"Biotechnology and Rural Development: Implications for Southern African Agriculture"

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Biotechnology and Rural Development: Implications for Southern African Agriculture[1]

> Technology reveals the active relation of man [sic] to nature, the direct process of the production of his life, and thereby it also lays bare the process of the production of social relations of his life, and of the mental conceptions that flow from those relations.
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> --Karl Marx, Capital, Vol. 1.

Introduction

Perhaps more than any other technology in recent memory, biotechnology has been celebrated with almost a religious fervor. Almost daily, it seems, there are new predictions for the heights to which biotechnology will take humanity. The Human Genome Project, we are told, will lead to cures for diseases and medical conditions as diverse as cancer, diabetes and hypertension, and the application of biotechnology to agriculture will end hunger and malnutrition around the world.[2]

With such grand predictions, it is almost passé to raise questions regarding the social and economic implications of the new technology. Indeed, critics of biotechnology are usually dismissed as Luddites[3] who will condemn humanity to a future of poverty, disease, hunger and malnutrition through their irrational resistance to "progress." Thus, a recent issue of *The Economist* concluded that, "the controversial science of genetic

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[1] This paper grew out of a series of interviews conducted in Zimbabwe during the spring of 2001. I am indebted to those who shared so generously of their time. My thanks also go out to Carol Thompson, who partnered with me during that research. This paper was originally presented at a workshop sponsored by the Rural and Community Development Group, the African Studies Program, and the Centre for the Study of Latin America and the Caribbean (all of York University). I am in debt to those who participated in the workshop, and in particular to Ricardo Grinspun, Pablo Idahosa and Liisa North for their comments and suggestions. All errors and omissions, of course, remain the responsibility of the author alone.

[2] See, for example, National Institutes of Health (2001), Council for Biotechnology Information (2001), and Guest (2001).

[3] Luddites were textile workers in England who, from 1811 to 1816, covertly destroyed knitting machines which they believed were displacing workers and driving down wages. Later, the term came to be associated with anyone who opposed technology or technological progress. For a more detailed discussion, see Sale (1995).

modification could feed the world, if only environmentalists would let it." (Guest, 2001: 4) A similar argument is made by the biotech industry, frequently articulated in terms of rationality, science, progress and education. At the recent Agricultural Biotechnology International Conference (ABIC) 2000 in Toronto, for example, industrial, scientific/academic, and governmental leaders focused extensively on overcoming 'irrational' public attitudes—especially among European consumers—perpetuated ostensibly by the fear-mongering media and fueled by 'bad science.' Delegates stressed the need for 'education' through initiatives like the Council for Biotechnology Information, a $250 million public relations initiative funded primarily by Monsanto, Aventis, DuPont and Novartis, with the aim of convincing North American consumers of the safety and necessity of biotechnology. (CBI, 2001)

Individual corporations have launched similar endeavors. Monsanto, for example, has undertaken a campaign in Europe hoping to undermine public pressure for strict regulation of genetically modified (GM) foods and crops. Their newsprint campaign features pictures of happy children and lush green fields with captions reading, "If it weren't for science, her life expectancy would be 41 years," and "Worrying about starving generations won't feed them—Food biotechnology will." The subtext of such advertising is clear: Biotechnology is a *necessary* because *only* biotechnology will solve human health and nutritional needs.

But is biotechnology the new messiah or a false prophet? This paper explores the promises and perils of agricultural biotechnology for Southern Africa. To that end, it begins by briefly exploring the development of agricultural biotechnology in the West. It then argues that a number of factors restrict the applicability of agrobiotechnology to the

regional context of Southern Africa. Specifically it addresses the following questions: What does biotechnology hold for agriculture in Southern Africa? Who are the beneficiaries, and who will likely pay the costs? The paper concludes by highlighting both the potential gains and losses associated with the adoption of biotechnology in the region. Drawing on parallels from the Green Revolution in Asia, the paper argues that smallholder farmers in Southern Africa are unlikely to reap the benefits attributed to advances in agricultural biotechnology. Instead, the advances in and adoption of new agrobiotechnologies are likely to exacerbate rather than mitigate existing inequalities, undermine rather than protect African biodiversity, and facilitate dependence rather than development.

Biotechnology Advances in the West

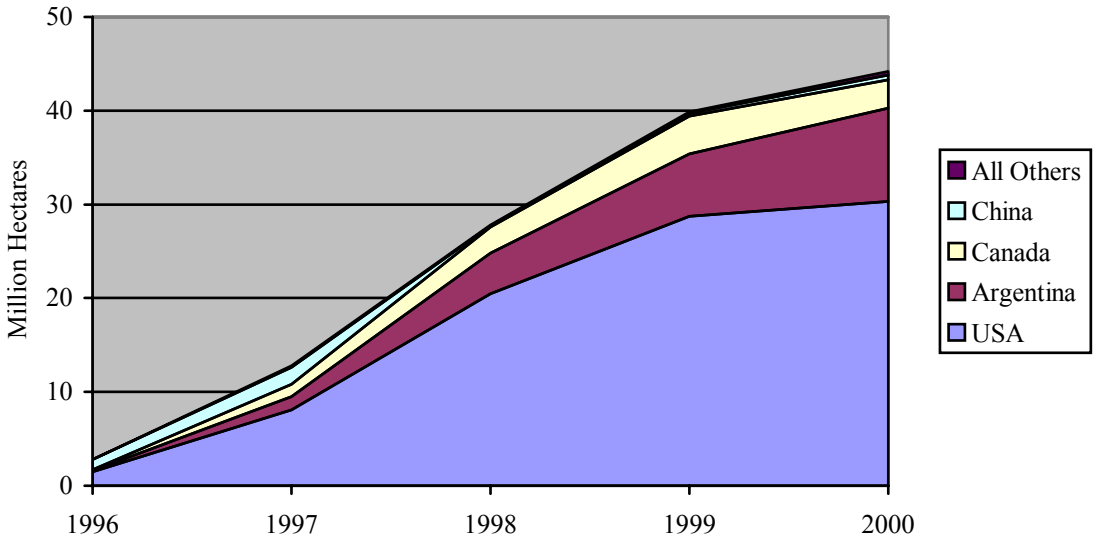
Since the discovery of recombinant DNA (rDNA)[4] and the creation of the first transgenic organism over twenty years ago, biotechnology has shifted from the laboratory to the marketplace.[5] Particularly in the West, biotechnology is a rapidly growing industry. Already there are almost 100 biotech medicines on the market, with another 350 in late-stage clinical trials. (Feldbaum, 2000) In purely market terms, 50 biotech companies had market capitalizations of more than US $1 billion by the end of 2000. (Van Brunt, 2001) And the completion of a preliminary map of the human genome has only served to fuel future hopes. (NIH, 2001)

[4] Recombinant DNA, or rDNA, is the process by which most biotechnology products are created. It allows the insertion of segments of DNA from one organism into the genetic code of another, usually by employing bacteriophages—viruses that inject their DNA into host cells. For an accessible introduction, see Grace (1997).

[5] A discussion of the political, economic and social context in which biotechnology developed falls outside the scope of this paper. For a more detailed discussion, see Zerbe (2002), Wright (1994), and Krimsky (1982).

In agriculture, the rapid of growth of the biotechnology industry has been equally impressive. By 2000, 16 per cent of area under cultivation worldwide was planted to GM crops. In just five years, the global area under transgenic cultivation increased more than 25 fold, from 2.8 million hectares in 1996 to 44.2 million hectares in 2000. (See figure 1) More than three-quarters of all GM crops, however, are produced in the developed world. (James, 2000) Four countries in particular account for 99 percent of the total area planted to GM crops: the US (with 68% of the world's total), Argentina (10%), Canada (7%), and China (1%), with nine countries[6] comprising the remaining one percent. (Ibid.)

Figure 1. Global Area Under Transgenic Cultivation
by Country, 1996-2000



Source: Adapted from James (2000).

The expansion of area planted to GM crops and the rapid growth of pharmaceutical biotechnology has been accompanied by increasing public opposition and

[6] South Africa and Australia each have more than 100,000 acres under transgenic cultivation. Bulgaria, Spain, Germany, France, Uruguay and Mexico also each have some land (less than 100,000 acres) under cultivation to GM crops. Ukraine and Portugal had some area under transgenic cultivation in 1999 but not in 2000. (James, 2000)

resistance. In Europe, consumers have successfully lobbied for mandatory labeling of products containing GMOs,[7] and major supermarket chains have agreed not to carry GM products. Even in North America, where public reaction has largely been marginal at best, several major corporations, including McDonald's, Gerber and Frito Lay have announced plans to move away from using genetically modified crops in at least some of their products.

Nevertheless, the rapid growth of area under transgenic cultivation suggests that the technology may have something to offer.[8] Its advocates contend that biotechnology has the potential to fundamentally improve agricultural production. In the West, improvements have largely taken the form of products engineered to be pest resistant (generally through the introduction of the *Bacillus-thuringiensis* (Bt) gene) and tolerant to specific herbicides (such as Monsanto's Roundup Ready or Pioneer's Liberty Link). While research into other traits, particularly increased yield, is currently underway, to date very few other traits have been added. Indeed, of the total area under transgenic cultivation worldwide, pest resistance (74%), herbicide tolerance (19%) or "stacked" (7%) cultivars, crops that incorporate both pest resistance and herbicide tolerance, comprise nearly all commercially available cultivars. (James, 2001) Further, research has to date been largely confined to temperate crops. The current generation of

[7] Mandatory labeling requirements in the EU have subsequently been challenged by the United States as an unfair trade practice in the WTO. The US contends that the mandatory labeling requirements of the EU, which require that all products made from genetically engineered material be labeled discriminates against American exports. The EU, however, maintains that labels provide information which allows for consumers to make informed decisions, and that the US is attempting to impose acceptance of GM food on European consumers. The case has not yet made its way to the WTO. (Sipress and Kaufman, 2001: A01)

[8] RAFI (2000a) argues that the adoption of GM crops by Western (particularly North American) farmers may have less to do with the advantages offered by such cultivars than with the lack of alternatives. Low producer prices combined with extensive concentration in the seed supply industry has created a situation of economic desperation in which conclusions regarding the adoption-cum-acceptance of GM technology by farmers are tenuous at best.

biotechnology is focused on just four cultivars: soybean (58%), maize (23%), cotton (12%), and canola/rape (6%) (*Ibid.*) Much less emphasis has been placed on tropical crops of importance to most developing countries.

Promise of Agricultural Biotechnology for Southern Africa

Given the importance of agriculture in Southern Africa,[9] biotechnology has been greeted with a mix of hope and suspicion in the region. This dichotomy is reflected both in public and elite attitudes toward biotechnology, and in legislative frameworks that deal with its introduction and regulation. Thus, according to Abasai Mafa, Biosafety Registrar for the Government of Zimbabwe,

> In the future, bananas engineered to include malarial provolactics could prove to have great health benefits for the region. Bt cotton could reduce pesticide use, freeing much-needed foreign exchange and reducing the need for farmers to handle dangerous chemicals, and drought tolerant crops could reduce losses associated with bad weather. At the same time, there are many unknowns, which will take time to resolve. DDT, for example, was used for years before its cumulative effects were realized. We should therefore not move recklessly towards the adoption of GM crops. (Mafa, 2001)

In their effort to expand production of GM crops (and with it demand for their products), agbiotech companies usually point to the potential of biotechnology to modernize agricultural production in the Third World. Increasing yields, they argue, will end hunger and malnutrition, and biotechnology will make agriculture more sustainable by reducing chemical inputs. Monsanto, for example, has begun marketing its herbicide

[9] Across the region, agriculture accounts for between 5 and 48 percent of gross domestic product and provides employment for between 65 and 80 percent of the labor force. Further, cash crops such as tobacco and cotton account for more than 60 percent of export earnings in half of the countries of the region. (World Bank, 1999b; Abdulai and Delgado, 1995) While such figures mask disparities in the region (between countries with larger industrial bases like South Africa, countries dependent on mineral extraction like Zambia, and countries dependent on agricultural exports like Malawi), such data nevertheless demonstrate the importance of agricultural production in the region.

Roundup in Zimbabwe under the rubric of (no-till) environmentally friendly farming, as it allows farmers to reduce tillage, a major cause of soil erosion while simultaneously reducing the amount of labor required for weeding. In fact, according to Calvin Fambisayi (2001), National Seed Manager for Monsanto Zimbabwe, the AIDS crisis in Southern Africa will make Roundup Ready and other herbicide tolerant crops increasingly necessary. As AIDS reduces the rural labor available for weeding and other time consuming aspects of agricultural production, labor-saving technologies traditionally associated with Northern farming methods will become increasingly necessary maintain current levels of agricultural output. To that end, Monsanto intends to begin aggressively marketing Roundup Ready cotton and maize to communal area farmers as a labor saving technology once it receives regulatory approval in Zimbabwe, and has already started to market Roundup Ready cotton in South Africa.

Perils of Agricultural Biotechnology for Southern Africa

But a number of factors limit the applicability of the current generation[10] of biotechnology to the African context, and cast doubt on future biotech products as well.

[10] RAFI (2001a) argues that agricultural biotechnology has evolved over three phases or generations. The first generation of GM crops was designed to be resistant to pests or tolerant to particular herbicides. Products were designed largely in the interests of the agro-chemical companies that created them, and, broadly speaking, dealt only with input controls. By and large, only first generation biotech products have been commercialized. In this paper, first generation biotech products are referred to as the current generation of products. The second generation of products, just starting to enter market, focuses on output traits largely of interest to processors. The classic example of a second-generation product was Calgene's Flavr-Savr tomato, designed for a longer shelf life. The third generation of products, designed for the food, pharmaceutical and retail sectors, promise extensive consumer benefits. Through still years away (and largely speculative in nature), these products are touted as the future of biotechnology. They include edible vaccines, anti-cancer vegetables, cholesterol-reducing grains, crops fortified with micronutrients, and so on. RAFI believes that the corporate sector has largely been unable to capture public acceptance through first and second-generation products, and the fate of agro-biotechnology thus rests on the promise of biotech's 'Generation 3.'

These limitations are, in large part, a function of Africa's position within the global political economy.

Current research is not generally informed by local conditions in Southern Africa. In many ways this reflects the classic problem of development and "appropriate technology." Development had historically been seen merely as a technical question to be solved through the application of modern technologies to the problems faced by the Third World. Thus, in the 1950s,

> There were few who doubted that technological progress—then conceived as powered by advances in science and engineering in the developed countries—would lead to a better world. The world was then confident that the technology needed by developing countries was available to them, perhaps with minor modifications, in the developed countries and that the major problem of technology policy in the developing countries was to master that technology and to overcome cultural and institutional obstacles to its rapid acceptance. (Weiss, 1979: 1084)

Following the adoption of the Green Revolution technology in Asia, however, it became clear that the importation and adoption of new agricultural technologies to existing political, economic and social institutions and networks was failing to generate anticipated results. While total agricultural production was increasing, higher yields were accompanied by higher levels of inequality, poverty and hunger. (Shiva, 1989 and 1991) There were thus widespread calls for "appropriate technology," that is, technology sensitive to the local conditions in the developing world. Appropriate technology would be small-scale, labor-intensive, more subject to local mastery, repair and control and would meet particular cultural and ecological demands of the communities where it would be applied. (Weiss, 1979) Such technology, it was believed, would be more likely to result in successful development. (Stewart, 1979; World Bank, 1978)

In this respect, commercial biotechnology reflects problems similar to those raised by the Green Revolution twenty years earlier. To that end,

> The green revolution focused on rapid production gains as a singular means to solve world food problems while stemming red revolutions. Indeed, the application of new technological packages, corresponding infrastructure development, and the growth of export markets are all legacies of the green revolution. This approach did lead to significant production gains. However, the contradiction arising from these developments also led to or exacerbated social, political, and economic inequalities within localities, nation-states, and regions of the developing and developed world. Moreover, the degradation of tropical agricultural resources has led to negative long-term environmental consequences resulting in profound ecosystem alteration, and in some cases the near extirpation of food production bases. The green revolution provides an important lesson with respect to the application of new agricultural biotechnologies: the ideology of inevitable technological process excludes consideration of the distributional and environmental consequences of such efforts. (Middendorf, *et. al.*, 1998: 93-94)

The current generation of GM crops under commercial production reflects the problem of inappropriate technology. They were designed for North American (and to a lesser extent European) farmers, not African smallholders, and focused on crops not usually grown by and adopt traits of secondary importance to most smallholder African farmers.[11] Soybeans, for example, one of the dominant commercial biotech crops, are almost exclusively cultivated by large-scale commercial farmers. The GM maize currently available is yellow maize, grown primarily as animal feed and considered unpalatable by many Africans. Similarly, the GM canola/rape currently on market is designed for high oil output, as the crop is grown for oil production in the West.[12] African farmers, however, grow rape as a household vegetable for domestic consumption.

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[11] Ironically, this is the same reason why Africa was excluded from the Green Revolution. Green Revolution technology generally focused on rice and wheat, crops that account for approximately 80 percent of cereal production in Asia, but represent only about 13 percent of cereal production in Africa. As such, Africa did not benefit from the yield increases facilitated by the Green Revolution. (Lipton and Longhurst, 1989)

[12] Kneen (1992) provides an excellent analysis of the development of GM canola.

While some research is now being directed into other crops of importance to smallholder farmers—crops such as cassava and sorghum—the vast majority of research remains confined to crops cultivated by commercial farmers in Europe and North America.

In the area of trait selection, similar problems emerge, as research in the West is informed first and foremost by considerations of yield. While higher yields would be welcomed, most smallholder farmers do not want to sacrifice other traits, such as drought tolerance, grain palatability, ease of processing and milling, and storability. (Mushango, 2001) Research is therefore directed not to the *actual* needs of smallholder farmers, but to their needs as *perceived* by corporate leaders in Western boardrooms—the classic problem of inappropriate technology resulting from the failure to include farmers in participatory research.[13]

In the end, the failure of market-based private research in biotechnology to account for the needs of African smallholders is hardly surprising. While public sector breeding efforts may be driven by considerations of equality, social welfare and need, private research is directed above all by profit. Corporations are not likely to invest significant amounts of money into crops or traits needed by farmers with little money and therefore no market power. And because their research is driven by considerations of profit, corporate breeding necessarily excludes certain traits and crops. Shiva astutely captures the bias inherent in private sector research driven only by considerations of profit, arguing that because of bias in corporate research efforts, "we are more likely to see herbicide not weed-tolerant, pesticide not pest-resistant, nitrogen-responsive not nitrogen fixing, and water-responsive not drought-tolerant varieties." (Shiva, 1989: 64) Similarly, Kloppenburg laments,

[13] On the question of farmer participation in agricultural research, see Scoones and Thompson (2000).

> There is no question that biotechnology holds unprecedented promise for plant improvement. But we cannot rely on private industry to explore the full range of technological possibilities. The research programs of private firms are necessarily limited by the inescapable parameters of profitability and the need to protect their own interests. (1988: 286)

Despite the needs of smallholder farmers, research has thus focused on temperate not tropical crops, and has been directed at traits such as pest resistance and herbicide tolerance. Private research in open-pollinated varieties, or OPVs, for example, has traditionally been non-existent, as corporations could not prevent farmers from purchasing seed once and then producing and saving it themselves. Instead, the public sector has historically taken upon itself the research and release of OPV seed, leaving the private sector to focus on hybrid crops.[14]

Indeed, historically the self-replicating nature of the seed has been one of the fundamental obstacles to the establishment of a commodity fiction[15] and the complete commodification of the seed industry.[16] Because farmers could produce and save their own seed from season to season, corporations argued that there was little reason for them to fund research into OPV seed, and instead focused on hybrid crops such as maize. Thus,

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[14] Because of the rapid loss of yield and deterioration of expressed traits in hybrids after the first generation, hybrid crops have a form of built in intellectual property protection that forces farmers to purchase new seed (nearly) every season to maintain traits and yields. As a result, private sector provision of hybrid seed developed much earlier and to a much wider extent in hybrid crops than in OPVs. In the US, for example, private seed companies began producing hybrid maize as early as the 1930s, while the commercial production of wheat seed in the US is still largely unsustainable. (Bramel, 2001; Kloppenburg, 1988)

[15] According to Polyani, capitalism rests on the principle that the market is "the sole director of the fate of human beings and their natural environment." (1957: 73) Because land, labor and money are central to the productive process, they too must be organized as commodities into markets. But the reconstitution of land, labor and money into commodities during the transition from feudalism to capitalism was entirely artificial. This element is discussed below in greater detail.

[16] Thus Kloppenburg (1988: 37) observes, "Seed is grain is seed is grain; the option to produce or to consume is there in each seed." The status of seed as means of production (as seed), or commodity (as grain) thus depends not on the physical characteristics of the product, but instead on its intended use which can be changed at the whim of the farmer.

> Since the 1930, immense effort has been put into getting better and better hybrids. Virtually no one has tried to improve the open-pollinated varieties, although scientific evidence shows that if the same effort had been put into such varieties, they would be as good as or better than hybrids by now. (Berlan and Lewontin, 1986: 36)

The selection of hybrid crops for research (and the corresponding exclusion of OPVs from research) was thus based neither on the potential of such crops nor on the needs of farmers, but instead on the potential profits opened by hybrid crops.[17] As a result, the (ever declining) public sector focused on OPV seed essential to smallholder food security—crops such as groundnut, sorghum and millet—and on crops like wheat and soybean, in which hybrids were unfeasible.

Three new trends, however, are challenging the traditional public-private division, and thereby facilitate the continued displacement of public sector breeding at the hands of an expanding private sector.

First, the general ideological shift towards privatization and restricting the role of the state is changing public and elite attitudes towards state spending on agricultural research and development. Prior to the introduction of structural adjustment in the 1980s and 90s, the public sector was the moving force behind seed research, production and distribution in Southern Africa. Indeed, under the direction of (and with funding from) the World Bank, the Food and Agriculture Organization, and the US Agency for

[17] Lewontin (1998: 77) thus concludes that, "The consequence of the central position of seed input in the production process is that seed companies are potentially in an extraordinarily powerful position to appropriate a large fraction of the surplus in agriculture. There is a barrier to this realization however. The seed of a desirable variety, when planted by the farmer, produces plants that themselves produce yet more seed of the variety. Thus the seed company has provided the farmer with a free good, the genetic information contained in the seed, which is reproduced by the farmer over and over again in the very act of farming. Some way must be found to prevent the farmer from reproducing the seed for next year's crop. The historical answer to his problem was the development of the inbred/hybrid method of breeding, using hybrid crosses between inbred lines, which makes it possible to sell seed that will produce hybrid pants, but which themselves will not reproduce hybrids. Because the second generation would not be true hybrids and thus would lose yield and be more variable, the farmer must go back to the seed company every year to buy new seed."

International Development, publicly funded seed research, production and distribution networks were established in many countries of the region. (Friis-Hansen, 2000) As a result, unlike seed networks in the West that are dominated by private corporations, seed networks in Southern Africa were largely the domain of the public sector, supplemented by NGOs and (relatively minor) commercial production. (Zerbe, 2001)

By the early 1980s, however, the public sector was increasingly coming under criticism. The Keynesian policies espoused in the OECD increasingly gave way to the neoliberal policies of the World Bank and IMF. Thus, Leys observes that

> It is hardly too much to say that by the end of the 1980s the only development policy that was officially approved was not to have one—to leave it to the market to allocate resources, not the state. In the World Bank's own ingenuous language, 'New ideas stress prices as signals; trade and competition as links to technical progress; and effective government as a scarce resource, to be employed as sparingly and only where most needed.' (Leys, 1996: 24)

The problem of debt and (under)development was thus cast in terms of the failure of Keynesian-inspired state intervention and domestic corruption. The solution was therefore to free prices from government interference, privatizing state-owned firms, reducing public expenditures and removing barriers to trade and capital flows.

The neoliberal critique of state-owned firms and public intervention in general as inefficient, mismanaged and unprofitable was applied to the agricultural sector in particular. Given the generally poor performance of governments and their parastatals in meeting the needs of smallholder farmers, such critiques were not unfounded. Across the region, agricultural production, investment and research largely stagnated throughout the 1970s. (Cornia, 1994) But the privatization and liberalization of agricultural services and networks in Southern Africa failed to address the underlying structural problems plaguing

regional rural production. (Mohan, *et. al.*, 2000) Nevertheless, by casting the problem of development in terms of efficiency and public sector mismanagement, rather than in terms of the unequal integration of African agricultural production into the global political economy, the solution advanced under adjustment was to increase efficiency by removing subsidies, privatizing parastatals, and freeing input and output markets from public sector interference.

Despite the reassurances offered by the theoretical model underpinning structural adjustment, the promises of the World Bank and IMF's packages largely failed to materialize. In agricultural production in particular, liberalization has largely failed to lead to the establishment of well-functioning markets for agricultural inputs, outputs, credit and rural transport. Further, production of many important food crops actually declined following the introduction of adjustment measures. Thus, while tobacco production expanded by approximately 4 tons per hectare between 1988 and 1992, food crops such as millet and sorghum (-3.0 tons/hectare) and maize (-5.7 tons/hectare) declined rapidly. (See Table 1)

Table 1. Yield Growth for Selected Crops in Sub-Saharan Africa, 1961-1992
(In tons per hectare)

	Maize (OPV and Hybrid)	Millet and Sorghum	Roots and Tubers	Tobacco
1961-1980	1.6	0.4	0.6	0.9
1981-1987	-0.4	0.2	1.1	1.8
1988-1992	-5.7	-3.0	0.7	4.0

Source: Cornia, 1994: 219

The market mechanism has thus been unable to meet the needs of many African smallholders. Because they have little cash (and thus no effective demand), smallholder farmers remain unable to affect change in markets informed only by price signals. Further, markets have failed to develop in many key areas, creating a problem of 'missing

markets' which, according to the World Bank, will be resolved through 'completing the liberalization process.'[18] (Cleaver and Donovan, 1995; Townsend, 1999)

In terms of agricultural research, a similar picture emerges. For-profit research remains confined to hybrids, where the farmer is forced to purchase new seed almost every year, rather than the OPVs grown by the vast majority of farmers in the region. Despite their importance in ensuring regional food security, corporate researcher has generally ignored OPV crops because of their inability to recapture investment and research spending on OPVs. Even where there is sufficient demand for hybrid seed by smallholder farmers, private seed companies have not provided the multiple varieties of seed in the small quantities desired by communal area farmers. They argue that the disjointed market among smallholder farmers increases inventory, storage and transportation costs, reducing economies of scale. Further, the uncertain, fluctuation demands of farmers in marginal areas make forecasting demand difficult and increases wastage costs. (Gwarazimba, 2001a and 2001b)

Thus, a World Bank study was forced to concede the ineffectiveness of adjustment vis-à-vis the agricultural sector, concluding that while "state involvement in the seed trade has declined in many countries, a viable commercial market is not yet filling the gap. In some cases, commercial monopolies have replaced the parastatals" but have proven themselves no more effective or efficient in the provision of seed than the state-sponsored monopolies they replaced. (World Bank, 1999a: 3) Thus, while structural adjustment opened the door for greater private involvement in the development and provision of seed, the corporate sector proved hesitant to replace the state,

[18] Townsend (1999), for example, contends that fertilizer markets will only develop when all restrictions on fertilizer imports are rescinded, all price controls are removed, and all fertilizer aid is terminated.

particularly in reaching smallholder farmers. The primary obstacle to greater private involvement in seed production was the self-replicating nature of the seed, which allowed farmers to save seed purchased once. Thus (ironically), the private sector called on the state to create a new national and international legal regime to enforce property rights in (among other areas) seed.

Property has always rested on protection afforded by the state. It represents the codification of social relations between the owner and the non-owner, protected as rights and enforced by the state. Property is thus not a natural phenomenon, but an artificial creation of society.[19] Polyani termed this a 'commodity fiction,' established over land, labor and money during the transition from feudalism to capitalism. For him, capitalism rested on the redefinition of land, labor and money as commodities and their organization into markets. Thus, Polyani (1957: 73) observes that the commodity fiction "supplies a vital organizing principle in regard to the whole of society affecting almost all its institutions in the most varied way, namely, the principle according to which no arrangement or behavior should be allowed to exist that might prevent the actual functioning of the market mechanism on the lines of the commodity fiction."

The establishment of a global regime of intellectual property rights, created under the TRIPs Agreement, mirrors Polyani's observations regarding the commodity fiction. The nature of the seed has historically prevented the total commodification of seed research and provision. Indeed, "the seed has only drudgingly and incompletely assumed

[19] Indeed, even while arguing that property was a natural right, early property theorists recognized the central role played by the state in protecting private property, This is the foundation of the social contract theory espoused by Locke and Jefferson. Thus Locke (1986: 54) asserts that, "Men being as has been said, by nature all free, equal and independent, no one can be put out of this estate and subjected to political power of another without his own consent, which is done by agreeing with other men, to join and unite into a community for their comfortable, safe, and peaceable living, one amongst another, in a secure enjoyment of their properties, and a greater security against any that are not in it."

the commodity-form." (Kloppenburg, 1988: 37) The fundamental obstacle is, in fact, the biological nature of the seed. Seed is both an input in the process of agricultural production and its output. In other words,

> The seed thus possesses a dual character that links both ends of the process of crop production: it is both means of production and, as grain, the product. In planting each year's crop the farmer also reproduce a necessary part of that means of production. The seed thus presents capital with a simple biological obstacle: given appropriate conditions, the seed will reproduce itself manifold. (Shiva, 1995: 199)

As a result, a farmer need only purchase a new variety once, and may then reproduce the seed on farm for many generations.

This simple fact undermines the ability of the private sphere to assert control over the seed trade. Indeed, particularly in the Third World, this has represented a central obstacle to the expansion of corporate seed production. Across Southern Africa, informal seed networks remain the primary source of seed for the vast majority of smallholder farmers. Regionally, less than 10 percent of seed sown by smallholder farmers is obtained from the formal sector. Instead, farmers rely extensively on farm saved seed (60-70 percent of total seed planted) and social networks (30-40 percent). Informal, community-based seed networks—saving seed on-farm, or acquiring seed from relatives, neighbors, or other community sources through barter or social obligation—thus represent a key component of agricultural production in Southern Africa. (Cromwell, 1996: 20)

While hybrid seeds have allowed a level of commercialization in some crops, open-pollinated varieties have so far escaped corporate control.[20] The TRIPs Agreement,

[20] According to Shiva (1995: 199-200), "Modern plant breeding is primarily an attempt to remove this biological obstacle to the market in seed. Seed reproducing itself stays free, a common resource and under the farmer's control. Corporate seed has a cost and is under the control of the corporate sector or under the

in this respect, represents an attempt to create a more favorable environment for capitalist penetration of agriculture. To that end, the TRIPs Agreement aims to strengthen and harmonize national standards of intellectual property protection through a globalization of the US patent system. TRIPs sets out minimum levels of protection to be afforded by member states, including subject mater to be protected, rights conferred on the owner of the intellectual property, permissible exceptions to the rights, and minimum durations of protection. The agreement mandates member states to provide twenty-year patents on all inventions, whether products or processes, in all fields of technology without discrimination, subject to nominal tests of novelty, inventiveness and industrial applicability. (GATT, 1994: Articles 27.1 and 33) Member states may exclude innovations from patent protection on specific grounds, including national security, public health and morality. Further, plants may be excluded from TRIPs patent protection, provided that the member state affords an effective *sui generis* system of protection. (GATT, 1994: Articles 27.2, 27.3a, and 27.3b)

While the TRIPs Agreement does not physically prevent farmers from saving seed or obtaining it through informal networks, the Agreement nevertheless creates a legal regime through which farmers can be punished for doing so. The quintessential case in point, and one widely known throughout Southern Africa, is the case of Canadian farmer Percy Schmeiser.

In 1998, Monsanto launched a suit against Schmeiser, alleging he had grown their patented glyphosate-resistant (Roundup Ready) canola without signing a technology licensing agreement or paying the $15 per acre technology use fee. Schmeiser countered,

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control of agricultural research institutions. The transformation of a common resource into a commodity, of a self-regenerative resource into mere 'input' changes the nature of the seed and of agriculture itself.

arguing that Monsanto's proprietary seed had contaminated his crops, grown from farm-saved seed, without his knowledge.[21] On 29 March 2001, Judge W. Andrew MacKay ruled on the case. He found Schmeiser guilty of growing Monsanto's proprietary canola, and ordered him to pay $150,000 in actual and punitive damages. Further, Schmeiser was enjoined from planting "brown-bagged" (farm saved) seed, and was ordered to turn over saved seed to authorities for destruction. In his ruling, MacKay upheld Monsanto's assertion that the source of the seed, how the seed entered Schmeiser's fields—was irrelevant.[22] The only fact under consideration was that Schmeiser was growing Monsanto's patented seed, and was therefore liable for the original licensing fees, plus damages.

Monsanto has hundreds of similar cases pending in American and Canadian courts, and has taken other aggressive actions attempting to enforce their patents.[23] Such actions and lawsuits, of course, raise questions regarding the TRIPs Agreement. While the Schmeiser case was tried under Canadian jurisdiction, TRIPs establishes a similar legal framework under the WTO. Farmers in Southern Africa and throughout the Third

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[21] Schmeiser puts the disparity in stark terms, asserting, "I never had anything to do with Monsanto, outside of buying chemicals. I never signed a contract. If I would go to St. Louis and contaminate their plots—destroy what they worked on for 40 years—I think that I would be put in jail and the key thrown away." (Schmeiser, 2001: np)

[22] The source of the patented seed in Schmeiser's fields was for some time at the center of the case. Monsanto believed that Schmeiser was growing their proprietary canola intentionally. Despite extensive investigations, however, Monsanto was unable to prove that Schmeiser had ever purchased their seed either from authorized dealers or informally from neighbors. For his part, Schmeiser contended that the seed entered his field either as pollen from neighboring fields, or by falling off trucks driving along roads bordering his fields. Either way, he argues, he was unaware of the contamination and did not benefit from the technology in his fields. Expert witnesses were unable to resolve the dispute, and assessments of the levels of contamination ranged from minimal to 95 percent. (*Monsanto v. Schmeiser*, 2001)

[23] These actions, including the use of private detectives and the establishment of 1-800 'snitch lines' to encourage farmers to report other farmers they suspect of illegally growing patented varieties. Public pressure has forced Monsanto to recent the 1-800 line. But other more serious accusations remain. Farmers have indicated that Monsanto's representatives have been illegally entering their fields to collect samples of suspected IP violations. And perhaps most distressingly, a farmer in central Saskatchewan accuses Monsanto of dropping Roundup spray bombs into suspect fields to verify the presence of Roundup Ready canola. (Schmeiser, 2001)

World thus fear that TRIPs will place similar legal restrictions on their ability to save and trade seed, and the Schmeiser case has become a rallying point for farmers in the region.[24]

However, recent advances in biotechnology may render the legal reforms embodied in TRIPs irrelevant vis-à-vis seed. By engineering second-generation seed not to germinate, the 'technology protection system,' dubbed 'terminator' by its critics,[25] corporations are essentially able to encode intellectual property protection at the genetic level. Because the second generation of seed will not germinate, farmers are unable to save seed and are thus forced to return to the seed company to purchase new cultivars every year.[26] Biotechnology is thus able to render legal intellectual property regimes redundant. It creates crops in which use value and exchange value is maintained only as grain, but which are unable to be employed as means of production.

Collectively, then, TRIPs and the new biotechnologies are likely to facilitate fundamental shifts in Southern African agriculture, continuing a trend of privatization and liberalization that started with structural adjustment. In a respect, they represent two prongs of attack, one legal, the other technical, which together represent an attempt to expand the site of surplus extraction in agriculture by circumscribing the traditional right of the farmer to brownbag seed. For many African smallholders, who traditionally operated on the margins of capitalist (agricultural) production, not employing improved

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[24] TRIPs, it should be noted, reverses the traditional burden of proof, meaning that farmers accused of growing patented varieties must prove their innocence. Given the huge disparities between the resources available to most African farmers and TNCs like Monsanto, this raises serious questions regarding the efficacy and impartiality of the WTO/TRIPs patent enforcement mechanism.

[25] Although public pressure forced Monsanto to withdraw its TPS, it has already begun work on a second generation of the product, dubbed 'traitor technology.' Crops containing the second-generation technology will fail to germinate unless sprayed with chemicals obtained from the seed supplier. (RAFI, 2001a)

[26] A number of critics have raised concerns regarding the potential environmental impact of such a technology. However, a full consideration of such questions falls outside the scope of this paper. For a more detailed discussion, see Levidow and Tait (1995), and van Weizsäcker (1995).

seed varieties, chemical fertilizers or pesticides, and consuming the vast majority of their production domestically, the expansion of market relations into seed may prove to be an untenable position.[27] The introduction of patents on genetically modified seed thus marks the culmination of the expansion of private property relations into agricultural production. By deploying legal and technical obstacles to brown bagging and informal seed exchange, smallholder farmers are forced more squarely into marketized production. In terms of inputs, farmers are forced to purchase new seed every year, while in terms of outputs farmers are forced to sell a portion of their production on markets to pay for required inputs.[28]

Increasing Inequality

In addition to the general questions of appropriate technology and agrarian transformation, agricultural biotechnology also holds significance for questions of equality. As demonstrated by the Green Revolution in Asia, new technologies have the potential to greatly exacerbate existing inequalities. Indeed, as Shiva notes,

> There is ample evidence available that the green revolution had a class bias and worked against the interests of the small peasant. The dispossession of the poorer sectors of rural society through the green revolution strategy and their reduced access to food resources is, in part, responsible for the *appearance* of surpluses at the macro-level. The

[27] Marx's analysis of primitive accumulation is directly on point here. For Marx (1990: 874-75), "The capital-relation presupposes a complete separation between workers and the ownership of the conditions for the realization of their labor. As soon as capitalist production stands on its own feet, it not only maintains this separation, but also reproduces it on a constantly expanding scale. This process, therefore, which creates the capital-relation can be nothing other than the process which divorces the worker from the ownership of the conditions of his own labor; it is a process which operates two transformations, whereby the social means of subsistence and production are turned into capital, and the immediate producers are turned into wage-laborers. So-called primitive accumulation, therefore, is nothing else than the historical process of divorcing the producer from the means of production."

[28] The ultimate expression of farmer as wage laborer is, of course, contract farming. Under such a system, widespread in the US and increasingly used in Southern Africa, the farmer is contracted to produce a certain crop under specified conditions using specified inputs. For a detailed discussion, see Hamilton (1994) and Lewontin (1998). With respect to Southern Africa, see Little and Watts (1994).

> surplus [however] is a myth because it is created by lack of purchasing power. While food stocks had shot up from 63 million tons in 1966 to 128 million tons in 1985, food consumption had dropped from 480 grams per capita, per day in 1965 to 463 grams per capita, per day in 1985…Large numbers of peasants who produced food for themselves have therefore been displaced from agriculture and do not have enough purchasing power to buy commercially produced and distributed food. (Shiva, 1989: 129)

The introduction of agricultural biotechnology guided solely by markets, without consideration of other, non-market conditions is similarly likely to exacerbate rather than ameliorate racial, class and gender divisions in Southern Africa. Biotechnology, like Green Revolution technology, is not scale-neutral but favors large-scale commercial producers. Thus, a study of biotechnology in Latin America by the International Labour Organization concluded that widespread adoption of agro-biotechnology would lead to greater concentration of land ownership patterns accompanied by higher levels of unemployment, poverty and inequality. (Galhardi, 1993)

Race, Class and Biotechnology

In terms of race and class, agricultural production in Southern Africa still bears the mark of colonialism. Many of the countries of the region continue to be dependent on cash crop production for the vast majority of their economic activity. In Malawi, for example, tobacco represents 76 percent of total exports, and is the major foreign exchange earner for Zimbabwe. (SADC, 1999) (See Table 2)

Table 2. SADC Main Exports and Food Exports

Country	Main Export	Main Exports as Percent of Total Exports	Food Exports as Percent of Total Exports
Angola	Crude oil	86	16.4
Botswana	Diamonds	88	
DR Congo	Copper	60	
Lesotho	Manufacture	80	

Malawi	Tobacco	76	90.5
Mauritius	Textiles	56	
Mozambique	Shrimp & fish	47	65.7
Namibia	Diamonds	35	
Seychelles	Fish	N/A	
South Africa	Gold	22	13.6
Swaziland	Food & sugar	58	
Tanzania	Coffee	25	49.2
Zambia	Copper & cobalt	90	3.9
Zimbabwe	Tobacco	20	44.1

Source: SADC (1999: 26) and van Wyk (2000)

Advances in biotechnology, however, have the potential to undermine cash crop production on two levels. First, as a laborsaving technology, biotechnology is likely to exacerbate rural unemployment, while simultaneously facilitating greater consolidation of land ownership. In countries like South Africa and Zimbabwe, land tenure patterns reflect the historic experience with settler colonialism, which resulted in dispossession of large numbers of native Africans from their land through the imposition of racialized systems of ownership. In South Africa, the white farming population comprises just 5 percent of the total population, but owns almost 87 percent of the land. Land holdings for black farmers average approximately 1 hectare, while white land holdings average 1,570 hectares. (Moyo, 2000b) Similarly, in Zimbabwe, approximately 4,500 white commercial farmers, representing 0.03 percent of the population, control approximately 42 percent of the country's agricultural land, while 1.2 million families subsist on 41 percent of the land. And even beyond the unequal patterns of land ownership, under which whites own large tracts of the most productive land while blacks are confined to small plots in marginal farming areas, white commercial farmers in Zimbabwe and South Africa continue to benefit from colonial structures which placed white commercial farmers closer to urban centers, allowing easier access to transportation and

communication infrastructures and greater control over water and electricity. (Moyo, 2000a)

Southern Africa is not capital rich, and smallholder farmers in particular lack the resources to take advantage of the current generation of agbiotech products.[29] The introduction of capital-intensive biotechnology to Southern African agriculture is thus likely to reproduce patterns that emerged following the introduction of Green Revolution technologies in Asia. If the promise of the biotech corporations hold true, large-scale commercial farmers will be able to use the new technologies to increase yields while simultaneously reducing labor required in production. This process will exacerbate rural unemployment, already hovering around 80 percent in some areas, and led to still greater disparities in patterns of land ownership.

Such a process is hardly unique to Southern Africa, but rather is characteristic of technological innovation under capitalism. According to Marx,

> Modern industry never views or teats the existing form of a production process as the definitive one…By means of machinery, chemical processes and other methods, it is continually transforming not only the technical base of production but also the functions of the worker and the social combination of the labor process. At the same time, it thereby also revolutionizes the division of labor within society, and incessantly throws masses of capital and workers from one branch of production to another [or into the reserve army of labor]. (Marx, 1990: 617)

[29] In the US, the technology licensing fee for Monsanto's Bt maize is US $25 per hectare, a price far out of reach of most African farmers. Indeed, according to Barry McCarter, General Manager for Seed Co Zimbabwe, "If the biotech companies charge similar prices in the Third World, the technology is dead before it starts. The Western agbiotech companies need to show good will towards the Third World [in the pricing of their products]—not free, but also not completely out of reach." (McCarter, 2001)

The introduction of labor-saving (bio)technologies to agricultural production in Southern Africa is, in this respect, simply part of the overall trajectory of capitalism towards the displacement of labor from the productive process.[30]

The second impact of biotechnology on crop production in Southern Africa is more long-term and more fundamental in nature. Several companies are working in the area of tissue culture research, attempting to regulate agricultural production by moving it from the field to the factory. The (now defunct) US-based Escagenetics, for example, was working on processes to produce vanilla in plant cell cultures in the laboratory. According to Rifkin,

> Vanilla is expensive to produce, however. The plant has to be hand-pollinated and requires special attention in the harvesting and curing processes. Now, the new gene-splicing technologies allow researchers to produce commercial volumes of vanilla in laboratory vats—by isolating the gene that encodes the metabolic pathway that yields the vanilla flavor and growing it in a bacterium bath—eliminating the bean, the plant, the soil, the cultivation, the harvest, and the farmer. (Rifkin, 1998: 18)

The widespread commercial production of vanilla through cell cultures would devastate cash-crop production of the crop in the Third World. Madagascar, which produces approximately two-thirds of the world's total vanilla production employing an estimated 70,000 farmers, would be particularly had hit. (Metzel, *et. al.*, 1999; RAFI, 2001b) Similar patterns could emerge in other high-value crops[31] and, ultimately, across agriculture itself. As in-vitro production displaced cash crop production in the Third World, small-scale producers will be displaced. And,

> in the medium term, over US $20 billion worth of Third World exports could be replaced by products of the new biotechnologies developed in the

[30] For Marx, this was a result of the tendency of the rate of profit to fall. For a more detailed discussion, see Marx (1991).
[31] Crops such as sugar, cocoa and oils, used primarily in processed food products, would be particularly hard hit.

> North. This would represent over a quarter of what developing countries are now exporting in the form of agricultural commodities, and would mean a dramatic setback in the development of the least-developing [sic] countries especially, who would find it difficult to find alternative ways to earn the foreign currency they so desperately need. (Hobbelink, 1995: 229-30)

Gender and Biotechnology

In terms of gender inequality, the potential impact of agricultural biotechnology is equally disturbing. Agriculture, especially in Southern Africa, has long been largely the domain of women. Across the region, women are responsible for the vast majority of agricultural production: three-quarters of the female labor force works in agriculture,[32] and women are responsible for approximately 80 percent of all food production. (World Bank, 1999b: 54-56). Even outside of production, women play a central role in guaranteeing food security. Historically, women's household gardens have been the primary guarantee of household food security. Further, women were responsible for selection of future cultivars, giving them a central role in seed security. "Women thus trained their daughters in seed selection, varieties and storage; the use of different soil types for grains, root crops and vegetables; the value of anthills and natural pest control measures [to] ensure food security from one generation to another." (ZWRCN, 1998: 34)

Despite their central role in food production and food security, women have historically been the last to benefit from access to credit, extension services or technological innovation in agricultural production. Gender bias in the provision of agricultural extension services, access to credit and agricultural inputs, and land rights,

[32] In some countries, this figure is significantly higher. In Mozambique, for example, 96% of women work in agriculture. Similar figures exist for Malawi (96%), Zambia (83%), and Zimbabwe (81%) (World Bank, 1999b: 54-56)

for example, has been well documented.[33] Technology transfer, historically laden with misguided assumptions regarding the ('appropriate') role of men and women's labor, was directed, almost without exception, towards men. This increasingly "marginalized women as farmers and [undermined] their ability to provide for their family. Women were left to farm using indigenous methods in a rapidly changing environment." (ZWRCN, 1998: 34) While the impact of agricultural biotechnology on women has yet to be fully documented, it is clear that biotechnology will affect men and women in very different ways.

Again the lessons of the Green Revolution are illustrative. As higher yielding varieties spread, men expanded the area under cash crop and monoculture cultivation, frequently displacing household gardens traditionally maintained by women. Because women's control over land was traditionally defined in terms of use rights rather than ownership, they had little recourse to protect themselves against dispossession.

Further, the introduction of Green Revolution technologies directly affected the balance of labor between men and women. Thus, "with the commercialization of the agricultural economy [a process intimately linked with the Green Revolution], women's work increases, but the very process of maldevelopment which *increases women's work* in producing subsistence, *decreases the value of women's work* because it is linked to subsistence not profits." (Shiva, 1989: 118, emphasis original) In the most general terms, technological innovation in agriculture largely corresponded to gender divisions in production. Thus, tasks such as plowing, performed primarily by men, were increasingly mechanized, while tasks such as weeding, storage and processing, traditionally performed

[33] See, for example, FAO (1995) or Davison (1988).

by women remained confined to traditional methods. Thus, in Zambia as elsewhere in the region,

> the penetration of capitalism and the money economy has led to a market and devastating erosion of the productive power of land and the power of women. The commercialization of agriculture [a process linked directly with the introduction of agricultural technology in general and with Green Revolution technology in particular] put constraints on the amount of land available for the production of food crops. Women's productivity, particularly of food crops, has stagnated and in some cases actually diminished, while cash crop production under male control has led to reduced food availability for the household. (Shiva, 1989: 112-13)

In short, the introduction of the new technology under the Green Revolution further increased the expected workload of rural female labor, while simultaneously undermining the economic security of rural women by excluding them from traditional productive functions.

The introduction of agricultural biotechnology in Africa is likely to result in similar patterns. Already research is directed towards crops produced primarily by men, excluding crops such as cowpea, bambaranut, sorghum and household vegetables traditionally grown by women. (Musango, 2001) Further, current research does not account for factors such as ease of milling crops or storability, which affect women's labor (in terms of processing maize into meal, for example), and household food security (in terms of losses during storage). Because they ignore the central role of women in agricultural production in Southern Africa, the widespread adoption of the current generation of agbiotch products is likely to increase demands on women's labor and undermine household food security.

BioDiversity

Agricultural biotechnology may also undermine local biodiversity in Southern Africa. It may contaminate local crops, as demonstrated by the case of Percy Schmeiser. More insidiously, however, it may simply replace local crops as farmers shift from traditional varieties to monocultures. Modern (industrial) agriculture rests on the genetic uniformity of monocultures rather than on the genetic diversity and intercropping characteristic of peasant production. Indeed, according to the Food and Agriculture Organization, "The chief contemporary cause of the loss of genetic diversity has been the spread of modern commercial agriculture. The largely unintended consequence of the introduction of new varieties of crops has been the replacement—and loss—of traditional highly variable farmer varieties." (FAO, 1996: 13) Indeed, a similar pattern emerged in many areas that 'benefited' from the Green Revolution, where farmer varieties were replaced by monocultures designed to respond more readily to chemical inputs.[34] From India to Indonesia, countries that adopted Green Revolution technologies saw the biodiversity in farmers' fields decline. Thus, in India, 75 percent of rice production is today based on just three cultivars, while in Indonesia, 74 percent of production and in Bangladesh 62 percent of rice production is based on varieties derived from just one cultivar. And in Sri Lanka, the estimated 2,000 varieties of rice under cultivation in 1959 have given way to just five varieties under cultivation in 1991, with 75 percent of rice production based on just one cultivar. (Swanson, 1996: 149)

[34] The dwarf and semi-dwarf hybrid varieties promoted under the Green Revolution can absorb three to four times the fertilizer traditional varieties can, but require more water and are more vulnerable to pests and disease. And in more marginal farming areas or under high stress conditions, traditional varieties frequently outperform 'high yielding' Green Revolution cultivars. (Shiva, 1989)

This loss of genetic diversity directly affects smallholder food security. Indeed, vitamin A deficiency, which 'Golden Rice'[35] is designed to cure is a direct result of monoculture farming introduced by the Green Revolution. As farmers shifted to monocultures in rice, traditional vegetables which provided rural families with their micronutrients were displaced, facilitating malnutrition.

Now, Golden Rice is touted as the panacea for malnutrition. But Golden Rice is not just about improving nutrition in the Third World—if this were the case, it would be far more efficient and less expensive to encourage the production of vegetables and other crops high in necessary vitamins. Instead, the new campaign around Golden Rice is directed, not at the malnourished in the Third World, but at consumers and critics in the first world. The advertising effort around Golden Rice speaks directly to this—television ads in which Asian children and African doctors are smiling as a caring voice describes the promise of Golden Rice to "help prevent blindness and infection in millions of children" suffering from vitamin A deficiency. Similarly, Time Magazine put Golden Rice on its cover, asserting that it could help save one million children per year. (*Time Magazine*, 3 July 2000) Indeed, Golden Rice is more problematic than its advocates assert. First, to get their minimum daily requirement of vitamin A from Golden Rice, the average 11 year old would have to eat 15 pounds of cooked rice per day. And even then, the body can only convert beta-carotene into vitamin A when fat and protein are present in the diet. Nevertheless, $100 million has been spent developing Golden Rice, and almost as much has been budgeted for touting the technology's future promise. (Pollan,

[35] Golden Rice, created by inserting a daffodil gene into rice, is engineered to be high in betacarotine.

2001) Golden Rice is instead intended to shift the discourse around biotechnology than solve the problem of malnutrition in the developing world.[36]

Returning to the problem of loss of biodiversity, the real problem is less contamination (though this is obviously a danger) than market shifts facilitated by the introduction of new crops. The new GM crops will likely be well marketed and subsidized during the first few years of introduction. Indeed, Monsanto is currently offering favorable terms to smallholder farmers in KwaZulu Natal to encourage adoption of its Roundup Ready cotton. (Mnyulwa, 2001) As farmers adopt new varieties, traditional varieties are abandoned and eventually lost. After a few years, when the subsidies are withdrawn, some farmers will likely wish to return to growing traditional varieties. However, they may have difficulty finding seeds for traditional varieties, forcing them to grow new 'improved' varieties at higher costs and creating monocultures based on the US model of agriculture. This is exactly what happened in the case of India's pigeon pea production, and is a likely model for what will happen as GM crops are introduced in Southern Africa. (Brammel, 2001)

Related to biodiversity is the question of indigenous knowledge. Biotechnology is unique in that the technology that makes the health and agricultural advances possible is dependant on genetic resources largely located in the South.[37] Based on the doctrine of "common heritage of mankind," the South's genetic resources have traditionally been freely available to Northern researchers, who are under little obligation to share benefits from their advances, even when their advances were based on the traditional knowledge

[36] Indeed, "Golden Rice is perhaps the best-intentioned product of agricultural biotechnology, and is therefore the best example of why genetic engineering is doomed to fail the poor. Basically, a perfect food is not the answer to hunger. Packing all to the nutrients into one food plant instead maintains the conditions that create poverty, for both people and the land." (Crouch, 2001: 34-35)

[37] Indeed, an estimated 90 percent of the world's biodiversity is located in the Third World. (UNDP, 2001)

of communities in the Third World. The fundamental problem is based on the TRIPs agreement, which precludes communities in the Third World from patenting their innovations because they are held in common and are thus deemed to have no market value. Only when innovation is derived from the laboratory by men in white coats is it eligible for protection under TRIPs. While the Convention on Biological Diversity goes some way in rectifying this, and while the African proposed *sui generis* TRIPs legislation would mandate benefit sharing, the reality is that governments in Third World have little power to force Northern TNCs to share anything.[38]

A few examples illustrate the point.

- In 2000, the Australian government secretly exported embryos from Zimbabwe's Tuli cattle, known for their high fertility, docile temper, excellent beef characteristics, and resistance to environmental stress, without the knowledge or permission of the Government or local communities of Zimbabwe. The introduction of new traits from Tuli cattle could increase profit in the Australian beef industry, already a US $2.4 billion market, by up to 30 percent. Zimbabwe has never received a share of the increased profits. (RAFI, 2000b)
- Several corporations are extracting proteins from berries in West Africa to create artificial sweeteners. The UK-based company Tate and Lyle already markets naturally occurring sweeteners obtained from West Africa, but the University of California and Japanese-based Lucky Biotech Corporation have received patents on the protein responsible for the sweetness of the katempfe and serendipity berries. The thaumatin protein in the berries is the sweetest substance on earth, 2000 times sweeter than sugar, and has no calories. The value of thaumatin development into consumer products is expected to be worth billions of dollars, if successfully brought to market. No agreement on benefit sharing has been signed with any West African country. (RAFI, 1997 and 2000b)
- Madagascar's rosy periwinkle plant was used by the pharmaceutical giant Eli Lily to devise two drugs, vinblastine (used to treat Hodgkin's disease) and vincristine (used in the treatment of leukemia). The sales of the two drugs have exceeded US $100 million, with none of the proceeds going to Madagascar. (RAFI, 1999)

[38] The implications of TRIPs and CBD has been explored elsewhere. See, for example, Zerbe (2002) and Downes (1999).

Conclusion

Agricultural biotechnology thus represents, at best, a mixed blessing for Southern Africa, holding both promise and peril for African smallholders in particular. The application of molecular techniques to agriculture *could* lead to increased yields and crops expressing many desirable traits. At the same time, however, the social, economic and environmental consequences of the new technology must be considered. The benefits of biotechnology will not be felt evenly. Some will benefit, others will not. Or perhaps more accurately, in Southern Africa, some will benefit, most will not. These are the contradictions of biotechnology, contradictions that reflect the integration of capitalist (capital-intensive) productive technology into non- and semi-capitalist agricultural production in Southern Africa. These contradictions will likely play out in several ways, most notably in the exacerbation rather than the reduction of existing racial, class and gender divisions, greater hunger amid increasing yields, greater poverty and inequality amid increasing levels of economic growth, and greater unemployment amid increasing economic production.

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