

# Norman Borlaug

## Geneticist of the Green Revolution

by R. Douglas Hurt

**I**n 1970 Norman Borlaug won the Nobel Peace Prize for his work promoting the Green Revolution in Mexico, Pakistan, Africa, and throughout the developing world. But his roots were on a farm about a dozen miles southwest of Cresco in Howard County, Iowa, where he was born in 1914. The Norwegians who had settled in that area instilled the values of work, discipline, and integrity in their children as moral obligations. In addition to instilling those values in the young Borlaug, his parents encouraged his education, which began at New Oregon Township School No. 8. In 1928, after graduation from the eighth grade, he entered Cresco High School, where he excelled in sports, particularly wrestling. Upon graduation in 1932, his work ethic and skill in the gym resulted in his application for admittance to the University of Minnesota.

There Borlaug became a star wrestler, but he also discovered a compelling field of study; by January 1933, he had chosen forestry as his major. He paid for his education by working on farms in Iowa and Minnesota

during the summers and by holding jobs with the National Youth Administration, a New Deal agency designed to provide employment for the nation's youth during the Great Depression. Upon his graduation in 1937, budget cuts in the National Forest Service during the late 1930s and the lack of job prospects encouraged him to pursue graduate study. He received his master's degree in 1939 and his Ph.D. in 1942 in plant pathology.

Before he completed his degree, he accepted a position in late 1941 with the E. I. Du Pont Nemours & Company in Wilmington, Delaware, where he worked on developing chemical pesticides and herbicides. When the United States entered World War II after the Japanese attack on Pearl Harbor on December 7, 1941, the federal government classified Borlaug as an essential industrial worker and refused his attempt to enlist in the army. At about the same time, the Rockefeller Foundation contacted him about joining a project to improve cereal grain production in Mexico. Borlaug expressed interest, but his government wartime employment classification prevented him from leaving Du Pont. The Rockefeller Foundation began working to gain his release from Du Pont, but more than a year passed before he received permission to leave the company.

**Norman Borlaug walks through a field of hybrid wheat, circa 1960s. His work in fighting hunger would earn him the Nobel Peace Prize in 1970.**

PHOTOGRAPH COURTESY OF CIMMYT



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**Rural schoolchildren in Mexico, in the early 1940s—a time when Mexican farmers raised less than half the wheat needed by the population. Assigned there in 1943, Borlaug and other scientists set out to improve wheat production.**

Borlaug's contributions to the Green Revolution began in 1943 when the 29-year-old geneticist joined the staff of the Cooperative Mexican Agricultural Program as an employee of the Rockefeller Foundation. The program resulted from a trip to Mexico by Vice President Henry A. Wallace and a request from Mexico for technical assistance to improve its agricultural research. American involvement in World War II prevented support in the form of government agricultural experts and funds, so Wallace sought assistance from the Rockefeller Foundation, which had international experience in public health work. The Rockefeller Foundation studied Mexico's agricultural problems and agreed to send a three-person scientific team to address them. As a member of that team, Borlaug was assigned to help Mexico improve its wheat production.

When Borlaug arrived in Mexico, its farmers raised less than half of the wheat necessary to meet the demands of the population. Rust, a serious disease caused by a parasitic fungus, perennially ruined or diminished the harvest. Borlaug, along with his team of agricultural scientists, emphasized an interdisciplinary approach to

solving the wheat production problem by integrating the work of geneticists, agronomists, plant pathologists, entomologists, and chemists. They labored for 13 years before they developed a disease-resistant wheat.

Still, problems remained. Although the new wheat variety resisted rust, its stems, like those of other Mexican varieties, were not strong enough to hold heavy heads of grain, particularly when farmers fertilized their fields. The new varieties produced low yields and toppled over in wind and rain. To solve the problem, Borlaug turned to several Japanese dwarf strains, which he crossed with varieties raised in the hot, dry fields of northern Mexico as well as in the cool highlands near Mexico City. The result was a hard spring wheat that resisted rust, tolerated the climatic and soil variations across Mexico, and resisted toppling. It also produced large yields with the use of nitrogen fertilizer and irrigation.

By 1956, Mexico had achieved self-sufficiency in wheat production, and by 1963, Borlaug had succeeded in increasing the average wheat harvest from 11.5 to 30 bushels per acre. His work breeding wheat and train-

ing Mexican agricultural scientists to continue his applied genetic research led to the creation of the International Maize and Wheat Improvement Center (known by its Spanish acronym as CIMMYT). Borlaug directed the wheat program at CIMMYT until he retired in 1979. More important, he had sowed the seeds of the Green Revolution—applying new technologies to farming to increase crop yields and alleviate world hunger.

In Mexico, Borlaug's team emphasized "production-oriented" research and restricted it to investigations that were "relevant to increasing wheat production." He recalled that "researches in pursuit of irrelevant academic butterflies were discouraged . . . because of the need to have data and materials available as soon as possible for use in the production program." As Borlaug's experimental plots produced increased yields, his staff distributed the improved seeds among farmers to help them improve their production. "We never waited for perfection in varieties or methods," he said, "but used the best available each year and modified them as further improvement came to hand."

**B**orlaug later claimed that his success breeding wheat and increasing production in Mexico put him out of a job. In truth, his success increased and complicated his work. The Cooperative Mexican Agricultural Program became a model that other nations adopted to increase wheat, corn, bean, millet, and sorghum production. In many respects, however, his career as a plant breeder was over. He then became an international advocate for agricultural education and extension, applied agricultural science, and a consultant for the United Nations and a host of countries. That, Borlaug later lamented, "was a disaster as far as I'm concerned. You get pushed off into so many things. A lot of your energies are cut off from the things you know best. Some of them you have to do. Because you end up being the spokesman for science in general."

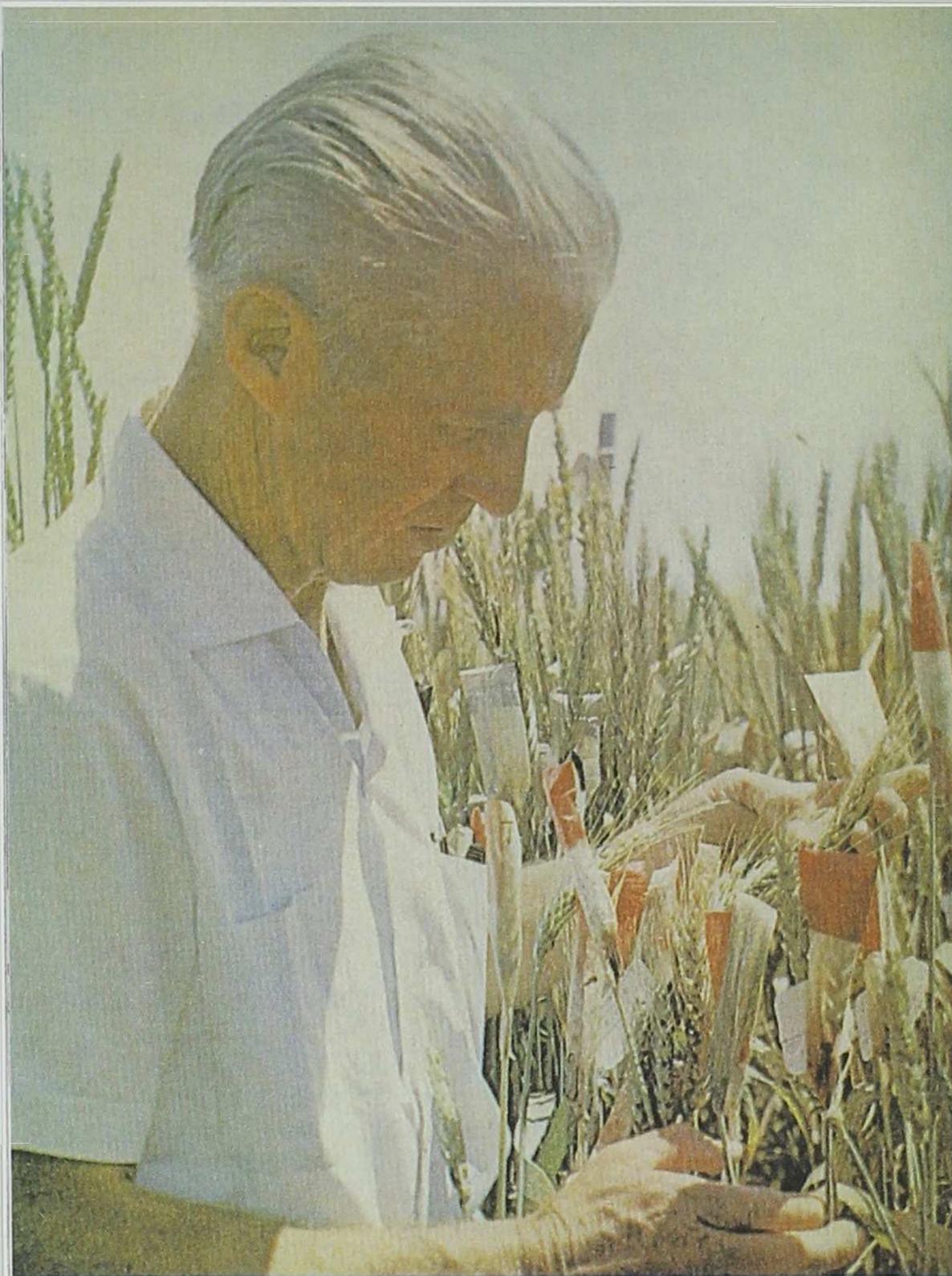
In 1962, for example, the Rockefeller Foundation and the Food and Agriculture Organization of the United Nations sent him to North Africa and the Middle East to evaluate wheat production and determine whether his Mexican wheat research could help increase yields in those regions. In 1963 the governments of India and Pakistan also invited him to visit and evaluate their agricultural research programs and wheat production. Borlaug traveled to Pakistan to observe the progress of the wheat varieties that scientists who had trained under him had taken back from Mexico. Their work convinced Borlaug that his Mexican dwarf vari-

eties could help increase wheat yields substantially in Pakistan and India. In 1968, as a result of Borlaug's help, Pakistan became self-supporting in wheat, although political instability and rapid population growth continued to make the achievement tenuous. Four years later India also became self-sufficient in wheat production. India's agricultural problem then became one of food distribution rather than production. At the same time, Chinese agricultural leaders also wanted to adopt the Mexican dwarf wheats and fertilization techniques that Borlaug had developed. By 1984, after Chinese farmers had adopted them, wheat production nearly doubled.

"The Green Revolution in India and Pakistan," Borlaug wrote, was "neither a stroke of luck nor an accident of nature." Its success was built on "sound research." He added, "There are no miracles in agricultural production. Nor is there such a thing as a miracle variety of wheat, rice, or maize which can serve as an elixir to cure all ills of a stagnant, traditional agriculture." Scientific advancement in agriculture took hard work and a team approach. It also required political savvy and diplomatic skills to convince both government leaders and farmers of the need for new seed varieties, fertilizers, insecticides, herbicides, and machinery.

Borlaug's success breeding wheat and disseminating technical information to underdeveloped, poverty-stricken, hungry nations ensured him a place in history as a benefactor of humankind. Without question, he was a skillful geneticist and plant breeder whose work ethic and commitment to applied research helped prevent famine, eliminated hunger in many countries, and revolutionized world agriculture, all of which led to his receipt of the Nobel Peace Prize. Yet Borlaug should be remembered equally for advocating government attention on an international scale to a host of issues that related to agricultural and food problems.

He realized that increased wheat and rice production required an "integrated" technological or systems approach to fighting world hunger, that is, a technological package that included improved seed varieties, fertilizers, irrigation, and pest and weed control practices. He advocated improved transportation networks in the form of farm-to-market roads as well as rural education and state subsidies for small-scale farmers to acquire chemical fertilizers and irrigation systems. All of these issues required attentiveness to politics on a world scale, because politicians made decisions about prices, credit, markets, land use and reform, and a variety of issues related to agriculture. Indeed, without government aid, Borlaug argued, subsistence farmers in food-deficit nations could not improve their agricultural



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**“There are no miracles in agricultural production,” Borlaug once said. “Nor is there such a thing as a miracle variety of wheat, rice, or maize . . . to cure all ills of a stagnant, traditional agriculture.” Scientific advancement in agriculture, he maintained, took hard work, a team approach, political savvy, and diplomacy.**

practices, and people would remain hungry because of inadequate purchasing power.

Borlaug also championed creation of state-supported demonstration projects in farmers’ fields. Subsistence farmers were justifiably hesitant to make major changes in their farming practices, because the risks and costs too easily could bring failure and even greater hunger. Recognizing that tradition dies hard among farmers, Borlaug drew on his knowledge of the land-grant college system as an agent of change. He wrote, “If a farmer sees the demonstration installed on his own farm or his neighbor’s farm, in his own village, he or his neighbor becomes the most effective extension agent in the whole countryside.”

In addition, Borlaug recognized the need to curb population growth. He never believed that the Green Revolution alone would solve the problem of world hunger. He consistently warned that, given genetic and environmental limitations, agricultural production was finite and that rapid population growth portended unprecedented food crises in the future. At some point, agricultural scientists and farmers would not be able to meet the food needs of the world’s people. Thus Borlaug believed that he had a moral obligation to warn political, educational, and religious leaders about the need “to face up to the population monster or lose the game by default.” “The tic-toc of the clock will continually grow louder and more menacing each decade.” Poignantly he wondered, “Where will it all end?”

In 1970, when Borlaug won the Nobel Peace Prize for his work fighting hunger, he reminded his audience that 50 percent of the world’s population remained undernourished and perhaps 65 percent were malnourished. He also warned that peace could not be maintained nor social justice secured as long as people went hungry. “If you desire peace, cultivate justice,” he said, “but at the same time cultivate the fields to produce more bread; otherwise there will be no peace.” Increased agricultural production was not only good for hungry people and national economies, but it also prevented political instability. Hunger fostered social disorder and violence. Hungry people cared only about survival—not about democracy.

He also told his audience that the Green Revolution did not apply to all crops, nor did it benefit all farmers equally. Rather, wheat, rice, and corn production had increased, but much work needed to be done to improve the yields of other cereal grains that farmers raised in drought-stricken countries on poor lands. Moreover, the greatest success in improving yields occurred on irrigated lands, and not all farmers could afford irrigation technology, particularly in Asia and Africa where subsistence farming prevailed. Borlaug later argued that “all who are born into the world have a moral right to the basic ingredients for a decent and humane life.” For him, access to adequate food that enables people to pursue a meaningful life was, in fact, a human right.

**D**espite Borlaug's success in fighting hunger in food-deficit nations, by the early 1970s environmentalists and other critics began attacking him for advocating what they considered unwise, if not dangerous, agricultural practices. Environmentalists, some of whom were scientists, particularly criticized him for advocating the use of nitrogen fertilizer that polluted water supplies as well as for supporting the use of DDT to kill mosquitoes and fight malaria.

Borlaug, in his usual direct, self-confident manner, never doubted that his work benefited humankind, and he was proud of it. He consistently attacked the environmentalists who criticized the Green Revolution for harming small-scale farmers as well as the environment in underdeveloped countries. To Borlaug, environmentalists were "extremists," largely from rich, well-fed nations, who sought to prevent the expansion of scientific knowledge and agricultural progress as measured by productivity alone. Those who would risk or support the continuation of hunger instead of full stomachs, he charged, were "fatbellied philosophers who have never been hungry;" in addition, they were members of "antiscience political movements" and "antibiotechnology zealots" who waged campaigns of "propaganda and vandalism." No one could turn back the clock on agricultural science, he argued, though he worried that the environmentalists who opposed his work would gain sufficient influence in national governments to prohibit biotechnology research in food-deficit nations.

Other critics charged that improved agricultural technology was affordable only for the rich, who used it to displace subsistence farmers from the land, because the economy of scale permitted them to raise more grain on extensive acres than poor farmers could produce intensively on a few acres. Borlaug bristled at these charges, but he met them directly and forcefully. "The wheat plant is pretty apolitical," he said. "It doesn't care whether it is growing on a big farm or a small farm."

Borlaug consistently argued that technology had to be used wisely and that governments were responsible for protecting the health and welfare of their people. But, he contended, "The haves are telling the have-nots that they should stay with their impoverished rural lifestyles, since greater material well-being leads to environmental destruction." Yet people in well-fed nations lived longer and healthier lives than others in food-deficit nations, and he argued that his environmental critics were unwilling to trade places with people in developing countries where the life span was at least a third less than in the United States and where half of the children died before the age of ten. Put simply, Borlaug con-

tended, "It is far better for mankind to be struggling with new problems caused by abundance rather than with the old problems of famine." He had intended his work to fight hunger, he said, rather than to solve socioeconomic problems that had existed from time immemorial. "The Green Revolution," he argued, "is a change in the right direction, but it has not transformed the world into a Utopia."

Writing in 2000, Borlaug continued to defend his position that more food was better than less food even if heavy applications of chemical fertilizers and genetic engineering were required to ensure bountiful harvests. He also contended that it had taken 10,000 years to produce about 5 billion tons of food per year, and that production would need to be doubled by 2025 because of the population explosion. Borlaug, perhaps more than anyone, recognized that the Green Revolution was only a "temporary success in man's war against hunger," because of "mushrooming world population, changing demographics, and inadequate poverty-prevention programs." His commitment never wavered. "The affluent nations can afford to adopt elitist positions and pay more for food produced by the so-called natural methods," he wrote; "the one billion chronically poor and hungry people of this world cannot. The new technology will be their salvation." Advances in biotechnology would soon benefit agriculture, particularly in transgenic or recombinant DNA research that would produce herbicide-resistant corn, cotton, wheat, and other crops. He worried, however, that privately conducted and controlled genetic research and the consolidation of agricultural bioengineering companies would prevent distribution of improved techniques to food-deficit nations on reasonable terms, if at all.

By the late 20th century, Borlaug also became a strong advocate of genetically modified foods. "Genetic modification of crops is not some kind of witchcraft," he contended, but the "progressive harnessing of the forces of nature to the benefit of feeding the human race." For him, genetic engineering complemented rather than replaced traditional plant breeding. Without scientific evidence that genetically modified foods harmed human health or the environment, he saw no reason for consumers to reject them. "Biotechnology," he wrote, "can improve crop productivity with reliable transgenic procedures; it can engineer plants with highly specific disease resistance; and it can help fulfill nutritional goals by adding vitamins, protein and vaccines." Most important, developing nations could use this new biotechnology to ensure their food supply. He gave no quarter to those critics who feared biotechnological changes of food plants. He believed that popu-

lation explosion, not agricultural science, was the greatest threat to the environment.

For Borlaug, the choice was not between feast guaranteed by chemical technology and famine ordained by the environment. Rather, agricultural science could create the opportunities for farmers to produce a sustainable agriculture, which had to be "farm friendly—economically advantageous, drudgery-mitigating, and simple enough that poor farmers are able to adopt the new techniques." The more important matters of concern by civil societies should be equity issues related to genetic ownership and control as well as access to transgenic agricultural products.

**B**orlaug achieved much of his success because he was a risk taker. "Plant breeding is like poker," he said. "If you've got a bad hand, throw it in. If you've got a good one, don't be afraid to bet." In 1970 he criticized scientists in the agricultural colleges for being afraid to risk their reputations by trying something new, something that might fail. Food-deficit nations needed "big breakthroughs." "Farmers in under-developed countries," he wrote, "won't pay attention to a 15% gain in yield. You've got to give them 100%. Maybe 200%." More than 20 years later, he reflected an impatience that had become legendary when he chided a group of African agricultural leaders for being "ultraconservative," and urged them to keep their minds open to new ideas. Borlaug also succeeded because he was not only a skilled plant breeder and a hard worker, but he was also lucky. In India and Pakistan, for example, the British had built the railroad system into the countryside to facilitate the shipment of cotton and other agricultural products. As a result, wheat and rice farmers had the means to ship seed, fertilizer, and harvested crops.

Above all, Borlaug succeeded because he advocated change in an achievable, practical way. As a scientist, he was a pragmatist. That is, he believed in "applied" research, and he criticized academic scientists for being too concerned with publishing scholarly papers based on "pure" or "basic" research with little or no immediate practical significance. Put differently, they concerned themselves with publishing papers "for the self-advancement of the senior author, rather than for producing more food." In addition, one of his greatest disappointments was the propensity of foreign agricultural scientists who trained at U.S. universities to return home and devote their careers to pure rather than applied research.

Always believing that agricultural science and common sense could improve the human condition, even under the most trying circumstances, Borlaug consid-

ered "team spirit" the most important tool in his fight against world hunger. "The defeatist spirit is the greatest enemy of progress, and it persists and is too widespread among scientists," he wrote. "If constructive change is to be provided there is no place for defeatism in the ranks of leadership or among the scientists charged with the responsibility."

Borlaug had good reasons to be both obstinate and optimistic: he had played a major role in helping farmers increase food production faster than the rate of population growth. The one major exception was sub-Saharan Africa. Thus, at the dawn of the 21st century, Borlaug led the Sasakawa-Global 2000 agricultural program, in conjunction with the Carter Center and the Sasakawa Africa Association, to improve the crop yields of more than 60,000 subsistence farmers in sub-Saharan African nations. He refused to concede defeat in the struggle to rescue this region from human suffering. He believed that sub-Saharan Africa could meet its food requirements if it had "reasonable social and political stability and economic policies to stimulate food production as well as expanded educational and health programs." But farmers and agricultural scientists, Borlaug warned, could not increase food production without peace, which would enable African governments to divert spending from armaments to agricultural science.

In retrospect, the Green Revolution in India and Pakistan gave Borlaug the greatest satisfaction of his scientific career. His achievements merit commendation, but his failure to end world hunger should surprise no one. Nor should anyone be amazed that he has had critics. People of vision, ability, and accomplishment usually confront others who disagree with their goals, methods, and achievements. Clearly, Borlaug made a difference in human history. That is rare, and that alone is a considerable accomplishment for an Iowa farm boy who went to the University of Minnesota to wrestle. ❖

*R. Douglas Hurt is head of the Department of History at Purdue University. He is the author of American Agriculture: A Brief History, rev. ed. (West Lafayette: Purdue University Press, 2002), and Problems of Plenty: The American Farmer in the Twentieth Century (Chicago: Ivan Dee Pub., 2002).*

#### NOTE ON SOURCES

Among the most valuable sources on Norman Borlaug are Norman Borlaug, "Living History Interview," *Transnational Law & Contemporary Problems* 1 (Fall 1991): 539-54; Leonard Bickel, *Facing Starvation: Norman Borlaug and the Fight Against Hunger* (New York: Reader's Digest Press, 1974); and Don Paarlberg, "Norman Borlaug—Hunger Fighter," USDA Foreign Economic Development Service PA 969 [no date].

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