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It is a great honor to be awarded the Congressional Gold Medal, in recognition of my work to feed a hungry world. I thank members of Congress for giving me an opportunity to comment on the challenges and complexities of feeding a world of 10 billion people who I expect will be living on the planet Earth sometime this century.

When I was born—in 1914—there were only 1.6 billion people on Earth. Today, we are 6.5 billion and growing by 80 million per year. The task of feeding this growing population has been made more complex, since agriculture is now being asked not only to produce food, feed and fiber, but also raw materials for bio-fuels. Thus, there is no room for complacency for those of us working on the food front.

I am now in my 63rd year of continuous involvement in agricultural research and production in low-income, food-deficit developing countries. I have worked with many scientists, political leaders, and farmers to transform food production systems. Any achievements I have made have been possible through my participation in this army of hunger fighters. There are too many to name, but you know who you are. I thank you for your dedication and assistance all of these years. I also thank my family, and my late wife Margaret, for the understanding and unselfish support you have given me.

The Green Revolution was a great historic success. In 1960, perhaps 60 percent of the world's people felt hunger during some portion of the year. By the year 2000, the proportion of hungry in the world had dropped to 14 percent of the total population. Still, this figure translated to 850 million men, women and children who lacked sufficient calories and protein to grow strong and healthy bodies. Thus, despite the successes of the Green Revolution, the battle to ensure food security for hundreds of millions of miserably poor people is far from won.

The Green Revolution

The breakthroughs in wheat and rice production in Asia in the mid-1960s, which came to be known as the Green Revolution, symbolized the beginning

of a process of using agricultural science to develop modern techniques for the Third World. It began in Mexico with the "quiet" wheat revolution in the late 1950s. During the 1960s and 1970s, India, Pakistan, and the Philippines received world attention for their agricultural progress. In the 1980s and 1990s, China, home to one fifth of the world's people, has been the greatest success story. China today is the world's biggest food producer and its crop yields are approaching those of the United States with every successive year. However, it is almost certain, that China and India—home to one third of the world's people—will become the largest agricultural importers in the coming decades, as their economies shift from being agrarian to industrial.

Critics of modern agricultural technology invariably turn a blind eye on what the world would have been like without the technological advances that have occurred, largely during the past 50 years. For those whose main concern is protecting the "environment," let's look at the positive impact that the application of science-based technology has had on land use. If the global cereal yields of 1950 still prevailed in 2000 we would have needed nearly 1.2 billion ha of additional land of the same quality—instead of the 660 million ha that was used—to achieve the global harvest of that year. Obviously, such a surplus of land was not available, and certainly not in populous Asia, where the population had increased from 1.2 to 3.8 billion over this period. Moreover, if more environmentally fragile land had been brought into agricultural production, the impact on soil erosion, loss of forests and grasslands, biodiversity and extinction of wildlife species would have been enormous and disastrous.

At least in the foreseeable future, plants—and especially the cereals—will continue to supply much of our increased food demand, both for direct human consumption and as livestock feed to satisfy the rapidly growing demand for meat in the newly industrializing countries. It is likely that an additional 1 billion metric tons of grain will be needed annually by 2025, just to feed the world, let alone fuel its vehicles. Most of this increase must come from lands already in production through yield improvements. Fortunately, such productivity improvements in crop management can be made all along the line—in plant breeding, crop management, tillage, water use, fertilization, weed and pest control, and harvesting.

Africa's Food Production Challenges

More than any other region of the world, African food production is in crisis. High rates of population growth and little application of improved

production technology during the last two decades resulted in declining per capita food production, escalating food deficits, deteriorating nutritional levels, especially among the rural poor, and devastating environmental degradation. While there are more signs since 2000 that smallholder food production is beginning to turn around, this recovery is still very fragile.

Sub-Saharan Africa's extreme poverty, poor soils, uncertain rainfall, increasing population pressures, changing ownership patterns for land and cattle, political and social turmoil, shortages of trained agriculturalists, and weaknesses in research and technology delivery systems all make the task of agricultural development more difficult. But we should also realize that to a considerable extent, the present food crisis is the result of the long-time neglect of agriculture by political leaders. Even though agriculture provides livelihoods to 70-85 percent of the people in most countries, agricultural and rural development has been given low priority. Investments in food distribution and marketing systems and in agricultural research and education are woefully inadequate. Furthermore, many governments pursued and continue to pursue a policy of providing cheap food for the politically volatile urban dwellers at the expense of production incentives for farmers.

In 1986 I became involved in food crop technology transfer projects in sub-Saharan Africa, sponsored by the Nippon Foundation and its Chairman, the late Ryoichi Sasakawa, and enthusiastically supported by former U.S. President Jimmy Carter. Our joint program is known as Sasakawa-Global 2000, and has operated in 14 sub-Saharan African countries the past 20 years. We have assisted several million small-scale farmers to grow extension demonstration plots for basic food crops: maize, rice, sorghum, millet, wheat, cassava, and grain legumes.

The recommended production technologies come from national and international agricultural research organizations, and include: (1) the use of the best available commercial varieties or hybrids (2) proper land preparation and seeding to achieve good stand establishment, (3) proper application of the appropriate fertilizers and, when needed, crop protection chemicals, (4) timely weed control, and (5) moisture conservation and/or better water use if under irrigation. We also work with participating farm families to improve on-farm storage of agricultural production, both to reduce grain losses due to spoilage and infestation and to allow farmers to hold stocks longer to exploit periods when prices in the marketplace are more favorable. Virtually without exception, farmers obtain grain yields that

are two to three times higher on their demonstration plots than has been traditionally the case. Farmers' enthusiasm is high and political leaders are taking much interest in the program.

Despite the formidable challenges in Africa, the elements that worked in Latin America and Asia will also work there. With more effective seed, fertilizer supply and marketing systems, hundreds of millions of smallholder farmers in Africa can make great strides in improving the nutritional and economic well being of their populations. The biggest bottleneck that must be overcome is lack of infrastructure, especially roads and transport, but also potable water and electricity. In particular, improved transport systems would greatly accelerate agricultural production, break down tribal animosities, and help establish rural schools and clinics in areas where teachers and health practitioners are heretofore unwilling to venture.

Crop Research Challenges

Crop productivity depends both on the yield potential of the varieties and the crop management employed to enhance input and output efficiency. Agricultural researchers and farmers worldwide face the challenge during the next 25 years of developing and applying technology that can increase the global cereal yields by 50-75 percent, and to do so in ways that are economically and environmentally sustainable. Much of the yield gains will come from applying technology "already on the shelf" but yet to be fully utilized. But there will also be new research breakthroughs, especially in plant breeding to improve yield stability and, hopefully, maximum genetic yield potential.

While we must continue to push the frontiers of science forward, we also must be mindful of the need to protect the gains already made. Agriculture is a continuing struggle against mutating pathogens and insects. A clear example is the new race of stem rust that has emerged in East Africa, which is capable of devastating most of the world’s commercial bread wheat varieties. Ironically, I began my career in agricultural science combating stem rust some 60 years ago and I am now in the twilight of my life, once again facing my old nemesis. There hasn’t been a major stem rust epidemic for more than 50 years, since the virulent race called 15B devastated much of the North America wheat crop during 1950-54. Out of that crisis came new forms of international cooperation in plant breeding, which led to accelerated development around the world of high-yielding, disease-resistant, broadly adapted wheat varieties. However, in the ensuing years,

complacency, increasing barriers to international exchange of plant breeding materials, declining budgets, staff retirements and discontinuity in training programs, has resulted in a much weakened system. This has been evident in the slow international response to a very serious new stem rust race, called Ug99, first spotted in Uganda and Kenya in the late 1990s. Ug99 has now escaped from Africa and begun its migration to North Africa and the Middle East. It won't be long before it reaches South Asia and later China, North America and the rest of the wheat-growing world. Wheat scientists are now scrambling to control this disease before it gains a foothold and causes catastrophic losses to the livelihoods of several hundred million wheat farmers and widespread global wheat shortages that will affect prices and the welfare of several billion consumers. Since 2005, excellent collaboration has been forthcoming from the USDA, key land grant universities, and USAID. A far-reaching research program is being considered by a major U.S. foundation located in Seattle that if approved could solidify and accelerate the progress to date. As part of this research effort we also hope to identify why rice, alone among the cereals, is immune to the rust fungi, and then use biotechnology to transfer this genetic immunity from rice to wheat and other cereals. If we are successful in this quest, the scourge of rust, mentioned in the bible, could finally be banished from the Earth.

What Can We Expect from Biotechnology?

During the 20th Century, conventional plant breeding has produced—and continues to produce—modern crop varieties and hybrids that have contributed immensely to grain yield potential, disease and insect resistance, stability of harvests and farm incomes, while sparing vast tracts of land for other uses, such as wildlife habitats, forests, and outdoor recreation.

The majority of agricultural scientists including myself anticipate great benefits from biotechnology in the coming decades to help meet our future needs for food, feed, fiber, and bio-fuels. Promising work, now utilizing the powerful new tools of biotechnology, is also under way to develop greater tolerance of climatic extremes, such as drought, heat, and cold. Such research is likely to become more important in the future as the world experiences the effects of climate change. We must also persist in scientific efforts to raise maximum genetic yield potential to increase food production on lands currently in use while protecting against serious negative environmental impacts.

Seventy percent of global water withdrawals are used for irrigating agricultural lands, which account for 17 percent of total cultivated land yet contribute 40 percent of our global food harvest. Expanding the area under irrigation is critical to meeting future food demand. However, competing urban demands for water will require much great efficiencies in agricultural water use. Through biotechnology we will be able to achieve “more crop per drop” by designing plants with reduced water requirements and adoption of improved crop/water management systems.

Developing country governments need to be prepared to work with—and benefit from—the new breakthroughs in biotechnology. Regulatory frameworks are needed to guide the testing and use of genetically modified crops, which protect public welfare and the environment against undue risk. They must be cost effective to implement yet not be so restrictive that science cannot advance.

Since the private sector patents its life science inventions, agricultural policy makers must be vigilant in guarding against too much concentration of ownership and also be concerned about equity of access issues, especially for poor farmers. These are legitimate matters for debate by national, regional and global governmental organizations.

Even with private sector leadership in biotechnology research I believe that governments should also fund significant public research programs. This is not only important as a complement and balance to private sector proprietary research, but is also needed to ensure the proper training of new generations of scientists, both for private and public sector research institutions.

U.S. agriculture is being asked to produce more food, feed, fiber and now biofuels, while protecting the environment and not greatly increasing land use. Science is ready for the task, but science will not succeed without wise and adequate support from the U.S. Department of Agriculture (USDA) and its congressional committees. Traditional programs of research and education at USDA and in the land grant universities must continue. Congress must also invest more generously in fundamental research to learn more about the cellular and molecular events that determine how plants and animals reproduce, grow and fight off stresses such as drought, cold and disease. Most of these major innovations will start first with acquiring deeper fundamental understanding.

Getting the most from fundamental research will require changes in the culture of decision making in public agricultural institutions. Leading scientists must be involved in deciding which programs have scientific merit and in setting realistic scientific priorities. There should be a council, like those of the National Institutes of Health, where scientists and stakeholders can pool their wisdom in recommending research priorities. Building such changes into the current farm bill is a high priority.

Educating Urbanites about Agriculture

The current backlash against agricultural science and technology evident in some industrialized countries is hard for me to comprehend. How quickly humankind becomes detached from the soil and agricultural production! Less than 4 percent of the population in the industrialized countries (less than 2 percent in the USA) is directly engaged in agriculture. With low-cost food supplies and urban bias, is it any wonder that consumers don't understand the complexities of re-producing the world food supply each year in its entirely, and expanding it further for the nearly 80 million new mouths that are born into this world annually? I believe we can help address this "educational gap" by making it compulsory in secondary schools and universities for students to take courses on agriculture, biology, and science and technology policy.

One exciting high school program, in which I am personally involved, is the World Food Prize Youth Institute program originated by Des Moines philanthropist Juan Ruan and led by the World Food Prize Foundation. Each year, more than a 100 high school students, mainly from Iowa but now expanding to other states and countries, convene at the George Washington Carver auditorium at Pioneer Hybrid Company headquarters in Johnston, Iowa, with teachers and parents, to present their well-researched essays on about how to increase the quantity, quality, and availability of food around the world. They make these presentations in front of past and present World Food Prize laureates and other experts, and lively discussions ensue. Each year, a select few graduating seniors win travel fellowships to go to a developing country where they live and work at an agricultural research institute, and learn first hand about hunger and poverty, and the role that science and technology can play to alleviate these calamities. It is especially gratifying to see the growth and development of these young, mostly female, summer interns. It literally is a life-changing experience for them, and it shows in their performance at university and in career selections. More programs like this are needed, so that future generations of Americans have

a better sense about the complexities and challenges of feeding a growing world.

Agriculture and the Environment

As the pace of technological change has accelerated the past 50 years, the fear of science has grown. Certainly, the breaking of the atom and the prospects of a nuclear holocaust added to people's fear, and drove a bigger wedge between the scientist and the layman. Rachel Carson's book ***Silent Spring***, published in 1962, which reported that poisons were everywhere, also struck a very sensitive nerve. Of course, this perception was not totally unfounded. By the mid 20th century air and water quality had been seriously damaged through wasteful industrial production systems that pushed effluents often literally into "our own backyards."

We all owe a debt of gratitude to environmental movement in the industrialized nations, which has led to legislation over the past 40 years to improve air and water quality, protect wildlife, control the disposal of toxic wastes, protect the soils, and reduce the loss of biodiversity. However, these positive environmental trends are not found in the developing countries, where environmental degradation, especially in Africa, threatens ecological stability if not reversed.

There is often a deadlock between agriculturalists and environmentalists over what constitutes "sustainable agriculture" in the Third World. This debate has confused—if not paralyzed—many in the international donor community who, afraid of antagonizing powerful environmental lobbying groups, have turned away from supporting science-based agricultural modernization projects still needed in much of smallholder Asia, sub-Saharan Africa, and Latin America. This deadlock must be broken.

We cannot lose sight of the enormous job before us to feed 10 billion people, 90 percent of whom will begin life in a developing country, and many in poverty. Only through dynamic agricultural development will there be any hope to alleviate poverty and improve human health and productivity, and reducing political instability.

Closing Comments

Thirty seven years ago, in my acceptance speech for the 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.

It took some 10,000 years to expand food production to the current level of about 5 billion tons per year. By 2050, we will likely need to nearly double current production again. This cannot be done unless farmers across the world have access to high-yielding crop production methods as well as new biotechnological breakthroughs that can increase the crop yields, dependability, and nutritional quality. Indeed, it is higher farm incomes that will permit small-scale farmers in the Third World to make desperately needed investments to protect their natural resources. As Kenyan archeologist Richard Leakey likes to reminds us, “you have to be well-fed to be a conservationist." We have to bring common sense into the debate on agricultural science and technology and the sooner the better!

The United States is the greatest agricultural success story of the 20th Century. Through science and technology and farmer ingenuity, American agriculture has achieved levels of productivity second to none. We also have a great tradition, especially in earlier decades, of helping low-income; food-deficit nations to get their own agricultural systems moving. Our private agri-businesses have invested heavily in the development of productivity-enhancing technology, not only to the benefit of this country but also around the world. American public institutions—the land-grant universities and colleges, the USDA, and the U.S. Department of State—have play key roles in the transformation of subsistence agriculture, especially in Asia and Latin America. This has been good for the American people and the world. Lest we forget, world peace will not be built on empty stomachs or human misery.

I would be remiss if I did not thank the Administration for establishing the USDA Borlaug Fellows program in 2004, in my honor, at the time of my 90th birthday. This is an international program that actively engages universities like my own Texas A & M University, my *alma mater,* the University of Minnesota, and many other of our fine land grant universities and colleges. The Borlaug fellows program also has links to the international agricultural research centers located abroad and to private agro-industry. The aim is to provide relatively young scientists from developing countries with opportunities to travel to the USA to gain practical experience and upgrade their technical skills at advanced agricultural laboratories. So far, USDA has

been able, with the assistance of USAID, to piece together funding for about 150 Borlaug fellows to come to the United States each year. With more permanent funding, along the lines of the Fulbright program, USDA and the partner universities could implement a more substantial range of learning and personal development opportunities for young scientists and agricultural leaders from developing countries. This would be good for the individual recipients, their sponsoring institutions and countries, and also, I believe, for America. Texas A&M University and Ohio State University have been working through the National Association of State Universities and Land Grant Colleges (NASULGC) to prepare a more substantial proposal for consideration by Congress.

My plea today to the members of Congress and to the Administration is to re-commit the United States to more dynamic and generous programs of official development assistance in agriculture for Third World nations, as was done in the 1960s and 1970s. Ever-shrinking foreign aid budgets in support of smallholder agriculture, and especially to multilateral research and development organizations such as the International Maize and Wheat Improvement Center (CIMMYT) where I have worked for 40 years, as well as its sister research institutes under the Consultative Group for International Agricultural Research (CGIAR), are not in our nation's best interest, nor do they represent our finest traditions.

As you chart the course of this great nation for the future benefit of our children, grand-children, and great-grandchildren, I ask you to think more boldly and humanely about the Third World and develop a new version of the Marshall plan, this time not to rescue a war-torn Europe, but now to help the nearly one billion, mostly rural poor people still trapped in hunger and misery. It is within America's technical and financial power to help end this human tragedy and injustice, if we set our hearts and minds to the task.