

Two Blades of Grass: The Role of Science in the Green Revolution

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Whoever could make two ears of corn or two blades of grass grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more service to his country, than the whole race of politicians put together.

- Jonathan Swift, in *Gulliver's Travels*

In 1798 the English clergyman-philosopher Thomas Malthus published "An Essay on the Principle of Population," in which he argued that while the population of the world would increase geometrically, the food available would increase only arithmetically. Malthus postulated that human population growth, therefore, would eventually outstrip the agricultural capacity of the Earth. At some point, he predicted, natural forces like famine and disease would reduce the human population to a sustainable level. His hypothesis has yet to be proven on any large scale with humans, but biologists have seen the Malthusian principle turn out to be correct with other animals, and there is no reason to believe that his hypothesis does not apply to humans.

Back in 1968, Stanford University ecologist Paul R. Ehrlich scared us to death when he published *The Population Bomb*, in which he maintained that the Malthusian principle was about to overtake us. His book began with this statement: "The battle to feed all of humanity is over. In the 1970s and 1980s hundreds of millions of people will starve to death in spite of any crash programs embarked upon now. At this late date nothing can prevent a substantial increase in the world death rate . . ." Professor Ehrlich was either unaware of, or chose to ignore, the fact that modern science was already being applied to the world food situation in a way that the world had never before seen.

THE ROCKEFELLER AND FORD FOUNDATIONS

Much of the world had been devastated by World War II. But the United States, protected by two great oceans, had largely escaped devastation in its own land. In fact, the U. S. came out of the war with a level of prosperity that had never before been seen on this planet. Our economy boomed, and we were

able to provide financial assistance and technical skills to restore the economies and infrastructures of our former enemies and our devastated allies alike.

Two very wealthy families, in particular, had become spectacularly rich as a direct consequence of the war. The Rockefeller family owned Standard Oil, and they had provided much of the petroleum that had given the Allies so much of an advantage over our adversaries. The Ford family, owning the Ford Motor Company, had built most of the powered land vehicles used by the Allies during the war.

Dean Rusk was president of the Rockefeller Foundation from 1952 to 1961, when President Kennedy recruited him to be Secretary of State. While Rusk was not trained in scientific agriculture, several of his highest officers were both trained and experienced agriculture scientists. In fact, Rockefeller had sponsored a wheat and maize improvement program in Mexico since 1943, with outreach to other Latin American countries and India. The early success of that wheat program convinced the Rockefeller leadership that applying modern scientific knowledge to widely grown crops could indeed have a positive effect on world food supplies and, most important, in the poorest countries. And so the germ of an idea to establish a research institute devoted to crop research was born. But which crop?

While wheat and rice both contend for recognition as the world's most important crops, wheat is generally consumed in products like bread, whereas for hundreds of millions of people in Asia, in particular, boiled rice makes up as much as 80% of the total diet. After touring Southeast Asia in 1952 and 1953, Rockefeller's top agriculture scientists concluded that rice was the crop. Rice production throughout Asia had been stagnant for many years, and the only way to increase production seemed to be the addition of more land under cultivation, and the cultivable land area was running out.

As they began to think seriously about starting a rice research institute, the Rockefeller officials began to realize that they did not have enough financial resources to build what was needed. They talked with the leaders of a number of countries that could benefit from rice research, and they all said they would contribute funds, but only if the research center were built in their country.

Enter the Ford Foundation, which had worked in many poor countries on various problems, but not agriculture. Meetings were held between Rockefeller and Ford executives. The Rockefeller executives made it plain that they believed rice to be the crop to begin with, even though they already had programs on maize and wheat. After one of these meetings one of the Ford executives stated, "We have some money. You have experience in conducting agricultural research in the developing countries. We both are interested in doing what we can to help solve the world's food problem. Why don't we get together and see what we can do?" That meeting led to the founding of the International Rice Research Institute (IRRI), in the Philippines, in 1960.

IRRI IS ESTABLISHED

In what has to be one of the most sagacious decisions in food history, they selected a middle-aged Rockefeller officer, Dr. Robert F. Chandler, Jr., who had been an agriculture professor at Cornell University, to be the first director general of IRRI. He brilliantly supervised the design and building of the IRRI physical plant, on the edge of the campus of the University of the Philippines, and he showed great wisdom in his selection of an international team of scientists, representing every area of science that could be needed in agricultural research. The foundations worked out an agreement with the government of the Philippines, and Bob Chandler opened an office in the Manila Hotel. IRRI was off and running almost at once. Chandler's very capable wife Sunny functioned as his administrative assistant until regular staff could be recruited.

Sunny Chandler is worth a mention in her own right. In addition to being Bob's first deputy, she played a major role in designing the IRRI residential compound and the buildings within the compound. Once the compound had been built and was occupied by the scientists and their families, Sunny, even though she was not all that old at the time, became a kind of mother figure for the spouses and their children. She did much to bring a warm atmosphere into a residential compound made up of families who were far from home. The family culture she brought to IRRI still binds the scientists together in both work and play.

The actual building of the facilities and the selection of professional staff is fascinating in itself, but it is beyond the scope of this paper. But it is noteworthy that Chandler understood that if he were to convince some of the world's best scientists to leave their homes and jobs for a period of years, IRRI would need to build good living quarters for them and their families. IRRI's beautiful residence compound is on the other side of the university campus from the research plant, at the foot of a dormant volcano, Mt. Makiling.

Nearly everything Chandler did was brilliant. He selected three plant breeders: T. T. Chang, a Cornell-educated experienced rice breeder from Taiwan; Henry "Hank" Beachell, an old pro in commercial rice breeding, from Texas; and Peter Jennings, an energetic young Ph. D. from Purdue University. Together, they developed in their minds the model of the ideal modern rice, and they knew where to get the genes needed to breed it.

The original widespread modern rice they bred was dubbed "IR-8," and it soon became known as "the miracle rice." The low number "8" indicates how early on they produced it. It was one of their earliest, a simple Mendelian cross between a dwarf Taiwanese variety called Dee-gee-o-woo-gen and an Indonesian variety, Peta. What characteristics did the breeder team seek to have in their miracle rice?

- short, stiff straw – to give the plant the strength to support large heads of grain without falling over;

- high tillering – a single rice plant stalk is called a “tiller;” each tiller has a grain head on the end, so the more the better;
- erect leaves – large numbers of erect leaves capture more of the sun energy that falls upon the plant;
- short growth period – so the farmer could plant more than one crop per year;
- daylight insensitivity – many rice varieties require a specific sequence of seasonal daylight changes, or they will not mature; that characteristic would keep some rices from being planted more than once a year;
- optimum responsiveness to fertilizer and modern cultural practices; all rice varieties respond to ideal culture, but some respond more than others;
- good taste and texture.



Figure 1: Modern rice culture in a nutshell. Two rice plants grown under the same ideal conditions. The traditional variety, on the left, has grown tall and spindly, and has few grain heads. It would have fallen into the water and the grain heads would have been lost. The modern variety, on the right, remains upright, has many leaves and tillers, and has developed large grain heads on the tillers.

IR-8 had virtually all of these characteristics (see Figure 1), but some ethnic groups preferred the taste of their traditional varieties. Later varieties also had disease resistance, pest tolerance, and lower fertilizer needs, and specific taste preferences were incorporated. Today, many new varieties continue to be developed, and nearly every rice variety grown in Asia, and many in other continents, has IR-8 genetic material in its background.

MORE CENTERS ARE ESTABLISHED

The early success of IRRI inspired the foundations to expand their maize and wheat programs into the second international agricultural research center, CIMMYT, in 1963. By this time the founders had been able to enlist the support of a number of governments, including the U. S. I believe the U.S. continues to provide about 20% of the total budget for the centers that are affiliated with the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is administered by the World Bank. Today about fifteen centers devoted to many crops and specific geographic areas are scattered around the world. (See the appendix.)

Virtually all of the international centers were established and built upon the model developed at IRRI by Robert Chandler. So how successful has all of this effort been? It is difficult to quantify, but in 1979, when we were at IRRI, we saw the very first shipload of surplus Philippine rice ever exported to another country. IRRI scientists have observed that a small farmer can increase his or her annual yield of rice by four times, using modern rice varieties and modern cultural practices. That is enough to make a huge difference in the lives of peasant families who may be farming only a few acres of land. Several other former food-deficit countries have become regular rice-exporting contenders.

Dr. Norman Borlaug received the 1970 Nobel Peace Prize for his pioneering work with wheat. Many CGIAR scientists have been awarded the World Food Prize, which is the agriculture equivalent of the Nobel Prize. Dr. Chandler was the recipient of the prize in 1988.

Today it would be difficult to find a non-IRRI-derivative rice variety growing in Southeast Asia, and high-yielding varieties of African rice (not the same species as Asian rice) have been developed, to the benefit of many African countries. The one country that probably has benefited the most from the work of the centers has been India, which grows several of the crops, in addition to rice and wheat that have been improved by the centers. When I was a child, my mother used to say to me, "Finish your dinner. Think of the poor starving children in India." She would almost certainly select some other country today! Partly because of the Green Revolution research, India now also has an excellent network of agriculture universities, with plant-improvement programs of their own.

The most modern scientific developments are being used in crop improvement at the centers. Genetic modification techniques hold great promise for improved nutritional quality of rice. In rice, the first GM variety, called "golden rice," will soon be released for cultivation. Golden rice contains beta-carotene, which the human body converts to vitamin A. Swiss and German scientists, working with IRRI, successfully inserted sections of DNA from a daffodil and a bacterium. Millions of poor people around the world who subsist largely on rice have been likely to suffer vision loss because rice grain has lacked vitamin A or its precursors. Golden rice will largely eliminate this deficiency in rice.

When Dean Rusk ended his tenure as Secretary of State under Presidents Kennedy and Johnson, he moved back to his native Georgia, and he became a professor of international law and director of the Rusk Center at the University of Georgia. For five years I was head of the Department of Agricultural Journalism at the university. I worked closely with Rusk on a number of projects. He once told me that, of all of his accomplishments in life, he was most proud of his part in establishing IRRI, and thus being a sort of father of the Green Revolution of the 1960s and '70s.

The gloomy forecasts of Malthus and Ehrlich may someday come true, but at this time the world has the largest population and the smallest ratio of malnourished people in its modern history, although malnutrition is still a serious health problem. Modern science, applied to agriculture, has accomplished more than anyone could have dreamed.

NOTES

Robert F. Chandler, Jr., *An Adventure in Applied Science: a History of the International Rice Research Institute* (Los Baños, Philippines: International Rice Research Institute, 1982).

APPENDIX

CGIAR DONORS IN 2011

Donor Countries

- Europe: European Commission, Switzerland, Sweden, United Kingdom
- North America: Canada, USA
- Asia: Japan
- Pacific: Australia
- North Africa: Egypt
- Latin America: Brazil
- Regional Forum: Association of Agricultural Research Institutions in the Near East and North Africa

Foundations and Global Organizations

- Bill and Melinda Gates Foundation International Development Research Centre Global Forum on Agricultural Research
- The World Bank
- The Food and Agriculture Organization of the United Nations

INTERNATIONAL AGRICULTURAL RESEARCH CENTERS AFFILIATED WITH THE
CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH (CGIAR)

- Africa Rice Center – Benin
- Bioversity International – Rome, Italy
- CIAT – Centro Internacional de Agricultura Tropical – Cali, Colombia
- CIFOR – Center for International Forestry Research – Indonesia
- CIMMYT – Centro Internacional de Mejoramiento de Maiz y Trigo (corn and wheat) – Mexico
- CIP – Centro Internacional de la Papa (potato) – Peru
- ICARDA – International Center for Agricultural Research in the Dry Areas – Syria
- ICRISAT – International Crops Research Institute for the Semi-arid Tropics
– India
- IFPRI – International Food Policy Research Institute – Washington, D. C.
- IITA – International Institute of Tropical Agriculture – Nigeria
- ILRI – International Livestock Research Institute – Nigeria
- IRRI – International Rice Research Institute – Philippines
- IWMI – International Water Management Institute – Sri Lanka
- World Agroforestry Center – Kenya
- World Fish Center – Malaysia

OTHER CENTERS

- ISNAR – International Service for National Agricultural Research – Netherlands
- INIBAP – International Network for the Improvement of Bananas and Plantains – France
- AVRDC – Asian Vegetable Research and Development Centre – Taiwan
- ICIPE – International Centre for Insect Physiology & Ecology – Kenya

These four centers should also be recognized. ISNAR and INIBAP have been absorbed into other centers. AVRDC cannot officially be part of the CGIAR because of the objection of the People's Republic of China. ICIPE has never been part of the CGIAR. All are worthy of inclusion, however, because they have played or do play an important part in the system of centers, and they are funded by the same agencies.