

The Technological Fix Criticisms of Agricultural Biotechnology

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It is common to hear critics of genetically modified crops dismiss this innovation as a mere “technological fix.” For example, in his essay, “The Myths of Agricultural Biotechnology,” UC Berkeley agroecologist Miguel Altieri writes:

By challenging the myths of biotechnology, we expose genetic engineering for what it really is; another technological fix or “magic bullet” aimed at circumventing the environmental problems of agriculture (which themselves are the outcome of an earlier round of technological fixes) without questioning the flawed assumptions that gave rise to the problems in the first place (Altieri, 2000).

The key terms in Altieri’s criticism of biotechnology are “technological fix” and “magic bullet.” It is not clear in the above remarks, but the notions of a “magic bullet” and a “technological fix” are conceptually distinct. In an earlier paper, I discussed the magic bullet criticism of biotechnology (Scott, 2005). In this essay I will examine the technological fix criticism. The technological fix criticism of biotechnology is most often raised in the debate over the social dimensions of agriculture, particularly those focusing on chronic food shortages and malnutrition. However, as in Altieri’s remarks above, it is also used in the debate over how to address the environmental impacts of industrial agriculture.

In general, the technological fix criticism asserts that attempting to solve problems by technological means is counterproductive; that, in the long run, it will make things worse. However, it is worth noting from the start that technological fixes in developed societies occupy a paradoxical status: while the term is used as a derisive label, industrial societies typically demonstrate an overriding preference for technological fixes. As philosopher Paul Thompson observes, the “social bias in favor of technology is a social fact that should be recognized. Industrial societies are organized in ways that institutionalize the bias favoring technology (Thompson, 1997, p. 23).” The preference for solving problems with technology is driven by

deep-rooted habits of thinking and tremendous institutional momentum within public and private research. I will return to these observations toward the end of this paper.

The debate over biotechnology is, in part, a debate over how to frame the challenges of twenty-first century agriculture: are these challenges fundamentally scientific and technological or are they social and political? Examining the technological fix criticism can clarify this debate. Toward that end, I will establish three general points about technological fix criticisms.

First, and my major point, there are two types technological fix criticisms, practical and philosophical. The practical technological fix criticism is limited in scope. It does not reject technology as a way of fixing social problems. Rather, it cautions about defects in this way of solving problems based on historical experiences. The philosophical technological fix criticism is more sweeping. It points out a fundamentally defective way of thinking about solving problems rooted in a discredited philosophy of history.

Second, the definition and criticisms of the notion of a technological fix presuppose a clear distinction between technological problems and social ones. For example, in his widely read book, *Society and Technological Change*, Rudi Volti writes that technological fixes “seek to use the power of technology in order to solve problems that are nontechnological in nature” (Volti, 1995, p. 23). This distinction is a misleading, as modern life is so intertwined with technology that a clear line between technological and social problems is, in many cases, contrived. This is particularly true in areas like agriculture, medicine and the environment.

Third, the technological fix criticism also assumes that there is *a single* “root cause” to a problem that is social and behavioral in nature, and that technological fixes only address “symptoms.” In other words, it presupposes that it is possible to identify *the* cause to a problem, and that if we are able to address the root cause of the problem then it can be resolved once and for all— without generating additional “side-effect problems.” This too is misleading as problems are generally multi-causal, and whichever cause we address involves, in some sense, a choice.

In an effort to develop these three points, it will be helpful to begin by looking at the origins of the concept of a technological fix and at scholarly work that examines technological fixes and the philosophy behind them.

In a recent collection of essays, *The Technological Fix*, Editor Lisa Rosner writes:

The term *technological fix* is ubiquitous: it is found everywhere in commentaries on technology. Perhaps that is why the phrase is so hard to define... It has become a dismissive phrase, most often used to describe a quick, cheap fix using inappropriate technology that creates more problems than it solves (Rosner, 2004, p 1).¹

While technological fix has become a derisive and dismissive label, it started as a recommendation for a positive course of action. Alvin Weinberg, the director of the Oak Ridge National Laboratory from 1955 to 1973, coined the term in his book *Reflections on Big Science* (Weinberg, 1967). Weinberg argued that while technological fixes cannot replace “social engineering” they should be used as a “positive social action” (Teich, 1993, p. 38). Weinberg characterizes a technological fix as the solution to a problem that results from reframing a social problem as a technological one. The major benefit of doing so is simplification: it reduces seemingly insurmountable social problems to manageable levels. Weinberg goes on to list the major benefits of technological fixes. First, technological problems are much simpler than social problems; they are easier to define and identify solutions. He writes: “the availability of a crisp and beautiful technological *solution* often helps focus on the problem to which the new technology is the solution (Teich, 1993, p. 31).” Second, technological problems do not have to deal with the complexity and unpredictability of human behavior. Technological fixes, for better or worse, factor out the human element. Third, they provide policy makers with more options—additional means for addressing social problems. Finally, they can buy time until the problem can be dealt with on a deeper level. In sum, the “technological fix” is ultimately a method of inquiry aimed at resolving problems. The pattern of inquiry basic to the notion of a technological fix is to

¹ In the 1973 study of technological fixes, *Technological Shortcuts to Social Change*, the authors write that it is almost a matter of definition to say that “[technological fixes] deal only with the symptoms of the problems and do not get at its fundamental causes, that they are only illusory solutions and cannot really handle the problems (Etzioni and Remp, 1973, p. 153).”

redefine, or “reframe,” a problem that is fundamentally social in nature as being a technological problem. Once this is done, the only factors that will be considered are those that can be interpreted in terms of a technological system.

However, reducing the complexity of a problem may exclude many important factors, generating unforeseen consequences. That is, in “fixing” one problem, technological fixes can generate others. Weinberg is aware of this, and lists the defects associated with technological fixes. As is commonly noted, quick technological fixes address the symptoms and not the disease. They do not focus on the root social causes of the problem, human behavior. For instance, Volti draws the following generalization about technological fixes: “Technological solutions only eliminate the surface manifestations of the problem and do not get at its roots” (Volti, 1995. p. 23). Nonetheless, even with these qualifying remarks, the overall impression of Weinberg’s essay is that “social engineering” rarely works, while technological fixes are quick, efficient and effective. Throughout his career, Weinberg remained an enthusiastic and unapologetic champion of technological fixes— he subtitled his 1994 memoir, “The Life and Times of a Technological Fixer.”

Turning to a recent study of technological fixes, Timothy LeCain’s analysis of technological fixes for environmental problems in the mining industry is helpful in outlining the practical criticism of technological fixes. Very briefly, LeCain analyzes technological solutions for problems created by the smelting of copper in Ducktown, Tennessee, and in Anaconda, Montana. In Ducktown, the smelting process released sulfur dioxide gas emissions that denuded the countryside. This created a strong backlash against the mine from the local community. In Anaconda, the smelting process released arsenic gas that killed local livestock. Again, this created a strong reaction from the local community. The technological solution at the Ducktown site was to convert the sulfur dioxide air pollutant into sulfuric acid, which was then be used to make superphosphate fertilizer and sold to farmers. The technological fix at the Anaconda site was to precipitate the arsenic from the smoke stream then sell it for use as a wood preservative and for

the production of pesticides. In both cases, at the time, these were seen as win-win technological fixes.

However, LeCain concludes that, “the success of the technological fixes in [Ducktown and Anaconda are] finally ambiguous. Transforming, relocating, and delaying effects of smelter smoke arsenic [and sulfur dioxide] eliminated a pressing local environmental danger (LeCain, 2004, p. 148).” The chemists working on these problems did find a technological solution for the problems they set out to solve, removing the toxic pollutant from the immediate environment and resolving the conflict between the mining companies and the local communities. However, in the case of Ducktown, while the environmental toxins were transformed and relocated, as there were unforeseen environmental consequences from the fertilizers made with the sulfur dioxide gas. In the case of Anaconda, the problem was both delayed and relocated, as the arsenic treated lumber eventually created environmental hazards, and did the pesticides made from the precipitated arsenic.

LeCain’s analysis is helpful in providing a more nuanced understanding of technological fixes. As noted, technological solutions to environmental problems are frequently dismissed. However, LeCain points out that, “data would suggest that, contrary to popular perceptions, environmental techno-fixes have indeed solved many environmental problems (Rosner, 2004, p. 138). Nonetheless, a major characteristic of these ‘solutions’ is they are ambiguous. As was seen in the cases of the Ducktown and Anaconda mines, the technological solutions transformed, relocated or delayed problems, but did not absolutely eliminate them.²

² LeCain’s analysis of technological fixes is more or less consistent with the 1973 study, *Technological Shortcuts to Social Change*. In that book, the authors, Etzioni and Remp, examined several technological fixes--among them were fixes for heroine addiction, drunk driving and gun control. Etzioni and Remp reached the following conclusion: “When all said and done, what did we find in our examination of specific technological shortcuts? Do the shortcuts we studied work? In view of the preceding analysis, obviously the answer will not be a simple yes or no. The question is: What works for what and whom? Do technological shortcuts solve the problem? None of the technologies we studied does that....Do the technological shortcuts work for important segments of the problem? In our considered judgment... the answer is a positive one (Etzioni and Remp, 1973, p. p. 178).”

Several conclusions can be drawn for LeCain's analysis. First, as was just noted, technological fixes generally do not solve problems, but they can serve an ameliorative role by transforming, relocating or delaying the problem. Second, the successes of technological fixes are ambiguous, as it depends on how narrowly or broadly the criteria for success are drawn. For instance, on the local level and for the short term, the solutions at Ducktown and Anaconda were successful. However, taking a broader and longer view it would be more difficult to judge them as successes, if at all.³ Third, technological fixes are frequently, but not always, conservative. In both Ducktown and Anaconda the technological fix was able to resolve the mining operations conflicts with the local community by reducing the harm on the local vegetation and livestock. The fix was designed to repair the existing technological system by solving the mining companies' conflict with the local community.

How might these conclusions be used to analyze technological fixes in agriculture? The Green Revolution of the 1960s and 1970s is seen as a paradigm of a technological fix in agriculture. But was the Green Revolution successful? Yes and no—again, it depends on who is defining the criteria for success.

Many see the Green Revolution as a great triumph in the history of modern, scientific agriculture, one that confirms the status of science and technology as the way to meet the future challenges of agriculture. In the 1950's and 60's, Norman Borlaug spearheaded the development of high-yielding varieties of wheat, which sparked the Green Revolution. In 1970 he was awarded the Noble Peace Prize for this work. For many, Borlaug is seen as a hero whose technological breakthroughs saved millions from starvation. For instance, in a 1997 article on Borlaug, titled, "Forgotten Benefactor of Humanity," Gregg Easterbrook writes:

[Borlaug] received the Nobel in 1970, primarily for his work in reversing the food shortages that haunted India and Pakistan in the 1960s, Perhaps more than anyone else, Borlaug is responsible for the fact that thought-out the postwar ear, except in sub-Saharan Africa, global food production has expanded faster than the human population, averting the mass starvations that were widely predicted (Easterbrook, 1997).

³ The Anaconda smelter did not close until 1980 is now a 300 square mile Superfund site.

Again, the technological breakthrough in raising yields is seen as a model of a successful technological fix in agriculture. However, its success is narrowly defined in terms of increasing yields through high yield varieties and associated inputs, which kept pace population growth.

The genetic improvement of crops that initiated the Green Revolution is used to justify the next generation of technological fixes. In his many articles defending biotechnology, Borlaug champions GM crops as the next great technological breakthrough. For example, in an article titled, “Ending World Hunger,” Borlaug writes, “For the genetic improvement of food crops to continue at a pace sufficient to meet the needs of 8.3 billion people projected to be on this planet by the end of the quarter century, both conventional technology and biotechnology are needed (Borlaug, 2000).” But while Green Revolution technologies dramatically increased production and fed millions of people, they did not solve the problem of world hunger. In some sense, these technologies repeated a classic role of a technological fix: delaying the problem. Borlaug writes, “Despite the success of the Green Revolution, the battle to ensure food security for hundreds of millions miserably poor people is far from won. Mushrooming populations, changing demographics, and inadequate poverty intervention programs have eroded many of the gains of the Green Revolution” (Ibid). To repeat, Borlaug—and perhaps a majority of scientists working in agricultural research—see the Green Revolution as a prototype that should set the general direction of normal, agricultural science. Moreover, proponents of agricultural biotechnology conceive of agricultural biotechnology as a technological fix. In doing so, they follow the pattern of inquiry associated with technological fixes. This point will be illustrated later in this paper.

However, many critics use different criteria for success and see the Green Revolution either as an ambiguous event or as an outright failure. While it is a fact that Green Revolution technologies raised yields, it undoubtedly also generated many negative consequences. These many negative environmental consequences may, in the long run, undermine the vaunted Green

Revolution successes. In their review of the consequences of the Green Revolution, Evenson and Gollen write that the critics of the Green Revolution have

...raised concerns about the sustainability of intensive cultivation—e.g., the environmental consequences of soil degradation, chemical pollution, aquifer depletion, and soil salinity—and about the differential socioeconomic impacts of new technologies. These are valid criticisms (Evenson and Gollen, 2003).

In addition, David Tilman observes: “It is unclear whether high-intensity agriculture can be sustained, because of the loss of soil fertility, the erosion of soil, the increased incidence of crop and livestock diseases, and the high energy and chemical inputs associated with it” (Tilman, 1998). Tilman concludes that “it is not clear which is greater—the success of modern high intensity agriculture, or its shortcomings (Ibid).” The cost of raising yields with Green Revolution technology is a tangle of environmental problems that threaten to undermine the successes of the last 40 years.

In addition to environmental problems, for many the Green Revolution technologies have generated inequalities and injustice. One unintended consequence of the Green Revolution is that these technologies tend to provide an advantage to large industrial style farmers over small farmers. As a consequence, small farms have been systematically displaced by large farms. Using a criterion of social justice for the poor, some have judged the Green Revolution to be a tragedy. This judgment is made clear in an open letter to the director of United Nations, Food and Agriculture Organization (FAO), signed by 670 nongovernmental organizations. The letter criticized a 2004 FAO report, “Agricultural Biotechnology: Meeting the Needs of the Poor?” The report advocates the use of agricultural biotechnology to address the problem of poor farmers. The letter challenged the use of “any ‘technological fix’ as a response to food problems in poor countries” (Paarlberg, 2005), and makes explicit reference to the Green Revolution as an unsuccessful technological fix.

[The FAO's 2004 report on biotechnology] proposes a technological ‘fix’ of crops critical to the food security of marginalized peoples... If we have learned anything from the failures of the Green Revolution, it is that technological ‘advances’ in crops genetics for seeds that respond to external inputs go hand in hand with increased socio-economic

polarization, rural and urban impoverishment, and greater food insecurity. The tragedy of the Green Revolution lies precisely in its narrow technological focus that ignored the far more important social and structural underpinning of hunger. The technology strengthened the very structures that enforce hunger (An Open Letter to the Director General of FAO, 2004).

Earlier, I noted how the success of Green Revolution technologies is used to justify agricultural biotechnology as a new technological fix. Here we see the failures of the Green Revolution as a technological fix being used as an argument against moving forward with agricultural biotechnology. The argument being that the narrowness of this approach generated unacceptable, if unintended, social injustices.

In light of the earlier discussion of LeCain's analysis of technological fixes for environmental problems, there are at least three cautions that can be drawn from this brief look at the ambiguity of the Green Revolution. Together these cautions constitute what I will refer to as the defect criticism of technological fixes. Technological fixes generally do not solve problems, but they can serve an ameliorative role by transforming, relocating or delaying the problem. This tendency is seen in the case of Green Revolution technology. The Green Revolution resolved some problems, but generated others. So the caution here is to have clear and limited expectations about what new technological fixes, like biotechnology, can accomplish and to expect new problems to arise. Technological fixes offer trade-offs, not solutions. Next, the Green Revolution is a classic illustration of how determinations of the success of a technological fix depend on how success is measured. The caution here is to be aware that technological fixes define problems, and evaluate solutions, in the narrow terms of technological systems. Finally, technological fixes are frequently conservative. This is an important point in looking at the relationship between biotechnology and Green Revolution technologies. Biotechnology is seen as a way of fixing the problems created by Green Revolution technologies. This is illustrated in an essay by Anthony Trewavas: "The benefits of modern agricultural technology are well understood; now is the time to reduce the undoubted side effects from pesticides, soil erosion, nitrogen waste, and salination. GM technology certainly offers some good solutions (Trewavas, 2001)." The caution here is that

technological fixes for the problems of intensive agriculture are designed to perpetuate the current technological system. In some cases, it may be wiser to question that system itself; to ask, in effect “is the current system worth conserving?”

The above cautions are one way of criticizing technological fixes. The defect criticism of technological fixes serves as warning against inherent defects in this way of addressing problems. However, there is a deeper and more sweeping criticism of technological fixes that is highly influential.

In addition to the type of criticism discussed earlier, there is also a deeper, philosophical critique of technological fixes. In an essay published in 1983, the historian of technology and culture Leo Marx writes:

To dismiss the possibility of a scientific or technological “fix” is a commonplace of contemporary intellectual discourse. But too often the idea is treated as if it were a single, discrete, isolable, vulgar error—a tiny speck of bad thinking easily removed from the public eye. Unfortunately, the dangerous idea of a technical fix is embedded deeply in what was, and probably is, our culture’s dominant conception of history (Marx, 1983, p. 7).

While Marx’s comments are over 30 years old and familiar in content, they are still surprisingly relevant. Marx’s criticism is deeper than the practical criticism described above because it identifies the tendency to pursue technological fixes as being driven by a nearly subconscious philosophy about the role of science and technology in history. The Enlightenment’s influential philosophy of history asserted a belief in the inherent progressiveness of science and technology. In the Enlightenment perspective, technological fixes are not one alternative among others for solving problems, science and technology are *the* way to solve problems. Marx writes, “The assumption is that the achievements of scientists and engineers translate more or less naturally and predictably—in the ordinary course of events—into solutions of such grave problems [as society must face] (Marx, 1987, p. 7). ” Marx calls it a “logical abyss in our thinking” that while this philosophy of history has been discredited, there still seems to be a habitual commitment to the idea that “the achievements of molecular biology will be translated into social progress”

(Ibid., p. 8). Again, Norman Borlaug serves as an example that this way of thinking persists. Borlaug writes, “Genetic modification of crops... is the progressive harnessing of the forces of nature to the benefit of feeding the human race. The genetic engineering of plants at the molecular level is just another step in humankind’s deepening scientific journey” (Borlaug, 2000).

In response to this “logical abyss in our thinking” Marx asserts that “few arguments could be more useful today than one aimed at persuading the world that science and technology, essential as they are, cannot save us” (Ibid, p. 9). He continues, “The most urgent problems on the human agenda inhere in the man-made, not the natural environment. They are political, not scientific, and thus scientific progress cannot be the basis for their resolution” (Ibid). For Marx, the technological fix criticism points to a discredited philosophy of history and worldview. In this worldview, technological fixes are not mere tools to be applied in a piecemeal fashion, where needed; rather, there is an unquestioned assumption that science and technology naturally translate into human progress.

It is important to point out for later discussion that this criticism assumes a clear distinction between scientific and technological problems and social and political ones. While Marx’s criticism is valuable in pointing out one error in our thinking, this distinction leads him into another error: the tendency to reject technological fixes altogether.

The philosophical criticism of technological fixes readily applies to the agricultural sciences. In his 1995 book *Spirit of the Soil*, Paul Thompson demonstrates that commitment to faith in technological progress, as illustrated by Borlaug’s comments, is pervasive. Over the last 100 years or so the habitual way of addressing problems in agricultural science is via intensive scientific research aimed at creating technologies that increase productivity. Thompson writes,

“Agricultural scientists regard their work as successful when it is widely adopted, and the surest path toward adoption is to increase productivity of farming operations... Agricultural disciplines, departments, and universities are measured by their success in the creation of production enhancing technology.”

Thompson labels reigning paradigm in the agricultural science “productionism.” This was the philosophy guiding the Green Revolution. It follows the pattern of “aggressive applied scientific research, followed by equally aggressive effort of technological transfer (Thompson, 1995, p. 22).”

Thompson’s philosophical criticism of the culture of agricultural research is similar to Leo Marx’s criticism of Western culture at large. In both cases, the defect in thinking is an unquestioned belief that science and technology are naturally progressive. As Thompson writes,

The cumulative effect of [productionism] is an industrial agriculture for which the goal of making two blades grow where one grew before is never questioned, where those who succeed at this quest are bestowed with honors, and where those who fail to take it up are regarded with puzzlement” (Ibid., p. 67).

For these reasons there is a tremendous amount of social and institutional momentum driving research in agricultural biotechnology. Hence, it is not surprising that for several decades many prominent scientists have argued that agricultural biotechnology is the way forward.

At this point it is helpful to look at how this philosophical criticism applies to the arguments for agricultural biotechnology as a technological fix. The purpose here is to demonstrate how these arguments are grounded in a philosophy of history that creates a prejudicial preference for technological fixes. This leads proponents of biotechnology to make sweeping claims about the potential of biotechnology to solve pressing problems, and because of this, makes their arguments vulnerable to the philosophical criticism of technological fixes.

As should be evident by now, two great challenges for twenty-first century agriculture are feeding an additional 3 billion people and, at the same time, reducing the environmental impacts of industrial agriculture. On the face of things, these goals seem incompatible: feeding a rapidly expanding population and environmental conservation is a zero-sum game. The reality of the situation is that at least since the Green Revolution it has been a zero-sum game. Soil scientist Daniel Hillel observes that, “At the same time that the people of the earth are proliferating, their treatment of the earth is diminishing its capacity to support them” (Hillel, 261). This, of course, is

not sustainable. To avoid this consequence, twenty-first century agriculture must somehow harmonize the seemingly conflicting goals of feeding people and “saving” nature.

Anthony Trewavas, a biochemist at the University of Edinburgh, has consistently argued for agricultural biotechnology as a win-win solution for the challenges of twenty-first century agriculture. I believe it is fair to take Trewavas and his arguments as representative of mainstream scientists working in this field. In one of his several pieces that have appeared *Nature*, Trewavas asserts that technological innovation is the only way to realize the win-win solution we see: “without technological change and economic development, there can be no solution to the predicament of meeting human needs while containing the impact on the planet” (Trewavas and Goklany, 2003). Trewavas’ argument is readily outlined in the pattern of thinking associated with technological fix: he frames the problem in terms of a technological system.

Trewavas begins with the seemingly obvious assumption that we must produce more food to feed 3 billion more people. This can be accomplished in one of two ways: either by increasing the amount of land under agricultural production using existing technologies or by increasing agricultural production on existing lands through technological innovations. If we increase the amount of land devoted to agriculture, we increase the ecological footprint of agriculture. Citing research by Vaclav Smil, Trewavas states that “to feed the increase in population expected by the 2050 with traditional agriculture would require a 3-fold increase in land put down to crops” (Trewavas, 2000). This, consequently, continues the zero-sum game between agriculture and the environment. Trewavas concludes: “To conserve the present ecosystems, increased food production must be limited to the cropland currently in use” (Trewavas, 2001). The goal, then, is to feed everyone by maximizing production on the minimum amount of land possible, and the best way to do this is by developing new technologies aimed at increasing efficiency.

Trewavas supports this conclusion by referring to the historical relationship between agricultural efficiency and technological innovation. According to Trewavas, if technology had

frozen at 1960 levels, to feed the current population of 6 billion people we would have needed to increase agricultural lands by a minimum of 80%. He goes on to list how series of technological innovations (e.g., pesticides, increased irrigation and fertilizer usage) over the last 40 years have increased productivity, thus eliminating the need for additional farmland. Trewavas concludes, “The lessons of history are clear. Successive lurches in population numbers have driven the development of new agricultural technologies designed to provide food for growing populations. This process of discovery will continue until there is an abundance of food equally enjoyed by the whole world (Trewavas, 2002).” From this, it is evident that Trewavas shares Borlaug’s philosophy of the history of agriculture, which is an outgrowth of the Enlightenment philosophy of progress criticized by Leo Marx. It is obvious, then, the Trewavas’ argument is open to the philosophical criticism of technological fixes.

It is also worth noting, however, that many critics are quick to point out that “it is misleading... to suggest that increasing total food production is the key element in solving problems of world hunger (Thompson, 1997, p. 28).” Peter Rosset, Co-director of Food First, has consistently argued against biotechnology with conventional arguments against technological fixes. Rosset points out that on a global scale modern agriculture has produced more than enough food for all people to live healthy, active lives. “The real causes of hunger are poverty, inequality and the lack of access. Too many are too poor to buy the food that is available (Rosset, 2002, p. 82).” Rosset also comments, “The subsistence farmer today isn’t principally constrained by technology [so] any technology fix is likely to be inadequate (PEW 2001).” Rosset mounts the standard criticism against technological fixes—that technology is being inappropriately used to solve problems that are nontechnological in nature.

Trewavas responds to such criticism with the typical arguments promoting the use of technological fixes.

Critics say to me there is enough food to feed the world and they may well be right, at present. We produce sufficient to feed 6.4 billion people, but the excess is largely in the West and it is far easier for scientists to conjure more food from the plant we grow than

to persuade the West to share its agricultural bounty with its poorer neighbors (Trewavas, 2002, p.150).

This reply is in line with Weinberg's original argument for technological fixes. Technological problems are much simpler than social problems; they are easier to define and identify solutions. And technological problems do not have to deal with the complexity and unpredictability of human behavior.

To summarize, Trewavas' philosophy of the history of agriculture leads him to the sweeping conclusion that biotechnology is the "way forward." Hence, his argument is open to Marx's philosophical criticism of technological fixes and cannot be justified, precisely because his philosophy of history cannot be justified.

Next, I would like to turn to a practical argument for biotechnology as a technological fix that is not vulnerable to the philosophical criticism. The Golden Rice Project is a textbook example of a "technological fix." The Rockefeller Foundation initially funded the Golden Rice Project with the goal of genetically engineering rice plants to contain beta-carotene, which the human body converts to vitamin A. Golden rice is designed to be the technological solution for vitamin A deficiency disease (VAD). According to the World Health Organization, VAD "causes some 250,000 to 500,000 children to go blind each year. More than half of those who lose their sight die within a year."⁴ Along with blindness, vitamin A deficiency can compromise the immune system and increases the risks of common childhood infections.⁵ VAD exists in roughly 40 percent of the children in the developing world; in areas where people depend upon a diet of mainly rice, the number of children suffering from VAD is extremely high, as rice contains no beta-carotene. In Southeast Asia, a staggering 70 percent of the children eat diets deficient in vitamin A.

VAD is a social problem because it is the direct result of poverty. Millions of poor people have no choice but to subsist on a diet of inexpensive rice, widespread vitamin A deficiency in

⁴ <http://www.goldenrice.org/> accessed 10/28/05/

⁵ Ibid.

children can be appropriately identified as a symptom of economic injustice. Economic injustice leading to world poverty is a complex, seemingly intractable socio-political problem. Addressing the root problem of VAD—poverty—seems unrealistic in the near term, particularly given constraints of time: each year hundreds of thousands of children are suffering from the horrible consequences of VAD. Hence, VAD seems like a perfect candidate for a technological fix. It is the result of a complex and intractable social problem that can be readily reframed as a technological problem.

Once the problem is reframed, the solution to VAD becomes a well-defined engineering puzzle: genetically engineer rice plants to produce enough beta-carotene in the endosperm of rice plants so that a child eating 100-200 g of rice per day will receive the recommended daily allowance (RDA) of vitamin A (300 µg).⁶ While the goal is well-defined, it has proven difficult to reach. It took a decade to develop the technology needed to introduce the genes into rice. It took nearly another decade to introduce genes that create the pathway for the production of beta-carotene.⁷ And biotechnologists continue to work toward the goal of engineering golden rice that contains the RDA of vitamin A in the amount of rice consumed per day by children eating primarily rice.

Again, golden rice is clearly a textbook example of a technological fix. Moreover, those defending golden rice have listed the same positive and negative attributes of technological fixes found in Weinberg's original discussion of technological fixes. First, vitamin A deficiency is rooted in deep social and political pathologies that are complex and difficult to identify. By reframing the social and political problem as a technological problem, a technological "solution" becomes clear. Second, technological fixes avoid the problem of changing people's attitudes and behavior. To address chronic poverty on the social level would require governments in the developed world to become more generous, and many of those in the developing world would

⁶ <http://www.goldenrice.org/> accessed 10/28/05.

⁷ Ibid.

need to become more competent and less corrupt. The technological solution avoids the troubling problem of trying to make people morally better. It simply aims to supply new biofortified rice seeds to the needy free of charge. Third, since poverty is such a complex problem golden rice is touted as another front for attacking chronic malnutrition. The Golden Rice Project Web site states: “Golden Rice offers developing countries another choice in the broader campaign against malnutrition.”⁸ Fourth, golden rice will lessen the severity of the problem making it easier for social solution to work. In his defense of golden rice, Gordon Conway of The Rockefeller Foundation says that golden rice provides an “excellent compliment” to there existing diets to make it easier for the poor people to obtain enough vitamin A in their diets. Finally, while golden rice may not solve the problem of malnutrition, it can buy time until the root problem of poverty can be addressed.

Moreover, the proponents of golden rice admit that it is not *the* solution to vitamin A deficiency. As Weinberg conceded, technological fixes do not get to the root of the problem. Gordon Conway writes that “[The Rockefeller Foundation does] not consider golden rice to be *the* solution to the vitamin A deficiency problem (Ruse and Castle, 2002, p. 63).” Also, The Golden Rice Project Website says,

The Golden Rice Humanitarian Board encourages further research to determine how the technology may play a part in the ongoing global effort to fight VAD in poor countries. While Golden Rice is an exciting development, it is important to keep in mind that malnutrition is to a great extent is rooted in political, economic and cultural issue that will not be solved by a technological fix.⁹

Thus, Golden rice is addressing a symptom—VAD—of a larger disease: economic injustice.

The argument for golden rice is not open to the philosophical criticism of technological fixes. It makes no appeal to the progressive history of agriculture. It offers to provide a concrete technological “solution” to a pressing problem. However, it is open to the practical criticism, which raises three cautions. The first caution is to have sober, limited expectations about what

⁸ <http://www.goldenrice.org/> accessed 10/28/05

⁹ Ibid.

new technological fixes can accomplish and to expect new problems to arise. Technological fixes offer trade-offs, not solutions. Golden rice will not solve the problem of VAD, but it is likely to serve an ameliorative function. The second caution is to be aware that technological fixes define problems and evaluate solutions in the narrow terms of technological systems. Because of this one should expect side-effect problems. Third, technological fixes are frequently conservative.

This third caution, the conservative nature of most technological fixes, is particularly important when considering golden rice. One of the main critiques of the golden rice project comes from Vandana Shiva. Shiva argues that this new technology is designed to correct a defect in the current industrial, technological system of agriculture that has given rise to VAD. As such it is fundamentally conservative, as it aims to perpetuate a flawed system. Shiva writes, “While the complicate technology-transfer package of ‘golden rice’ will not solve vitamin A problems in India, it is a very effective strategy for corporate take over of rice production, using the public sector as a Trojan horse” (Shiva, 2002). These cautions should be taken into consideration, but there is no reason that golden rice should not be listed among the options for addressing vitamin A deficiency disease.

In this paper’s analysis of the technological fix criticism, I noted that there are two distinct criticisms. The practical criticism serves to caution us about the ambiguous nature of technological fixes. It points to inherent defects and limitations of technological fixes as a method of inquiry and as a means to address problems. This criticism warns about the limits and dangers of using agricultural biotechnology as a technological fix. The philosophical criticism points to the discredited philosophy of history that is implicit in the arguments of many of the most vocal advocates of agricultural biotechnology. The arguments of Trewavas and Borlaug make sweeping claims that biotechnology *should* be the way for solving the challenges of twenty-first century agriculture. These claims are grounded in a philosophy of history that cannot be justified. Furthermore, this criticism draws attention to a habitual pattern of using technology to solve social problems. This habit leads to using technological fixes when they may not be the most

appropriate means to addressing a problem. As John Dewey notes, “People think in ways they should not when they follow methods of inquiry that experience of past inquiries shows are not competent to reach the intended ends of the inquiries in question (Dewey, 1981-19p, p. 107).”

The distinction between philosophical arguments and practical arguments is a helpful one. The arguments for golden rice do not make sweeping claims about the future direction of agriculture. Golden rice is a reasonable response to a specific, concrete problem. Nonetheless, it is prudent to apply the practical criticism to this technological fix. Even with these warning, golden rice may simply be the most appropriate response at the moment. It could play the positive role of technological fixes as listed by Weinberg—providing policy makers with more options and additional means for addressing social problems.

In addition, I think the case of golden rice points out the problems of making too much of the distinction between technological problems and social problems and to the idea that there are root causes to all problems. This might lead one to err in the opposite direction and reject technological fixes altogether. But a better model of thinking would be to follow a pattern of practical reasoning. This means to carefully define the goals one hopes achieve, to list all the available alternatives, both technological and political, to examine the obstacles and side-effects that each alternative is likely to produce, and finally to pick the alternative(s) that is (or are) most likely to help reach the stated goals. In doing so, it should not matter if the most appropriate alternative at hand is a technological fix or a political solution: the appropriate decision is simply to do the best that we can do.

As was noted at the beginning of this paper, the debate over biotechnology is in part a debate over how to frame the challenges of twenty-first century agriculture: are these challenges fundamentally technological or are they social and political? Hopefully it has been shown that this focus is misleading: the obvious conclusion is that the challenges of twenty-first century agriculture are both scientific and technological and as well as social and political.

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