs. He notes that the soybeans never entered production, and never entered the human food chain. Yet as more genes are transferred across more species lines, without any requirement for warning labels, such problems could become more common. An estimated 2% of adults and eight percent of children have food allergies, which can be deadly.[13]

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[11] http://www.psrast.org/wanho.htm

[12] http://biz.yahoo.com/prnews/990331/ia_pioneer_1.html.

[13] http://www.leopold.iastate.edu/centers/leopold/sum98scistew.html

Recent statistics are frightening. Infectious diseases were responsible for 1/3 of the 52 million deaths from all causes in 1995. Multi-drug resistant tuberculosis is now estimated to affect 10 million each year with 3 million deaths. At least 50 new viruses attacking humans emerged between 1988 and 1996. Between 1986 and 1996, E. coli 0157:H7 infections increased by 10-fold in England and Wales and 100-fold in Scotland. Vancomycin resistance rose from 3% to 95% in San Francisco hospitals in the four years between 1993 and 1997. And Horizontal gene transfer can effectively create new LMOs across national boundaries. It is a runaway process that cannot be regulated. This makes it paramount to control what is released in the first place.[14]

2.4 Imminent impacts on the farming communities.

Crop genetic diversity is not just a raw material for industrial agriculture; it is the key to food security and sustainable agriculture because it enables farmers to adapt crops suited to their own ecological needs and cultural traditions. Without this diversity, options for long-term sustainability and agricultural self-reliance are lost. The type of seed sown to a large extent determines the farmers need for fertilizers, pesticides and irrigation. Communities that lose community-bred varieties and indigenous knowledge about them risk losing control of their farming systems and becoming dependent on outside sources of seeds and the inputs needed to grow and protect them. Without an agricultural system adapted to a community and its environment, self-reliance in agriculture is impossible. Genetic engineering techniques have made possible the extension of the private ownership and patenting of life forms down to the level of the gene. The new patenting and intellectual property regulations will permit corporations to continue to freely appropriate unpatented seeds from around the world, to modify a single gene of these seeds, and then patent and acquire exclusive rights over them.

These new patenting laws are clearly designed to transfer the ownership and control of the world's seed diversity - most of which has been developed and maintained by traditional farmers in the Third World **B** into the hands of First World corporations.

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[14] http://www.psrast.org/wanho.htm

[15] http://www.fao.org/sd/EPdirect/EPre0040.htm

Meanwhile, seed/biotech corporations have been buying out or taking control of seed banks and smaller seed companies in order to reduce the availability of unpatented and non-hybrid seed varieties. It is in the interests of these corporations that farmers repurchase these patented seeds year after year.[16]

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[16] http://www.grain.org/publications/gtbc/issue3.htm

There are two strategies now being used to prevent farmers from being able to save and replant their seeds from the previous year's crop. Firstly, seeds may be engineered to be biologically sterile, like the hybrid seeds of the Green Revolution. Hybrid seeds produce high yields but do not perform well if they are saved and replanted, ensuring that farmers repurchase their seeds every year. Genetic engineering now makes possible the creation of hybrid varieties of some common food crops that had previously proven too difficult or too costly to hybridize using earlier plant breeding techniques. It will also be possible for scientists to deliberately engineer any crop variety to be sterile or non-reproducible. This technique, which critics refer to as 'Terminator Technology', has been patented in the USA, and will be used to target important crops such as wheat and rice. In these ways, the logic of 'planned obsolescence', and therefore the interests of the corporation, will be able to be engineered directly into the seed's DNA.[17]

Secondly, all patented seeds will now be legally sterile, as the new patenting and plant breeding regulations give patent holders rights which enable them to prohibit farmers from freely saving and replanting their seeds. Farmers either have to repurchase their seeds, or pay royalties to the company to save and replant patented seeds. To help enforce these regulations, new DNA 'finger-printing' techniques can be used to identify the genetic structure, and therefore the ownership, of crops growing in any farmer's fields. For the first time in history farmers are losing both the ability and the right to save and replant their seeds. Yet it is these very practices of saving, replanting and crossbreeding seeds by farmers that have created the enormous diversity of domesticated crops and crop varieties we have inherited to this day.[18]

2.5 Increasing dependence of the have - nots on the haves.

One of the consequences of the non-reproducibility of these 'static' seeds is that plants will no longer be able to dynamically evolve within and maintain their adaptation to local agroecological conditions, such as local climates, soils and pests. Through these processes the seed is transformed from a self-generating and shared resource into a commodified

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[17] http://www.psrast.org/prhortra.htm

[18] http://www.netspeed.com.au/cogs/gen3.htm

input of an industrialized production system. These biotechnological interventions can also be understood as further extending the colonization and commodification of the seed. Techno-industrial agriculture colonizes the seed in the sense that it penetrates into and takes control of the functioning of the seed, and imposes its own logic upon it - the logic of accelerated productivity, in-built obsolescence, and private-corporate ownership. The seed is commodified in two senses: first, in the sense that farmers must pay for a product that they formerly attained from the plant at no cost; and secondly, in the sense that farmers are no longer involved in the reproduction of the seed, and therefore are not able to shape the character of it, and are instead delivered a ready-made, pre-packaged product. In these ways, farmers will become more dependent on the agribusiness corporations that supply the seeds and other agricultural inputs. Genetic engineering therefore makes possible the further growth and centralization of control of the food sector in the hands of transnational food corporations. In this sense, genetic engineering does not so much constitute a more precise control over nature, as make possible a more precise control over farmers. It is not only biological processes, but also social structures and power relations that are being re-engineered through this new technology.[19]

Proponents of the new biotechnologies typically claim that the new seeds and techniques will be essential for feeding a growing global population. But of course hunger and malnutrition even today are not the result of food scarcity. Rather they are due to people being denied access to land to grow food or an adequate income with which to purchase food. Global hunger already exists on a wide scale in the context of a global over-supply of food. Much of this excess food (one third of all global grain production) is wasted by being fed to livestock during their last four months to produce a choice beef for those of us able to afford it. Genetic-industrial agriculture will, in fact, most likely exacerbate global poverty and malnutrition given the way it will favor large-scale producers over small producers and undermine local agricultural markets. In this sense, techno-industrial agricultural systems directly create food scarcity for many people given the way they

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[19] http://www.netspeed.com.au/cogs/gen3.htm

transform the culture and structures of food production, distribution and demand, even if they increase the overall volume of food produced globally in the short term.[20]

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[20] http://www.netspeed.com.au/cogs/gen10.htm

Farmers that are already locked into the techno-industrial system will find it difficult to avoid the adoption of any new seeds or inputs that increase the 'productivity' of their farms, regardless of how narrow, short-term and ecologically degrading these 'productivity increases' are. Farmers otherwise risk being priced out of the market due to the downward pressure on prices that result from increased levels of output. It is small-scale Third World farmers whose livelihoods have been most seriously affected by such dynamics. The new biotechnologies also present a further threat to farmers where new tissue culture techniques are used to manufacture industrial substitutes for agricultural crops. For example, the development of artificial sweeteners replaces the need for sugar-cane crops, thereby reducing their demand and further depressing prices. Other crops that are currently threatened by industrial substitutes include cocoa and vanilla. Third World communities and countries that have been forced into dependency upon these cash crops are the hardest hit by this form of substitutionism.[21]

Another threat is where GE accelerates the trend of substituting crops with industrial systems based on cell culture. Corporate giants would control biosynthetic food factories. Farmers and consumers would have little choice over what is produced. Supplementing these factories would be contract-controlled farming, the altered states way.[22] Genetic-industrial agriculture will enable seed-chemical corporations to extend their control over farmers and over the entire industrial food chain.[23]

2.6 Lack of preventive research.

So far, scientists have identified a number of ways in which genetically engineered organisms could potentially adversely impact both human health and the environment. Once the potential harms are identified, the question becomes how likely are they to occur. The answer to this question falls into the arena of risk assessment. In addition to posing risks of harm that we can envision and attempt to assess, genetic engineering may also pose risks that we simply do not know enough to identify. The recognition of this

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[21] http://www.psrast.org/prhortra.htm

[22] http://www.netspeed.com.au/cogs/gen10.htm

[23] http://www.netspeed.com.au/cogs/gen3.htm

possibility does not by itself justify stopping the technology, but does put a substantial burden on those who wish to go forward to demonstrate benefits.

In developing new products, scientists take plant samples from the field to the laboratory, where the simple act of moving a single gene from one spot to another within a cell - whether or not it causes an actual variation in the next generation, creates a "plant variety" deemed sufficiently "new" to qualify as a patentable invention. In most cases, such genetic engineering experiments produce nothing worthwhile. In a few cases, the variations have desirable traits that can be reproduced and marketed. The emphasis on finding and isolating plants with the most marketable traits leads to the decline of other plant species, as only those required to create the new techno-varieties are cultivated. In the U.S. alone, the focus on commercial varieties has already led to the loss of many varieties of plants in seed bank storage. A survey of U.S. seed banks showed that some varieties of non-commercial crops such as chufas, martynia and rampion have been lost entirely.[24]

Commercial pressures have led to regulatory guidelines based largely on untested assumptions, all of which have been invalidated by recent scientific findings. For example, biologically "crippled" laboratory strains of bacteria can often survive in the environment to exchange genes with other organisms. Genetic material (DNA) released from dead and living cells, far from being rapidly broken down, actually persists in the environment and transfer to other organisms. Naked viral DNA may be more infectious, and have a wider host range than the virus. Viral DNA resists digestion in the gut of mice, enter the blood stream to infect white blood cells, spleen and liver cells, and may even integrate into the mouse cell genome.[25]

2.7 Inadequate rules and regulations.

Risk assessments can be complicated. Because even rigorous assessments involve numerous assumptions and judgment calls, they are often controversial when they are used to support particular government decisions. Under the current US regulatory framework for biotechnology, some sort of risk assessment is routinely produced before decisions to

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[24] http://www.leopold.iastate.edu/centers/leopold/sum98scistew.html

[25] http://www.psrast.org/prhortra.htm

allow commercialization of products under the Federal Plant Pest Act; the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); and the Toxic Substances Control Act (TSCA). In the case of the Plant Pest Act, risk assessments are done according to the procedure specified by the National Environmental Policy Act (NEPA). These risk assessments could lead to full blown environmental impact statements, but so far all evaluations of engineered agricultural organisms have led to the legal conclusion that no environmental impact statement is needed.

3. CONCLUSIONS & SUGGESTIONS

3.1 Conclusion.

For the most part, scientists and policymakers in the relevant agencies (USDA or EPA) do risk assessments with information provided by the companies seeking the approvals. The public often has a brief opportunity to review and comment on the risk assessments. There is no standard set of questions that risk assessments must answer because of the great range of potential impacts of biotechnology products. A risk assessment for a microbial pesticide, for example, would be substantially different from a risk assessment for genetically engineered salmon. Like all efforts at risk evaluation, risk assessments done for regulation depend on the base of scientific knowledge for generation of list of possible harms to be assessed.

3.2 Suggestion.

Therefore, a new set of rules and regulations should be developed, implemented and impartially enforced with respect to all genetically modified products on the basis of a risk **B** benefit approach.