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Agricultural Production Impact and Challenges

I am now in my 51st year of continuous involvement in food production programs in developing nations. During this period, I have seen much progress in increasing the yields and production of various crops, especially the cereals, in many food-deficit countries. My first foreign agricultural assignment was in Mexico, where I participated in developing the wheat revlution in the 1940s and 1950s. In the 1960s and early 1970s, much of my effort was devoted to increasing wheat production in the densely populated countries of South and East Asia, which then were the most critical food-deficit and famine-plagued areas of the world. Spectacular increases in yield and production of cereals and other crops in India, China, Pakistan, Indonesia, and Thailand from 1968-1985, have made this vast region essentially self-sufficient in basic foods. Much of the research information and plant materials that catalyzed this dramatic change in production and produced huge economic returns was generated by the International Agricultural Research Centers (IARCs), and the predecessor Mexican Government-Rockefeller Foundation agricultural research and production program.

Yet, despite a more than tripling in the world food supply over the past three decades, the so-called 'Green Revolution' in cereal production has not solved the problem of poverty and chronic undernutrition for hundreds of millions of people around the world, who are unable to purchase the food they need, despite its abundance in world markets.

We must also acknowledge that in many of the most productive areas--especially the irrigated areas located in warm climates--there are problems of soil degradation, salinity, and declining water quality which, if left unchecked, can lead to the permanent loss of prime agricultural land. These are not new problems that resulted from the use of high yield Green Revolution technology. In most cases, they date back 50 to 100 years or more. The root cause of much of this environmental degradation has been mistaken economic policy (e.g. irrigation systems without provision for drainage)--not modern, science-based technology. Low crop yields and little profit have prevented farmers from investing as they should have done in resource conservation, while excessive subsidies in a few countries have caused mis-use and over-use of agricultural pesticides, with the consequent environmental damage.

Poets--and city folk--love to romanticize agriculture, portraying it as some sort of idyllic state of harmony between humankind and nature. How far this is from the truth! Since Neolithic women domesticated crop species some 10,000 to 12,000 years ago, agriculture has been a battle between the forces of natural biodiversity and the need to produce more food for more people under increasingly intensive production systems. Through advances in science during the 20th Century, world food supplies have increased more rapidly than population, and, in general, have become more reliable.

In 1990 global food production of all types stood at about 4.6 billion metric tons of gross tonnage--approximately 2.4 billion tons of edible dry matter. Of this total, 98% was produced on the land--less than 2% came from the oceans and inland waters. Plant products constituted 92% of the human diet, with about 30 crop species providing most of the world's calories and protein. These included eight species of cereals, which collectively accounted for 69% of the world food supply. Animal products, constituting 8% of the world's diet, also come indirectly from plants.

Let me take a minute to illustrate the world food production/distribution dilemma. Had the 1990 total world food production been distributed evenly, it would have provided an adequate diet for 6.2 billion people, nearly one billion more than the actual population. However, had the people in the Third World countries attempted to obtain 30% of their calories from animal products--as in the United States, Canada and EEC countries--a world population of only 2.5 billion people could have been sustained--less than half the present world population.

These statistics point out two key problems to feeding the world's people. The first is the complex task of producing sufficient quantities of the desired food, and to accomplish this Herculean feat in environmentally and economically sustainable ways. The second task, equal or even more daunting, is to distribute food equitably. The impediment to equitable food distribution is poverty and lack of purchasing power resulting from unemployment or under-employment which, in turn, is made more severe by rapid population growth.

At best, the governments of most low-income food-deficit developing nations only have the foreign exchange to import the minimum amount of food to avoid famine and social unrest in the cities. Yet the problems of hunger and famine are usually greatest in the rural areas, where 60% to 80% of the people live. Even if the governments had the financial resources to import food for distribution in rural areas, they would be confronted with the enormous problems of physically transporting and distributing such commodities among dispersed rural populations in areas often devoid of roads. Clearly then, if the problem of world hunger is to be solved, it must begin with expanding food production in the low-income food-deficit countries where the majority of the world's hungry people live. Moreover, without the development of agriculture and achievement of an adequate and reliable food supply--the development of commerce and industry will be forever retarded.

During the 1990s, world population will grow by nearly one billion people, and then again by another one billion people during the first decade of the 21st Century. A medium projection is for world population to reach 6.2 billion by the year 2000 and about 8.3 billion by 2025, before <u>hopefully</u> stabilizing at about 10 billion toward the end of the 21st Century (I am becoming more and more skeptical of these "optimistic" projections.)

For the foreseeable future, we will continue to rely on plants, and especially the cereals, to supply virtually all of our increased food demand. Even if current per capita food consumption stays constant, population growth would require that world food production increases by 2.6 billion gross tons--or 57%--between 1990 and 2025. However, if diets improve among the hungry poor, estimated to be one billion people, living mainly in Asia and Africa, world food demand could increase by 100%--to 9 billion gross tons--over this 35-year period. And we have to achieve this production increase in environmentally sustainable ways!

To achieve this goal will require continuing aggressive research across many scientific disciplines by both the IARCs and the National Agricultural Research Systems (NARSs), to develop progressively more-efficient and higher-yielding packages of improved crop production practices. Similarly, the efficiency of the transfer of technology from research centers to farmers' fields by the National Agricultural Extension Systems (NAES), must be greatly improved.

<u>Keeping IARC Science Relevant</u>

The IARCs have obviously played an important role in increasing world food production, but what about their future?

The late Dr. F.F. Hill, Vice President of the Ford Foundation and one of the forces in the creation of both the first four IARCs and then the CGIAR, told me in 1968--when we were traveling together in Pakistan viewing the tremendous impact of the Green Revolution wheat production technology-- "Enjoy it! Such dramatic changes in yield and commercial production are rare, once in a lifetime, events." He stated he was pleased to see the key role the IARCs were playing in bringing both the wheat and rice revolutions to fruition, but he went on to warn, "I doubt the IARCs will have more than 25 years of highly productive life, before succumbing to the twin ills of bureaucracy and complacency." If this happened, he thought, it would probably be easier to build a new set of institutions, rather than trying to reform the old ones. I often ask myself, when reflecting on the current IARC problems, is Dr. Hill's prediction coming true? I hope it is not, but I must confess that I am fearful. We must not let it happen!

Although IARC and NARS scientists certainly have advanced the frontiers of knowledge over the past three decades, I believe their more significant contribution has been the integration of knowledge across scientific disciplines and its application in the form of improved crop production technologies to overcome pressing crop production problems. This should continue to be their mission. Moreover, impact on farmers' fields and alleviation of rural poverty--rather than the number of learned publications--should be the primary measure by which to judge the value of IARC and NARS work.

Unfortunately, agricultural science--like many other areas of human endeavor--is subject to changing fashions and fads, generated from both within the scientific community and imposed upon it by external forces, especially the politically induced ones that affect the actions of financial donors. In my own career, I have seen various "scientific bandwagons" come and go. In the 1930s and 1940s, plant improvement by the development of polyploid varieties (doubling of chromosomes) was promoted as the panacea. By the 1950s and 1960s, mutation genetics was the rage. In the 1970s and 1980s, anther culture, somatic tissue culture and farming systems research were the craze. In the late 1980s and 1990s, biotechnology and genetic engineering, computer modeling of cropping systems, maximizing biodiversity, low-input sustainable agriculture, and participatory farmer research are now the terms in vogue.

Each of these lines of research has had, or will have, some beneficial aspects. But all have had something else in common: their proponents, certainly partly driven by the desire to secure research funds, have too often exaggerated the potential for benefits in these new specialized spheres of research, especially in the near-term. Increasingly, I fear, the IARCs are falling prey to highly specific scientific bandwagons that will not do much to solve Third World food production problems.

Some of the recent IARC down-sizing, while painful, has probably been for the better, since many centers had grown too big and bureaucratic. In this process, however, staff morale has declined considerably. One disturbing aspect of reduction in the IARC core budgets, while special project funding has not been affected, is the distortion it brings into overall program plans. Moreover, as a consequence, it increases friction between different members of the teams. More broadly, the perception that good career opportunities no longer exist within the CGIAR system needs to be dispelled. Twenty-five years ago, the IARCs were able to attract the best and the brightest outstanding young scientists, who wanted to direct their talents to helping to solve Third World agricultural problems. Is this still true today?

The IARCs should attempt to retain the best and brightest of their staff for as long as they can. The notion of forced staff turnover, following a rigid formula, is one of the craziest and nonsensical ideas I have ever heard. Outstanding senior IARC staff members are much more than scientists. They must also have strong communication skills and also have a good understanding of development, in general.

From my perspective, IARC research managers and decision makers need to spend more time on the ground, monitoring what is happening--or not happening. Further, IARC researchers themselves must strengthen their interactions with NARSs, with NAESs and farmers, both large and small. Too many have become detached from the realities in farmers' fields, preferring to measure their achievements by the information and products generated--and learned papers published--rather than by assuring the adoption of their technologies in the countryside to increase food production. This should be changed.

Agricultural Extension

I have mentioned extension but this process of technology transfer to the small farmer deserves a few more words. While the generation of new technology is essential, it is technology transfer which is the weakest link in the research-extension-farmer chain. Imaginative solutions drawing on the experience of the many development strategies, that have been tried over the last 100 years, are required. But do not believe its application is going to be easy or inexpensive.

Linking IARC Research and Production

The transfer of IARC research results to the Third World farmer is heavily dependent upon the capacities of the publicly funded national research and extension systems. Privately funded agribusiness is currently playing only a very small role in technology generation and transfer in developing African countries, consequently, publicly funded efforts must still be the central components in any strategy to reach the small-scale farmer.

Thus, any strategy to maximize investments in technology generation and transfer must find ways to fund adequately, and with stability, the IARCs, the NARSs and the NAESs. Funding one without the others will not result in significant impact. Rather, there is a need to jointly finance all three levels and to maximize the potential from scientific networking between IARC and outstanding NARSs and NAESs researchers and extension workers. In particular, it is essential that outstanding national researchers have adequate funds to engage fully in cooperative research with the international scientific community.

One of the important functions of the IARCs is to serve as the hub of various research networks. In addition to research collaboration on specific problems, IARC networking functions include germplasm development, regional agronomic research and information exchange, which should include, I believe, a continuing program of practical in-service training for early and mid-career researchers from national programs, as well as opportunities for senior level visiting scientists.

The key point here is that for a network to function properly, there has to be lots of interaction between the members of the network. Even with all of the advances in information technology, there is still no substitute for face-to-face contact. This means that NARS scientists need to visit the IARCs with fair frequency while IARC scientists need to spend significant time visiting national program scientists and touring agricultural production areas.

Confusion in Policy Circles

Professor Robert Paarlberg of Wellesley College has written an IFPRI Policy Brief (No. 4, August 1994) which describes succinctly the consequences of the debilitating debate between agriculturalists and environmentalists about what constitutes so-called 'sustainable agriculture' in the Third World. This debate has confused--if not paralyzed--policy makers in the international donor community who, afraid of antagonizing powerful environmental lobbying groups, all too often have turned away from supporting science-based agricultural modernization projects, so urgently needed in sub-Saharan Africa and parts of Latin America and Asia.

This policy deadlock must be broken. In doing so, we cannot lose sight of the enormous job before us to feed 8-10 billion people. We cannot turn back the clock. We must also recognize the vastly different circumstances faced by farmers--large and small--in different parts of the Third World, and assume different policy postures.

For example, in Europe or the US Corn Belt, the application of 300-500 kg of fertilizer nutrients (often part of it from animal manures) per hectare of arable land can occasionally cause some local environmental problems. But surely, increasing fertilizer use in sub-Saharan Africa from 10 kg of nutrients per hectare (currently most of it is applied to export crops, e.g. coffee, tea, cocoa, cotton, pineapple and bananas) to 30 to 40 kg per hectare of arable land is not an environmental problem but a central component in Africa's environmental solution.

And in Asia, where fertilizer use has risen markedly in the last two decades driving the rapid growth in grain production, there is no way the nutrient demands of further increases in food production can be met without recourse to chemical fertilizer. Research on improving fertilizer use efficiency and recycling organic matter, including human waste, can help, but these means can never meet more than a fraction of the nutrient demands. For example, China, historically the most skillful, efficient and extensive user of organic fertilizers, including the use of animal manures, human excrement, composted crop residues and silt from rivers and canals has, within the last decade, also become the world's largest producer and consumer of chemical nitrogen fertilizer. It has also become the second largest consumer and third largest producer of chemical phosphatic fertilizers. As a result, today China has become the world's largest producer of cereals--which it could never have achieved without the use of chemical fertilizer.

Another example of the confusion is the extent to which fertilizers are lumped with pesticides in public debate on policy with respect to agrochemicals, where all pesticides are considered equally dangerous and modern agriculture is branded as polluting. Yet has anyone thought what the development of disease and insect resistance in modern varieties has done for reducing pesticide use? This confusion prevents logical debate on the risks and alternatives that agricultural research has provided mankind.

It seems to me that we have failed to educate policy makers about the strong linkages in the Third World between population, primitive agricultural production methods, environmental degradation, and rural poverty. Without doubt, the reduction of rural poverty among small-scale farmers is a necessary condition for improved resource conservation and lower population growth. As Richard Leakey correctly points out, "you have to have at least one square meal a day to be a good conservationist or environmentalist." Take for example the land-saving effect of employing high yield food production technology output to increase over the last 30 years. By being able to feed many more people from each hectare suitable for high yield agricultural production, many hectares of environmentally sensitive land has been saved. Do most environmentalists and policy makers realize this?

Take the United States as an example. In 1940, the production of the 17 most important food, feed and fiber crops totaled 252 million tons from 129 million hectares. Compare these statistics with 1990, when American farmers harvested approximately 600 million tons from only 119 million ha--10 million less than 50 years previously. If the United States had attempted to produce the 1990 harvest with the technology that prevailed in 1940, it would have required an additional 188 million hectares of land of similar quality. This theoretically could have been achieved either by plowing up 73% of the nation's permanent pastures and rangelands, or by converting 61% of the forest and woodland area to cropland. In actuality, since many of these lands are of much lower productive potential than the land now in crops, it really would have been necessary to convert a much larger percentage of the pasture and rangelands or forests and woodlands to cropland. Had this been done, imagine the additional havoc from wind and water erosion, the obliteration of forests and extinction of wildlife species through destruction of their natural habitats, and the enormous reduction of outdoor recreation opportunities.

Impressive savings in land use have also accrued in China and India through the application of modern technology to raise yields. Had the cereal yields of 1961 still prevailed in 1992, China would have needed to increase its cultivated cereal area by more than three fold and India by about two fold, to equal their 1992 harvests. Obviously, such a surplus of agricultural land is not available in China.

Within the last 8 to 10 years, research has developed new appropriate technologies--based on liming, combined with appropriate fertilization and the development of aluminum tolerant crop varieties of pasture grasses, soybeans, maize, wheat and several tree species that has opened, or will open, vast areas of the "Cerrado" type acid oxisoils in Brazil, Colombia and several African countries to successful cultivation. The application of this new improved technology, if supported by continuing research, promises a huge increase in food production over the next three to five decades.

Twenty-five years ago, in my acceptance speech for the 1970 Nobel Peace Prize, I said that the Green Revolution had won a temporary success in man's war against hunger, which if fully implemented, could provide sufficient food for humankind through the end of the 20th century. But I warned that unless the frightening power of human reproduction was curbed, the success of the Green Revolution would only be ephemeral.

So far, agricultural research and production advances--and the efforts of the world's farmers--have kept gains in food production ahead of aggregate world population changes. However, there can be no lasting solution to the world food-hunger-poverty problem until a more reasonable balance is struck between food production/distribution and human population growth. The efforts of those on the food-production front are, at best, a holding operation which can permit others on the educational, medical, family planning, and political fronts to launch an effective, sustainable human attack to tame the population monster.

Agricultural scientists, responsible environmentalists and policy makers have a moral obligation to warn the political, educational, and religious leaders of the world, as well as the general public, about the magnitude and seriousness of the arable land, food, population and poverty problems that lie ahead. If we fail to do so in a forthright manner, we will be negligent in our duty and inadvertently will be contributing to the pending chaos of incalculable millions of death by starvation. The problem will not vanish by itself; to continue to ignore it will make a future solution ultimately more difficult to achieve.