AgBioForum – Volume 2, Number 3 & 4 – 1999 – Pages 226-236

Comment and Reply

STRENGTHENING THE CASE FOR WHY BIOTECHNOLOGY WILL NOT HELP THE DEVELOPING WORLD: A RESPONSE TO MCGLOUGHLIN

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Upon reflecting on McGloughlin's response to our original essay it becomes quite clear that we and she speak from different world views. Where she sees simple problems that can be solved with quick technological fixes provided by private industry, we see an unequal world where problems like hunger are the product of inequality, and can only be solved by striking at that inequality head on. In what follows we briefly respond to a number of her points.

1. McGloughlin superficially acknowledges the roots of hunger in inequality—not in insufficient food production—but then quickly returns to the basic biotechnology-industry argument that, even if more food is not needed today, it will be in the future. That may well be correct, yet if we have learned anything from the decades of the Green Revolution, it is that we can all too easily fall into the "'Paradox of Plenty': more food accompanied by greater hunger (Lappé *et al.*, 1998; Boucher, 1999). Because the true root cause of hunger is inequality, any method of boosting food production that deepens inequality is bound to fail to reduce hunger. Conversely, only technologies that have positive effects on the distribution of wealth, income and assets, that are pro-poor, can truly reduce hunger. Fortunately, such technologies do exist, and can be loosely grouped together in the discipline of agroecology, the potential of which has been amply demonstrated (Altieri *et al*., 1998a; 1998b; Uphoff & Altieri, l999). Furthermore, attacking inequality head-on via true land reform holds the promise of productivity gains far outweighing the potential of agricultural biotechnology. While industry proponents will often hold out the promise of 15% , 20%, or even 30% yield gains from biotechnology, smaller farms <u>today</u> produce from 200 to 1,000 percent more per unit area than larger farms, worldwide (Rosset, 1999). Land reforms that bring average land holdings down to their optimum (small) size, from the inefficient, unproductive overly large units that characterize much of world agriculture today, could provide the basis for production increases, beside which the much ballyhooed promise of biotechnology would pale in comparison.

2. McGloughlin disagrees with our assertion that most biotechnology research is profit- rather than need-driven. In doing so she holds out the examples of so-called "Vitamin-A rice" and edible vaccines. Two counter examples, however, do little to counter our assertion about <u>most</u> biotechnology research, most of which takes place in private industry laboratories. Furthermore, the examples she gives are of questionable benefit to society. Scientists have only just begun to

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scratch the surface of edible vaccine development, which is many years off in practical terms, and presents a number of serious known and unknown health risks.

The suggestion that genetically altered rice is the proper way to address the condition of two million children at risk of Vitamin A deficiency-induced blindness reveals a tremendous naiveté about the reality and causes of vitamin and micro-nutrient malnutrition. If one reflects upon patterns of development and nutrition one must quickly realize that Vitamin A deficiency is not best characterized as a problem, but rather as a symptom, a warning sign if you will. It warns us of broader dietary inadequacies associated with both poverty, and with agricultural change from diverse cropping systems toward rice monoculture. People do not present Vitamin A deficiency because rice contains too little Vitamin A, or beta-carotene, but rather because their diet has been reduced to rice and almost nothing else, and they suffer many other dietary illnesses that cannot be addressed by beta-carotene, but which could be addressed, together with Vitamin A deficiency, by a more varied diet. A magic-bullet solution which places beta-carotene into rice—with potential health and ecological hazards—while leaving poverty, poor diets and extensive monoculture intact, is unlikely to make any durable contribution to well-being. To use the words of Vandana Shiva (personal communication), such an approach reveals *blindnes*s to readily available solutions to Vitamin A deficiency-induced *blindness*, including many ubiquitous leafy plants which when introduced (or re-introduced) into the diet provide both needed beta-carotene and other missing vitamins and micro-nutrients.

Although wild green vegetables have been regarded as peripheral to the peasant household, gathering, as currently practiced in many farming communities, affords a meaningful addition to the peasant family nutrition and subsistence. Within and in the periphery of paddy rice fields, there is an abundance of wild and cultivated green leafy vegetables rich in vitamins and nutrients (Greenland, l997).

3. To assess farm economics and the impacts of transgenic crops on United States farmers, we may examine the realities faced by Iowa farmers (in the heartland of transgenic corn and soy). While weeds are an annoyance, the real problem they face is falling farm prices, driven down by long-term overproduction. From 1990 to 1998 the average price of a metric ton of soybeans decreased 62 percent, and returns over non-land costs declined from $530 to $182 per hectare, a 66 percent drop. Faced with falling returns per hectare, farmers have no choice but to “get big or get out.” Only by increasing acreage to compensate for falling per acre profits can farmers stay in business. Any technology that facilitates “getting big” will be seized upon, even if short-term gains are wiped out by prices that fall still farther as the industrial agricultural model expands.

For these Iowa farmers, reductions in returns per unit of cropland have reinforced the importance of herbicides within the production process, as they reduce time devoted to mechanical cultivation and, thus, allow a given farmer to farm more acres. A survey of Iowa farmers conducted in 1998 indicated that the use of glyphosate with glyphosate resistant soybean varieties reduced weed control costs by nearly 30 percent compared with conventional weed management for non-transgenic varieties. Yields for the glyphosate resistant soybeans were about 4 percent lower, however. Yet, net returns per unit land area from glyphosate resistant and conventional soybeans were nearly identical (Duffy, l999).

From the standpoint of convenience and cost reduction, the use of broad-spectrum herbicides in combination with herbicide resistant varieties appeals to farmers. Such systems fit well with large-scale operations, no-tillage production, and sub-contracted chemical applications. However, from the standpoint of price, any penalty for transgenic varieties in the marketplace will make the impact of existing low prices even worse. Taking into account that American exports of soybeans to the European Union plummeted from 11 million tons to 6 million in 1999, it is easy to predict disaster for transgenic crop dependent farmers. Durable solutions to the dilemmas facing Iowa farmers will not come from herbicide-tolerant crops, but from a fundamental re-structuring of Midwest agriculture (Brummer, l998).

4. Our assertion that transgenic crops do not increase crop yields is based on a U.S. Department of Agriculture (USDA) Economic Research Service (ERS) report (1999) which analyzed data collected in 1997 and 1998 for 12 and 18 region/crop combinations, respectively. The crops surveyed were *Bacillus thuringiensis* (Bt) corn and cotton, and herbicide tolerant (HT) corn, cotton, and soybean, and their nonengineered counterparts.

In 1997, yields were not significantly different in engineered versus nonengineered crops in 7 of 12 crop/region combinations. Four of 12 regions showed significant increases (13-21 percent) in yields of engineered versus nonengineered crops (HT soybeans in 3 regions and Bt cotton in 1 region). Herbicide tolerant cotton in one region showed a significant reduction in yield (12 percent) compared with its non-engineered counterparts.

In 1998, yields were not significantly different in engineered versus nonengineered crops in 12 of 18 crop/region combinations. Six crop/region combinations (Bt corn in 2 regions, HT corn in 1 region, Bt cotton in 2 regions) showed significant increases in yield (5-30 percent) of engineered over nonengineered crops but only under high European corn borer pressure, which is sporadic. Herbicide tolerant cotton (glyphosate-tolerant) was the only engineered crop that showed no significant increase in yield in either region where it was surveyed. Reports from Argentina show the same non-yield enhancing results with HT soybeans.

Yield losses are amplified in crops, such as Bt corn, where it is mandatory for farmers to leave 20 percent of their land as refuges. It is expected that patchworks of transgenic and non-transgenic crops can delay the evolution of resistance by providing susceptible insects for mating with resistant insects. The crops in the refuge are likely to sustain heavy damage and, thus, farmers will incur yield losses. A refuge kept completely free of pesticides must be 20-30 percent the size of the engineered plot, but the refuge should be about 40 percent the size of the biotechnology plot if pesticides are to be used, since insecticide spraying can increase the odds of Bt resistance developing (Mellon & Rissler, l999).

If, instead, 30 percent of arable land was devoted to growing soybeans in a strip cropping design (as many alternative farmers do in the Midwest), yield advantages up to 10 percent over comparable monocultures of corn and soybean would be achieved, as well as introducing potentials for internal rotation in the field and contour arrangements of strips to minimize erosion on hillsides (Ghaffarzadeh, *et al*., l994)). Moreover, European Corn Borer would be minimized as pest populations tend to be lower in mixed and rotational cropping systems (Andow, l99l).

In the case of cotton, there is no demonstrated need to introduce the Bt toxin into the crop at all, as the Lepidopteran pests of this crop are pesticide-induced secondary pests. Therefore, the best way to deal with them is not to spray insecticides, but instead use cultural techniques, such as rotation or strip-cropping with alfalfa. In the Southwest, the key pest is the boll weevil, a beetle immune to the Bt toxin.

5. Despite widespread use of refuges by Bt corn growers in the U.S., it is only a matter of time before insect populations adapt and overcome the Bt genes. Nobody seriously disputes this. All experts agree that development of pest resistance to transgenic crops is inevitable, the question is how fast this will occur (Mellon & Rissler, 1999). Several Lepidopteran species have been reported with resistance to Bt toxins in both field and laboratory tests, suggesting that major resistance problems are likely to develop in Bt crops (Tabashnik, 1994). Industry however, claims that transgenic plants expressing high levels of endotoxin represent a different type of selective pressure, that is, a chronic high-dose exposure. No reports of resistance to chronic high-dose exposure of Bt endotoxins are known as yet. Moreover, given that a diversity of different Bt-toxin genes has been isolated, biotechnologists argue that if resistance develops alternative forms of Bt toxin can be used (Kennedy & Whalon, 1995). However, because insects are likely to develop multiple resistance or cross-resistance, such a strategy is also doomed to fail (Alstad & Andow, 1995). In fact, scientists have already detected development of "behavioral resistance" by some insects that take advantage of the fact that expression of toxin potency is uneven within crop foliage, thus attacking tissue patches with low toxin concentrations. Moreover, as genetically inserted toxins often decrease in leaf and stem titer as crops reach maturation, the low dose can only kill or debilitate completely susceptible larvae (homozygous) and consequently adaptation to the Bt toxin can occur much faster if the concentration always remained high. Recent observation of transgenic corn plants in late October indicated that most European corn borers that survived had entered diapause in preparation for emergence in the following spring as adults, suggestive of emerging problems (Onstad & Gould, 1998).

When the Bt genes fail, what will we be left with? Preliminary reports suggest that widespread Bt deployment may seriously deplete natural enemy populations, which would magnify pest rebound once Bt genes are overcome (Hilbeck, *et al.* , l999). Resources have already been drained away from research into management alternatives to Bt crops, with most corn entomologists now focussing on studying Bt resistance management and resistance failure. We may well find ourselves worse off after Bt crops fail than we were before they were introduced.

The farmers that face the greatest risk from the development of insect resistance to Bt are the organic farmers who grow corn and soybeans without agrochemicals. Once resistance appears in insect populations organic farmers will not be able to use *Bacillus thuringiensis* in its microbial insecticide form to control Lepidoptera pests that move in from neighboring transgenic fields. In addition, genetic pollution of organic crops resulting from gene flow (pollen) from transgenic crops can jeopardize the certification of organic crops and, thus, farmers may lose premium markets. Who will compensate organic farmers for such losses?

In the case of HT crops, the picture is similar. Herbicide resistance has been reported for 145 weed species in 45 countries. Weed biotypes now exist with resistance to one or more herbicides. With the exception of glufosinolates, all herbicides now paired with HT crops have evolved resistance in at least one weed species (Duke, l999). Glyphosate resistance, previously thought unlikely to occur in weeds, has evolved in *Lolium rigidum* in Australia and *Eleusine indica* in Malaysia.

In addition, there is concern over the heavy reliance on herbicides such as bromoxynil and glyphosate. There is evidence that bromoxynil causes birth defects in laboratory animals, is toxic to fish, and may cause cancer in humans (Goldburg, 1992). Because bromoxynil is absorbed dermally, and because it causes birth defects in rodents, it is likely to pose hazards to farmers and farm workers. Similarly, glyphosate has been reported as toxic to non-target species in the soil -- both to beneficial predators such as spiders, mites, carabid and coccinellid beetles and to detritivores such a earthworms, as well as to aquatic organisms, including fish (Pimentel, *et al*., 1989). This herbicide is known to accumulate in fruits and tubers, as it suffers little metabolic degradation in plants. Thus, questions about food safety also arise.

A recent study by eminent oncologists Dr. Lennart Hardell and Dr. Mikael Eriksson of Sweden revealed links between glyphosate and non-Hodgkin's lymphoma, a form of cancer. This is particularly alarming given the fact that Monsanto portrays the herbicide as safe, and in 1998 it is estimated that over 112,000 tons of glyphosate were used worldwide.

6. The premature commercial release of transgenic crops due to commercial pressures, and lax Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) policies, which consider genetically modified crops to be "substantially equivalent" to conventional crops, has occurred in the context of a regulatory framework that is inadequate, non-transparent and, in some cases, completely absent. It is only now, after three years of massive commercial use of transgenic crops, that the U.S. Secretary of Agriculture, Dan Glickman, has called for studies assessing the long-term ecological and health effects of these crops. A bit late, given that the ecological release of genes is non-retrievable. The rapid release of transgenic crops and the ensuing financial disarray (share prices for biotechnology companies are sinking toward all-time lows) is disturbingly reminiscent of the earlier uncritical bandwagons for nuclear energy and chlorinated pesticides like DDT. A combination of public opposition and financial liability eventually forced retrenchment of these earlier technologies, after their effects on the environment and human health proved to be far more complex, diffuse and lingering than the promises that accompanied their rapid commercialization.

The 130 countries that recently signed a global treaty that will govern the trade of genetically modified organisms (GMOs) have been wise in adopting the “precautionary principle”. The precautionary principle holds that when a new technology may cause suspected harm, scientific uncertainty as to the scope and severity of the harm should not prevent precautionary action. Instead of requiring critics to prove that the technology poses potential damages, the producers of the technology shoulder the burden of presenting evidence that the technology is safe. There is a clear need today for independent testing and monitoring to make sure that self-generated data is not biased or twisted to accommodate industry interests. Moreover, a worldwide moratorium should be enforced until the questions raised both by credible scientists who are seriously investigating the ecological and health impacts of transgenic crops, and by the public at large, can be cleared up by independent bodies of scientists.

Questions Remain

Some questions that must be addressed include the following:

(1) What is the potential of genetic variants to introduce risky foreign substances into the food supply, and what are the potential effects vis-à-vis allergens or antibiotic resistant marker genes?

(2) How serious, in terms of potential scale and impact, are the environmental problems suggested by the research of ecologists who have documented (Rissler & Mellon, l996; Krimsky & Wrubel, l996; Paoletti & Pimentel, 1996; Snow & Moran, l997; Kendall, *et al*., l997) the following:

- Geneflow between transgenic crops and wild relatives or conspecifics.
- Accumulation of the insecticidal Bt toxin, which remains active in the soil after the crop is ploughed under where it binds tightly to clays and humic acids.
- Disruption of natural control of insect pests through inter-trophic level effects of the Bt toxin affecting predators.
- Unanticipated effects on non-target herbivorous insects (i.e., monarch butterflies) through deposition of transgenic pollen on foliage of surrounding wild vegetation.
- Vector mediated horizontal gene transfer and recombination to create new pathogenic organisms.
- Vector recombination to generate new virulent strains of virus, especially in transgenic plants engineered for viral resistance with viral genes.

With massive releases of transgenic crops, these impacts are expected to scale-up in those developing countries that constitute centers of genetic diversity (Altieri, *in press*). In such biodiverse agricultural environments, the transfer of coding traits from transgenic crops to wild or weedy populations of these taxa and their close relatives is expected to be higher. Genetic exchange between crops and their wild relatives is common in traditional agroecosystems and transgenic crops are bound to frequently encounter sexually compatible plant relatives, therefore the potential for "genetic pollution" in such settings is inevitable.

The fact that Bt retains its insecticidal properties and is protected against microbial degradation by being bound to soil particles, persisting in various soils for at least 234 days, is of serious concern for poor farmers who cannot purchase expensive chemical fertilizers. These farmers instead rely on local residues, organic matter and soil microorganisms for soil fertility (key invertebrate, fungal or bacterial species) which can be negatively affected by the soil bound toxin (Donegan & Seidler, l999; Saxena, *et al*., l999).

Small farmers also rely for insect pest control on the rich complex of predators and parasites associated with their mixed cropping systems (Altieri, l994). But research results showing that natural enemies can be affected directly through inter-trophic level effects of the toxin (i.e., Swiss scientists observed higher mortality of predaceous green lacewing larvae reared on Bt corn-fed target and non-target prey) raises serious concerns about the potential of the disruption of natural pest control. Polyphagous predators that move within and between mixed crop cultivars will encounter Bt-containing non-target prey throughout the crop season (Hilbeck, *et al*., l999). Disrupted biocontrol mechanisms may result in increased crop losses due to pests or to the increased use of pesticides by farmers, with consequent health and environmental hazards.

The Alternatives Exist

We must reiterate the great and still-to-be-tapped potential of small farmers located throughout the world through the use of agroecological technologies (Uphoff & Altieri, 1999). Evidence from hundreds of grassroots development projects show that increasing smallholder agricultural productivity with agroecological techniques not only increases food supplies, but also increases smallholder incomes, reducing poverty, increasing food access, reducing malnutrition and improving the livelihoods of the poor. Data from thousands of successful experiences of sustainable agriculture implemented at the local level, show that over time agroecological systems exhibit more stable levels of total production per unit area than high-input systems; produce economically favorable rates of return; provide a return to labor and other inputs sufficient for a livelihood acceptable to small farmers and their families; and ensure soil protection, conservation, and enhance agrobiodiversity (Pretty, l995).

With increasing evidence and awareness of the advantages of agroecology, why has it not spread more rapidly and how can it be multiplied and adopted more widely? Clearly, technological or ecological interventions are not enough. Major changes must be made in policies, institutions, and research and development to ensure that agroecological alternatives are made equitably and broadly accessible, and multiplied so that their full benefit for sustainable food security can be realized. Existing subsidies and policy incentives for conventional chemical and biotechnological approaches must be dismantled, the brakes must be placed on private-public sector alliances that drain resources away from alternatives, and institutional structures, partnerships, and educational processes must change to enable the agroecological approach to blossom. In addition, participatory, farmer-friendly methods of technology development must be promoted. The challenge is to increase investment and research in agroecology and scale up projects that have already proven successful, thereby generating a meaningful impact on the income, food security, and environmental well-being of the world's population.

Innocence Or Self-Interest?

Most biotech proponents hide behind a rhetoric of neutrality masking a series of social contradictions. When closely examined, technical choices are simultaneously *political* choices not necessarily congruent with the fuller aspirations of a free, democratic society. The current developments in biotechnology reflect a decision-making process in which commercial interests override societal and environmental concerns. In fact, biotechnology has been imposed in the United States and other countries without public participation. This fundamental contradiction is at the heart of the politics of the new agricultural biotechnologies which so called “neutral” scientists pretend to ignore by limiting the discussion to “sound science”.

When looking at the experiences abroad of “neutral” agricultural scientists from Northern countries (the same type that now want to bring biotechnology to the South), one constantly encounters a maddening sort of “moral innocence”, and it is often hard to say what degree of wisdom or crass self-interest such innocence disguises (Wright, 1984). Such researchers have had profound social and political effects on Third World agriculture, yet they consistently disclaim any responsibility for anything but the purely technical aspects of their work.

In his analysis of the historical role of the International Maize and Wheat Improvement Center (CIMMYT) in Mexican agriculture, Jennings (1988, p. 192) concluded that:

> Perhaps the most significant consequence of the rise and spread of international agricultural research, therefore, is with respect to the production of knowledge, not plants. The dramatic transformation that occurred in Mexican agriculture following the establishment of CIMMYT, moved well beyond farmers’ fields to include public institutions. The Rockefeller Foundation’s success in patterning agricultural colleges, research stations, and national bureaucracies according to a U.S. model, signaled the gradual demise of struggles regarding the distribution and

> control of land, water and capital. A debate that began in Mexico at the turn of the century over the political control of resources became altered in the 1940s with a discussion of what techniques to employ in agricultural production practices. The scientific practices, institutions and professions fostered by U.S. agricultural scientists effectively displaced the legitimacy of political demands challenging the class control of resources.

According to Jennings (p. 190),

> A historic view of the achievements of international agricultural scientists, in addition to replacing one crop variety with another, must also include the replacement of one kind of knowledge about agriculture with another one. A marked tendency in the twentieth century is to accept this new knowledge, science as we have come to understand it, as an improvement over earlier styles of thought.

Jennings' study showed how at the time the Rockefeller Foundation ignored the views of distinguished University of California, Berkeley geographer Carl Sauer, favoring instead the view of more "neutral" and "objective" biological scientists. While Sauer agreed that productivity represented part of the problem, he directed attention to the social factors he believed to account for poverty. In one of his many letters to the Foundation Sauer wrote (Wright, 1984, p. 137),

> A good aggressive bunch of American agronomists and plant breeders could ruin native resources for good and all by pushing their American commercial stocks…. And Mexican agriculture cannot be pointed toward standardization on a few commercial types without upsetting native economy and culture hopelessly. The example of Iowa is about the most dangerous of all for Mexico. Unless the Americans understand that, they'd better keep out of this country entirely. This must be approached from an appreciation of native economies as being basically sound.

Clearly, the practice of international agricultural development has been dominated by technical questions, ignoring more fundamental social and economic ones, and neglecting competing kinds of knowledge, such as traditional farmers' knowledge and perspectives from the social sciences. The result has been the imposition of inadequate development models, of which biotechnology is the latest variant. This is especially dangerous when one considers that biological research in agriculture is no longer in the public domain; the new technology is under the direction of corporations who increasingly influence the direction of public sector research in ways unprecedented in the past. To agribusiness small farmers do not represent an interesting market, and if, as expected, transgenic seeds continue to be developed and commercialized exclusively by private firms (with exclusive intellectual property rights (IPRs)) small farmers will become dangerously dependent on the annual purchase of seeds. Their choices will be limited by private firms insisting on IPRs that deny on-farm seed multiplication options, a key aspect for farmers that for generations have freely saved and shared seeds. There is strength in the diversity of small farming systems and our goal is to make sure it endures for the benefit of the developing world.

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