PN-AAT-016
ISN: 40033

Is the green revolution still green?

Robert D. Havener

Director General
International Maize and Wheat Improvement Center
El Batan, Mexico
CIMMYT

IAFP Working Paper Series Publication No. 8 (1985)
A Grant F. Walton International Lecture

Rutgers University/Cook College
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Contact Dr. G. William Wolfe, Department of Entomology and Economic Zoology, Cook College. Phone: 201-932-9459

REVISED DRAFT

IS THE GREEN REVOLUTION STILL GREEN? [1/]

Robert D. Havener[2]

It is a pleasure to participate in this lecture series on agriculture and enviornmental affairs organized by my long-time colleague and friend, Dr. Reed Hertford. The topic I have been assigned, "Is the Green Revolution Still Green," is a subject I welcome exploring with you and is particularly fitting for this, the World Food Day. In sharing my views on this subject let me set the stage with a brief review of recent development history. [3/]

Historical Background

Until the end of the 1950s, few policy makers or development economists viewed agriculture as an important sector with the potential to become a driving force in the economic growth of the Third World. Rather, industrial growth was seen as the "engine of development," with agriculture serving as the residual sector to provide "surplus" labor as

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1/ Presented at the Grant F. Walton International Lecture Series on Agriculture and Environmental Affairs, Rutgers University, New Jersey, October 16, 1984.

2/ Director General, International Maize and Wheat Improvement Center (CIMMYT), El Batan, Mexico.

3/ The insights of various writers have helped to shape th s paper; a selected list of references is included as an appendix to the paper.

needed to transform the industrial-urban sectors. Therefore, despite the dominance of agriculture in developing countries, most development funds were channeled toward industrial investments. The agricultural development assistance that did occur placed a heavy emphasis on the direct transfer of agricultural technology from high-income countries to the Third World and promoted the U.S. model of extension education to transfer this technology to the farm level. Implicit in this approach was the view that peasant farmers were tradition-bound and thus, poor decision makers. Hence, the development of grass-roots, community-action, self-help groups guided by community development "change agents" was seen as the appropriate model to introduce more efficient production systems.

Origins of the Green Revolution

By the early 1960s, declining per capita cereal production rates, exacerbated by several years of drought, led to accute food shortages in south Asia and dire predictions of growing famine. Political leaders, many with their backs to the wall, were receptive to the then "radical" advice of a handful of agricultural scientists--and even a few economists--who were convinced that agricultural sector development was essential to overall economic growth and that local farmers were indeed rational in their decision making and receptive to change. They further argued that the direct transfer of agricultural technology developed in the high-income temperate countries had generally not been appropriate to the conditions found in the Third World.

This "radical" thinking about Third World agricultural development had its origins in Mexico when the Rockefeller Foundation initiated in 1944 its first cooperative international agricultural research program with the Government of Mexico. In slightly more than a decade Mexico

had made great strides, essentially becoming self-sufficent in food production. The success of this effort led the Rockefeller Foundation to launch a "Campaign Against Hunger" in the Third World, with agricultural scientists stationed in a number of developing countries.

By the late 1950s, the Ford Foundation had joined forces with the RF program, helping to create IRRI in 1960 and CIMMYT in 1966, followed by a host of other international centers in ensuing years. With their applied, commodity-oriented, interdisciplinary research programs directed toward solving food production problems in the Third World, CIMMYT and IRRI were unique research institutions. They later became the model for the network of international research centers concerned with the major food production problems of the Third World.

By the mid 1960s, scientists at CIMMYT and IRRI had developed new wheat and rice varieties with radically improved grain efficiency (harvest index) ratios compared to the tall, traditional varieties. Even under the same agronomy of the traditional varieties, the new semidwarf wheats and rices yielded more than the local materials. However, with adequate moisture and soil fertility, these new broadly adapted, disease-resistant materials yielded up to four times as much grain as the traditional varieties. Nevertheless, many scientists were skeptical of the new semidwarf wheat and rice varieties. Not only were they phenotypically different from the traditional types, but their agronomy, especially in the area of fertilizer use, water management and weed control, was also different. In short, the new technologies challenged the conventional wisdom of previous crop research programs.

The seed and fertilizer required to gain maximum advantange from the new technology were not readily available in most

of developing Asia. In general, seed organizations did not exist and there was little domestic production of fertilizers, a situation which could only be remedied through imports and/or a major change in investment policy to build national fertilizer industries. Faced with the dire food situation in Asia, concerned and courageous political leaders in India and Pakistan became convinced that if these new high-yielding wheat and rice varieties were made available to farmers, along with sufficient quantities of fertilizer and advice on how to grow the new materials, national production could be dramatically increased in the near term. Overruling the advice of many researchers, national leaders in India and Pakistan decided to embark on a major production program to introduce the new seed-fertilizer technologies as quickly as possible, importing seed and fertilizers in the beginning, and lauching massive farm demonstration programs. Once farmers saw the new technology, they themselves became the major spokesmen for its adoption and spread.

This introduction and rapid diffusion of the new early-maturing, fertilizer-responsive varieties of wheat and rice in Asia came to be known as the "Green Revolution." In reality, it was a process of helping the people of the Third World to grow more food for themselves. It involved the application of modern principles of genetics, plant breeding and agronomy to the cereal production problems of the developing world.

The rapidity with which the HYV wheat and rice technologies spread across Asia and their production impact has few parallels in the history of agriculture, other than perhaps the spread of hybrid corn in the USA during the 1940s and 1950s. Permit me to use the case of wheat to illustrate this diffusion. The first ten years (1966-76) after the HYV wheats were introduced from Mexico into south Asia, the area

planted to these varieties climbed from zero to 29 million hectares. Production was affected in two important ways: (1) crop yields increased considerably through the use of these fertilizer-responsive genetic materials, and (2) the early maturity characteristics of the varieties permitted greater cropping intensification in the more-favored environments and, therefore, higher total farm output.

Criticisms of the Green Revolution

Despite tremendous production gains achieved in a very short time, the green revolution wheat and rice technologies have been the subject of intense controvery since their introduction. At the heart of this debate was the role technologists should play in Third World development. Although the new technologies achieved their primary objective--to overcome seriously lagging food production--many other rural development problems facing low-income, food-deficit nations were not solved. Unfortunately in some respects, so great were the successes of the green revolution technologies that they seemed to challenge the relevance of the existing models of rural development based on community action programs; generally a slower, more expensive, and more difficult process. Social scientists concerned with rural development rushed to document the potential second and third order effects associated with the adoption of the new seed-fertilizer technologies.

In the intial years, two major lines of criticism were levelled against the green revolution. On one side were the population doomsayers who said that, because of overpopulation, it was already too late in many developing countries, that the situation in countries like India and Bangladesh was helpless, and that the rich nations could only make things worse by trying to make them better.

The other major line of criticism argued that unless a redistribution of wealth occurred first, the new technologies would only worsen income distribution and general welfare in the Third World. These critics labelled the high-yielding varieties as being only suited to the rich landowners who could afford the fertilizer and irrigation systems needed to obtain the maximum yield potential. Green revolution technologies were also said to encourage farm mechanization, thus potentially increasing rural unemployment and the number of landless poor in countries where there already was an abundance of labor.

In more recent years, green revolution criticism have taken an additional twist: that modern technology, per se, is bad for the developing world. These critics tend to view peasant life in the Third World in bucolic terms: a harmony between man and the environment at low levels of resource use. Green revolution technologists, they argued, were trying to get Third World farmers "hooked" on energy-intensive, agricultural technologies. These critics viewed chemical fertilizers and pesticides, pump irrigation systems and mechanization as inherently bad for the Third World; in effect, they advocated status quo in developing country agricultural production systems.

Defenders of the new technologies admitted that the benefits were uneven across regions. They also recognized that, because of different land and operating capital endowments, benefits in an absolute sense were different among classes of farmers. However, they contended that the seed-fertilizer technology was highly divisible and could be equally effective on small and large farms. Therefore, even with existing problems of wealth and income distribution, green revolution proponents argued that the new technologies were improving the welfare of all farmers in regions of adoption.

Green revolution proponents also argued forcefully in favor of the use of chemical fertilizers. While they agreed with the value of organic materials and the desirabilty of soil-restoring crop rotations, given the existing and future pressures on the land to produce more food, they concluded that adequate soil fertility could not be realistically maintained in this way. With soil infertility already a major problem in many of the nutrient-depleted soils of Asia, and with farmland being a very scarce factor of production, the restoration of soil fertility through chemical amendments and the introduction of high-yield agriculture were seen as the only viable solution for increasing per capita food production in the near term.

Who Benefited from the Green Revoultion?

Vernon Ruttan does a thorough job of reviewing the large volume of research literature on the new wheat and rice technologies in his article, "The Green Revolution: Seven Generalizations." Ruttan's summary of findings follows:

1) "The new wheat and rice varieties were adopted at exceptionally rapid rates in those areas where they were technically and economically superior to local varieties.

2) Neither farm size nor tenure has been a serious constraint to the adoption of new high-yielding grain varieties.

3) Neither farm size nor tenure has been an important source of differential growth in productivity.

4) The introduction of the new high yielding wheat and rice technologies has resulted in an increase in the demand for labor.

5) Land owners have gained relative to tenants and laborers from the adoption of the higher yielding grain varieties.

6) The effect of introduction of the new high-yielding varieties has been to contribute to a widening of wage and income diffentials among regions.

7) The effect of the introduction of the new high yielding varieties has been to dampen the rate of increase in food grain prices at the consumer level."

Today, Asian farmers--large and small--are harvesting nearly twice as much wheat and rice--250 million extra tons annually--as they did two decades ago, with yield levels and per capita production much increased over this period. This expansion in agricultural production has resulted in higher real wage rates for rural labor and has led to the development of new agro-industries and service organizations in rural areas.

The major absolute beneficiaries of the new wheat and rice technologies, however, have been consumers, and especially the urban and landless rural poor, whose diets rest heavily on cereals. With nearly a doubling in Asian wheat and rice production over the past two decades, the real price of these commodities has steadily declined. Given the higher proportion of income spent by the poor on their food supply, lower real food prices have permitted an increased dietary level, and thus improved welfare for low-income people.

Is the Green Revolution Still Green?

While the term, "green revolution" generally refers to the initial period of rapid diffusion of the HYV wheats and rices in Asia during 1966-76, the adoption of these

varieties and associated production practices has continued to grow at impressive rates in other Third World countries during the last decade. Let me again use the case of wheat for illustration.

Since 1977, the developing country area planted to HYV wheat varieties continued to expand, from 29 million hectares at that time to an estimated 45 million hectares in 1984--approximately 45 percent of the total Third World area devoted to wheat production. Much of the expansion in recent years has been in rainfed environments. The widespread adoption of HYV wheats in Bangladesh is perhaps the most spectacular example. This non-traditional wheat-producing country acheived an 11-fold increase in production, from 89,000 tons in 1973 to over a million tons in 1983. The take off in Bangladeshi wheat production is directly attributable to the introduction in 1975-76 of the short-season semidwarf variety, Sonalika, from India. At the time of introduction, approximately 80 percent of the albeit small Bangladeshi wheat area was planted to tall, traditional varieties; today 97 pecent of the 600,000 ha wheat area is seeded to high-yielding semidwarf wheats. Similar effects could be cited in Turkey, Yemen, Saudia Arabia, Nepal, Argentina and Brazil.

The impact of the higher-yielding wheat technologies on Third World wheat production has been astounding. In the space of two decades, average wheat yield levels in the developing world have doubled and per capita production has increased by 73 percent. If we only attribute 200 kg per hectare in additional production due to the "variety effect" alone, the 45 million hectares in developing countries now growing high-yielding wheat varieties are adding 9 million tons annually to production, worth more than US$ 1.50 billion per annum at current prices.

Overall, some 60-65 million hectares, including developed country wheat lands, are now growing semidwarf wheat varieties carrying CIMMYT germplasm. Something on the order of 65 million additional tons, worth approximately US$10-11 billion annually, are being produced as the result of the work of the green revolution technologists.

Richard Critchfield, a noted American journalist who has spent 20 years monitoring economic and social change in rural areas of the developing world filed this dispatch to the Economist news magazine after a revisit to Asia villages in 1979:

> "Unexpectedly, and most desirably, in almost all of Asia east of Pakistan food production is rising and human fertility falling. Contraception and high-yield grain are producing, at last, a change in the general human condition."

With over 80 percent of the wheat areas of south Asia and nearly half of all developing country wheat land planted to HYV varieties, the "scale neutrality" issue of the seed-fertilizer technology should now be settled: obviously, both large and small farmers have benefitted from the new technology.

Can the Third World's Green Revolution be Sustained?

Despite the tremendous food production successes achieved in recent decades in Asia and parts of the Middle East and Latin America, developing country governments face even greater production challenges to feed future generations. First, the more-favored environments cannot be neglected, since substantial yield improvements are still acheivable and necessary. However, it appears that the major unexploited production gains must be made through the

application of new technologies--which are economically viable and sustainable--to the more marginal cereal crop environments of the developing world.

Some 600 million people live in the semi-arid tropics and more than 1 billion live in tropical and subtropical areas characterized by serious biological constraints in terms of moisture and temperature stresses, soil fertility and toxicity problems, and diseases and pests. The number of people inhabiting these less-favored areas is expanding at an alarming rate. Africa, in particular, is in a critical situation having experienced declining per capita food production for more than a decade. Although some of the biological limitations are simply too overpowering to erase with current techniques, newly applied science and technology can ameliorate many of the important constraints found in these marginal lands.

CIMMYT's research agenda for the 1980s places a major emphasis on the generation of new technological components that can increase yield dependability in less-favored rainfed environments within acceptable "risk" levels for resource-poor farmers. Two major research approaches are being pursued in our germplasm development work. One involves conventional breeding procedures in search of genetic variation within a particular crop species for added tolerance or resistance to specific agroclimatic and soil-stress conditions. Improved genetic materials--in terms of drought, cold and heat resistance, and tolerance to mineral stresses such as those found in saline and acidic soils--are emerging from this work. The development of high-yielding, disease-resistant wheat varieties with tolerance to higher and normally toxic levels of aluminum exemplifies such work. These varieties, developed in cooperation with Brazilian scientists, stand to transform wheat production on millions of hectares with acid soils

which principally produce inferior livestock forage at present.

Research directed at crossing domesticated crop species with related wild species is another promising research avenue that may lead to the development of varieties with greater yield potential and dependability in a number of important marginal areas. Generally, such "wide crosses" involve the breaking down of natural barriers between crop species in order to introduce useful genes from alien plant genera into domesticated crop species. CIMMYT's initial work with wide crosses was with triticale, a hybrid cross of wheat and rye. Our work today is less concerned with creating new crop species than with transferring useful genes from related species to wheat and maize. CIMMYT scientists have identified a number of wild species with greater resitance to certain diseases and insects and more tolerance to salinity, temperature and moisture stresses than we have found to date in the conventional germplasm of the major crop species. Successful introgression of these desirable genes could lead to crop varieties with greater tolerance to higher levels of enviornmental stress.

In some scientific circles today, there is great euphoria that major production breakthroughs will be soon forthcoming from the use of genetic engineering. The new techniques in tissue culture, cell fusion, and DNA transer are all being heralded as the scientific answers to further raising the genetic yield potential of food crops; increasing the breadth, level and stability of disease resistance; and eliminating the need for conventional chemical fertilizers and pesticides. Although great progress has been made in employing genetic engineering techniques with bacteria or yeasts, there is little firm evidence as yet that similar results can be easily or economically obtained with higher plants such as the cereal grains. Leaving aside asexually

propagated species such as potatoes, it will likely require many years, perhaps decades, before these techniques can be successfully used to produce superior field crop varieties. Further, we should not assume that the transfer into crop species of disease- and insect-resistant genes through genetic engineering will necessarily result in substantially more durable resistance than we have been able to achieve in present varieties. Pathogens and insects, when faced with extinction, mutate into new races capable of attacking a previously resistant variety. This biological reality will continue in force even in the "new age" of genetic engineering.

While some crop improvement research funds should be directed toward the development of genetic engineering techniques to improve the yield potential and dependability of our food crop species, most of the research funds for crop improvement in the Third World should continue to be used to support conventional plant breeding research. We at CIMMYT believe that much can be done by further exploiting conventional plant breeding methods to improve disease and insect resistance, enhance tolerance to environmental extremes, and increase genetic yield potential.

Fortunately, there are still large, unexploited agricultural production potentials in the Third World on which to capitalize. For the gap between actual and potential yields to be substantially diminished, new agricultural development programs must be built on a firmer foundation of: (1) research to generate improved technologies appropriate the production circumstances of farmers; (2) investments in the rural sector in land and water resource development, input production and distribution systems (including credit), and transportation and grain storage facilities; and (3) policies which stimulate increased agricultural productivity in ways consistent with the wise use of endowed resources.

Despite the fact that 50 to 80 percent of the total population in the Third World countries directly engages in agriculture and animal husbandry, the agricultural sector in many developing nations is still the economic "ugly duckling" that is exploited for the benefit of the minority urban sector. In too many countries, relatively low priority is still given to agricultural sector investments in crop research, water resource development, rural roads, input delivery systems (for seed, fertilizers, pesticides), credit, and grain storage facilities.

Farmers in many developing countries have also suffered from government food policies designed to placate the more vocal and organized urban groups. Too often, these domestic "cheap food" policies have been reinforced by easy-term food aid and/or surplus disposal programs sponsored by food-surplus nations. Such policies have, time and again, retarded agricultural development in food-deficit developing nations. Obviously, humanitarian food-aid in times of emergencies caused by wars and natural disasters, such as droughts, floods, frosts and disease epidemics, is a very different matter.

The development and widespread application of adapted and more productive technology is a necessary condition for transforming a low-yielding, stagnant, traditional agriculture. An aggressive interdisciplinary research effort is generally the most cost-effective way for developing such technologies, which must have the potential, when properly applied, of substantially increasing yields on farmers' fields within acceptable risk levels. The importance of on-farm research in technology generation and validation is an especially important dimension here.

Effective research programs, capable of developing useful methods and materials for revolutionizing crop production,

will also require greater continuity of scientific personnel and program objectives. It generally takes a minimum of eight to ten years of creative, dedicated and adequately supported research work in various disciplines to produce the information and materials (improved varieties) from which improved production practices can be formulated. The transfer of new production technologies often also requires research entrepreneurs who are able to anticipate and sense when political leaders--often because of serious pending food shortages--are willing to make important changes in agricultural development strategies.

The agricultural extension programs in developing nations have frequently been accused by researchers of not transferring the improved technology already available from experiment stations to farms, thereby contributing to the perpetuation of low yields and food shortages. In all too many cases, the "new technologies" emerging from experiment stations have not been capable of increasing yields adequately within acceptable levels of risk to the farmer. It is clear that without the development of dynamic research systems, agricultural extension services have little to extend to farmers in the way of improved technology. With a growing trend for part of the technology generation process to be conducted "on-farm," that is, on the fields of representative farmers for whom the technology is being developed, and with extension agents participating in this process, I am confident that developing country agricultural research and production systems can become more effective in the years ahead.

What Can the USA do?

The United States has a critical role to play in helping to solve the food-poverty dilema in the Third World. First, as the largest food exporter, the USA will likely experience a

strong demand for its agricultural commodities, especially from the newly industrialized countries. Our domestic crop production policies must take account of the changing nature and extent of this growing food demand in ways that are consistent with Third World market development and human welfare goals.

Second, as the country which has done the most to transform its domestic agriculture into a dynamic, highly efficient production system, the USA through its universities, other scientific institutions, and foreign aid programs can play an even larger role in future years to help assure agricultural development in the poor, food-deficit nations of the world. However I must caution that the lack of continuity in many U.S. technical assistance programs has seriously affected the payoffs from past efforts. One of the main causes is the rapid turnover of expatriate scientific or advisory staff. While production constraints can often be identified quickly, it takes a minimum of three to five years for an expatriate scientist to develop an appreciation for the relevant solutions to these problems.

Cautious Optimism

In summary, I believe that if proper emphasis is given to agricultural development in the Third World and if sound financial policies are established and implemented, the line can be held on the food production front during the time of the next doubling of the world population. But to achieve this goal will require hard and sensible work plus the commitment of sustained and substantial financial resources. Moreover, it must be remembered that producing more food and fiber and rehabilitating the environment can, at best, be only a holding operation while the current and threatening rates of human population growth in the developing world are tamed. The green revolution is indeed still green, but it

must be tended and nurtured if the bountiful harvests promised are to be available and adequate for the next generation.

In closing I would like to quote from William Tucker's thoughtful book, "Promise and Privilege: America in age of environmentalism," which in my view provides an excellent examination of the controversies surrounding overpopulation and the green revolution as well as the current "anti-technology" movement centered mainly in the industrialized world. Tucker concludes his book with following plea:

"It is time, then, [for America] to shed the feeling of being the world's declining aristocracy--wedded to the past, wringing our hands in despair over every new event, and finally becomming too refined, sensitive, and enfeebled to bear even the smallest changes. Progress will continue, even if we decide to rest on our priviliges. There are enough hungry people in the world to ensure that. But without our leadership, our technology, our wisdom, our genius for invention, it will not happen nearly as well."

APPENDIX

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