Transgenic Crops to Address Third World Hunger? A Critical Analysis

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Industry and mainstream research and policy institutions often suggest that transgenic crop varieties can raise the productivity of poor third world farmers, feed the hungry, and reduce poverty. These claims are critically evaluated by examining global-hunger data, the constraints that affect the productivity of small farmers in the third world, and the factors that explain their poverty. No significant role is found for crop genetics in determining hunger, productivity, or poverty, casting doubt on the ability of new transgenic crop varieties produced by genetic engineering to address these problems. An examination of the special risks these varieties pose for poor farmers in the complex, diverse, and risk-prone environments that characterize peasant agriculture on a global scale suggests that transgenic crop varieties are likely to be more of hindrance than a help to the advancement of poor farmers.

Keywords: *transgenic; genetic engineering; poverty; hunger; productivity; third world; risks; peasant agriculture*

In this analysis, I take very seriously the oft-repeated claim that genetic engineering of crop seeds could be an important way to attack hunger in the nations of the south, submitting it to a rigorous critical analysis. Industry and mainstream research and policy institutions often suggest that transgenic crop varieties can raise the productivity of poor third world farmers, feed the hungry, and reduce poverty (e.g., http://www.whybiotech.com; McGloughlin, 1999a, 1999b; Pinstrup-Andersen, 1999). To address these propositions critically, we must examine the assumptions and claims that lie behind them. To do so, I first briefly review the notion that hunger is due to a scarcity of food and, thus, that it could be remedied by producing more. I then look into the situation faced by poor farmers in the third world, including the issue of their productivity. I close by examining some of the special risks that genetic engineering for agriculture may pose for peasant farmers.

Food Availability and Hunger

Global data show that there is no relationship between the prevalence of hunger and our ability to produce enough food. In fact, per-capita food production increases during the past 4 decades have far outstripped human population growth. The world today produces more food per inhabitant than ever before. Enough is available to provide 4.3 pounds for every person every day, including 2.5 pounds of grain, beans, and nuts; about a pound of meat, milk, and eggs; and another pound of fruits and vegetables—more than enough for a healthy, active life. The real causes of hunger are poverty, inequality, and lack of access to readily available food—food that can only be obtained with money—by people who are cash poor. Too many people are too poor to buy the food that is available (but often poorly distributed) or lack the land and resources to grow it themselves (Lappé, Moore, Collins, Rosset, & Esparza, 1998). In fact, farmers around the world, both north and south, believe that overproduction—and consequent low crop prices—is one of the most persistent problems generating poverty (and thus hunger) in rural areas (McMichael, 2004).

At this level of macroanalysis, then, it should be clear that we most definitely do not need more food to end hunger. Thus, at a global scale, improved crop-production technology of any kind is unlikely to help.

However, this may not be true in all cases of individual countries, or regions within countries, where per capita food production figures and food availability

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may lag behind global averages. Thus we must take seriously the notion that in some cases (i.e., parts of sub-Saharan Africa) we may have to address the productivity of poor farmers who grow foodstuffs for consumption in regional and national markets to effectively combat hunger (de Grassi & Rosset, in press).

When we speak of these national markets, we find that small and peasant farmers, despite their disadvantaged position in society, are the primary producers of staple foods, accounting for very high percentages of national production in most third world countries. This sector, which is so important for food production, is itself characterized by poverty and hunger and, in some cases, lagging agricultural productivity. If these problems are to be addressed by a proposed solution—transgenic crop varieties in this case—we must begin with a clear understanding of their causes. If the causes lie in inadequate technology, then a technological solution is at least a theoretical possibility. Thus let me begin by examining the conditions faced by peasant producers of staple foods in most of the third world.

Historical Background

The history of the third world since the beginning of colonialism has been a history of unsustainable development. Colonial land grabs pushed rural food-producing societies off the best lands most suitable for farming: the relatively flat alluvial or volcanic soils with ample, but not excessive, rainfall (or water for irrigation). These lands were converted to production for export in the new global economy dominated by the colonial powers. Instead of producing staple foods for local populations, they became extensive cattle ranches or plantations of indigo, cocoa, copra, rubber, sugar, cotton, and other highly valued products. Where traditional food producers had utilized agricultural and pastoral practices developed over thousands of years to be in tune with local soil and environmental conditions, colonial plantations took a decidedly short-term view toward extracting the maximum benefit at minimal costs, often using slave labor and production practices that neglected the long-term sustainability of production (for further development of the arguments put forth in this section see Lappé et al., 1998; Ross, 1998).

Meanwhile, local food producers were either enslaved as plantation labor or displaced into habitats that were marginal for production. Precolonial societies had used arid areas and desert margins only for low-intensity, nomadic pastoralism; steep slopes only for low population density, long-fallow shifting cultivation (or sophisticated terracing in some cases); and rain forests primarily for hunting and gathering (with some agroforestry)—all practices that are ecologically sustainable over the long term. But colonialism drove farming peoples—accustomed to the continuous production of annual crops on fertile, well-drained soils with good access to water—en masse into these marginal areas. Whereas precolonial cultures had never considered these regions to be suitable for high population densities or intensive annual cropping, in many cases they were henceforth to be subject to both. As a result, forests were felled, and many fragile habitats were subject to unsustainable production practices—in this case by poor, newly destitute and displaced farmers—just as the favored lands were being degraded by continuous export cropping at the hands of Europeans.

National liberation from colonialism did little to alleviate the environmental and social problems generated by this dynamic because the situation, in fact, worsened in much of the third world. Postcolonial national elites came to power with strong linkages to the global export-oriented economy often, indeed, connected to former colonial powers. The period of national liberation, extending for more than a century, corresponded with the rise of capitalist market and production relations on a global scale and, in particular, with their penetration of third world economies and rural areas. New exports came to the fore—including coffee, bananas, ground nuts, soy beans, oil palm, and others—together with new, more capitalistic (as opposed to feudal or mercantile) agroexport elites. This was the era of modernization, whose dominant ideology was that bigger is better. In rural areas, that meant the consolidation of farmland into large holdings that could be mechanized and the notion that the so-called backwards and inefficient peasantry should abandon farming and migrate to the cities where they would provide the labor force for industrialization. This ushered in a new era of land concentration in the hands of the wealthy and drove the growing problem of landlessness in rural areas. The landless rapidly became the poorest of the poor, subsisting as part-time, seasonal agricultural or day laborers and share croppers or migrating to the agricultural frontier to fell forests for homesteads. Also among the poor were the land poor: sharecroppers, renters of small plots, squatters, or legal owners of parcels too small or too infertile to adequately support their families.

Thus rural areas in the third world are, today, characterized by extreme inequities in access to land, security of land tenure, and the quality of the land farmed. These inequities underlie equally extreme inequities in wealth, income, and living standards. The poor majority are marginalized from national economic life because their meager incomes make their purchasing power insignificant. This creates a vicious circle.

The marginalization of the majority leads to narrow and shallow domestic markets, so landowning elites orient their production to export markets where consumers do have purchasing power. By doing so, elites have ever less interest in the well-being or purchasing power of the poor at home because the poor are not a market for them but, rather, a cost in terms of wages to be kept as low as possible. By keeping wages and living standards low, elites guarantee that healthy domestic markets will never emerge, reinforcing export orientation. The result is a downward spiral into deeper poverty and marginalization even as national exports become more competitive in the global economy. One irony of our world, then, is that food and other farm products flow from areas of hunger and need to areas were money is concentrated: northern countries.

The same dynamic drives environmental degradation. On one hand, rural populations have historically been relocated from areas suitable for farming to those less suitable, leading to deforestation, desertification, and soil erosion in fragile habitats. This process continues today as the newly landless continuously migrate to the agricultural frontier.

On the other hand, the situation is no better in the more favorable lands. Here the better soils of most nations have been concentrated into large holdings used for mechanized, pesticide and chemical fertilizer intensive, monocultural production for export. Many of our planet’s best soils—which had earlier been managed sustainably for millennia by precolonial, traditional agriculturalists—are today being rapidly degraded and, in some cases, abandoned completely in the short-term pursuit of export profits and competitiveness. The productive capacity of these soils is dropping rapidly because of soil compaction, erosion, waterlogging, and fertility loss together with growing resistance of pests to pesticides and the loss of in-soil and above-ground functional biodiversity. The growing problem of yield decline in these areas has recently been recognized as a looming threat to global food production by a number of international agencies (see also Lappé et al., 1998).

Structural Adjustment and Other Macropolicies

As if that were not enough, the past 3 decades of world history have seen a series of changes in national and global governance mechanisms, which have, in their sum, eroded the ability of governments in southern nations to manage national development trajectories with a view to the broad-based human security of their citizens. Their ability has been critically weakened to ensure the social welfare of poor and vulnerable people, achieve social justice, guarantee human rights, and protect and sustainably manage their natural resources. These changes in governance mechanisms have been made within a paradigm that sees international trade as the key resource for promoting economic growth in national economies and sees that growth as the solution to all ills (Lappé et al., 1998).

To make way for increased import/export activity and export-promoting foreign investment, structural adjustment programs (SAPs), and regional and bilateral trade agreements, GATT and WTO negotiations have all shifted the balance of governance over national economies away from governments and toward market mechanisms and global regulatory bodies like the WTO. Southern governments have progressively lost the majority of the management tools in their macroeconomic policy toolboxes. They have been forced to drastically cut government investment through deficit-slashing requirements, unify exchange rates, devalue and then float currencies, virtually eliminate tariff and nontariff import barriers, privatize state banks and other enterprises, and slash or eliminate subsidies of all kinds, including social services and price supports for small farmers. In most cases—either in preparation for entering trade agreements or with international financial institution funding and/or guidance—governance over land tenure arrangements has followed suit with privatization, land markets, and market mechanisms coming to the fore in search of greater investment in agricultural sectors (Bello, Cunningham, & Rau, 1999; Rosset, 2004).

Although such changes have, in some cases, created new opportunities for poor people to exploit new niche markets in the global economy (organic coffee, for example), they have, for the most part, undercut both government-provided social safety nets and guarantees and traditional community management of resources and cooperation in the face of crises. The majority of the poor still live in rural areas, and these changes have driven many of them to new depths of crisis in their ability to sustain their livelihoods. Increasingly, they have been plunged into an environment dominated by global economic forces where the terms of participation have been set to meet the interests of the most powerful. Small farmers find the prices of the staple foods they produce dropping below the cost of production in the face of cheap imports freed from tariffs and quotas. They are increasingly without the subsidized credit, marketing, and prices that once helped support their production and with communal land tenure arrangements under attack from legal reforms and private-sector investors. The result is the declining productivity of small farmers who produce food for domestic consumption, especially in regions like sub-Saharan Africa (de Grassi & Rosset, in press; Lappé et al., 1998).

Lagging Productivity

Third World food producers demonstrate lagging productivity not because they lack so-called miracle seeds that contain their own insecticide or tolerate massive doses of herbicide but because they have been displaced onto marginal, rain-fed lands and face structures and macroeconomic policies that are increasingly inimical to food production by small farmers. When development banks are privatized by SAPs, credit is withdrawn from small farmers. When SAPs cancel subsidies for inputs, small farmers stop using them. When price supports end and domestic markets are opened to surplus food dumped by northern countries, prices drop and local food production becomes unprofitable. When state marketing agencies for staple foods are replaced by private traders, who prefer cheap imports or buying from large, wealthy farmers, small farmers find there are no longer any buyers for what they produce. These, then, are the true causes of low productivity. In fact, in many parts of the third world, especially Africa, farmers today produce far less than they could with presently available know-how and technology because there is no incentive for them to do so—there are only low prices and few buyers. No new seed, good or bad, can change that. Thus it is extremely unlikely that, in the absence of urgently needed structural changes in access to land and in agricultural and trade policies, genetic engineering could make any dent in food production by the world's poorer farmers (de Grassi & Rosset, in press; Lappé et al., 1998).

When seen in this light, it should be clear that genetic engineering is tangential, at best, to the conditions and needs of the farmers we are told it will help: It in no way addresses the principal constraints they face. But tangential is a far cry from bad. Now I turn to the question of whether genetically engineered crops are simply irrelevant to the poor or if they might actually pose a threat to them. First we must ask about the actual circumstances of peasant farming.

A Complex, Diverse, and Risk-Prone Agriculture

Because peasant farmers have historically been displaced, as described above, into marginal zones characterized by broken terrain, slopes, irregular rainfall, little irrigation, and/or low soil fertility and because they are poor and victimized by pervasive antipoor and antismall-farmer biases in national and global economic policies, their agriculture is best characterized as complex, diverse, and risk prone (Chambers, 1990, 1993).

To survive under such circumstances and improve their standard of living they must be able to tailor agricultural technologies to their variable but unique circumstances in terms of local climate, topography, soils, biodiversity, cropping systems, market insertion, resources, etc. For this reason, such farmers have for millennia evolved complex farming and livelihood systems that balance risks of drought, market failure, pests, etc. with factors such as labor needs versus availability, investment needed, nutritional needs, seasonal variability, etc. Typically, their cropping systems involve multiple annual and perennial crops, animals, fodder, even fish, and a variety of foraged wild products (Chambers, 1990, 1993; de Grassi & Rosset, 2003, in press).

Repeating the Errors of Top-Down Research

Such farmers have rarely benefited from top-down, formal institution research and green revolution technologies. Any new strategy to truly address productivity and poverty concerns will have to meet their needs for multiple suitable varieties. Peasant farmers typically plant several different varieties on their land, tailoring their choice to the characteristics of each patch—whether it has good drainage or bad, is more or less fertile than the rest, etc. However, such varieties cannot be easily developed with current research and extension structures and methods, the same structures that biotech proponents use for genetically engineered varieties (the arguments in this section are developed in Chambers, 1990, 1993; de Grassi & Rosset, 2003, in press).

Formal research methods are not able to handle the vast complexity of physical and socioeconomic conditions in most third world agriculture. This stems from the discrepancy between hierarchical research and extension systems that value monocultural yield above all else and complex rural realities. The result of the mismatch is that numerous variables important to farmers have to be reduced to produce new technologies. Measured in a few variables, new seeds are perceived by researchers to be better than old ones. Therefore, researchers are puzzled when farmers fail to adopt new seeds widely.

In reality, seeds have multiple characteristics that cannot be captured by a single yield measure—as important as this measure may be—and farmers have multiple site-specific requirements for their seeds, not just controlled condition high yields. These interconnections stand in direct contrast to formal breeding procedures where varieties are selected individually for discrete traits then crossed to combine these individual traits. According to Jiggins, Reijnjets, and Lightfoot (1996), high-yielding variety trials in sub-Saharan Africa show

> larger variations, for both "traditional" and "improved," *among* farmers and *between* years, than the mean differences between "traditional" and "improved" yields in a single year. There is indeed overwhelming evidence throughout SSA that the yield response to fertilizer and improved varieties, soil management and other practices is highly site-, soil-, season-, and farmer-specific.

Given such conditions, the inescapable conclusion is that a different approach—participatory breeding by organized farmers themselves—which takes into account the multiple characteristics of both seed varieties and farmers, is essential: Miracle seeds will not just be developed in laboratories and on research stations and then be effortlessly distributed to farmers. Yet genetic engineering is the very antithesis of participatory, farmer-led research. Proponents of genetically engineered varieties are repeating the very top-down errors that led first-generation green-revolution crop varieties to have low adoption rates among poorer farmers.

Yet many would argue that the possibility of delivering enhanced nutrition to the poor should outweigh such concerns, for example in the case of the famous golden rice, which has been engineered to contain additional beta-carotene, the precursor of vitamin A.

Enhanced Nutrition?

The suggestion that genetically altered rice is the proper way to address the condition of 2 million children at risk of vitamin A deficiency-induced blindness reveals a tremendous naiveté about the reality and causes of vitamin and micronutrient malnutrition. If one reflects on 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 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 could be addressed, together with vitamin A deficiency, by a more varied diet. A magic-bullet solution that 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. In fact, there are many readily available solutions to vitamin A deficiency-induced blindness, including many ubiquitous leafy plants that when introduced (or reintroduced) into the diet provide both needed beta-carotene and other missing vitamins and micronutrients (ActionAid, 1999; Altieri & Rosset, 1999a, 1999b; Ho, 2000).

Yet it is clear that the genetic engineering juggernaut is moving ahead at full speed. What then are the risks associated with forcing transgenic (genetically engineered) varieties into complex, diverse, and risk-prone circumstances?

Risks for Poor Farmers

When transgenic varieties are used in such cropping systems, the risks are much greater than in green-revolution, large, wealthy farmer systems or farming systems in northern countries. The widespread crop failures reported for transgenics because of stem splitting, boll drop, etc. (e.g., Eckardt, McHenry, & Guiltinan, 1998; Gertz, Vencill, & Hill, 1999; Hagedorn, 1997) pose economic risks that can affect poor farmers much more severely than wealthy farmers. If consumers reject their products, the economic risks are higher the poorer one is. Also, the high costs of transgenics introduce an additional antipoor bias into the system (Altieri & Rosset, 1999a, 1999b).

The most common transgenic varieties available today are those that tolerate proprietary brands of herbicides and those that contain insecticide genes. Herbicide-tolerant crops make little sense to peasant farmers who plant diverse mixtures of crop and fodder species because such chemicals would destroy key components of their cropping systems (Altieri & Rosset, 1999a, 1999b).

Transgenic plants that produce their own insecticides—usually using the Bt gene—closely follow the pesticide paradigm, which is itself rapidly failing because of pest resistance to insecticides. Instead of the failed one pest, one chemical model, genetic engineering emphasizes a one pest, one gene approach, shown over and over again in laboratory trials to fail because pest species rapidly adapt and develop resistance to the insecticide present in the plant. Bt crops violate the basic and widely accepted principle of integrated pest management (IPM), which is that reliance on any single pest-management technology tends to trigger shifts in pest species or the evolution of resistance through one or more mechanisms. In general, the greater the selection pressure across time and space, the quicker and more profound the pests' evolutionary response. Thus IPM approaches employ multiple pest-control mechanisms and use pesticides minimally and only in cases of last resort. An obvious reason for adopting this principle is that it reduces pest exposure to pesticides, retarding the evolution of resistance. But when the product is engineered into the plant itself, pest exposure leaps from minimal and occasional to massive and continuous, dramatically accelerating resistance. Most entomologists agree that Bt will rapidly become useless both as a feature of the new seeds and as an old standby natural insecticide sprayed when needed by farmers that want out of the pesticide treadmill. In the United States, the EPA has mandated that farmers set aside a certain proportion of their area as a refuge where non-Bt varieties are to be planted to slow down the rate of evolution by insects of resistance. Yet it is unlikely that poor, small farmers in the third world will plant such refuges, meaning that resistance to Bt could occur much more rapidly under such circumstances (Altieri & Rosset, 1999a, 1999b).

At the same time, the use of Bt crops affects nontarget organisms and ecological processes. Recent evidence shows that the Bt toxin can affect beneficial insect predators that feed on insect pests present on Bt crops and that windblown pollen from Bt crops found on natural vegetation surrounding transgenic fields can kill nontarget insects. Small farmers rely, for insect pest control, on the rich complex of predators and parasites associated with their mixed cropping systems. But the effect on natural enemies raises serious concerns about the potential of the disruption of natural pest control because polyphagous predators that move within and between mixed crop cultivars will encounter Bt-containing, nontarget prey throughout the crop season. Disrupted biocontrol mechanisms may result in increased crop losses because of pests or the increased use of pesticides by farmers with consequent health and environmental hazards (Altieri & Rosset, 1999a, 1999b; Dutton, Klein, Romeis, & Bigler, 2002; Hillbeck, Baumgartner, Fried, & Bigler, 1998).

The fact that Bt retains its insecticidal properties after crop residues have been plowed into the soil 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 and who, instead, rely on local residues, organic matter, and soil microorganisms (key invertebrate, fungal, or bacterial species) for soil fertility, which can be negatively affected by the soil-bound toxin (Altieri & Rosset, 1999a, 1999b; Donnegan et al., 1995; Zwahlen, Hilbeck, Gugerli, & Nentwig, 2003).

When the Bt genes fail, what would poor farmers be left with? It is entirely possible that they would face the serious rebound of pest populations freed of natural control by the impact Bt had on predators and parasites, and reduced soil fertility because of the impacts of Bt crop residues plowed into the ground. These are farmers who are already risk-prone, and Bt crops would likely increase that risk.

In the third world, there will typically be more sexually compatible wild relatives of crops present, making pollen transfer to weed populations of insecticidal properties, virus resistance, and other genetically engineered traits more likely with possible food chain and superweed consequences. With massive releases of transgenic crops, these impacts are expected to scale up in those developing countries that constitute centers of genetic diversity. 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 (Altieri & Rosset, 1999b).

Perhaps of greater concern to peasant farmers is the possibility that their locally adapted crop varieties will be contaminated with transgenes via cross-pollination from transgenic varieties planted by other farmers. This concern was recently highlighted by the contamination with transgenes of local maize varieties in Mexico. It is in Mexico that maize was domesticated by indigenous peoples, and the region remains the present-day center of genetic diversity for this staple food crop so critical to global food security. The thousands of local varieties still cultivated by peasant farmers contain untold genetic diversity on which crop breeders and farmers worldwide depend as a source of novel traits for their breeding programs. Recognizing that this constitutes a critical biological heritage for all of humanity, the Mexican Environment Ministry in 1996 prohibited the import of transgenic maize seed for fear of contaminating this resource. Unfortunately, transgenic maize grain was still imported for human consumption and is sometimes planted by the poor in lieu of maize sold specifically as seed. Thus in 2001 scientists discovered alarmingly high rates of contamination of local maize races, presumably via wind-borne pollination from such plants (Quist & Chapela, 2001). Because of molecular promoters of gene expression incorporated into transgenic varieties, contamination poses a threat to the genetic integrity of local landraces because these promoters can potentially scramble the genomes of contaminated varieties (Ho et al., 2003; Wilson, Latham, & Steinbrecher, 2004). Thus peasant farmers could lose the locally adapted varieties that they depend on, and the world could lose germplasm that is critical to future food security.

There is also potential for vector recombination to generate new virulent strains of viruses, especially in transgenic plants engineered for viral resistance with viral genes. In plants containing coat protein genes, there is a possibility that such genes will be taken up by unrelated viruses infecting the plant. In such situations, the foreign gene changes the coat structure of the viruses and may confer properties such as changed method of transmission between plants. The second potential risk is that recombination between RNA virus and a viral RNA inside the transgenic crop could produce a new pathogen leading to more severe disease problems. Some researchers have shown that recombination occurs in transgenic plants and that under certain conditions it produces a new viral strain with altered host range (Steinbrecher, 1996). Crop losses caused by new viral pathogens could have a more significant impact on the livelihoods of poor farmers than they would for wealthier farmers who have ample resources to survive poor harvests.

In sum, these and other risks seem to outweigh the potential benefits for peasant farmers, especially when we consider the factors that currently limit their ability to improve their livelihoods, which are largely structural in nature—and thus political—rather than technological. Furthermore, to the extent that so-called better technologies are needed to improve farmer livelihoods and/or productivity, there is a wealth of proven agroecological, participatory, and empowering alternatives available to them (for an introduction to these alternatives see Altieri, Rosset, & Thrupp, 1998; Ho et al., 2003; Pretty, Morison, & Hine, 2003).

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