Sustainable Agriculture and Transgenic Crops

In a modern context the concept of "Sustainable Agriculture" is a response to a number of challenges in the use of our natural resources and in the vulnerabilities of our current food system. Transgenic technologies have been proposed as a manner to address many of these challenges. Adamant stances on the moral right or wrong of transgenic technologies and their application abound. This paper attempts to address these issues using *ethical considerations to determine if the use of transgenic crops is compatible with the goals of sustainable agriculture.*

Sustainable Agriculture

A succinct definition for sustainable agriculture presented by the International Alliance for Sustainable Agriculture is: "A sustainable agriculture is ecologically sound, economically viable, socially just and humane." This definition provides standards that can be used for evaluation of any component of agricultural systems.

> Conceived in this sense, sustainable agriculture presents a positive response to the limits and problems of both traditional and modern agricultural systems. It is neither a return to the past nor an infatuation with the new. Rather, it seeks the best aspects of both traditional wisdom and the latest scientific advances. This leads to integrated, agroecosystems designed to be self-reliant, resource-conserving and productive in both the short and long terms. (Gips 2000)

Sustainable agriculture is a philosophical and technical approach and therefore interpretations of what constitutes its application can differ or emphasize different aspects of ecological, economic, and social considerations. Examples of key characteristics implied by these terms follow.

Ecological soundness can readily be understood in terms of Aldo Leopold's concept of the Land Ethic. Leopold (1949), wrote "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It's wrong when it tends to be otherwise". Conservation of species diversity in both wild and domesticated landscapes is a key element of ecological stability (Gliessman 1998) (Garcia and Altieri

2005). Additionally, an ecological approach to agriculture must use resources efficiently both to conserve natural resources and mitigate disruption of natural processes.

True economic viability must include measures taken to promote appropriate security, and quality of life issues (Gips 2000). Externalized costs such as water pollution or human health issues resulting from agricultural practices or the effects of various types of subsidies must be taken into account. The time scale for resource management would need to be long term and ensure a balance of resources expended and renewed.

Social justice implies that basic needs are met and rights upheld for all. The system itself should ensure equitable distribution of not only the resources but also the control of those resources and the ability to participate in vital decision-making affecting quality of life. For example, land tenure provides the potential to overcome rural poverty to the extent that there also exists the means to succeed, including capital, technical assistance and market opportunities (Gips 2000). Sociological research has revealed a connection between industrialization of agriculture and community decline, as documented in a five year study of four communities in the American Midwest (Flora 1995). Findings of the study indicated that "communities where sustainable agriculture was more widely practiced experienced significant increases in their ability to mobilize community resources for development," as well as greater cohesion and effectiveness than found in communities characterized by industrial agriculture (Flora 1995).

Transgenic Technologies

Human mediated changes to the genetics of crop plants have been made since the advent of agriculture. While conventional plant breeding involves crosses between reproductively compatible organisms, advances in molecular technologies have expanded the scope of the potential genetic pool that can be manipulated.

Recombinant DNA technology is used to insert the genes associated with a desired trait from one organism into the genome of a target organism. The products of genetic engineering are commonly referred to as GMO's (genetically modified organisms) but in this paper we will refer to them as transgenic organisms (transgenics) to distinguish them from the products of genetic modifications made using conventional breeding. Transgenic crops contain a gene or genes which have been artificially inserted into the genome of a recipient plant, instead of the plant acquiring the gene(s) through pollination ("EPA" n.d.-a). The inserted DNA sequence represents a “transgene,” which may be from a different plant species or from a different genera, family, phyla or kingdom.

Plant breeding is continually addressing goals related to the improvement of agricultural systems. In a sense, transgenic technology is another method being put to the task. However, its uses and the technology itself are controversial for a variety of reasons.

Our objective in this paper is to present the main arguments on both sides of this controversy and provide relevant knowledge to inform a discussion of the ethical considerations related to the use of transgenic crops and if they fit into a sustainable agriculture framework. We will introduce the different types of ethical concerns involved and review the status, purported benefits and associated risks of transgenic technology. We will then consider major issues within the following categories: world hunger, environmental issues, human health implications, and distribution of benefits.

Ethical Concerns

Debate about the relative good or bad, problems or successes with transgenic crops has been widely publicized, perhaps more so than other agricultural topics that could invoke discussion of the same issues. Public perceptions and objections have had a large impact on the business and commerce of “GMO” tagged (transgenic) crops have driven many of the objections to transgenics. To a large extent this is a result of media coverage and the level of understanding by the general public. Sensationalist media coverage has introduced terms such as “Frankinfoods,” “terminator-technology” and fostered stories such as the publicized “fish genes in strawberries,” which in fact were never developed ("Fish-Gene"n.d.-b). Despite the often emotive presentation, from dramatic objections to glowing praises for transgenics it is important to recognize that there is a complex of issues to consider.

Numerous studies have been conducted on consumer attitudes towards biotechnology and several of the studies have suggested that moral concerns can be significant determining factors informing viewpoints (Reiss and Straughan 1996). Much of the impetus for these studies is in the interest of biotechnology stakeholders who would like to prevent new techniques and products from failing to gain 'consumer acceptance.' A transgenic ***Bacillus thuringiensis*** (***Bt***) potato NewLeaf® never gained widespread use in large part because of consumer resistance to transgenic foodstuffs, which influenced both McDonalds and FritoLay to decide to refuse to buy these potatoes.

Intrinsic and extrinsic concerns are two major categories of ethical objections. Intrinsic moral concerns are based on the assertion that transgenics are inherently objectionable, which is usually framed in terms of theology and naturalness (Comstock 2000), (Straughan 2000). The "natural" argument raises the questions "What is meant by natural?" and "Is natural always good?" which upon dissection may not be easily defended. Yet, these are certainly worthwhile considerations, especially when taking into account the timescale and the rate of incidence of human mediated occurrences relative to natural ones (Reiss and Straughan 1996). One viewpoint is that this objection takes the form of a lack of respect for nature. Certain "holistic" or "ecological" arguments also fall in this category and can be described as including "claims and theories about the interdependence of all life-forms in a complex, self-regulating, 'biotic community', and the consequent extension of moral rights and moral value to the non-human world" (Reiss and Straughan 1996).

Extrinsic objections arise from the real or perceived consequences of a transgenic product or process, such as the possibility and degree of harm to people and the environment. The presence of risks is a matter of moral concern insofar as they require decision-making about responsibility, accountability and justifiability (Straughan, 2000). Because it is "impossible to guarantee the total safety of transgenic crops, a value judgment must be made" (Straughan, 2000). Extrinsic concerns therefore carry weight in proportion to the likelihood and the nature of undesirable consequences (Reiss and Straughan 1996).

Much of the difficulty in reaching consensus or generalizable conclusions about these issues results from ambiguity in determining the balance or risks and benefits. This is complicated by three main reasons set forth by Reiss and Straughan (1996). For one, in the unlikelihood that agreement is reached about what the consequences are, there still follows no clear conclusions to the ethical questions involved. Second, there is always more than a single isolated consequence which in fact may occur at different times and affect different parties. Third, the consequences of various courses of action need to be weighed and compared, which often escapes clear factual assessment. Many risks and benefits are not strictly quantifiable, or known. “Hazard identification, exposure modeling, and comparison populations each involve value judgments that are ethical or pragmatic but in either case cannot be characterized as following from established scientific findings or theories” (Thompson 2003).

There are critics of transgenic technologies that argue that the risks involved with transgenics and associated technologies are high enough to make their further use and development irresponsible (Straughan, 2000). A general question can be posed as to the role that scientists should play in this dilemma. On one hand, as stated by Krimsky (as cited in Reiss and Straughan 1996), a fundamentally ethical position for science to hold is that of do-no-harm, “which implies reducing the risks to a negligible factor regardless of the anticipated benefits.” Alternatively, some argue that it is morally wrong to restrict research activities or that by halting further research we run the risk of never producing an innovation that could solve a future crisis.

It’s easy to oversimplify the controversy into, “Are you anti- or pro- transgenics?” To further complicate the matter, transgenic technology is developing rapidly and already enables diverse applications that present different risks and benefits and in differing proportions to various stakeholders. The following are five main categories of concern that apply in critical evaluations of transgenics: (1) The process of transgenic organism development may produce risks beyond the apparent phenotypic characteristics of the organism; (2) Unknown human health and environmental impacts, in particular those that are indirect or only realized over the long-term; (3) Inequitable social and economic implications; (4) Inadequate regulation, oversight, and testing/evaluation; (5) The degree of potential for future benefits of transgenic technologies. These topics of concern will be addressed in what follows.

Transgenic Technology: purported benefits and associated risks

Transgenic crops have been commercially produced since 1995. In 2003 transgenic crops already occupied one quarter of the globe’s cultivated land area and more than half of the acreage planted to transgenics was located in the US ("Genetically"

2004). The acreage of transgenic crops under cultivation has steadily expanded, including an annual increase of 13% between ’05 and ‘06, to total about 252 million acres (James 2007). Worldwide, more than half of the soybeans planted are transgenic varieties (James 2007). Other transgenic crops with significant land area include corn, cotton and canola. A majority of commercial transgenic crops express herbicide tolerance, followed by crops with insect resistance (James 2007). In addition to pest resistance (insect, weed, virus) there are other transgenic alterations in different stages of development that aim to modify nutrient or other product-quality characteristics, or allow production of industrial compounds and pharmaceuticals. Transgenics with enhanced crop characteristics such as drought or salt tolerance are given as prime examples of possible future products. Critics often point out that such plant physiological modifications are complex enough to necessitate multiple gene control and related interactions that will likely make such transformation unattainable in the foreseeable future. Multiple gene control could also lead to an increased possibility for unintended consequences.

An obvious advantage of the use of transgenic technologies in plant breeding is that it greatly increases the potential genetic sources from which desired traits can be selected. The bulk of food worldwide comes from a very limited number of crops. These represent the few major crops that have been domesticated. Steven Strauss, a researcher in genomics at Oregon State University, expressed that the limited gene pool available to conventional breeding methods can be overcome with genetic engineering, which is uniquely able to make large, significant changes possible (personal communication Dec. 2006). Others argue that it isn’t prohibitively restrictive, for example, a soybean cultivar with resistance to certain herbicides was achieved with conventional breeding (Dupont 2006). The transgenic approach is also criticized as being too reductionist because it underutilizes existing crop diversity that is available for conventional breeding, including desirable polygenic traits in traditional varieties and wild relatives.

It’s commonly held that transgenic technology 1) reduces the time required for crop improvement and that it 2) allows for more precise modifications. However, these conclusions depend on how an evaluation is framed and the exact opposite can be argued.

A comparison of the time required for development and deployment of corn inbreds produced by either transgene insertion or conventional breeding (hybridization combining the germplasms of common and exotic varieties) found them to be of comparable duration but that the transgenic hybrid cost at least 25 times more to produce than the conventional hybrid (Cox 2001). Furthermore, incorporating a transgene into a commercially desirable variety and assuring it to be agronomically viable does require the process of conventional backcrossing and thus the time lapse of plant generations (Thompson 2003).

Transgenic techniques could be called more precise in that they use selected alleles for a specific trait whereas conventional breeding is generally a process of shifting a population of plants toward desired traits. Nevertheless, the specific location of insertion of a transgene, the number of copies inserted and the nature of related genomic alterations are not precisely controlled. To at least some degree, recombinant gene insertion disrupts or alters the function and expression of a plant genome. We may simply not know enough about what precisely happens when using transgenic technologies. On the other hand, Bradford et al. (2005) point out that random genetic alterations occur both independent of human intervention (e.g., mutagenesis) and as a part of a number of intensive breeding methods including mutation breeding (using irradiation or chemicals to induce random mutations). Further, as stated by Ozcan et al. (as cited in Bradford et al. 2005) , commonly used methods such as “intervarietal hybrids, interspecies crosses, inbreeding, ploidy modification and tissue culture, produce pleiotropic effects on gene structure and trait expression in plants”. What transgenic technologies allow however, are insertions that do not occur in nature. There are widely differing scientific opinions about the probability of unpredictable behavior in what appears to be a stable transformed variety when it is exposed to any number of factors from diverse climates and cultural practices (Thompson 2003).

At any point in these considerations it’s important to recall that science is an on-going learning endeavor, which means that further study generally increases our understanding, yet also raises new questions and can at any time debunk a previously held theory. That’s not to mention the very real occurrence of contradictory findings. This is difficult to relay to a general public audience that is looking for more explicit un-ambiguous explanations. Even the “scientist” has a more or less informed perception.

The relevance of the method of genetic modification is an underlying aspect in evaluating many issues about transgenics. Dale et al. (2002) found "no compelling scientific arguments to demonstrate that [transgenic] crops are innately different from non-[transgenic] crops." Even taken at face value this finding does not ensure that transgenic crops are benign or pose the same risks as conventional crops. An evaluation of all plant expressed characteristics and their implications would be necessary to state comprehensive equivalence.

"For both food safety and environmental safety, U.S. regulatory decision making has been based on the assumption that once transgenes are integrated into the genome of a transformed crop and both gene function and reproductive stability have been verified, risks may be evaluated exclusively with respect to phenotypic traits" (Miller 2000 as cited in Thompson 2003). It's worth noting that a comparison based on phenotype does not acknowledge any difference between transgenic *Bt* corn which is expressing an insect toxin and a non-transgenic corn plant whose tissue does not contain *Bt*. Because conventional crops are assumed to pose minimal environmental risks this stance does not support differential regulation of transgenic crops based solely on the way they were developed. This implies for example that there is no basis for requiring evaluations of the possible human health implications of transgenic food crops. While, there are certain permits, regulations and costs specified for transgenic research and development there are contentions ranging from the stance that these restrictions are cost prohibitive for some projects, to those who find the degree of regulatory oversight strikingly inadequate. The U.S. Department of Agriculture Animal and Plant Health Inspection Service (APHIS) permitted field trials for backcrossing and generating data on transgenic crops, however, by 2002 the National Research Council (NRC) identified a lack of appropriate regulatory oversight of some biotechnology companies for approval of new transgenic crops (Thompson 2003).

Another justification of the pursuit of transgenics is the belief that novel transgenics will be produced in the future beyond what is currently feasible. There is no way to prove that there is greater potential in pursuing transgenics versus other approaches that may rely less on modern biotechnology. This is where one of the most powerful arguments against transgenics comes in, that there are alternatives. As noted by

Burkhardt (2001) proponents of transgenics place a lot of emphasis on promises of a better situation in the future, “Future agricultural biotechnology is projected to increase productivity and yields more proportionally and equitably than Green Revolution technologies, which have been criticized for favoring wealthier and more powerful agricultural interests.” However, it’s easily argued that the transgenic technology initiatives have many of the same strategies and similar pitfalls. Considering the observable and potential problems that may be tied to transgenics Burkhardt (2001) suggests if we continue to employ these technologies the logical implications are (1) a more precautionary approach, (2) more equitable distribution of benefits of the technology, (3) reorienting and restructuring of biotechnology research and development institutions.

World Hunger

Improvements in agricultural production, especially in terms of increasing yield and efficiency, are generally accepted as addressing both the challenge of feeding an increasing human population, and providing food for the undernourished. The transformation of agriculture to relieve poverty/hunger and improve equity in poorer countries around the world is commonly held to be a ‘moral imperative’ (Serageldin, Ortiz as cited in Robinson 2000).

A food shortage is generally emphasized as the principal cause of hunger, which to a great extent overlooks the reasons that poverty exists, for example, “inequitable distribution of food, land tenure inequity, overpopulation, poor health, poor education” (Robinson 2000). Crouch (1995) argues that transgenics, as a component of commercial agriculture, undermine self-reliance and food security in particular because they are being driven by business economics that shift resources away from food grown for home consumption.

Another aspect of food security is crop genetic diversity. The widespread use of a transgenic crop is less robust against the dynamics of pests, weather and other agricultural stresses because it represents a genetically uniform monoculture. This is in contrast to a basic premise of diversity in sustainable agricultural systems. Many indigenous cultures traditionally plant numerous species and varieties of a staple to better insure at least some harvestable yield even in a year with extreme conditions.

Another major objection to transgenic agriculture on the grounds of sustainability is that it is a system highly dependent on purchased inputs. Transgenic seed must be purchased every year instead of farmers having the option of saving their own seed. The technology itself is capital intensive and its use comes at an increased cost to growers in the form of more expensive seed among other externalities. Often, the cultivation of transgenic crops requires adopting a whole system of industrial agriculture including seeds, monoculture, mechanization, petrochemical fertilizers, herbicides and pesticides, irrigation and commercialization (Crouch 1995). The most commonly planted transgenics, Roundup Ready® and *Bt*- crops, are those that necessitate the concurrent use of a pesticide or herbicide.

Environmental Issues

The main environmental concerns involve the unintended spread of transgenes and detrimental ecosystem effects. In all practicality, there isn't a question of whether a transgene will escape but rather when, and how to manage for that. This is a serious cause for concern over field-testing transgenic crops that are in the development process. There are already a number of examples of transgenes being found in non-transgenic crops or crop products. This isn't to say that greater effort couldn't be made to further insure isolation of transgenes, especially in open pollinated species. For example, an early version of glyphosate resistance was achieved by inserting the transgene in the nuclear genome, whereas a later transformation involved the insertion of the transgene into the chloroplast DNA which prevented the transgene from being transferable via pollen.

Transmission of a transgene via pollination beyond the modified crop plant leads to an array of concerns. An often overlooked concern is the spread of the transgene to landraces. To the extent that preserving the genetics of traditional varieties is valued, the unintentional addition of genes from transgenic plants (or conventionally bred varieties for that matter) is unacceptable. Alarm over these issues was sparked recently in relation to maize in Mexico, which is a center of corn genetic diversity. Though there is a ban on planting transgenic corn in the country, kernels of transgenic corn are imported for food.

Evidence of transgenic material having spread into open pollinated corn was found by researchers at the University of California, Berkeley and two teams of Mexican government researchers in 2001 (Mann 2002). However, these findings were contested and a follow-up study in 2004 did not find evidence of introgressed transgenes in a new collection of corn samples (Kaiser 2005).

In certified organic production the spread of a transgene to a crop is an issue of contamination. The transgene renders the crop no longer certifiable organic. This results in an economic loss because it can not be sold as an organic product, which generally receives a price premium. Additionally this could be seen as an infringement on the grower's right to farm organically. There are liability issues to address as well when contamination occurs. Some regulations have been put in place to avoid or minimize impacts on organic growers and organic certification requirements, including a 50 foot buffer zone between fields and tolerance levels for the amount of allowable contamination in an organic product. Maximum tolerable levels (0.1%) of transgenes in organic crops have been legally established in Europe. However, it is easily argued that there should be a zero tolerance in order to preserve the transgenic-free characteristic of organic produce. "Tolerance" standards can be viewed as violating consumers' right to choose not to consume transgenic foods. Further, this leads to the controversy over labeling food for transgenic content, which includes ethical considerations about who should cover the cost of labeling, who regulates it and what exactly needs to be labeled.

National Research Council (NRC) committees identified the potential for ecosystem damage from phenotypic traits of certain transgenic crops and associated cultural practices such as herbicide and insecticide use (Thompson 2003). Some argue that there is little relevance to a transgene transferred to wild plant species because in the absence of selection pressure the transgene may not persist in the population. This is assuming that there is a fitness cost to the transformation (i.e., that the transgene or transformation will have side effects in the plant that are in some way disadvantageous), and that there are no other negative ecological repercussions. The effects on ecosystems are very difficult to detect or quantify due largely to the scope and complexity of natural systems, and the potential for small effects that may only be apparent after time.

There is already evidence that even short term field trials can lead to the unintended spread of transgenes to wild grass species. Experimental plantings of glyphosate-resistant creeping bentgrass in central Oregon recently led to the escape of the herbicide resistant transgenes into wild plant populations. The transgene was found in plants three miles outside of the buffer area surrounding the plots and was likely transmitted both by pollen and seed dispersal (Reichman et al. 2006). Riechman et al. (2006) stated that this transgene could easily persist in the environment both in the presence and absence of herbicide selection. The scale of potential impact is quite large when considering that 70% of the world's commercially available creeping bentgrass comes from Oregon (Andrew 2006). Due to the global scale of commerce the potential for world-wide economic and weed management repercussions is considerable.

It is worth noting that glyphosate is considered by many to be an effective, relatively safe and environmentally benign chemical herbicide. There are, however, findings of toxic effects of glyphosate containing herbicides (adjuvants in the formulations generally increase toxicity) on amphibians among others (Cauble and Wagner 2005). Richard et al. (2005) found evidence of endocrine and toxic effects in mammals from Roundup®. Any findings of ecosystem harm due to Roundup® (glyphosate) are cause for great concern because of its widespread use, especially on Roundup Ready® crops. Other problems can arise from repeated use of a particular herbicide such as glyphosate because it places selection pressure on weeds to evolve resistance. Glyphosate resistance has now been reported in eleven different weed species (Perez-Jones et al. 2007). A loss of weed control with glyphosate tends to cause increased applications and a resort to herbicides that are more toxic. In addition, loss of weed control from glyphosate in Roundup Ready® crops could reduce the feasibility of no-till and conservation tillage practices which have environmental benefits including mitigation of soil erosion.

Unintentional increased selection for insect pest resistance is another potential problem with the use of transgenic plants that contain a pesticide such as *Bt.* Conflicting theories hold that transgenic crops expressing an insecticide either increase the likelihood of pest resistance because the toxin is present continuously, or alternatively that likelihood of resistance is decreased because of the consistently high dose of insecticide expressed in the plant. There are also differing opinions as to what constitutes effective management to reduce occurrence or speed at which resistance develops. Planting non-transgenic plants on some of the acreage as a pest refuge is generally agreed to be an essential component of the use of *Bt* crops. Appropriate implementation of this strategy depends on coordinated and voluntary action on the part of the farmers, which presents challenges especially because buffers and refuge areas generally increase complexity and reduce profits in the short term. While there are regulations mandating certain amounts of refuge plantings, there is very little policing to ensure compliance. A failure in appropriate resistance management could be seen as an infringement on the rights of organic growers because *Bt* is one of very few effective organic insect control spray options. Bates et al. (2005) expressed the commonly held opinion that "current strategies to delay resistance remain far from ideal."

Whether or not the amount of crop spraying has been reduced with the use of transgenics is not clear cut since it depends on the crop and the specific cultural practices used. There is evidence that herbicide use has increased with the cultivation of herbicide resistant crops (Benbrook 2004). However, it appears that insecticide use has been reduced due to the use of transgenic *Bt* cultivars. Benbrook (2004) used United States Department of Agriculture (USDA) data on pesticide use for corn, soybean and cotton crops and acreage planted to transgenic varieties of these three crops in the U.S. over the years 1996 to 2004 to summarize the impact of transgenics. Resulting estimates indicated about a 5% reduction in the amount of insecticide applied to both corn and cotton crops that could be attributed to the use of transgenic crops. This reduction has however been influenced by registration and adoption of pesticides that are applied at lower rates. For example, in 1996 permethrin was the most widely used corn insecticide (applied at an average rate of 0.12 pounds per acre) whereas by 2003 the primary insecticide was cyfluthrin, which is applied at 0.006 pounds per acre. (Benbrook 2004)
Cannon (2000) also suggested that *Bt* transgenic crops have generally reduced pesticide use, and in some situations even resulted in a significant crop yield increase. However, the effective control of ***Lepidopteran*** pests with *Bt* soon led to outbreaks of other insect pests, in the case of *Bt*-cotton plant bugs (family Miridae) have been causing significant

damage whereas they were previously only minor problems. This is an excellent illustration of the unending dynamics of agro-ecosystems.

Some proponents of transgenic crops hold the opinion that globally less land will need to be under cultivation due to improved efficiency and higher yields of transgenic cultivars. Less cultivated land implies less environmental impact in terms of loss of habitat and biodiversity, erosion, chemical runoff and water pollution. Similarly, perhaps degraded land in some traditionally productive agroecosystems could be addressed with future transgenic crops, for example those with transgenically-induced salt or drought tolerance. Alternatively, remedial efforts could possibly just as well be addressed without transgenic approaches.

Human health implications

The most frequently identified potential human health risk is allergenic reaction to foodstuffs from transgenic crops. One publicized example of this is the contamination of taco shells with the transgenic StarLink® maize which was approved for animal consumption but not for humans. StarLink maize contains the *Bt* insecticidal protein Cry9C. About 37 US citizens reported becoming ill and there was a massive food recall ("Starlink" 2005).

As recently as 2003 transgenic pharmaceutical-producing crops (e.g., corn, tobacco and rice) were planted on 130 acres (Anantharaman 2003). The manufacturing costs of certain pharmaceuticals are expected to be far less if produced in plants rather than mammalian cell culture methods. This has raised concerns about transgenes escaping especially when the transformed crops include major food producing crops of the world. For example, does a company ethically have the right to put at risk the contamination of important food crops such as rice, corn or wheat that are considered as global staple foods?

Some crops are being transformed to improve their nutrient qualities, including making crops that produce “healthier” oils. Arguably there is little need for novel nutrient enhancements as there are other options for improving diets. A variation on this approach is the attempt to produce transgenic rice that would contain the vitamin whose deficiency leads to blindness in poverty stricken areas around the world. A case study of

Golden Rice and the controversy and ethical considerations it raises are available as a supplement to this document[1].

Distribution of benefits

The great expense involved in research and development of transgenic crops suggests it is most readily applicable to large-scale, capital-intensive operations. Increased seed costs for transgenic crops may be offset by increased yields or reduction in other inputs but again this depends on the crop in question and the particular season and market prices.

Due to the global scale of commerce and our food system, the economic gap between countries could perpetuate and widen further from unbalanced distribution if these products are only available from Western laboratories (Straughan 2000). Multinational Agro-chemical companies are profit-driven entities and many critics feel that they may obtain undue control over farmers, in particular those in the poorest countries. It’s not difficult to imagine the extent of market control when the same companies are selling both a transgenic crop and the obligatory herbicide.

Patenting of crops and genes has also become a major issue. Some argue that living organisms should not be patented because they have not been “invented” and should not be restricted by ownership. In addition, corporate owned patents can require farmers to pay royalties or technology fees, which reduce the independence of growers and could increase their costs. Patents may also result in misappropriation of genetic resources (“bio-piracy”), particularly from “Third World” countries. Focus on patents also limits the exchange of information and genetic material that could otherwise foster further developments. (Straughan 2000)

In short it appears that the benefits have been accrued largely to biotech companies. Some farmers have benefited in terms of greater ease of farming operation and in some situations some cost savings. Consumers have thus far received little direct benefit. The degree to which any of these technologies benefit society (particularly the poor) will depend on who controls and regulates its use.

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[1] http://www.biotech.iastate.edu/case_studies/golden_rice/

Another important consideration is the role of universities, which are increasingly pursuing transgenic research and development with corporate partners. Some question whether this is in accordance with the mission of the public land grant universities.

A Sustainable Approach?

Lyson (2002) describes sustainable agriculture as based on ecological approaches, which are at odds with the reductionist approach of transgenics. This is a criticism of a strategy that "targets specific problem-causing agents with specific technological solutions, without adequately modeling cultural, ecological, and evolutionary factors that lead to a technological treadmill phenomenon" (Scott 2005). The "treadmill phenomenon" refers to the situation when unintended consequences of previous technologies are subsequently addressed with further technological developments as when a new insecticide is pursued in order to counter the occurrence of insect-resistance.

When considering the potential for great benefits despite some risks, Crouch (1995) states "I can imagine such benefits, if I divorce the individual application from the infrastructure required for it." Regardless of one's stance on transgenics many "agree that we need more impartial communication, less propaganda and an effective regulatory regime that is based on a careful case-by-case consideration of [transgenic] technology" (Arntzen et al. 2003). A strong argument can be made for implementing a precautionary approach, yet there are conflicting interpretations of what constitutes an adequate degree of precaution. "The precautionary approach is based on the ethical judgment that present people are obligated to consider the interest of future people and refrain from engaging in practices that might threaten future people's autonomy" (Jonas as cited in Burkhardt 2001). Five member states of the EU "demanded stricter regulation of the traceability and labeling of [transgenic] products, together with clarification of liability for environmental damages" (Madsen and Sandoe 2005).

All in all, transgenic technologies have had an extensive impact on agricultural practices and are currently a major component of large scale agriculture worldwide. Without a doubt transgenics will continue to be a point of contention, especially as they present options for novel farming strategies. Nonetheless, sustainable agriculture is a holistic concept guided by a comprehensive assessment of ecologic, economic, and social factors over the long-term. As such, the preoccupation with promotion of new transgenic technologies to simultaneously feed the world, benefit farmers and consumers, and save the environment is a form of reductionism at odds with the sustainable agriculture paradigm. However, modern biotechnology can be a powerful tool if these technologies are guided by the public interest instead of, for example, furthering input intensive farming, rushing novel products to market and patenting plant genetic material for the benefit of corporate profit. Our modern day societies are intimately connected through a global food system and we would encourage extreme care be taken to avoid damaging or destroying the resources that sustain our existence.

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