


HIDDEN HARVEST: U.S. BENEFITS FROM INTERNATIONAL RESEARCH AID

PHILIP G. PARDEY • JULIAN M. ALSTON • JASON E. CHRISTIAN • SHENGGEN FAN

FOOD POLICY REPORT
THE INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute was established in 1975 to identify and analyze alternative national and international strategies and policies for meeting food needs of the developing world on a sustainable basis, with particular emphasis on low-income countries and on the poorer groups in those countries. While the research effort is geared to the precise objective of contributing to the reduction of hunger and malnutrition, the factors involved are many and wide-ranging, requiring analysis of underlying processes and extending beyond a narrowly defined food sector. The Institute's research program reflects worldwide collaboration with governments and private and public institutions interested in increasing food production and improving the equity of its distribution. Research results are disseminated to policymakers, opinion formers, administrators, policy analysts, researchers, and others concerned with national and international food and agricultural policy.

IFPRI is a member of the Consultative Group on International Agricultural Research and receives support from the Andina Foundation, the Asian Development Bank, Australia, Belgium, Canada, China, Denmark, Food and Agriculture Organization of the United Nations, Ford Foundation, France, German Agency for Technical Cooperation (GTZ), German Federal Ministry for Economic Cooperation (BMZ), India, Inter-American Development Bank, International Development Research Centre (Canada), International Fund for Agricultural Development, Italy, Japan, Netherlands, Norway, Overseas Development Administration, the Philippines, Rockefeller Foundation, Rural Industries Research and Development Corporation (Australia), Spain, Sweden, Switzerland, United Kingdom, United Nations Children's Fund, United Nations Development Programme, United States, and the World Bank.

HIDDEN HARVEST: U.S. BENEFITS FROM INTERNATIONAL RESEARCH AID

Philip G. Pardey, Julian M. Alston,
Jason E. Christian, and Shenggen Fan

FOOD POLICY REPORT

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
WASHINGTON, D.C.
SEPTEMBER 1996

Contents

PREFACE

International crop improvement research has made a dramatic difference in the amount and quality of food available to the world's people. Wheat, rice, potatoes, beans, cassava, corn, and other vital staples have been greatly enhanced through the efforts of scientists in many disciplines. Their research has developed higher-quality plants that grow more food on the same amount of land and are capable of withstanding disease, drought, insects, and other threats. Much of this research has been conducted overseas, funded in part by U.S. taxpayer investments through the U.S. Agency for International Development contributions to the Consultative Group on International Agricultural Research (CGIAR), a network of 16 international research centers. Though the primary purpose of the CGIAR is to alleviate poverty and hunger in developing countries by enhancing yields of crops and animals that the people of those countries rely on for survival, new plant varieties developed by CGIAR research centers have also found their way onto American farms from California to the Great Plains and the Mississippi Delta region, delivering benefits to U.S. farmers and consumers.

This report spells out the benefits to the United States from its partnership with the CGIAR. Using wheat and rice to illustrate the gains from international research on important food crops, the report shows that U.S. investments in CGIAR wheat and rice research have paid off many times over for U.S. farmers. From an overall investment of $134 million in wheat and rice improvement research at the CGIAR's International Maize and Wheat Improvement Center (CIMMYT) in Mexico and International Rice Research Institute (IRRI) in the Philippines, the U.S. economy has realized a return of up to $14.7 billion.

Now, U.S. investments in international agricultural research are declining sharply. U.S. contributions to the CGIAR for 1996 are projected to be less than half what they were in 1990. This trend mirrors a general scaling back of the U.S. commitment to international assistance. Further cutbacks in U.S. contributions to international agricultural research threaten the investments already made—and the many gains yet to be realized—through more than three decades of research.

U.S. involvement in the CGIAR is not only financial, of course. U.S. scientists and policymakers participate in decisions about the direction of research and development within the CGIAR. U.S.-based scientists are deeply involved in the scientific work of the international centers. Perhaps most significant, scientific knowledge and the products of research flow freely between the United States and its partners through the CGIAR system. Although this report focuses on narrow economic benefits and costs, it is useful to keep these more subtle interactions, which also lead to important benefits for U.S. consumers and agricultural producers, in mind.

This report summarizes the findings of a study by economists from the International Food Policy Research Institute (IFPRI) and the University of California at Davis that describes and quantifies the benefits of U.S. investments in the CGIAR. These findings are presented in more detail and with greater technical information in the complete study, to be published by IFPRI, entitled *A Productive Partnership: The Benefits from U.S. Participation in the CGIAR*.

The authors are grateful for the support received from colleagues at CIMMYT, IRRI, and the Secretariat of the CGIAR, as well as staff at the Current Research Information System of the U.S. Department of Agriculture in Beltsville, Maryland, and scientists from various state agricultural experiment stations throughout the United States. Nienke Beintema and Behjat Hojjati provided valuable research assistance, and Douglas Hattaway and Heidi Fritschel helped prepare this summary report.

U.S. Participation in International Agricultural Research

For more than two decades, the United States has been an important player in a global partnership for agricultural research through its investments in the work of the Consultative Group on International Agricultural Research (CGIAR), a network of 16 agricultural research centers around the world (see Box 1). The primary goal of the CGIAR is to alleviate hunger in developing countries, and it has had some major successes in pursuit of this goal. Research by the CGIAR and its predecessor agencies that aimed at improving rice and wheat, two of the world's most important food crops, gave rise to the agricultural Green Revolution, which saved millions of people from the threat of starvation beginning in the 1960s. Research on wheat, rice, and many other crops conducted at CGIAR centers around the world continues to improve the lives of people in developing countries today.

But the new higher-yielding plants that feed millions in the developing world also yield more for U.S. farmers. Have the U.S. contributions to CGIAR research been good investments for the United States? This report suggests they have. It compares the investment made by the U.S. Agency for International Development in CGIAR research with the contributions that investment has made to U.S. farm production and shows that past taxpayer contributions to the CGIAR have been repaid many times over.

Although the United States is an important contributor to the CGIAR, the shares of the CGIAR's budget borne by its various members demonstrate a true partnership in funding (Table 1 shows funding levels in 1993 dollars). In 1995, the United States invested $40.5 million, or 0.56 percent of its foreign aid. This amounted to 12.4 percent of the CGIAR's 1995 budget of $335.6 million. In the same year, European countries as a group provided $113.1 million, or 34.9 percent of the CGIAR budget, while the World Bank contributed $50 million (15.2 percent) and Japan provided $37.3 million (11.4 percent).

Box 1
The CGIAR

The Consultative Group on International Agricultural Research (CGIAR) is a global network of 16 agricultural research centers working to eradicate human hunger and poverty by increasing food production in developing countries. The CGIAR grew out of a joint program to improve wheat yields established by the Rockefeller Foundation and Mexico in the 1940s and a related effort to increase Asian rice yields, which began in the Philippines in 1960. The wheat program ultimately evolved into the International Maize and Wheat Improvement Center (CIMMYT) while the rice research was performed by the International Rice Research Institute (IRRI). In 1971, four international agricultural research centers, including CIMMYT and IRRI, came together as centers of the CGIAR. These centers developed the plant varieties and technologies that led to the Green Revolution—the dramatic increases in food crop yields in the developing world in the 1960s and 1970s. Other research centers focusing on other regions and commodities have joined the CGIAR since 1971. With broad international support, the CGIAR system has expanded to conduct research on a wide range of topics, including crops, livestock, agroforestry, irrigation, aquatic resources, and food policy.

Table 1—Funding for the CGIAR, 1972–95

Source	1972–75	1981–85	1991–94	1995
	(millions of 1993 U.S. dollars per year)			
United States	18.3	69.0	57.4	39.1
Japan	0.9	13.3	31.9	36.0
Europe	19.2	53.7	98.6	109.0
Other	9.6	20.5	27.7	21.6
Total from developed countries	48.0	156.5	215.6	205.7
World Bank	6.7	28.9	41.2	48.2
Foundations	22.8	4.3	6.2	6.4
Others	10.1	54.5	50.6	56.1
Total	87.6	244.2	313.5	316.5

Source: Authors' calculations based on financial reports of the CGIAR Secretariat.

Crop Improvement Research Means More, Better Food

Most wheat and rice varieties grown in the United States have been developed through crop improvement research. In this field of study, scientists select plants with traits desired by farmers and employ methods ranging from traditional cross-breeding to advanced bioengineering to develop new varieties with various combinations of the desired characteristics. These improved food crops can have many benefits:

- Higher yields, enabling farmers to grow more food on the same amount of land
- Higher productivity, which allows farmers to produce the same amount of grain at a lower cost using less natural resources and other inputs
- Pest and disease resistance, which saves crops from costly damage and can reduce reliance on environmentally harmful chemicals
- Tolerance of cold, drought, and other adverse conditions, which allow crops to grow in a wider variety of environments
- Shorter growing seasons that enable farmers to choose the best planting dates in response to the vagaries of the weather
- Higher-quality plants, determined by characteristics such as protein content, grain size and shape, and other factors

The development of high-yielding crops with resistance to insects and diseases has proved effective in alleviating food shortages worldwide (see Box 2). Two breakthroughs in crop improvement science have particularly benefited U.S. growers of wheat and rice:

- Semidwarfing. Semidwarfing makes plants shorter and stronger, allowing more of the plant's energy to be directed to the production of the grain rather than stalk and leaves. This means more grain per acre of farmland and higher yields for farmers. Almost all spring wheat grown in California now consists of semidwarf varieties, and in 1993, 58 percent of the total U.S. wheat acreage was sown to semidwarfs. The corresponding share for rice is 75 percent.
- Rust resistance. Rust fungi that attack the leaves and stems of wheat plants

Box 2
New Rice Varieties Keep Ahead of Pests and Disease

The development of new varieties of rice—one of the world's oldest and most widely consumed food crops—is among the great success stories of modern crop improvement research. The history of rice improvement research at the International Rice Research Institute (IRRI) in the Philippines illustrates the need to continually improve plants in order to keep ahead of crop-killing diseases and pests. A new chapter in the story of rice began in the mid-1960s, when millions of people in developing countries of South Asia were faced with the prospect of starvation.

In 1966, IRRI scientists introduced a new variety of rice they called *IR-8,* which the news media soon dubbed "miracle rice." This new strain of rice could produce more than 9,000 pounds per acre. It quickly became a flagship of the Green Revolution and was credited with helping to save millions of people from the threat of starvation. Within two years of introduction, *IR-8* had also increased the value of Asian rice crops by nearly a billion dollars.

IRRI scientists developed the miracle rice by crossing an Indonesian variety known as *Peta* with a Chinese variety called *Dee-geo-woo-gen.* They chose *Peta* for its resistance to certain diseases, its ability to produce many stems on a single plant, and the hardiness of its seeds and seedlings. *Dee-geo-woo-gen* was a short-statured plant, which meant it was physically strong and able to devote more energy to producing grain, rather than inedible straw. IRRI scientists perfected this cross with extraordinary speed: in just four years they came up with *IR-8,* which gave hope for food security to the millions of Asians who depend on rice for food.

Despite its hardiness, *IR-8* was threatened in 1969 by an epidemic of the rice disease known as tungro. Crops in the Philippines, where the tungro epidemic broke out, were threatened with devastation. Fortunately, scientists had been working on a new variety with an in-bred resistance to tungro—*IR-20.* This new plant was introduced to farmers' fields, and disaster was averted.

New threats arose in 1973. The grassy stunt virus cropped up in the Philippines, joined by a plague of brown planthoppers, a rice-devouring grasshopper. IRRI was ready with another new strain, *IR-26,* that was immune to grassy stunt virus and repelled the brown planthoppers.

Three years later, the brown planthoppers were back, in a new biotype that rendered the defenses of *IR-26* less effective. To defend Asian rice crops, IRRI drew on plants from the United States, Vietnam, Taiwan, India, and Indonesia to develop a strong new variety that was resistant to many disease and pests, tolerant to drought, and not particular about the quality of the soil in which it grew. Using the new variety, *IR-36,* farmers increased rice yields and saved millions of dollars by avoiding the purchase of potentially hazardous and expensive pesticides.

In 1980, yet another type of brown planthopper appeared, and IRRI fought back with *IR-56.* The cycle continues. New threats arise, and new varieties of rice are released to combat them. Each new variety requires years of work, extraordinary cooperation among scientists, and the support of policymakers and taxpayers. Without continued investment in crop improvement research, the success stories of rice could come to a bitter end.[1]

[1]International Food Policy Research Institute (IFPRI) and Rockefeller Foundation, *1992 Facts and Figures. International Agricultural Research* (Washington, D C : IFPRI, and New York: Rockefeller Foundation, 1992), p. 6.

have always threatened wheat yields. The disease mutates rapidly, and quickly becomes immune to chemicals that farmers may use to kill it. New varieties of wheat are constantly being developed that have a natural resistance to new strains of rust fungi.

CIMMYT and IRRI, in partnership with scientists from the United States and elsewhere, have been at the forefront of many breakthroughs in these critical areas. Scientists at CIMMYT, for example, achieved major advances in breeding technologies and carried out important work to identify and incorporate disease-resistance traits into food crops (see Box 3). IRRI researchers pioneered the use of parent varieties and new breeding strategies that gave rise to broadly adopted and extensively used semidwarf rice varieties.

Box 3
Wheat Researchers Achieve Breakthroughs in Breeding

In the 1940s, a team of scientists began work to improve wheat yields in Mexico as part of a joint program created by the Rockefeller Foundation and the government of Mexico. Under scientist Norman Borlaug, breeders sought to develop a high-yielding plant resistant to rust fungi. Work was slow, because breeding progress was limited to one cross per growing season. To speed things up, breeders developed an innovation known as shuttle breeding. They grew two breeding cycles per year instead of just one by shuttling successive generations of plants between an irrigated, sea-level region in Sonora and a cool, rainfed highland plateau in Toluca. Plants sown in the fall in Sonora and harvested in the spring were transferred to Toluca for immediate planting. This innovation not only cut in half the time required to develop improved varieties but also produced disease-resistant varieties that could be grown in a wide range of environments.

By the early 1950s, however, grain yields of the wheat varieties developed by Borlaug's team had reached their limit. As higher levels of fertilizer were added, the plants fell over, unable to support the heavier heads of wheat. Around this time, Borlaug heard about the semidwarf wheat plants grown by Orville A. Vogel, a U.S. Department of Agriculture wheat breeder in Washington State. Vogel had crossed a short-stemmed Japanese variety called *Norin 10* with American varieties to produce short, sturdy plants that could give high yields with heavy doses of fertiziler and irrigation. After some initial difficulties, Borlaug successfully crossed the American semidwarf varieties with the rust-resistant Mexican varieties, producing disease-resistant, high-yielding strains of wheat that could grow in many different conditions. These strains required more fertilizer, water, and pesticides than traditional varieties, but they yielded two to three times more wheat.

The varieties developed in Mexico were particularly well suited to conditions in many developing countries, and in the 1960s and 1970s, they spread rapidly through the developing world. They were instrumental in the Green Revolution, which averted the catastrophic famine that had been predicted for Asia. The wheat varieties developed in Mexico, at what eventually became the International Maize and Wheat Improvement Center (CIMMYT), and their offspring, are now grown by millions of farmers worldwide, including in the United States.

Wheat and Rice Research Affect Many States

Wheat and rice are not indigenous to the United States, but these food crops are important to the agricultural economies of large regions of the country and are thus useful to illustrate the benefits and costs of CGIAR research. Wheat is among the top 10 agricultural commodities by value in 26 U.S. states, from California across the northern plains and the Midwest to northeastern states like Pennsylvania and New York. In 1993, the United States produced 65 million metric tons of wheat—about 12 percent of the world's total output—with a gross value of $7.7 billion.

In California and the northern plains states of Montana, Minnesota, and the Dakotas, spring wheats are common, including the high-protein hard red wheats used for bread making and the durum wheats used for pasta. In the central plains of Nebraska, Colorado, Iowa, and Kansas, as well as the southern plains states of Oklahoma and Texas, winter wheats dominate, primarily hard red and white wheat. The Northwest states of Idaho, Oregon, and Washington grow soft winter wheats useful for biscuits and noodles.

Rice is an important crop in California

Table 2—New Varieties of Wheat and Rice Released in the United States, Pre-1900–1990

Period	Wheat	Rice
	(number of varieties)	
Pre-1900	35	4
1901–40	106	38
1941–50	62	8
1951–60	76	6
1961–70	113	12
1971–80	210	29
1981–90	222	39
Total	824	136
Average number of varieties released per year		
1901–90	8.8	1.5
1901–70	5.1	0.9
1971–90	21.6	3.4

Source: Authors' calculations based on data obtained online from GrainGenes databank and various issues of *Crop Science* and *The Rice Journal.*

and the Mississippi Delta regions of Arkansas, Louisiana, Mississippi, Missouri, and Texas. The United States is a major exporter of rice, accounting for nearly 18 percent of internationally traded rice. In 1993 rice production generated $1.3 billion for the U.S. economy. The *indica* varieties, which are native to the humid tropics of South and Southeast Asia, are well suited to the Delta region of the United States. *Japonica* varieties, first grown in China and later Japan, are tolerant of cool temperatures and thrive in subtropical climates such as swampy areas of the Sacramento Valley in northern California. Through modern breeding methods, the short-grained varieties that once dominated California production have been replaced by more desirable longer-grained rice.

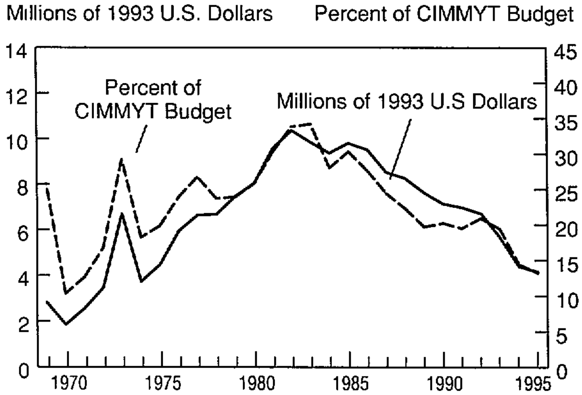
Farmers in these wheat- and rice-growing areas have ever greater numbers of varieties available to them, for wheat and rice breeding have accelerated rapidly over the past two decades. From the turn of the century to 1970, an average of 5.1 varieties of wheat were released into U.S. fields each year (Table 2). Since 1970, the rate has increased to 21.6 new varieties per year. In total, 824 new wheat varieties and 136 new rice varieties were developed and released to farmers from about 1900 to 1990.

Many of the new varieties draw directly on CGIAR research. Wheat research for the CGIAR is conducted primarily at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico. Research to improve rice is carried out at the International Rice Research Institute (IRRI) in the Philippines. Since 1960, U.S. government support of wheat improvement research through its contribution to CIMMYT and its predecessor institution has amounted to less than $71 million. The U.S. investment in rice improvement research through support of IRRI has cost about $63 million (Figures 1 and 2).

By the early 1990s, about one-fifth of the total U.S. wheat acreage was sown to varieties with CIMMYT ancestry. In 1993, virtually all of the California spring wheat crop was grown with varieties from CIMMYT or with CIMMYT-based ancestors (Figure 3). In the same year, nearly 9 percent of the acreage of the northern plains states of Minnesota, North Dakota, South Dakota, and Montana was sown to varieties with CIMMYT ancestry. CGIAR varieties of winter wheat have also had a sizable influence on the crops grown in the central and southern plains states of Nebraska, Iowa, Kansas, Colorado, Oklahoma, and Texas.

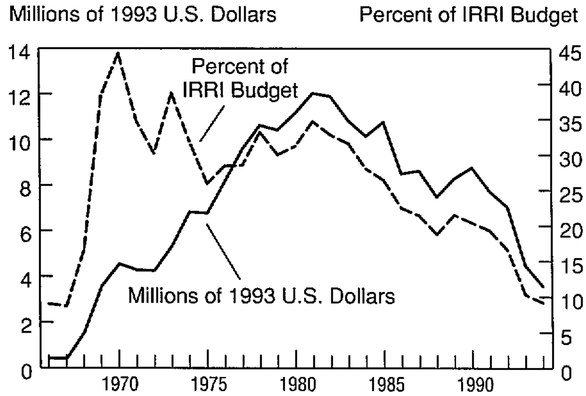
Around 73 percent of the total U.S. rice

Figure 1—U.S. Government Funding for CIMMYT, 1969–95



Source: Authors' calculations based on unpublished financial data provided by CIMMYT.

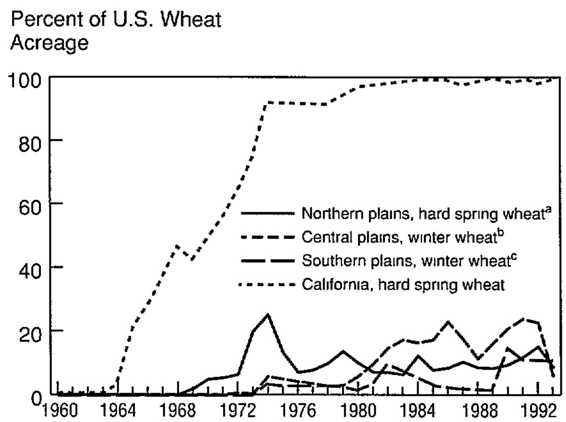
Figure 2—U.S. Government Funding for IRRI, 1966–94



Source: Authors' calculations based on unpublished financial data provided by IRRI.

acreage in 1993 was sown to varieties with IRRI ancestry (Figure 4). Many of these new varieties have developed as IRRI germplasm has gradually found its way into locally bred varieties. IRRI rice varieties have been used primarily as parent stock in the development of medium- and long-grain, semidwarf rice varieties in California and the Mississippi Delta states of Arkansas, Louisiana, Mississippi, Missouri, and Texas.

Figure 3—U.S. Wheat Acreage Sown to Varieties with CIMMYT Ancestors, 1960–93



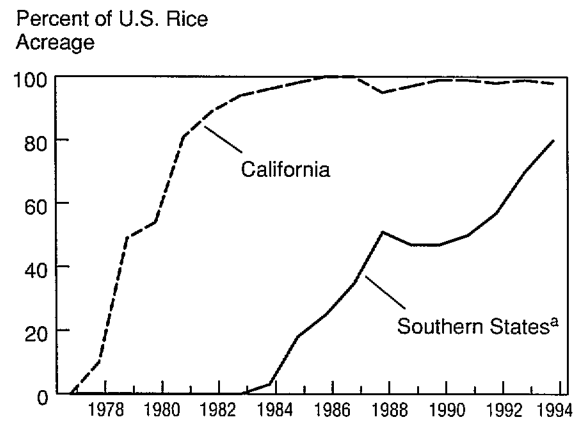
Source: Authors' calculations.

[a]Minnesota, Montana, North Dakota, and South Dakota.

[b]Oklahoma and Texas.

[c]Colorado, Iowa, Kansas, and Nebraska.

Figure 4—U.S. Rice Acreage Sown to Varieties with IRRI Ancestors, 1978–94



Source: Authors' calculations.

[a]Arkansas, Louisiana, Mississippi, Missouri, and Texas.

U.S. Investments in International Research Reap Ample Rewards

The widespread use of wheat and rice varieties developed through CIMMYT and IRRI research demonstrates the extent to which improved crops developed overseas find their way onto the fields of U.S. farmers. As a result, American consumers benefit from the cheaper and better products. U.S. agriculture benefits from the widespread adoption of farming technologies that increase yields and lower production costs. Overall, the U.S. economy reaps enormous rewards from the nation's investments in international agricultural research.

To measure the benefits realized by the U.S. economy due to CGIAR research, the study team tracked the development and use of improved, higher-yielding varieties of rice and wheat developed by IRRI, CIMMYT, and U.S. breeders, and identified the yield gains realized by U.S. farmers that were attributable to these new varieties. The rate and extent of their adoption by U.S. farmers from 1970 to 1993 were measured, and the economic value of the improved productivity from these varieties was estimated. Finally, those economic benefits that were due to the CGIAR were determined and compared with the corresponding costs (see Box 4).

This approach finds that the U.S. economy gained at least $3.4 billion and up to $13.7 billion from 1970 to 1993 from the use of improved wheat varieties developed by CIMMYT (Table 3). Since U.S. government support of wheat improvement research at CIMMYT has amounted to less than $71 million since 1960, the country's investment amounts to less than 2 cents for every $100 of U.S. wheat production. The benefit-cost ratio for U.S. government support of CIMMYT is as high as 190 to 1.

In the same 23-year period, the U.S. economy realized at least some $30 million and up to $1.0 billion through the use of improved rice varieties developed by IRRI. Total U.S. government support of IRRI has cost about $63 million, an investment equal to about 9 cents per $100 of U.S. rice production. The benefit-cost ratio for U.S. government contributions to IRRI is as high as 17:1.

Table 3—U.S. Benefits and Costs from CGIAR Wheat and Rice Research

Benefits and Costs	Wheat	Rice
	(millions of 1993 U.S. dollars)	
Present value of benefits	13,653	1,042
Present value of costs	71	63
Benefit-to-cost ratio	190:1	17:1

Source: Authors' calculations.

Note: Benefits from varietal improvement research are expressed in present value terms for the 1970–93 period; costs represent U.S. government support to international wheat and rice research and cover the 1960–93 period.

Box 4
Measuring Benefits from International Agricultural Research

Analyzing the benefits and costs of international agricultural research is a complicated task. The approach taken here was to begin by measuring the increased wheat and rice yields in the United States from 1970 to 1993 due to improved varieties, no matter where those varieties were developed. Some jumps and declines in yields resulted from year-to-year changes in weather, and this was taken into account.

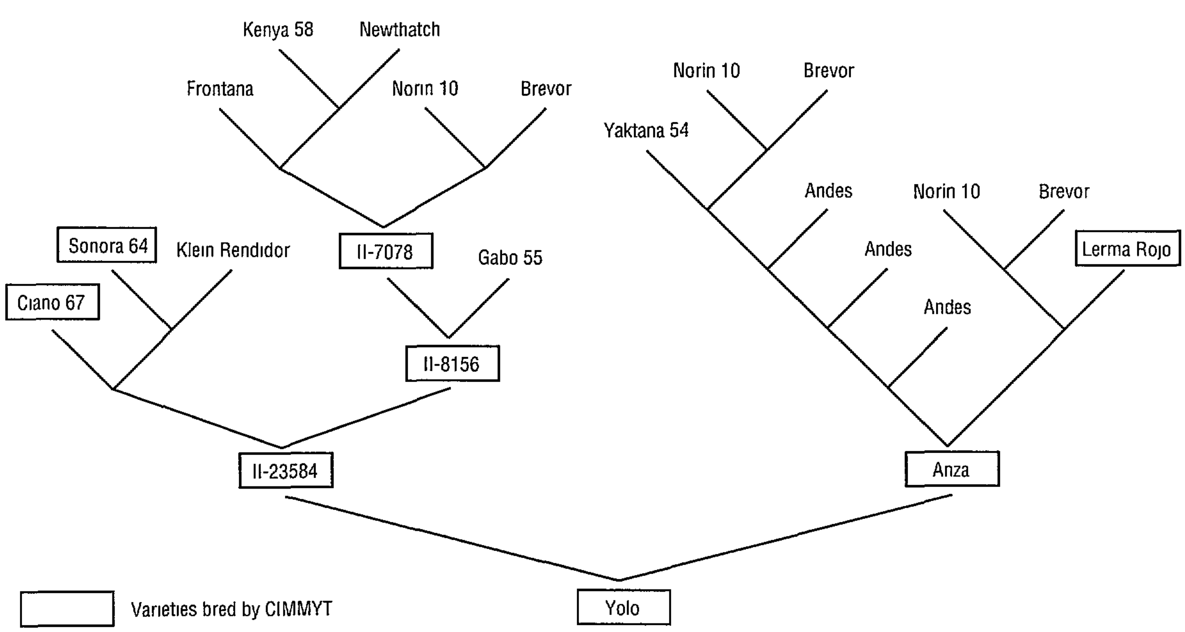
The next step was to determine the value of these yield increases by multiplying the price of wheat and rice of various kinds and in various regions by the corresponding gain in yield. The cost of any additional fertilizers and other inputs that farmers used as a consequence of adopting the new varieties was deducted.

But what portion of these total benefits is due to the work of the CGIAR centers? To what degree are the desirable qualities of a particular variety of wheat due to the work of the U.S. breeder who produced the last cross, or to the breeders beforehand who produced the plant's parents and grandparents?

Answering these questions is tricky. Before the varietal revolution of the 1950s and 1960s, grain plants changed slowly, as farmers repeatedly selected plants with desirable characteristics. But then breeders began to cross a wider variety of plants, using new methods to systematically achieve a particular combination of desired traits. This work has contributed to detailed knowledge about which varieties can provide which traits, such as disease resistance and tolerance to drought, but it has also led to exceedingly complicated family trees for the new varieties, which contain genetic material from dozens of parent plants from all over the world (see Figure 1).

There is no generally accepted procedure for attributing the benefits of particular varieties to particular breeders. A number of approaches are possible. One approach, for example, is to divide these benefits equally between all of a variety's antecedents. But this approach cannot accurately measure the contribution a particular parent or grandparent makes to the yield or

Figure 1—Pedigree of the Wheat Variety *Yolo*



Box 4 (continued)
Measuring Benefits from International Agricultural Research

quality of the variety. For example, *Norin 10/ Brevor* provided only 1/16th of the genetic content of the variety *Yolo,* shown in Figure 1, but may be responsible for a greater share of *Yolo*'s value.

The top figure for benefits reported here credited the CGIAR with all the benefit for any U.S. variety that contains any CGIAR germplasm, regardless of the importance of that germplasm in the overall genetic makeup of the variety (the any ancestor method). The low figure for benefits gave greater weight to the most recent breeding work and progressively less weight to breeding work performed in each previous generation (the geometric method). The larger report on this study also used other methods of attributing the benefits of new varieties, and results generally fell between these two extremes (see Figures 2 and 3).[1]

The final step was to match benefits with costs—a difficult process because of the long lag between when resources are spent on research and when a new variety is developed and achieves widespread use. For instance, the lag between the initiation of research investments and the availability of new wheat and rice varieties is often 7 to 10 years. It could take another decade or more for large numbers of farmers to adopt the new varieties. Furthermore, since some benefits from a variety can be achieved through planting its offspring, the effects of a particular innovation can persist for a long time even after the first variety is displaced. The analysis in this report attempts to take all of these factors into account.

Figure 2—U.S. Benefits by Calculation Method and Costs from CGIAR Wheat Research

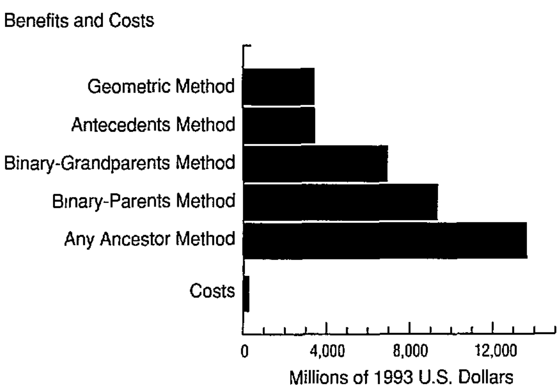
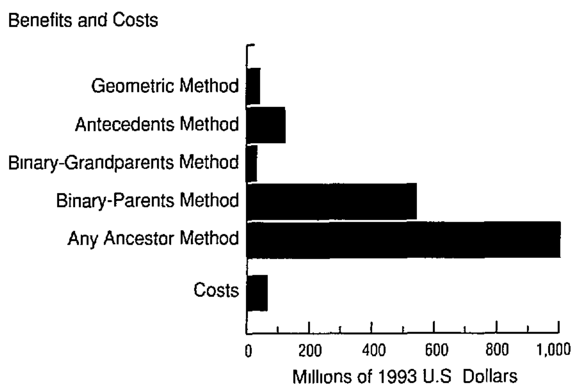


Figure 3—U.S. Benefits by Calculation Method and Costs from CGIAR Rice Research



[1] *A Productive Partnership: The Benefits from U.S. Participation in the CGIAR* (Washington, D.C.: International Food Policy Research Institute, forthcoming). For two methods of attributing benefits, the U.S. benefits from IRRI research were less than the U.S. investment. These estimates, however, may not reflect the actual benefits to the United States from international rice research, for two reasons. First, almost all rice production in the United States now uses semidwarf varieties, and IRRI led the way in developing semidwarf technology. Without IRRI, such rice would have appeared in the United States much later than it did. Second, evidence suggests that years of work adapting varieties originating at IRRI to U.S. conditions are beginning to pay off; the research may thus yield greater benefits in the future. In any case, the U.S. benefits given here ignore the substantial benefits to the rest of the world from international agricultural research.

Conclusion

The U.S. investments in international agricultural research on wheat and rice were made primarily for humanitarian reasons, and they have been extremely effective at reducing poverty and hunger in developing countries. But they have also yielded direct economic benefits to the United States that far outweigh the U.S. costs. CIMMYT breeding achievements have generated U.S. benefits as high as 190 times the total U.S. contribution to CIMMYT's wheat improvement budgets, while IRRI's work in rice has realized U.S. returns of as much as 17 times the U.S. investment in rice research through the CGIAR.

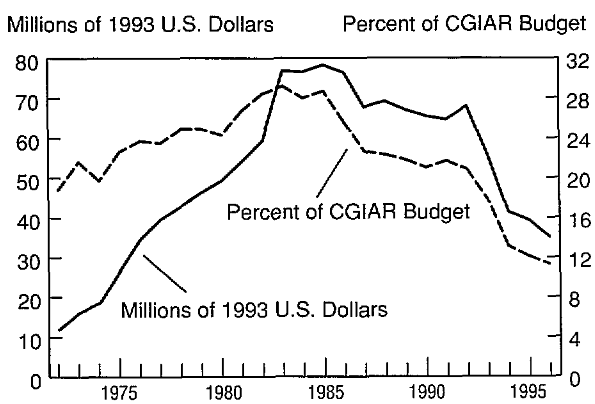
Besides generating agricultural advances, investment in agricultural research is an investment in international stability and economic growth overseas, which reaps further rewards for the United States and other donor nations. CGIAR research enhances food security, alleviates poverty, and promotes economic growth in developing nations. Growing more food on the same amount of land without further degrading natural resources can only be accomplished with cutting-edge technology. Agricultural research is absolutely essential to producing enough food to feed the world's burgeoning population while sustaining the natural resource base that supports agriculture. Farming is also critical to economic growth in largely rural developing countries whose economies are heavily dependent on agriculture. Improved food security and economic growth can reduce political instability and conflicts in developing countries that often lead to pressure on developed countries in the form of refugee crises, costly emergency relief aid, and dangerous military interventions. Economic growth in developing countries has also opened lucrative new export markets for donor countries.

In 1996, the planned U.S. contribution to the CGIAR totaled $37.2 million, down sharply from its level in the 1980s and early 1990s (Figure 5). This decline in agricultural assistance mirrored an overall cutback in U.S. investments in international aid.

Can the United States gain the benefits of international agricultural research without investing in the CGIAR? It is possible that some of the new varieties that have been used in the United States would have been developed in the absence of the U.S. contributions. But U.S. support has been of vital importance to the centers, especially to CIMMYT and IRRI in the early years, and still is vital to many of them. Further, if each country invested only in domestic agricultural research, the broad spillover benefits that international research can generate for all countries, including the United States, would be eliminated.

U.S. support for international agricultural research has generated sizable benefits for those it was intended to help directly—developing country farmers and consumers—and has yielded handsome

Figure 5—U.S. Government Funding for the CGIAR, 1972–96



Source: Authors' calculations based on unpublished financial data provided by CGIAR Secretariat.

dividends for U.S. taxpayers in the form of more productive food production at home. But without further investment and research, the benefits already gained through crop improvement research can be undermined or lost as diseases mutate, pest problems recur, populations grow, and climatic conditions shift. Scientific research must continue apace in order to keep ahead of rapid population growth, changing consumer demands, and other changing conditions that threaten crop yields.

Philip G. Pardey and Shenggen Fan are research fellows in IFPRI's Environment and Production Technology Division. Julian M. Alston and Jason E. Christian are a professor and a research associate, respectively, in the Department of Agricultural Economics at the University of California at Davis.