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CHAPTER 12

# New Crop Varieties in a Green Revolution for Africa[1]: Implication for Sustainability and Equity

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## THE PROGRAM AND THE ASSUMPTIONS

The green revolution began after World War II in Mexico and the Philippines as the large-scale application of industrial agriculture from the First World to the Third World. At its center are new crop varieties created by plant breeders which produce much higher yields in the optimal and stable environments created by irrigation, chemical fertilizers, and pesticides, and often mechanization. The green revolution has been widely adopted in Asia and parts of Latin America, and has led to some dramatic increases in production. It has not fared so well in Africa.

Many observers see the growing agricultural crisis in Africa as largely a consequence of the failure of the green revolution to take hold there. As a result there are increasing calls to adapt the green revolution to Africa's unique environmental and socioeconomic conditions. This means strategies that will work on poorer soils with less water management (Christensen et al., 1981:105-107; Lal, 1987; Mellor et al., 1987:361) and that place the small-scale farmer at the center, with scarce resources prioritized to achieve maximum production results (Mellor et al., 1987:356-357, 359).

Adapting the green revolution in Africa is part of a broader response of the international development establishment to experiences with the green revolution in Asia and other areas of the world. Proponents have realized that in the future the green revolution will not produce the quantum leaps in production that characterized its early years. Expansion to less optimal environments, increasing cost of inputs, increasing resistance of pests, social disruption, increasing economic inequity, and resistance of consumers to new varieties have led to plant breeding programs placing more emphasis on traits such as taste, cooking, and storage qualities. Emphasis has also increased on drought tolerance and disease resistance that adapt crops to less optimal conditions of poorer farmers on more marginal land, and which demand less expenditure on inputs.

Changes in the green revolution and in its adaptation to Africa are also part of profound developments in industrial agriculture in the First World (Cleveland, 1991). These changes are the result of two major factors: first, the decreasing profits and increasing consumer and environmental pressures that are leading to calls for a more "sustainable" agriculture; and second, the growth of the new agricultural biotechnologies like genetic engineering that promise the creation of dramatically new crop varieties.

In summary, the new green revolution in Africa has the stated goal of increasing production, while at the same time promoting both environmentally sustainable agriculture to assure that future generations will not pay the cost of present production, and social equity so that the poor will not pay the cost of national and global growth.

However, to understand what this new green revolution means, it is necessary to move beyond the platitudes and wishful thinking which fill the international agricultural development project proposals and newsletters, and to examine the assumptions about agricultural development on which it is based. Two of the most important assumptions are the unilineal evolution of world culture and agriculture following an idealized Western model, and the necessity of unlimited economic growth, along with the availability of the resources to support it, on which that evolution is based (for examples see Harrison, 1987:113,333; Lal, 1987; Todaro, 1985:304-310).

These assumptions are ethnocentric and constrain intellectual inquiry, resulting in analysis of and solutions for Africa's food and agricultural crisis which are inappropriate, and likely to fail. For example, the cause of the crisis is seen to be within the continent, and the solution is massive investments "To *give* Africa the tools to meet her food needs," including biotechnology to accelerate the development of drought tolerant and disease resistant varieties (Brady, 1985, emphasis added). "Biological science research" and the "dynamic institutions of modernization" will comprise the green revolution for Africa, leading to "major increases" in productivity (Mellor et al., 1987: 363). This means increasing integration with the world economic and agricultural system, with the ultimate aim of transforming small-scale, "inefficient" African agriculture into a replica of large-scale, capital intensive industrial agriculture. The ultimate goal is the total replacement of indigenous agriculture, since it is "incapable of feeding rapidly growing urban and rural populations" (Plucknett et al., 1987:174-175; see also Lal, 1987). There is no alternative to industrial agriculture: its "the only game in town, and in the countryside too" (Lipton and Longhurst, 1985:15).



Large-scale, high input, commercial agriculture will in turn fuel the rise of urban industrialism (La-Anyane, 1985:28; Mellor and Gavian, 1987; World Bank, 1984:36). The "transformation from an agrarian to an industrial society must proceed through the development of the agricultural sector....Agricultural commercialization generates incomes and surpluses necessary to absorb occasional disruption" and liberates "resources for industrial expansion" (Mellor and Gavian, 1987:543). The farmer will move to the city, find a job in industry, and, being no longer dependent on her/his children, will curb her/his fertility to replacement levels (Mellor and Gavian, 1987).

Thus, the assumptions preclude consideration of the possibility that the cause of Africa's food crisis lies primarily in the disruption of African agriculture and society under colonialism, the imposition of inappropriate production models, and the dependence of African economic development on the Western economic system. Sustainability and equity are defined in ways that make them subservient to production economics, and indigenous agriculture is not considered at all. "Sustainable" has become the ubiquitous buzz word in agricultural development (CGIAR, 1987; Holden, 1987; Jahnke et al., 1987). However, the time scale of economists is much shorter than that of ecologists (Goldsmith, 1987), and in the words of one ecologist, "economic analysis is utterly incapable of coping" with sustainability (Ehrenfeld, 1987:7). In fact, sustainable agriculture is being totally transmogrified by the development establishment from its ecological sense to fit the assumptions of industrial production dominated agriculture and the green revolution (*see* Orr, 1988).

The concept of equity also takes on a special meaning in the context of an inevitable evolution toward industrial, large-scale agriculture. "Small-scale farmers" and "low input" agriculture are relative terms, and geographical areas and farmers with the most potential to make a rapid return to the required investments will continue to be targeted (Flinn and Denning, 1982:10-11; Mellor et al., 1987; World Bank, 1981:52). In light of their underlying assumptions it is not surprising for proponents of the new green revolution for Africa to state that "the low-input systems now recommended in Africa as an intermediate measure may be obsolete by the year 2000," replaced by "commercial enterprise" with "high inputs of agrochemicals and water management" (Lal, 1987:1075; *see also* Harrison, 1987:323, 332- 333).

Many of the critics of the green revolution in Africa emphasize the social relations of production as encouraged by the Western capitalist system as the primary cause of increased inequity (e.g., Lawrence, 1988; Clough and Williams, 1987). Unlike the development establishment, the cause of Africa's agricultural crisis for them is to be found outside the continent in the industrial world. Yet they often assume that if small farmers could have access to the green revolution technology, it would be to their long-term benefit. In doing so they, to, seem to adopt a unilineal model of cultural evolution. Like the establishment, these critics do not appreciate the need for a long term, ecological view of agricultural development.

My purpose in this chapter is to analyze the assumptions on which proposals for a green revolution are based in order to help encourage more open discussion of alternatives for agricultural development in Africa. Most anthropologist have rejected unilineal evolutionist models of cultural and biological evolution since Franz Boas stood up to the racist eugenics movement at the beginning of this century. Then as now, when the ratio of data to social importance is low, science too easily falls into the tautological trap, and produces results which do little "but validate a social preference" (Gould, S.J., 1981:22–23). Yet in agricultural development these unilineal evolutionist models are not challenged often enough or vigorously enough by anthropologists and other social scientists.

Admittedly this will be difficult, as it has been only recently in the United States that the accumulation of environmental, economic, social, and health problems resulting from industrial agriculture has created sufficient awareness and pressure to allow discussion at the national level of alternative systems of food production (Cleveland, 1991). The success of the green revolution in Africa will depend on many factors, including the markets and infrastructure necessary to deliver inputs to the farm and export produce from the farm. I will focus here on the crops themselves, suggesting that the green revolution approach of the development establishment is not ecologically sustainable or socially equitable. First, the development of new crop varieties for Africa is controlled by the Western dominated international development establishment, and this control will increase to the extent that the green revolution becomes more dependent on the new agricultural biotechnologies. Second, the high yielding varieties themselves lead to instability in biological systems and thus in yields, and green revolution approaches to reducing this instability in the garden or field only delay its ultimate expression, and will lead to greater instability in economic and social systems.

## THE CONTROL AND ORGANIZATION OF CROP DEVELOPMENT

The international plant breeding system is the source of green revolution varieties, and understanding its organization gives insights into the nature of



the varieties themselves (Jahnke et al., 1987:27). The first level in the system is basic scientific knowledge and technological innovation in plant science provided by commercial and university research in the industrial world. Techniques and breeding material are then picked up by applied international research organizations, epitomized by the International Agricultural Research Centers (IARCs) of the Consultative Group on International Agricultural Research (CGIAR),[2] in which research is organized primarily by commodity and by region, and to some extent by discipline. The CGIAR is headquartered in Washington, D.C., and is controlled by the Western industrial nations. The IARCs send plant material to National Agricultural Research Centers (NARCs) in the Third World for either direct release or further breeding for local or regional conditions.

While biotechnology, through tissue culture and induced mutation, has been contributing to the creation of new crop varieties for some time, the latest techniques, most notably genetic engineering, promise to revolutionize research and development in this area. Whatever its ultimate contribution to African agricultural development, genetic engineering promises to be even more removed from the influence of African farmers and less appropriate for sustainable agriculture than conventional green revolution research, because it requires more technical and capital resources, and it is much more under the control of private business interests (Buttel et al., 1985; Gould, F., 1988). Whether genetic engineering or more conventional methods of creating new crop varieties are used, traditional landraces, their wild and weedy relatives, and associated microorganisms are now widely acknowledged to be the main source of the genetic diversity needed for future agricultural production. This is true for the development of new varieties by plant breeders, not only for Africa and the rest of the Third World, but especially for the industrial north (Edwards, 1987; Kloppenburg and Klienman, 1987; Plucknett et al., 1987:16–18). It is also true for the maintenance of traditionally based production (Oldfield and Alcorn, 1987).

The success of new green revolution varieties in Africa will be measured by the extent to which they replace landraces in farmers' fields (Plucknett et al., 1987:96). The greater the success, the more indigenous genetic diversity would depend on *ex situ* conservation in gene banks. The world gene bank system is administered by the International Board for Plant Genetic Resources (IBPGR) housed at the FAO in Rome, but controlled by the CGIAR in Washington, D.C. A world network of base seed collections at gene banks has been designated by IBPGR to serve as conservation centers for major crops. Of the 127 base collections in 1987, 81 are in industrialized countries, 29 at IARCs, and only 17 in Third World countries, including only one African gene bank housing several collections, in Ethiopia (Fowler et al., 1988:269-270; IBPGR, 1987:27-32). Objections by Third World countries that this leads to lack of control over their own genetic resources is countered by the argument that as a matter of scientific ethics, there is free exchange of germplasm between plant breeders world wide (although not from gene banks to farmers). The place where genetic diversity is maintained, whether in gene banks or the gardens and fields of African farmers, is a major difference between the green revolution and indigenous agriculture.

## INDIGENOUS AGRICULTURE AND THE GREEN REVOLUTION

Indigenous agriculture is often dismissed by green revolution proponents as inadequate to meet the needs of a growing population. Richards has pointed out how "cultural evolutionist" models continue to result in misunderstanding and undervaluing African agriculture, and in the promotion of inappropriate green revolution development (1985:138-140; see also 1986: Chapter 2).

Replacement of many locally adapted varieties or landraces by a much smaller number of widely adapted green revolution varieties has led to increased production at the price of decreased diversity in crop genetics and field ecosystems. This results in increased instability, i.e. increased variation in yield from year to year, when subject to environmental fluctuations, e.g., in water supply or pest and pathogen attacks (Cleveland and Soleri, 1989, n.d.). The green revolution varieties also require more inputs and the replacement of varieties which succumb to evolving pests and pathogens, thus increasing yield instability further due to failure in the supply infrastructure. This increased yield instability means increased risk for farmers, especially those with limited resources, and therefore often increases inequity. In addition, the destruction of existing diversity within indigenous agriculture, and the dependence on non-renewable resources, Western technology, and economic growth means that production based on these new varieties is not sustainable.

The new, more sustainable and equitable green revolution for Africa based on new crop varieties is likely to be unsustainable and inequitable because it fails to address realistically the trade-off between production on the one hand and stability and diversity on the other.

## CROP GENETIC DIVERSITY AND PRODUCTION STABILITY

Traditional African crops (both indigenous and introduced) are characterized by a large degree of intraspecific variation (that is, many different varieties or landraces within each crop species). In addition, each variety is genetically heterogeneous, that is contains a large amount of genetic variation.[3] This diversity is expressed in a range of phenotypic characteristics and makes crops more able to cope with environmental variability in both space and time (Clawson, 1985).



In contrast, relatively few varieties of each green revolution crop are bred and released, with each variety developed for production over much wider areas than landraces. Homogeneity, or a small amount of genetic variability, is the outcome of these breeding programs which emphasize increased production under optimal and stable environments in which yield per unit of labor and land increase.

The lack of genetic diversity leads to the inability of crops to respond to changes in the environment (social, biotic, and abiotic). Thus the need to create relatively homogenous agricultural environments that are maintained with a package of energy intensive inputs which often includes commercial fertilizers, insecticides, fungicides, and herbicides, irrigation, and mechanization. In addition, the yield per unit of capital and energy inputs and yield per unit of degraded soil, water, or genetic resources seldom appear to be considered as criteria in such breeding programs.

Plant breeders commonly work under the assumption that adaptability to a wide range of environments is correlated with stability of yield through time, and therefore use the former as a proxy for the latter in selecting for stability (Buddenhagen, 1985; Flinn and Garrity, 1986). In more favored environments, where new varieties are commonly evaluated, this means that low variability in yield between different test locations is correlated with low variation in yield through time at a given location (Flinn and Garrity, 1986:7). However, in marginal (e.g. non-irrigated) environments (subject to water stress, drought, and flooding) there is high variability in yield at different locations and through time (Lynam et al., 1986) and landraces typically perform better here.

For example, photoperiod sensitivity, which varies in some landraces with latitude, has many advantages in highly variable rainfall regimes (Smith and Francis 1986:229), such as those which characterize savanna Africa (Kassam, 1976). Green revolution varieties are often photoperiod insensitive so that they can be grown at many different latitudes and in different seasons. This makes them less resistant to drought, because they are programmed to develop according to schedule regardless of environmental conditions. They do not have a long vegetative period in which to take advantage of variable rainfall. So without irrigation or adequate rainfall, productivity is much less than is the case for landraces under similar circumstances. Modern, short-duration, photoperiod insensitive varieties of rice have lower yield and higher variability of yield than do traditional varieties in long rainy season, highly erratic rainfall areas of Asia (Flinn and Garrity, 1986:8-9).

Resistance to pests and disease offers another example of the trade-off between production and stability. Breeding for green revolution varieties emphasizes high levels of resistance to a few strains of pests or pathogens to achieve high production. This results in fairly rapid evolution of the pest or pathogen to overcome the varieties' resistance (Gould, F., 1988).

Overall, green revolution varieties often last only a few years before they need to be replaced. High yields depend on a "varietal relay race," a steady stream of new varieties produced by the research establishment, because "even superstars in the varietal relay race eventually succumb to new diseases, pests, or other environmental challenges," and if the race falters, "crop yields would dip" (Plucknett et al., 1987:19, 21, 184). The rapid replacement of varieties as they fail is so important to maintaining yield stability that Lipton and Longhurst even state that "if there is a Green Revolution, it is fast and responsive breeder-farmer interaction, not this or that vulnerable variety" (1985:17). Although landraces, too, are replaced as environments (social, biotic, and abiotic) change, it is a much slower process which maintains a high level of genetic diversity and does not depend on massive investments of resources (*see* Oldfield and Alcorn, 1987).

In Africa the inappropriateness of green revolution varieties in the past is evidenced by the fact that the great majority of the many varieties sent there by IARCs and others have not been as productive as the local varieties, either as field crops or breeding stock (Jahnke et al., 1987; Eicher, 1984). In Sierra Leone, for example, "Three of the most successful improved varieties now offered by IADPs [Integrated Agricultural Development Projects] ...are selections from local strains rather than HYVs [high yielding varieties]" developed by IARCs (Richards 1986:26). Increasing awareness of these problems has led to emphasis on the fact that "adoption of widely adapted varieties at best buys time for national programs working to develop varieties with high yields and stable performance under specific ecological conditions and market preferences" (Flinn and Garrity, 1986:7).

## DIVERSITY IN GARDEN AND FIELD

Much of our Western scientific knowledge of crop production is based on the study of industrial varieties grown as sole crops. In Africa, however, the great majority of food production is in mixed or multiple cropping systems. These systems combine many different crop species as well as different varieties of each species, i.e., they possess intraspecific as well interspecific diversity (Clawson, 1985). For example, in Northern Nigeria 25 crops are grown in 200 different crop combinations (Norman, 1972:74), in northern Ghana a single field may have as many as a dozen different crop mixtures, some in an area as small as 0.01 acre (Lynn, 1937:20). The number of species increases with the intensity of land use and increasing inputs of labor and resources epitomized by gardens (Cleveland and Soleri, 1987). One survey in southern Nigeria found a total of 146 species (range:18–54) in 84 compounds (household gardens) (IITA 1986:31). Another study in this region found a mean of 47 species in four compounds (Lagemann, 1977:35). In a sample of small-scale women farmers in Malawi only four varieties make up the majority of beans planted, yet they maintain an average of 16–19 varieties per household (mean = 13) (Ferguson and Sprecher, 1987).



There has been increasing study of mixed cropping systems by Western science as their potential for sustained high productivity has been recognized. Mixed cropping often produces more total, but less of any one crop compared with yields in sole stands. Yet in a major publication on multiple cropping published in 1986, there is general consensus that Western science remains largely ignorant of it (Francis, 1986). While evaluation methods for selection of two crop mixtures have been developed, interactions in systems with three or more species are little understood (Smith and Francis, 1986), and in fact most research on intercropping in Africa has been done on just two crops (*see* e.g. Keswani and Ndunguru, 1982). The study of *indigenous* multiple cropping "represents a fundamental change in the organization of agricultural research" because there are too many variables to break the system down into components for conventional plot research (Lynam et al., 1986:261).

Another problem in attempting to apply standard approaches to crop breeding for multiple cropping systems is that in the marginal conditions which characterize many African farms, the level of environmental variability swamps genetic differences, making selection under atypical conditions of more optimal environments, like those of research stations, necessary (Smith and Francis, 1986). This points to the necessity of selecting varieties for each specific multiple cropping system, yet to do this using current research methods and infrastructure would require a large investment of resources.

## CONCLUSION

The production oriented goals of a new green revolution for Africa promoted by the development establishment rest, as we have seen, on the same assumptions of unilineal agricultural development and unlimited resources for perpetual economic growth upon which the original green revolution was founded. Existing diversity in crop genetic resources, field ecosystems, and social organization is increasingly to be replaced with simpler green revolution systems that increase production over the short run. The short-term instability inherent in such an approach is to be mitigated with ever increasing investments in sophisticated research, new crop varieties, inputs, and infrastructure, thus increasing, long-term instability and risk even further (Ehrenfeld, 1987). The technology and resources needed to maintain this response will be increasingly concentrated in the industrialized world, beyond the control of African governments and farmers.

Proponents of a green revolution for Africa admit that "resource requirements for moving the food sector are immense" (Mellor et al., 1987:357), yet it seems unlikely that the large investments needed to begin and sustain a green revolution in Africa will be forthcoming. Africa's foreign debt is now $40 billion, with annual debt service of $3 billion, and annual development assistance is only $8 billion (World Bank, 1987:239-243).

Goals of environmental sustainability and social equity are incompatible with such an approach to agricultural development. By failing to understand indigenous African agriculture holistically, ecologically, and non-ethnocentrically with a view to enhancing it, this approach destroys the diversity that begets long-term stability.

This does not mean that traditional indigenous agriculture can feed Africa's growing population. These systems did not evolve under conditions like those that exist today. Demographic, environmental, social, and economic conditions have changed drastically, and indigenous systems need to adapt more rapidly than they have before. To do this, Western science can be helpful, but it must be a science which does not tautologically reinforce its own assumptions and theories. This means that it must discard the present approach of the agricultural development establishment, which says, for example, that "on-farm social science research has an important role in *support* of the biological science effort" (Mellor et al., 1987:363, emphasis added). Rather, social science has an important role to play in grounding biological science in the ecological and sociocultural realities as they are experienced by African farmers, in helping Africa to take charge of her own development, and in elucidating some of the ethnocentric assumptions, both tacit and explicit, on which the current drive by the development establishment for a new green revolution in Africa rests. This approach appears to offer a realistic alternative with some hope of achieving sustainability and equity in African agriculture.

## NOTES

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2. Four international regional institutes dominate food crop research in Africa, ICRISAT, IITA, WARDA and IRAT, and all are part of CGIAR except IRAT, which is French (Eicher, 1984:12). However, bilateral and multilateral assistance to national agricultural research in Africa is also very important (Jahnke et al., 1987:63) and deserves more attention than I can give it here.
3. This is true for even self-pollinated crops. For example, one study of 25 lines of 15 different landraces of common bean (*Phaseolus vulgaris*) in northern Malawi found considerable variability in all 25 quantitative characteristics examined (Martin and Adams, 1987a). The progeny of a single heterozygous seed segregated into 60 unique seed types (Martin and Adams, 1987b).

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