Consultative Group on International Agricultural Research

CGIAR

Study Paper Number 8

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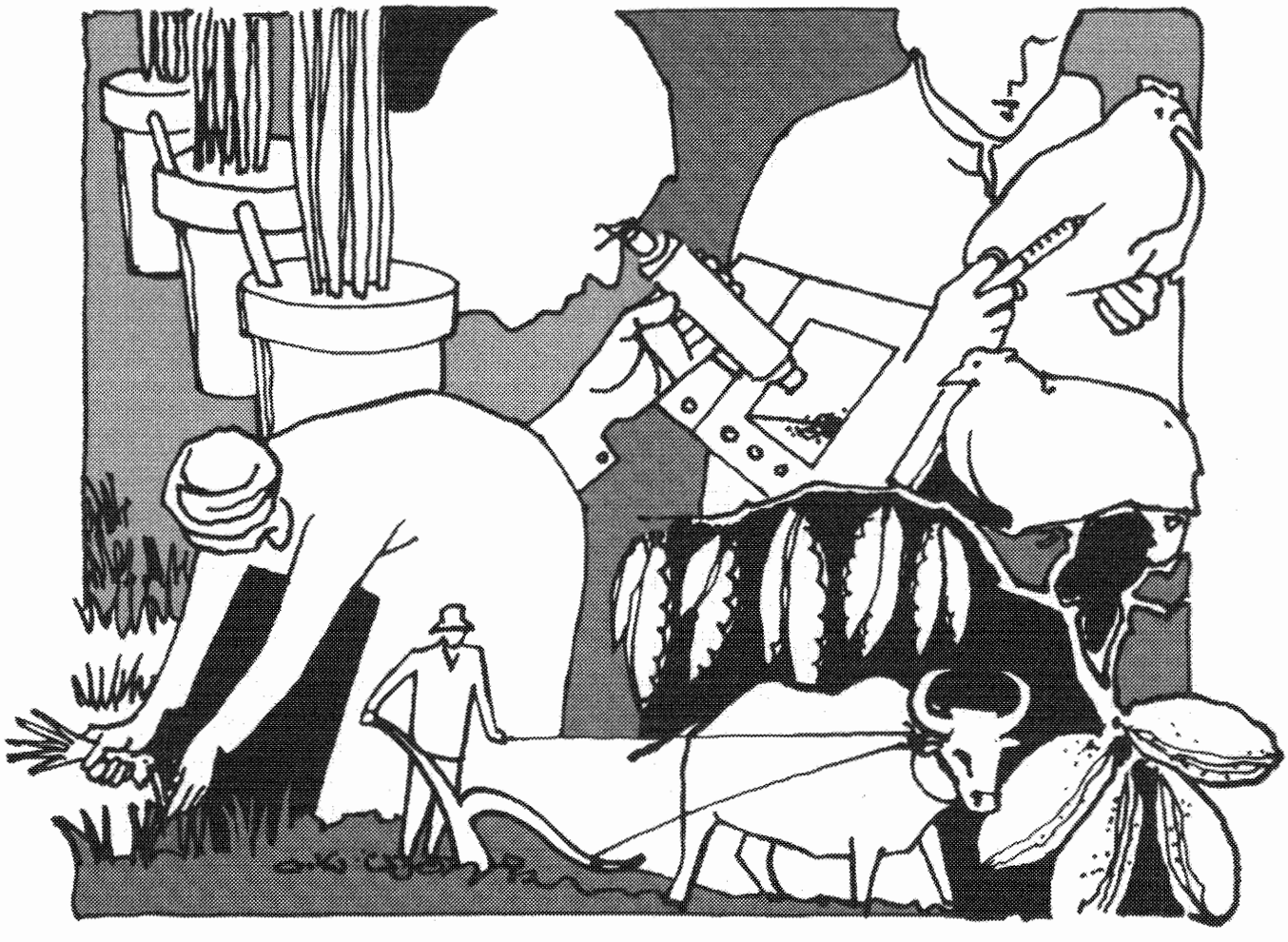
Bangladesh and the CGIAR Centers

A Study of Their Collaboration in Agricultural Research

Carl E. Pray
Jock R. Anderson



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At its annual meeting in November 1983 the Consultative Group on International Agricultural Research (CGIAR) commissioned a wide-ranging impact study of the results of the activities of the international agricultural research oganizations under its sponsorship. An Advisory Committee was appointed to oversee the study and to present the principal findings at the annual meeetings of the CGIAR in October 1985. The impact study director was given responsibility for preparing the main report and commissioning a series of papers on particular research issues and on the work of the centers in selected countries. This paper is one of that series.

The judgments expressed herein are those of the author(s). They do not necessarily reflect the views of the World Bank, of affiliated organizations, including the CGIAR Secretariat, of the international agricultural research centers supported by the CGIAR, of the donors to the CGIAR, or of any individual acting on their behalf. Staff of many national and international organizations provided valued information, but neither they nor their institutions are responsible for the views expressed in this paper. Neither are the views necessarily consistent with those expressed in the main and summary reports, and they should not be attributed to the Advisory Committee or the study director.

This paper has been prepared and published informally in order to share the information with the least possible delay.

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SUMMARY

The collaboration between the international agricultural research centers and the national agricultural research system of Bangladesh has been very important to the growth of agricultural research and agricultural productivity in Bangladesh. The collaboration started in 1966 with the beginning of IRRI's relationship with the Agricultural Research Institute. The number of collaboratively researched crops has expanded gradually to include wheat, maize, potatoes, some pulses and cassava. The most important types of contact included posting center researchers in Bangladesh to work with local researchers on local problems, regular visits by center staff, training programs at the centers or run by the centers, joint programs of germplasm testing, and publications.

These activities have influenced the size and direction of Bangladesh research. The well publicized success of IRRI rice and CIMMYT wheat elsewhere in Asia made it easier for the national program to acquire budget allocations and resources from the East Pakistan and Bangladesh governments and from the donors. The increases in funding have been most rapid in foodgrains, potatoes, pulses and oilseeds, while the research on export crops has grown more slowly. The proportion spent on export crops has thus declined. Within the commodity programs, joint planning of research in on-farm research programs has influenced priorities toward farmers' needs. The institutional structure of research has been influenced by the centers' emphasis on multidisciplinary teams organized around a single commodity. The general efficiency of the research programs that are in touch with the centers seems to have improved - training at the centers has encouraged researchers to be more practical in outlook and work style. There is more incentive to perform vigorously with the prospect of wider recognition through participation in international yield trials or in international meetings. Center outposted (special project) staff have resources that must be helpful in overcoming crucial research bottlenecks.

The outcome of this collaboration has been more food production and probably improved income distribution. Modern varieties of rice and wheat

have increased the demand for labor, which benefits the landless laborers who are the poorest group in Bangladesh. Increased food production has reduced the real price of foodgrains, which primarily benefits poorer consumers both in the cities and the countryside.

Many aspects of institutional arrangements for agriculture research in Bangladesh reflect the influences of several international centers, ranging from the structure of the rice research institute to aspects of the ongoing debates on input and food pricing policies in the country. The centers are widely appreciated for their contributions.

ACKNOWLEDGMENT

This report reflects the ideas and concerns of many friends in Bangladesh although they may not all agree with our synthesis of the achievements of the centers. We share their general enthusiasm for the past and future contributions of the centers' partnership arrangements to the future welfare of Bangladesh. Many people helped us but we must particularly acknowledge the strong support and active personal assistance of Dr. Kazi M. Badruddoza, and that of Zafar Ahmed on an earlier version of this paper. We are also grateful to Dorothy Marschak for assistance in reaching this stage of publication.

WEIGHTS AND MEASURES

1 acre (ac)	= 0.405 hectares (ha)
1 maund (md)	= 36.3261 kilograms (kg)
1 seer (sr)	= 0.933 kg
1 (long) ton	= 27.22 maunds

SPECIAL TERMS USED

Aman - rice planted before or during the monsoon (which begins in June) and harvested in November-January: B. aman is broadcast aman, T. aman is tranplanted aman.

Aus - rice planted during March-April and harvested during July-August

Boro - rice planted in winter and harvested druing April-June

Thana - administrative unit comprising between 6 and 15 villages

FISCAL YEAR

The Bangladesh Fiscal Year (FY) runs from July 1 to June 30.

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ACRONYMS USED

ADAB	Agricultural Development Agencies in Bangladesh
ADC	Agricultural Development Corporation
AVRDC	Asian Vegetable Research and Development Center
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Concept
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BIDS	Bangladesh Institute of Development Studies
BRRI	Bangladesh Rice Research Institute
BTC	Bangladesh Tobacco Company
CARE	Cooperative for American Relief to Everywhere
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CIP	Centro Internacional de la Papa
FAO	Food and Agriculture Organization
FSR	Farming systems research
IADS	International Agricultural Development Service
IARC	International Agricultural Research Center
IBRD	International Bank for Reconstruction and Development
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IFPRI	International Food and Policy Research Institute
JRI	Jute Research Institute
NGO	Non-Government Organization
RDRS	Rangpur Dinajpur Rehabilitative Service
SRI	Sugar Research Institute
UPLB	Univesity of the Philippines at Los Banos
USAID	United States Agency for International Development
WAPDA	Water and Power Development Authority

BANGLADESH

1 Overview of Bangladesh Agriculture and Growth of the Research System

1.1 Importance of agriculture

The agricultural sector dominates the economy of Bangladesh. It accounts for about half of the GNP, 79 percent of employment and 80 percent of exports. Since separation from Pakistan agricultural output has grown about 3 percent annually, which was just slightly more than population growth. Table 1.1 shows the area, output and value of the major crops of Bangladesh. The crop that dominates the agriculture of Bangladesh is rice. It is planted in three major seasons - aus, aman, and boro. The planting and harvest dates of rice and the other crops are shown in Figure 1.1. The major cropping patterns are listed at the bottom of Figure 1.1.

The trends in area, production and yield of the major field crops are shown in Table 1.2. Wheat is the only crop in which there is evidence of rapid productivity growth. Yield increased 12 percent annually. Yields of the two major rice crops grew about 2 percent annually.

1.2 Agricultural research systems in East Pakistan

The national research system (NARS) that East Pakistan inherited from the British had been disrupted by World War II and the Bengal famine. It was further weakened by disruptions occasioned by the Independence movement. The main Bengali experiment stations were in East Pakistan, but the research institutes were completely shattered during partition. Almost all of the jute research workers went to India (Chaudhuri 1949) and other sections were affected nearly as much. The long-serving Director of BRRI describes the period from 1947 to 1956 as "the Dormant Period." He has observed that due to lack of funds and manpower, the research was curtailed to the maintenance of

Table 1.1 Area, Output and Value of Major Crops

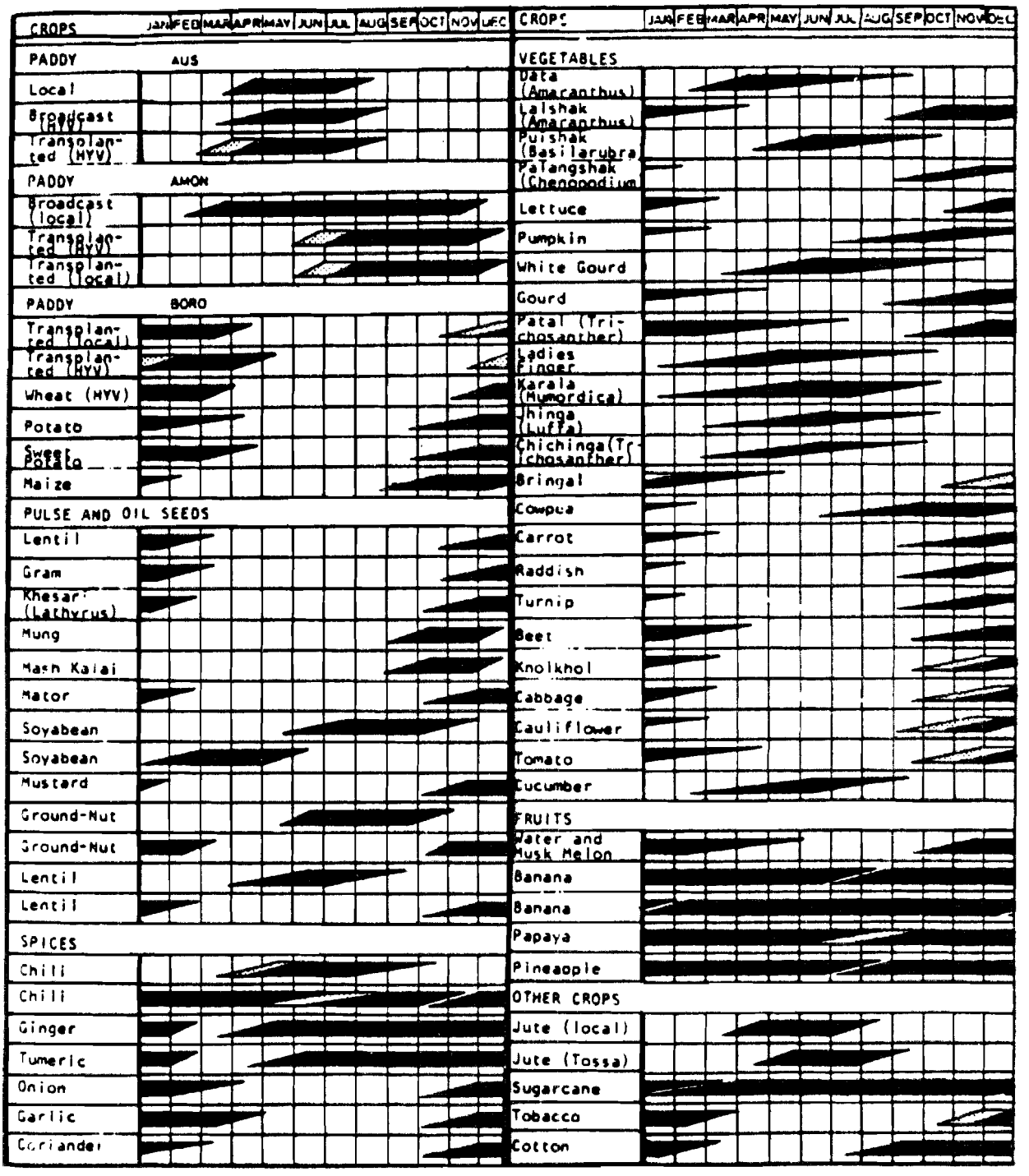
	Area (000 acres)	Production (1000 tons)	Value (million takas)	Value Added (million takas)
Rice (All)	25,106	18588	51246	48350
Aus	7,505	4162	8589	7594
Aman	14,762	10228	32468	30793
Boro	2,839	3598	10194	9963
Wheat	1,071	787	2105	2928
Maize	5	1	4	4
Tea	107	40	645	220
Tobacco	111	37	433	426
Jute	1,874	1049	2729	2566
Oilseeds	768	235	1186	1124
Pulses	816	211	479	711
Potato	238	902	1259	1142

Source: BBS (1982).

Figure 1.1

CROP CALENDAR OF BANGLADESH

Existing Cropping Patterns



EXISTING CROPPING PATTERNS:

AUS/Jute + T. Amon
AUS + T. Amon + Khesari (Lathyrus)
Jute + Kalai (Pulse)
AUS and T. Amon Mixes

5. AUS + Mustard/Pulses/Rabi Vegetables/Tobacco/Cotton/Potato
6. AUS and Arhar (Cajanus)/Til (Sesamum) Mixed
7. B. Amon
8. AUS and B. Amon Mixed
9. Boro
10. Sugarcane
11. Summer Vegetables + Mustard/Pulses

Source: Moseman (1980).

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Table 1.2 Average Annual Growth Rates in Crop Production

	Area	Production	Yield
Rice	0.37	2.11	1.74
(Aus)	(-0.14)	(1.77)	(1.92
(Aman)	(0.37)	(2.42)	(2.05)
(Boro)	(1.85)	(1.59)	(-0.36)
Wheat	19.75	32.21	12.45
Pulses	-1.1	-2.8	(-1.8)
(Gram)	(-1.0)	(-2.8)	(-1.8)
(Mash Kalai)			
(Masur)	(1.8)	(-0.7)	(-2.4)
(Khesari)	(0.4)	(-1.3)	(-1.8)
Oilseeds	-0.2	-0.4	.
(Rape & Mustard)	(-0.2)	(0.3)	(0.4)
Potatoes	1.5	1.0	-0.5
Sweet Potatoes	0.5	0.0	-0.6
Tobacco	2.0	2.1	0.1
Jute	-1.58	-0.02	1.56

. = not significant

Note: FY70 - FY81 for rice and wheat, FY70 - FY80 for the other crops. Growth coefficients are average annul rates of change (in percent) estimated on the basis of fitted least-squares trend lines.

Source: BBS data, IBRD mission estimates, ad Edward J. Clay, Rabi Crops in Bangladesh: A Situation Report on Production, Prices and Research on Compaative Profitability (Dacca, Janauary 1981), Table 2.

plant resources and limited field and laboratory tests (Zaman 1975). Tea planters lost contact with their research institute, which was in India. A new tea research station was not established by the government until the late 1950s. Sugarcane improvement suffered because it was cut off from its source of genetic material. During this period, however, some research personnel were sent to the USA for PhD study.

After 1956, well trained professionals returned from training, and research activity started to expand. However, the expansion of the Agricultural Research Institute suffered another setback in 1962 when the Pakistan government decided to take over the fields of the research institutes near Dacca to build the Second Capital of Pakistan. The land available for experiments was quickly reduced to about 4 ha and by 1965/66 no land at all was available for research. "Thousands of germplasm samples collected during the past 50 years at a tremendous cost were lost forever" (Zaman 1975). Financing of the Sugar Research Institute of Ishurdi was shifted from the provincial to the Pakistan central government. However, sugarcane research was returned to the province in 1966 but with no increase in budget.

The 1960s were a period of growth for the Jute Research Institute which received a large increase in funds from the central government. However, its major research farm was also appropriated to build the Second Capital. It was left with less than two ha in the grounds of the Institute, and substations about 20 miles away from the Institute. In the mid-1960s the first foreign assistance for agricultural research started. The Ford Foundation funded IRRI to provide some technical assistance and to administer Foundation support for the development of a rice research institute in Joydebpur to replace the lands lost to the Second Capital. In 1970 USAID provided its first direct funds to research by partially funding the rice research program.

Several other government institutions outside the regular crop research institutes started doing agricultural research during the 1960s. The Academy for Rural Development at Comilla, supported by the Ford Foundation and others, accomplished a considerable amount of social science research throughout the

1960s. In the mid-1960s it conducted field trials on a number of rice varieties from SE Asia, China and Taiwan, several of which, especially Pajam, became very popular. It ran trials of IR8 and helped to popularize this semi-dwarf rice. It also introduced several varieties of vegetables and melons which gained widespread acceptance. In addition, an elaborate system for communicating and providing modern inputs through the village cooperatives was developed and supervised credit systems schemes were introduced.

In the early 1960s the Bangladesh Agricultural University (BAU) at Mymensingh was founded with the assistance of the USAID and later also received support from the World Bank. By the end of the decade, research was under way in rice breeding and the social sciences. Another institution that developed during the decade was the Agricultural Division of the Dacca Atomic Energy Commission which later became the Institute for Nuclear Agriculture. This institution attracted very well qualified staff by offering relatively high salaries and prestige, but there is little evidence that it has produced any results with measurable impact.

The major privately financed agricultural research program in British Bengal and Assam was the tea research system. At Independence, the tea research institutions were in India. The government then financed the Tea Research Institute in Sri Mangal in East Pakistan. However, there were still a few small, privately financed efforts to improve agricultural technology. Around 1960 the government gave permission for several of the sugar mills in North Bengal to import sugarcane varieties for testing on their mill farms. In the late 1960s the Pakistan Tobacco Company started some trials of Virginia tobacco varieties in East Pakistan.

After President Ayub came to power in the late 1950s, the government took a more active role in agricultural development. In addition to the Academy for Rural Development at Comilla and the Agricultural University at Mymensingh, the government established two other institutions which supplied inputs and some extension advice. The first was the Agricultural Development Corporation (ADC) which provided fertilizer, pesticides and improved seed.

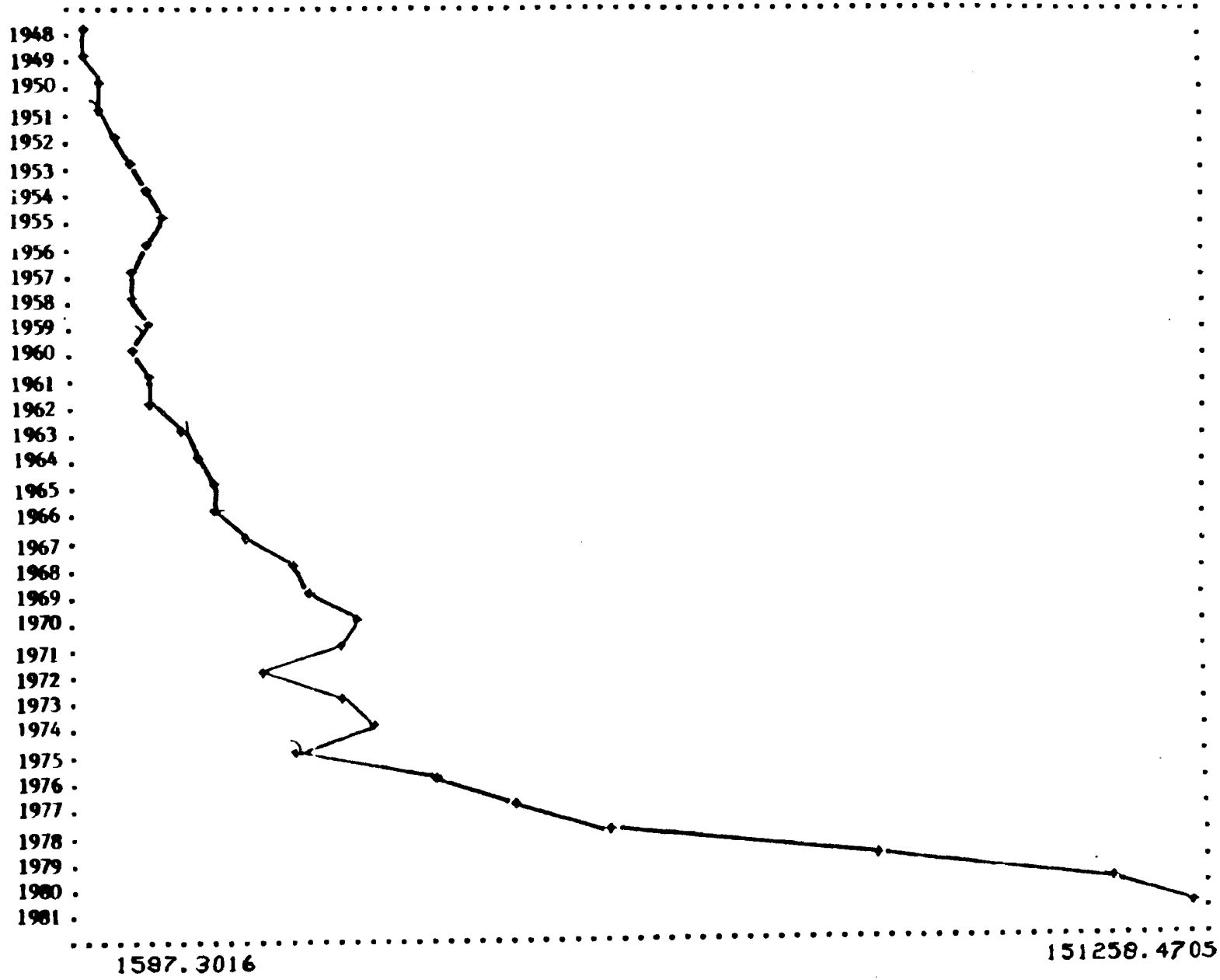
The second was the Water and Power Development Authority (WAPDA) which provided most of the irrigation facilities during the 1960s. It had its own extension service for certain project areas. The national agricultural extension service was also strengthened. Another deliberate step was raising the price of rice relative to inputs through government procurement and input subsidy policies.

1.3 Agricultural research in Bangladesh

The War of Liberation disrupted work at all the research institutes. The Rice Research Institute (BRRI), thanks to strong leaderslip, survived better than most. The Sugar Research Institute (SRI) was virtually destroyed in 1971. It was shifted to the Bangladesh Sugar and Food Industries Corporation in 1973 and its research program was revived in 1974. The Central Jute Committee was abolished and the Jute Research Institute (JRI) was given autonomous status under the Ministry of Industries in 1973. The Agricultural Research Institute (BARI), which by 1974 dealt with only the "minor" crops, did not fare as well. In fact, it had no land of its own near Dacca to use for experiments until the mid-1970s. The Bangladesh Agricultural Research Council (BARC) was established in 1973 to plan and coordinate the research system as a whole, but it had little power. The Agricultural University (BAU) continued to teach but did little research in the period immediately after Liberation.

Since 1975 the research system of Bangladesh has been growing at a rapid rate (Figure 1.2). In the period between 1975 and 1980, the BARI budget grew by more than 50 percent annually. BARC and SRI grew by about 40 percent annually. BRRI, BJRI and the Forestry Research Institute grew by about 20 percent a year (Gill 1981). Only the Institute of Nuclear Agriculture showed signs of declining expenditure. There have been several important structural changes. BARI has been granted a considerable degree of autonomy from the Ministry of Agriculture. BJRI shifted to the Ministry of Science, then back to the Ministry of Industries, and has more recently returned to the Ministry of Agriculture. BARC has gained status and power as its budgets and technical

FIGURE 1.2
Agricultural Research Expenditures on Crops (TK 000 at 1975/76 Prices)



competence have grown. It is now playing an important role in encouraging communication between research workers, coordinating research efforts, and allocating resources between different institutes and research areas.

The major non-government research efforts of the 1970s were by the Bangladesh Tobacco Company (BTC, formerly the Pakistan Tobacco Company), and by some of the non-government organizations (NGOs) such as local voluntary agencies, missionary and relief organizations. The Bangladesh Tobacco Company program has been very successful in transferring the production of Virginia tobacco to Bangladesh. There was no Virginia tobacco grown commercially in East Pakistan but, by 1976, Bangladesh was self-sufficient in Virginia tobacco production. This was due largely to an applied research program run on farmers' fields by BTC.

The NGOs have had much smaller operations, but some of them such as the Mennonite Central Committee in Comilla and Noakali, RDRS in Rangpur, and CARE around Dacca have played useful roles in introducing improved varieties of vegetables, soybeans, rice and wheat, not to mention their other wide-ranging contributions including some innovative machines.

In the national agricultural research system it is also important to understand the relationship of the research institutions to the ministries which control their funds and to the extension services which communicate their findings of research to the farmers. Figure 1.3 indicates the current structure of the research service. A research institute such as the Sugar Research Institute has to compete for funds in the Ministry of Industries against other uses of funds such as improvements for the sugar factories or edible oil factories. In the case of the institutes under the Ministry of Agriculture, the competition for funds is with other programs such as extension and the Bangladesh Agricultural Development Corporation which supplies inputs, and also with other research institutions. The extension agencies have been consolidated recently under the Ministry of Agriculture. The major extension service outside that Ministry is the sugarcane extension program.

Figure 1.3 Agricultural Research Organizations

Ministries	Institutions
Ministry of Agriculture	Bangladesh Agricultural Research Council
	Bangladesh Agricultural Research Institute
	Bangladesh Rice Research Institute
	Forest Research Institute
	Livestock Research Centre
	Fisheries Research Institute
	Bangladesh Jute Research Institute
	Bangladesh Agricultural University
	Institute of Nuclear Agriculture
Ministry of Industries- Sugar Mills Corporation	Sugarcane Research Institute
Ministry of Commerce - Tea Board	Bangladesh Tea Research Institute
Ministry of Local Government and Rural Development - Cooperative and Rural Development	Bangladesh Academy of Rural Development at Comilla and Bogra
Ministry of Education	Bangladesh University of Engineering and Technology
	Dacca University
	Chittagong University
	Rajshahi University
Ministry of Finance and Planning	Bangladesh Institute of Development Studies
Science and Technology	Bangladesh Council of Scientific and Industrial Research

2 History of IARC Activities

2.1 IRRI

IRRI's first contact with the Bangladesh agricultural research system came in 1965 when the Assistant Director of IRRI was invited by the Government of East Pakistan and the Ford Foundation to visit. He was invited "to observe rice research, and offer suggestions on an accelerated rice research program in cooperation with IRRI" (McClung 1965). Soon afterwards, an IRRI staff member was placed in Bangladesh to initiate a presence that has continued to the present, except for a brief interruption because of the War of Liberation in the early 1970s.

The number of IRRI staff members grew to four in 1970. They included a rice adviser, assistant rice adviser, a civil engineer who provided advice on construction projects and a plant pathologist. Only the rice adviser returned in 1972 after the obligatory exit for the War of Liberation. In 1974 the IRRI staff grew again and since then has consisted of 4 or 5 advisers stationed in Bangladesh. The 1984 staff consists of a research systems specialist and liaison scientist, deep water rice breeder, an agricultural economist and a rice production specialist working jointly with BRRI's staff. In addition to the long-term advisers, many IRRI staff have made short visits to Bangladesh.

A major activity of the IRRI program from the earliest period has been training. In 1966 the staff of the Agricultural Research Institute consisted of about 130 people with at least a bachelors degree. Of these 3 had PhDs and about 36 had MAg or MSc degrees, mostly from Pakistani universities and colleges. In 1966 the first of a series of groups of 10 scientists were sent for training to the University of the Philippines at Los Banos (UPLB) and to the USA for post-graduate degrees (Alim 1966). There has since been a regular flow of trainees as shown in Table 2.1.

In addition to agricultural scientists, by 1970 BRRI had sent 17 senior agricultural officials and planners on short-term training trips. These trips

Table 2.1 **Summary table of training**

Year	CIMMYT Degree related	CIMMYT Production	CIMMYT Specialized	CIMMYT Total	CIP Degree related	CIP Production	CIP Specialized	CIP Total	IRRI Degree related	IRRI Production	IRRI Specialized	IRRI Total
1962	–	–	–	–	–	–	–	–	–	–	–	–
1963	–	–	–	–	–	–	–	–	–	–	1	1
1964	–	–	–	–	–	–	–	–	–	–	–	–
1965	–	–	–	–	–	–	–	–	–	–	1	1
1966	–	–	–	–	–	–	–	–	–	–	–	–
1967	–	–	–	–	–	–	–	–	2	4	2	8
1968	–	1	–	1	–	–	–	–	1	3	3	7
1969	–	–	–	–	–	–	–	–	–	–	3	3
1970	–	1	1	–	–	–	–	–	–	1	2	3
1971	–	–	–	–	–	–	–	–	–	1	–	1
1972	–	–	–	–	–	–	–	–	2	–	–	2
1973	–	3	–	3	–	–	–	–	1	–	–	1
1974	–	2	–	2	–	–	–	–	–	2	1	3
1975	–	2	–	2	–	–	–	–	3	1	1	5
1976	–	6	–	6	–	–	–	–	1	–	3	4
1977	–	4	–	4	–	–	–	–	1	3	4	8
1978	–	7	–	–	–	–	–	–	6	4	8	18
1979	–	7	–	7	–	2	5	7	2	7	11	20
1980	–	10	–	10	–	1	1	14	13	13	40	–
1981	–	9	2	11	–	7	7	14	10	12	16	38
1982	–	5	–	5	–	19	4	23	4	12	27	43
1983	4	5	–	9	–	23	4	27	9	2	2	13
1984	5	4	–	9	7	–	1	8	14	6	3	23
TOTAL	9	66	2	77	7	52	21	80	71	70	101	242

Table 2.1 Summary table of training (cont.)

Year	IITA Degree related	IITA Production	IITA Specialized	IITA Total	IBPGR Degree related	IBPGR Production	IBPGR Specialized	IBPGR Total	ICARDA Degree related	ICARDA Production	ICARDA Specialized	ICARDA Total
1962	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	-	-	-	-	-	-	-	-	-	-
1966	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	1	-	-
1979	-	1	-	1	-	-	2	2	-	2	-	2
1980	-	-	1	1	2	-	7	9	-	1	-	1
1981	-	-	1	1	-	-	-	-	-	1	-	1
1982	-	-	-	-	-	-	-	-	-	1	-	1
1983	-	-	-	-	-	-	2	2	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	0	1	2	3	2	0	11	13	0	6	0	6

Source: Badruddoza (1984).

Table 2.1 Summary table of training (cont.)

Year	Degree related	ICRISAT Production	Specialized	Total
1962	-	-	-	-
1963	-	-	-	-
1964	-	-	-	-
1965	-	-	-	-
1966	-	-	-	-
1967	-	-	-	-
1968	-	-	-	-
1969	-	-	-	-
1970	-	-	-	-
1971	-	-	-	-
1972	-	-	-	-
1973	-	-	-	-
1974	-	1	-	1
1975	-	-	-	-
1976	-	-	-	-
1977	-	-	-	-
1978	-	-	-	-
1979	-	-	-	-
1980	-	-	2	2
1981	-	-	2	2
1982	-	-	3	3
1983	-	-	1	1
1984	-	-	1	1
TOTAL	0	-	9	9

Source: Badruddoza (1984).

went to IRRI to see the development of new techniques and then elsewhere in the Philippines or Japan to observe new technology as it was applied by farmers. It can only be speculated that these trips were quite useful in convincing policy makers of the importance of rice research and the potential of the new high yielding technology.

The influence of IRRI varieties and germplasm was felt almost immediately. In 1966 IRRI sent 303 selections of improved rice for testing. Before the first tests were harvested the government decided to order over a ton of rice from IRRI for commercial seed multiplication. This order included both IR8 and IR9, which had performed best in the initial trials. Since then IRRI genetic material has regularly been sent to Bangladesh including replacements for materials lost from the BRRI rice gene bank.

2.2 CIMMYT

The first contact of CIMMYT with the Bangladesh research system was also during the East Pakistan period. In 1965 a kilogram each of Sonora 64 and Penjamo 62 were sent to East Pakistan from West Pakistan. These varieties yielded almost five times the provincial average wheat yield and matured more rapidly than the local wheats. On the basis of these results 160 kg of seed was sent for testing in the 1966-67 season. These trials were also impressive. The CIMMYT representative in West Pakistan visited these sites in 1968 and provided some initial technical assistance to the scientists. The next year the CIMMYT representative, along with West Pakistani wheat breeders, sent a collection of 265 promising Mexican lines to be tested. The same year the first Mexican variety was released to farmers - based on 1212 tons of Penjamo62 (Zaman 1968). Since 1970, genetic materials have come directly from CIMMYT.

Perhaps the second most important input from CIMMYT, after genetic material, has been training. This is epitomized by the three early wheat production trainees who have become the nucleus of today's Bangladesh wheat research team (Badruddoza 1984). During the period 1968-82, 46 Bangladeshis have spent at least one full crop cycle at CIMMYT in wheat-related training

courses. There were 15 trainees in experiment station management. Of those, 12 were from the Bangladesh Agricultural Development Corporation which undertakes seed multiplication of wheat and other crops for the government.

Unlike IRRI, CIMMYT had no staff posted in Bangladesh until 1982. However, there were visits at least annually during the wheat season by CIMMYT staff. These visits have served to strengthen the research program in a variety of ways. They have helped the local researchers solve some of their technical problems. They have provided new ideas and advice, and generally helped to sustain researchers' motivation. In addition they played an important role in persuading the government to push wheat in its development strategy. The relationship with CIMMYT was particularly strengthened by frequent visits by Dr G. Anderson and Dr E. Saari who, with active support from senior national administrators, sensitized the government to the possibility that wheat cultivation in Bangladesh could be vital for food production. The government then decided to import 4,000 tons of Mexican varieties from India and Mexico in 1975/76, and wheat production was firmly launched.

2.3 CIP

CIP started working in Bangladesh in 1979 when a consultant, supported by the World Bank and the Australian Government, was posted to the Bangladesh Agricultural Research Institute. Several CIP staff members have visited the project to provide special skills. By 1983 the project had sent two research workers for short-term training at CIP, seven officials of BADC and BARI to seed production courses in India and Scotland, and three research workers to Sri Lanka and the Philippines to study diffused light storage (Bangladesh PIP 1983). The first collection of CIP material was tested in 1980-81 and a supply of genetic materials has been available from CIP since then.

2.4 Other CG Centers

IFPRI has carried out several studies on agricultural price policy and one study of the food aid program in Bangladesh. Several members of its staff make regular trips to Bangladesh. The main contribution of ICRISAT, IITA and ICARDA until 1984 has been the provision of germplasm of their mandate crops. A few Bangladeshi scientists have also received training at these institutions.

3 The Role of the CG Centers in the Evolution of the National Agricultural Research System

The major actors in the development of the Bangladesh research system were obviously the Bangladeshi research personnel, administrators and politicians. Others have been important at certain times. The Ford Foundation played a very important role from the mid-1960s until the mid-1970s. During the 1960s, USAID invested heavily in the Agricultural University and in 1970, it began significant support of research. It has since become the largest foreign contributor of external funds for research. In the mid-1970s the World Bank began lending money for research, university and extension facilities, especially infrastructure. Many bilateral agencies have since started to support research. Table 3.1 mentions the donors active in 1982.

The role of the IARCs is quite closely related to the activities of the donors - particularly the Ford Foundation, USAID, the World Bank, ADAB and CIDA. Most of the activities of the IARCs within Bangladesh are sponsored by donors rather than from either local funds or core funds from the centers.

The centers have provided technical assistance, training, germplasm, networks of scientists and publications. Other organizations provide many of these same services in Bangladesh. Local institutions also provide many such services, but most are provided by foreign organizations. FAO has provided technical assistance, training, networks and publications. IADS, which is closely related historically and intellectually to the centers, and other consulting firms, provide technical assistance. Universities in industrial and some developing countries provides technical assistance, training, some networks and training. The research system also has effective contacts with non-CGIAR institutions such as AVRDC and IFDC.

Table 3.1 Estimated Research Expenditures and Associated Donors

	Annual Average Expenditure (million taka)	Research Expenditure as Percent of Value of Crop	Beginning of Breeding Program	Donors (1982)
Rice (BRRI)	26.46	0.08	196/67	IDA, Australia, Canada, Ford Foundation, USAID
Jute (BJRI)	8.12	0.35	1978	ADB,UNDP
Sugarcane (SRI)	6.76	0.39	1975/76	Australia
Tea (TRI)	4.66	0.62	d/	UK, EEC
BARI	54.50	0.89 (0.55)c/	1968/69 Wheat	USAID, IDA
Cereals a/	(13.10)b/	1.47	1978 Maize	Canada (CIDA & IDRC)
Pulses	(4.40)	0.74 (0.37)	1979	IDRC
Oilseeds	(9.80)	0.91 (0.61)	1974	Sweden
Spices	(3.80)	0.28		
Fruits	(6.50)	0.32		Japan, ADB
Roots and Tubers	(7.10)	0.50	1977 White Potatoes	Netherlands
Other Vegetables	(6.00)	0.99 (0.33)		Japan
Fibers/Tobacco	(4.40)	1.55	?Tobacco	EEC (Cotton)
BARC	4.34			USAID, IDA
IRA	6.86			Sweden

a/ Cereals include wheat, corn and millets.

b/ BARI gives an estimate od the current allocation of manpower among crops; this was used to allocate BARI's expenditue among crops.

c/ This uses value of crop adjusted as suggested by Pray, 1980.

d/ Relatively small selection. Program centers on Manyjuri and hybrid jates — they do not include commercial varieties.

Sources: Gill (1981) and BARI (1980).

3.1 Size of research budgets

The IARCs seem to have had some influence on the decision makers who increased the budgets for agricultural research, extension, education and subsidies during the late 1960s. First, the centers' success at developing modern rice varieties in the Philippines and with modern wheat varieties in the Punjab, and the publicity that they received, enabled local research advocates to convince administrators and politicians that research could be effective and that investment in research should be increased. Second, they were effective in convincing policy makers (recall the IRRI-sponsored trips to the Philippines and Japan to see HYVs in action). HYVs were also grown on the farms of politicians. Third, the early rice and wheat successes convinced many donors that research projects were useful to support.

Many of the more senior research administrators in Bangladesh perceive the whole agricultural research thrust to be under active threat from the government, which may be suffering some of the same "fatigues" that are purported to be held in the donor community generally. Needless to say, a military government's perceptions of priorities does not always give due attention to agricultural research, which usually claims only a rather small part of the country's budget and, given its long-term orientation, is subject to regular scrutiny as to its appropriateness vis-a-vis other issues of national development or defense. The centers really have an important role to play in maintaining credibility of the research thrust in Bangladesh, and this may well prove eventually to be their most important input, namely, helping to protect the already strong national commitment to research investment.

3.2 Commodity allocation of resources

It appears that the centers also helped the Bangladeshis to shift their research resources from cash crops to the major foodgrains. In the early 1960s, jute received the largest share of financial resources. By 1974, the budgets of both the Rice Research Institute and the Agricultural Research Institute had surpassed the Jute Research Institute (see Table 3.2). In

addition, in the 1970s, there was a considerable boost to the resources invested in BARI, which is concerned with the other crops of the IARCs such as wheat, maize, potatoes and pulses. When compared with the value of these crops, it still seems that there may be some under-investment in rice in Bangladesh (Table 3.3). The ratios of the expenditure on research to the value of the crop (research intensities) indicate that rice is still receiving far less than its share of the research, while tea and other food crops are receiving far more than their share. In column 1 of Table 3.1, the other crops research expenditure is arbitrarily partitioned on the basis of the number of BARI scientists working on each crop in 1979. This shows that cereals other than rice - wheat, maize and millets - receive a far bigger share of research than their share of total output. In fact, they had the largest research intensities except for tobacco and cotton.

This shift of resources to the crops of the IARCs has been closely related to the centers' activities. As mentioned, the rice successes in the 1960s led policy makers to invest in rice research. In the 1970s, the wheat success story has been the major justification for both government and donor support for BARI. The hope for similar successes in maize, pulses, oilseeds and potatoes has motivated the large investment in that institution.

Encouraging governments to encourage the culture of wheat, potatoes and maize in regions where there is little demand for them, or where the growing conditions are far from optimal, is clearly questionable. However, there are examples of areas of Asia that were once considered to be unsuitable for production or where there was little demand, where HYV rice and wheat are now grown. The case of wheat in Bangladesh itself is a prime example. Bangladesh now needs to step back and ask whether this same strategy will work with maize and potatoes. Perhaps too many research resources are being devoted to them?

Table 3.2 Allocation of Agricultural Research Expenditures
(Tk 000 current)

Crop/ Institution	1950-1960	1960-1965	1967	1974	1979	1980
Rice	176[a]/	300	1,230	6,612	28,330	39,870
Other Food Crops	189[a]/	200	n.a.	12,531	77,153	129,230
Jute	153	500	2,000	2,159	10,210	11,000
Tea	0	n.a.	n.a.	2,233	6,015	5,110
Sugarcane	n.a.	70	101[b]/	550	10,330	13,590
BARC	0	0	0	n.a.	5,000	10,575
Livestock	n.a.	644	n.a.	2,800	n.a.	n.a.

a/ Expenditure on botanists multiplied by 1.5 to account for entomologist, plant pathologist and others.
b/ Budgets

Source: Pray and Ahmed (1985).

Table 3.3 Research Intensity[a] for Agricultural Research

Crop	1950s	1965	1967	1974	1979
Rice	0.04	0.04	0.12	0.26	0.67
Other Food Crops	n.a.[b]	n.a.	n.a.	2.20	8.00
Jute	0.29	0.61	1.78	1.50	2.60
Tea	n.a.	n.a.	n.a.	20.60	9.70
Sugarcane	n.a.	0.29	0.32	0.56	4.70

a = (value of agricultural research/value of output) x 100 at current prices
b = n.a.- not available

Source: Pray and Ahmed (1985).

3.3 Institutional structure

IRRI appears to have influenced the organizational structure of agricultural research in Bangladesh in several ways. One of the first things done after IRRI's initial work in Bangladesh was the organization of a multidisciplinary rice research program within the Agricultural Research Institute. Eventually, local rice research workers, with the help of IRRI and the Ford Foundation, were able to set up the relatively autonomous BRRI under the Ministry of Agriculture. The new institute was modeled closely on IRRI (Alim 1966). Instead of the disciplinary divisions of ARI, the divisions of the institute are the same as IRRI's (a) rice varietal improvement (b) physiology, (c) agronomy, (d) pathology, (e) entomology, (f) soil chemistry, (g) economics and statistics (h) rice technology (i) agricultural engineering and (j) communications. In addition, considerable emphasis was placed on multi-disciplinary, problem-solving research. To provide this interaction among disciplines, BRRI set up seven task forces which met three times a year to discuss the problems on which to concentrate, how these problems should be tackled, and to assign projects or parts of projects to individuals for implementation. The task forces deal with varietal improvement, fertility management, cultural practices, cropping systems, adaptive research and training, pest management and agricultural engineering.

3.4 Goals and priorities within the commodity program

The goals and priorities of the commodity research programs appear to have changed since they came in contact with the centers. It appears that, before 1965, rice specialists placed more emphasis on the t.aman crop and the aus crop with less emphasis on boro and b.aman. By 1961, 25 varieties of t.aman and 17 varieties of aus, 6 varieties of b.aman and 6 varieties of boro had been developed and approved for use by agricultural scientists of British Bengal and East Pakistan. With the success of IR8 in the boro season, more emphasis appears to have been placed on this crop, although t.aman and aus still received much attention. In contrast to the earlier period between 1967 and 1980, BARC reported that 6 varieties were released for the boro season, 3

for aus, 5 for the t.aman and none for b.aman (BARC 1983). More attention has been devoted to b.aman since 1975.

Local rice workers had already been searching for varieties that were both resistant to lodging and fertilizer responsive before IRRI arrived. They were involved in the FAO Japonica-Indica crossing program that was aimed at producing fertilizer-responsive varieties. One change after IRRI's involvement may have been to screen varieties at higher levels of fertilizer.

Another change seemingly associated with IRRI was the introduction of agricultural economists into multidisciplinary rice research teams. When IRRI staff arrived, there was no division of agricultural economics in the Agricultural Research Institute. The new rice research institute established a division of economics and statistics, and the project sent people for training in agricultural economics. The IRRI resident teams in recent years have included agricultural economists. Another change has been the introduction of cropping systems research by BRRI and IRRI staff in the mid-1970s. This represents a significant step towards implenting a farming systems research orientation to work in Bangladesh.

Both economics and cropping systems programs have helped to change research priorities in other areas by providing evidence that the prevalent priorities were incorrect or that there were new problems being faced by farmers. The studies of b.aman yields, which were carried out jointly by economists, entomologists and cropping systems agronomists, showed that the yield goals set by the breeders of b.aman were already being matched or surpassed by the yields of farmers (Clay 1978). This led to modification of research goals in the deep water rice program. The cropping systems workers played an important role in identifying zinc and sulphur deficiencies as important problems in some areas. This led to a major research and extension effort on these problems.

The potato program has had a more dramatic reorientation than either the wheat or rice programs. Most of the 1980 research resources, for instance,

were concentrated on testing Dutch and a few Indian varieties under high fertility conditions and good water control. Now the program is selecting varieties from a wide range of sources, including a number of tropical varieties. A breeding program has been established which uses both exotic material and material from a collection of local varieties that has been established. In addition, completely new programs have been started on inexpensive diffused light storage facilities, reducing the cash cost of potato cultivation, producing potatoes through true seed, and developing a disease-free seed production facility in northwest Bangladesh. The dramatic shift is due to the joint efforts of the BARI staff in the new Potato Research Center, CIP and IADS.

There was a quantum leap in the amount of potato genetic material screened. About 100 Dutch and Indian varieties were tested by BARI before 1980 (Ahmad 1980). In 1981-82, 2426 progenies from different families were tested in initial evaluation trials and 39 genotypes were studied in secondary and advanced variety trials (Sikka 1982).

Undertaking research as a multidisciplinary team seems to have been a concept introduced by the centers, and used most widely at BRRI and increasingly also at BARI.

3.5 New research methods

New techniques of rice breeding were introduced, as they were elsewhere in Asia. The use of new breeding techniques in maize is now practiced. In potatoes, CIP staff introduced new techniques such as the use of true seed to produce disease-free tubers, and possibly later for commercial production. Improved methods of screening varieties for resistance to pests have also been introduced.

Cropping systems research was first introduced to Bangladesh by BRRI/IRRI and later something of the CIMMYT version was taken up by BARC and

BARI with the assistance of IADS. This gave institutional sanction and resources to on-farm and interdisciplinary research.

3.6 Efficiency of the research system

A number of ways in which collaboration has affected the efficiency of the research system have already been discussed. There are, however, some further and more subtle effects. In general they are factors that motivate researchers to be more effective. The centers provide a new set of rewards for "good" research and in some cases have changed the definition of what "good" research is. "Good" research includes on-farm research that meets farmers' needs. Good research may or may not be publishable in a national or an international research journal - it depends on the center one is working with. Rewards include trips to other countries for conferences, scholarships for foreign degrees, approval and praise from a new group of peers - research and administrative personnel in the CGIAR networks in which Bangladeshi researchers participate - and ultimately perhaps a job at a centers or in other international organizations. In addition to rewards, the training programs of the centers emphasize certain types of research, such as on-farm research, which gives the research a more practical bent than perhaps would otherwise have been the case. While the definitions of good research may not have universal approval, it seems clear that they are superior to the old system where one was promoted primarily on the basis of years of service.

This influence of the centers can be detected in the styles of the research workers within the different national programs, which have varying level of contact with such outside agencies. A strong contrast can be easily observed, because of their geographic contiguity, between BRRI and BARI. The substantial interaction with IRRI has led to quite different working styles at BRRI where people tend to work long hours, especially in the field, relative to those of nearby BARI where there has been relatively little after-hours work, and the more senior research personnel seldom get into the field. Part of this is due to the housing situation, since there is insufficient housing at BARI, but much of it is also due to contact with centers. The wheat

program is the exception at BARI, which manifests the influence of CIMMYT on work styles. There is evidence that a period spent at a center encourages a more committed and effective attitude towards problem-solving work. Again, some of the more negative attitudes that may be in need of correction may emerge from research workers' early educational experience at BAU, where there seems little philosophy of "hands on work" with regard to agronomic and other research activities.

4 Local Perceptions of the Centers

4.1 Nature of collaborative research in Bangladesh

This section attempts to summarize the perceptions of the centers by the administrators and researchers of Bangladesh. It is based on discussions held by J.R. Anderson during a visit in March 1984 with the research administrators and program leaders of the national research system. In addition, a questionnaire was sent to a random sample of the research staff of the national agricultural research system. Forty scientists from a wide range of institutions and levels within those institutions replied in this first survey. The third major source of perceptions was the report of Dr Kazi M. Badruddoza (1984) "Training in the CGIAR System: The Case of Bangladesh" which reports on a survey of Bangladeshi scientists about the CGIAR training.

In general, the centers active in Bangladesh are highly regarded for their independence and objectivity. The fact that they are perceived as having ample resources to assist research and to provide opportunities for scholarships and communication with foreign scientists reinforces the positive feelings about the centers.

The two surveys indicated far more contact with IRRI than any other center. In the first survey IRRI had by far the greatest number of contacts, followed by CIMMYT, CIP, ICARDA, and IITA. In terms of training, IRRI had trained 242 out of a total of 431 trainees in CGIAR centers' training programs. CIP was next with 80 and then CIMMYT with 77. The others had 13 or fewer trainees.

The respondents in the first survey were asked to assess the importance of the centers in building up the national system. They felt that the centers were moderately active in Bangladesh. Not surprisingly, they rated IRRI and CIMMYT as the most active followed by ICARDA, CIP and ICRISAT. In addition, IRRI and CIMMYT were rated as the centers whose services were of most practical use and most helpful in building research capacity. There were too

few respondents to know which services were most important or which alternative source of information and services were important.

The major group which indicated they had had little or no contact with the centers were faculty members at the agricultural university and the biological and soil science departments of the general universities. Some of them received publications but few had any other contact. They stated that they would like to but have not had the chance.

The nature of the contacts came out especially in the longer discussions with senior officials. Most of the early center contact was with IRRI which, in the initial years, was perceived to be too "top down". Typically, IRRI staff were perceived as having too fixed an idea of what was needed within Bangladesh, without listening to the perceptions of local authorities. This was a problem with regard to some of the deficiencies in the varieties that were initially introduced, and with individuals being too dogmatic about a chosen research approach which frequently turned out to be inappropriate. It should be noted, however, that by the mid-70s, IRRI had learned from its early experiences. It had become much more sympathetic to the expressed local needs (e.g., for training) and is very highly regarded in Bangladesh in recent years. There are broadly similar experiences with regard to CIMMYT within the country. Perhaps profiting from the experiences of others, CIP has done a rather better job, in spite of some criticisms that it may be too blind to agricultural realities beyond potatoes. Such enthusiasms, however, are inevitable with commodity-specific centers.

The germplasm received from the centers has been a major input into the research system. In the first survey it was the second most frequent contact point with the centers, following publications and slightly ahead of training. It was also rated as one of the most important services provided by the centers. Discussions with research leaders also emphasized its importance.

A number of scientists mentioned the importance of even small amounts of external assistance. For instance, the external assistance to the rice

research program provided by the Ford Foundation, USAID, and Australian and Canadian sources oftentimes proved very useful in eliminating the impact of domestic constraints on operation. For example, there are many difficulties in importing scientific equipment through very restrictive input regulations. International organizations sometimes can help to circumvent these and thus to facilitate more effective research implementation. Similarly, there are many constraints imposed on travel arrangements of Bangladeshi research personnel. Most junior officers cannot use aircraft for domestic travel, which can conceivably hamper flexibility and perhaps the critical timing of, for example, a visit to an outbreak of a rice disease in a distant part of the country. Relatedly, there are many restrictions on travel outside Bangladesh by research personnel at all levels. Intervention by the centers can and does help to relieve some of the restrictions.

The usefulness of these key inputs from the centers is, in part, related to the usefulness of foreign aid in general, whether it is distributed by the centers or other agencies. However, in the absence of the centers, it is not clear whether these resources would indeed be available to the country, and if they were, if they could be protected from the viscitudes of the regular budgetary process.

Both IRRI and CIMMYT have actively fostered FSR-related type activities in Bangladesh. Local authorities see this as being important in broadening the perspective of agronomic and related research. They see a continuing need for the centers in such fledging work. There is still some distance to go in matching experimental orientation with on-farm reality. For instance, it seems that most of the research sites claimed to be "rainfed" have, in fact, been irrigated.

The area of human capital improvement is the main topic of Dr. Badruddoza's report, and so some of the main points of his report are taken along with observations from our own field discussions. There is considerable agreement that this is one of the major contributions of the centers. Short-term training has been the most important in terms of numbers of people.

However, there is a continuing need for assistance to accomplish more degree training.

The practical character of training at the centers was particularly appreciated. "Trainees are required to spend a considerable part of their time in the field or laboratory and learn practical research methods applicable to actual field conditions. This is a contrast to other training programs where emphasis is placed on classroom study. The general feeling and experience is that IARC training programs assist in development of practical vision and an ability to handle field programs more efficiently" (Badruddoza 1984).

The centers have regularly played a "brokers'" role of placing people effectively in advanced tertiary institutions or in appropriate training. This brokerage role depends on informal contacts with the concerned institutions and in some cases also involves a period at a center for thesis work that is perceived to be more relevant than the typical thesis work conducted in temperate-climate advanced educational institutions.

4.2 Concerns

There has been some criticism expressed in the country as to the degree of "pampering" by the centers of domestic institutions. Part of this criticism relates to judgements about the inherent qualities of local staff who, in some cases, have been perceived as not really being adequately prepared for effective collaborative work. Some of this criticism is directed at the style of teaching at the Bangladesh Agricultural University (BAU) which, at least in some departments, may offer professional preparation of a somewhat limited level of achievement, especially in regard to developing capacity for independent thought.

One high-level bureaucrat expressed a fresh perspective on combinations of multilateral and bilateral assistance. The concept was one of "mixing one's drinks" in assistance terms, because, when both are somewhat

competitively supplying assistance, the recipients can easily become intoxicated by the readiness with which resources are made available to them. The implication is that some research institutions have more resources than they can effectively handle at the moment.

Some concern was expressed about representation on boards of governors of the centers. The main concern was that, if partner governments did not have direct representation on such boards, unfortunate gaps could develop between what centers perceived to be national priorities and those articulated within the government concerned. The criticism being expressed was that centers really needed an "official" brief from the partner governments to facilitate maximal coherence with individual national priorities.

With regard to training, it is felt by some reflective observers in Bangladesh that the CGIAR system should switch its emphasis from short-term training to more advanced degree training, to help develop greater leadership capability within the national system. It was also felt that the in-country and regional training programs in Bangladesh by CIP are examples of what should be done in the future for short-term training.

One significant issue that has not yet been adequately addressed in the research programs concerns soil salinity. Apart from some rice selection work in Barisal nothing of substance has yet been done to address this problem, but it is to be hoped that eventually the national and international institutions concerned will embark with some vigor on plant selection and a search for agronomic practices to mitigate the influences of high levels of salt on agricultural productivity.

One suggestion that emerged from discussions with senior officials in Bangladesh concerned the staffing arrangements of the centers with personnel from partner countries. The idea was that a period of service in an international center could be useful to a national research worker, but the tendency is for such people to be economically and bureaucratically "trapped" for longer periods, after which it is difficult for them to reenter the

professional service from which they departed. If centers had a rule for a fixed maximum term for all their staff, this would facilitate an exchange arrangement with national personnel into center staff with mutual benefit all around. It must admitted that this would force additional difficulties in an already challenging recruiting environment for all the centers but, given the tendency to experience differential turnover rates among different nationalities, there may well be merit in such a suggestion.

The centers have been criticized by some for their lack of strong attention to developing "appropriate" technologies in the field of mechanical aids in general. The machines developed by IRRI, for example, are not as low in cost as they could be. For instance, some of the NGOs working in Bangladesh have developed extremely low-cost irrigation pumps which seem appropriate for their simplicity of construction and their reliance on mainly local natural materials, such as bamboo. IRRI has recently acquired a copy for study in the Philippines. Government agencies in general tend to be mostly concerned with the technological problems of large-scale farmers and tend not to concentrate on the problems of small-scale farmers.

The complex problems inherent for international organizations working in difficult environments are epitomized by the work on deep-water rice. On the one hand, IRRI has been criticized by many for not giving sufficient attention to improvement in this form of production. On the other hand, in spite of the considerable effort that has been addressed to this particular difficulty, which is particularly a problem in Bangladesh and other delta areas in Southeast Asia, there has been very little progress made. Such are the challenges of development.

5 Impact on Other Institutions

5.1 Extension

The Bangladesh Agricultural Development Corporation (BADC) has improved the effectiveness of its seed production capacity through its contact with the centers. The main direct contact has been through training at the Centers. BADC staff members have attended courses on seed production and farm management at IRRI, CIMMYT and CIP. BADC expanded greatly with the increased demand for improved seeds, fertilizer and irrigation that the HYVs of rice and wheat inculcated. In recent years, its importance has declined somewhat as private companies have been allowed to play a larger role in the distribution of inputs, but its rapid growth in the late 1960s and the decade of the 1970s was due in large part to the research activities both nationally and internationally.

BRRI and BARI have been actively working to close the gap between research and extension. The IRRI rice production specialist works full time on this activity. Some extension staff from both the Department of Agriculture and the Water Development Board have gone to IRRI for training on various aspects of rice production. Since June 1974 more than 2000 people have graduated from BRRI's various short courses. This includes 337 people who have graduated from the 4-month rice production course. Nearly 200 of the people from the 4-month course were mid-level technicians from the Extension Service of the Ministry of Agriculture. In total, almost 600 extension personnel have received some training (IRRI 1984). They also include agents from the Water Development Board, NGOs and BADC. BRRI staff have then provided technical backstopping to these agents on their return to the field. In addition, these extension agents are then involved in BRRI's various networks like the advanced-line adaptive research trials, the farmers' varietal observation trials, and the multilocation testing of the farming systems network. BARI is carrying out similar programs to improve the links with extension. They have been particularly successful in the northwestern

part of the country, where a World Bank project has been fostering these links as part of a project to strengthen extension.

BRRI and BARI have had active contact with the agricultural programs of the NGOs. IRRI staff members have been active participants in ADAB (Agricultural Development Agencies in Bangladesh) which is the umbrella organization for many of the NGOs working in agriculture. BRRI and BARI staff have provided articles to the ADAB newsletter, made presentations to ADAB meetings, and visited the sites of NGOs in the villages. The wheat, maize, and millets, programs at BARI have also worked closely with those NGOs that have more technical capacity. The Mennonite Central Committee, in particular, has had close links with BARI as well as BRRI. It tests their technologies and participates in their training and workshops.

Another important link with the NGOs is the BRRI cropping systems network. This network contains sites that are run by various NGOs. BRRI has provided training, technical backstopping and, in some cases, materials such as the seed of new varieties for testing. The network meets at least once a year to discuss results and to plan the next year's activities. This network provides the NGOs with the latest technology from BRRI which is spread through their organization, and provides BRRI with information about the problems of farmers. Zinc deficiency has been discovered at several of the NGO sites and applications of zinc fertilizer allowed some farmers to grow their first successful crop in years.

5.2 Policy

Senior scientists from BRRI and BARI play an important role in formulating the seasonally intensive rice and wheat production schemes that the extension service and BADC carry out.

Most of IFPRI's impact has been through and on organizations that are not primarily agricultural research institutions. These include the Bangladesh Institute of Development Studies (BIDS), the Planning Cell of the

Ministry of Agriculture, and the Planning Commission. The joint research project on food aid with BIDS shifted some BIDS resources to an examination of this topic that is very important in Bangladesh. IFPRI publications have been widely circulated as models of policy research analyses. In addition, the knowledge embodied in the IFPRI staff and its published research has influenced the policy of international organizations such as IFAD and the World Bank when their staff members have worked as consultants in Bangladesh.

6 Impact of Collaborative Research on Farmers and Consumers

6.1 Productivity growth

Agricultural productivity has risen slowly in Bangladesh. The estimate of the growth in output for the period from 1948 to 1981 is 2.4 percent, while total factor productivity has increased by 0.78 percent annually (Table 6.1). Figure 6.1 shows the growth of output, inputs and productivity for the period. For the first decade after Independence from Britain, productivity declined. Since then there has been slow growth. Figure 6.2 indicates that there was almost no growth in land inputs, while current inputs grew from a very low base at a high rate - almost 6 percent annually. The data on individual crops (Table 6.2) show considerable diversity among crops and periods. The three crops which had the largest increases in yield per unit area for the whole period were boro rice, wheat and potatoes. The growth in the first two was surely largely due to the collaborative research of the NARS and the IARCs. The growth in potato productivity came largely in the 1960s before CIP existed.

The impact of the collaborative work of the IARCs and the Bangladesh NARS has come primarily through the development of the new varieties and the practices that are related to them. The main wheat and rice varieties that have at least one parent from the centers are listed in Table 6.3. The spread of HYV rice and wheat is shown in Table 6.4.

The problem of attribution in plant breeding work is epitomized by the Bangladesh wheat experience. The most important variety was Sonalika, bred in India using materials from CIMMYT and its predecessors based on "Mexican" material which actually had most of its origins in the USA and Japan. This is a clear case of successful transmission of technology across national boundaries, with assistance from multilateral support agencies such as CIMMYT. Related to the difficulties in attribution is the appropriate costing of the plant breeding materials that are used in the programs of selection for improved varieties, but which never find their way into the final selections.

Table 6.1: Analysis of Agricultural Growth

		FY48-FY81	FY48-60	FY60-FY71	FY71-FY81
1.	Total Production	2.40	0.41*	2.12	3.53
2.	Total Conventional Inputs	1.62	1.15	1.82	2.56
3.	Total Factor Productivity	0.78	-0.74	0.29*	0;97
4.	Net Sown Area: (NSA)	0.12	0.22	0.43	-0.06
5.	Net Cropped Area: (NCA)	1.10	0.08*	2.07	0.89
6.	Male Agricultural Labor Force	1.77	1.79	1.41	2.77
7.	Draft Animals	0.84	0.98	0.80	1.27
8.	Value of Capital Services	1.19	1.00	1.44	1.58
9.	Value of Current Inputs	5.60	1.77	8.77	6.49
10.	Fertlizers	20.58	24.22	21.89	12.46
11.	Irrigation	8.29	3.81	14.03	3.55
12.	Labor Productivity	0.63	-1.38	0.71*	0.76
13.	Land Productivity: NSA basis	2.28	0.19*	1.68	3.53
14.	Land Productivity: NCA basis	1.30	0.33*	0.04*	2.64
15.	Percentage of Area Under HYV Crops	62.94	0.00	89.50	14.45
16.	Research Expenditures	10.61	12.73	13.36	17.67
17.	Literacy	0.21*	-2.48	1.55	1.62

* Not significant at the 95% level.

Source: Pray and Ahmed (1984).

Figure 6.1: Index of total output, total input and total productivity
(Using Revised Time Series Data)
(Base 1957/48 = 100)

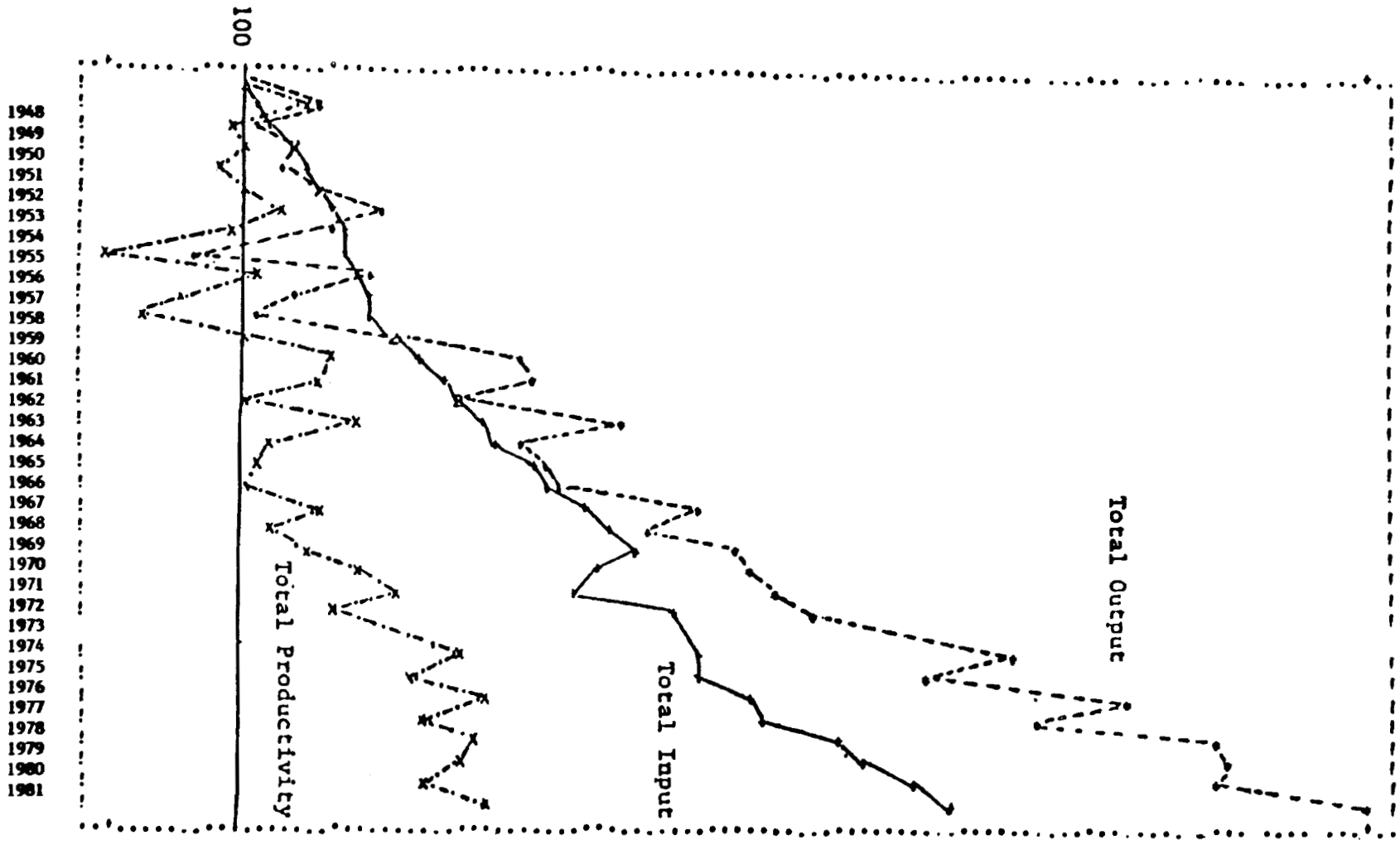
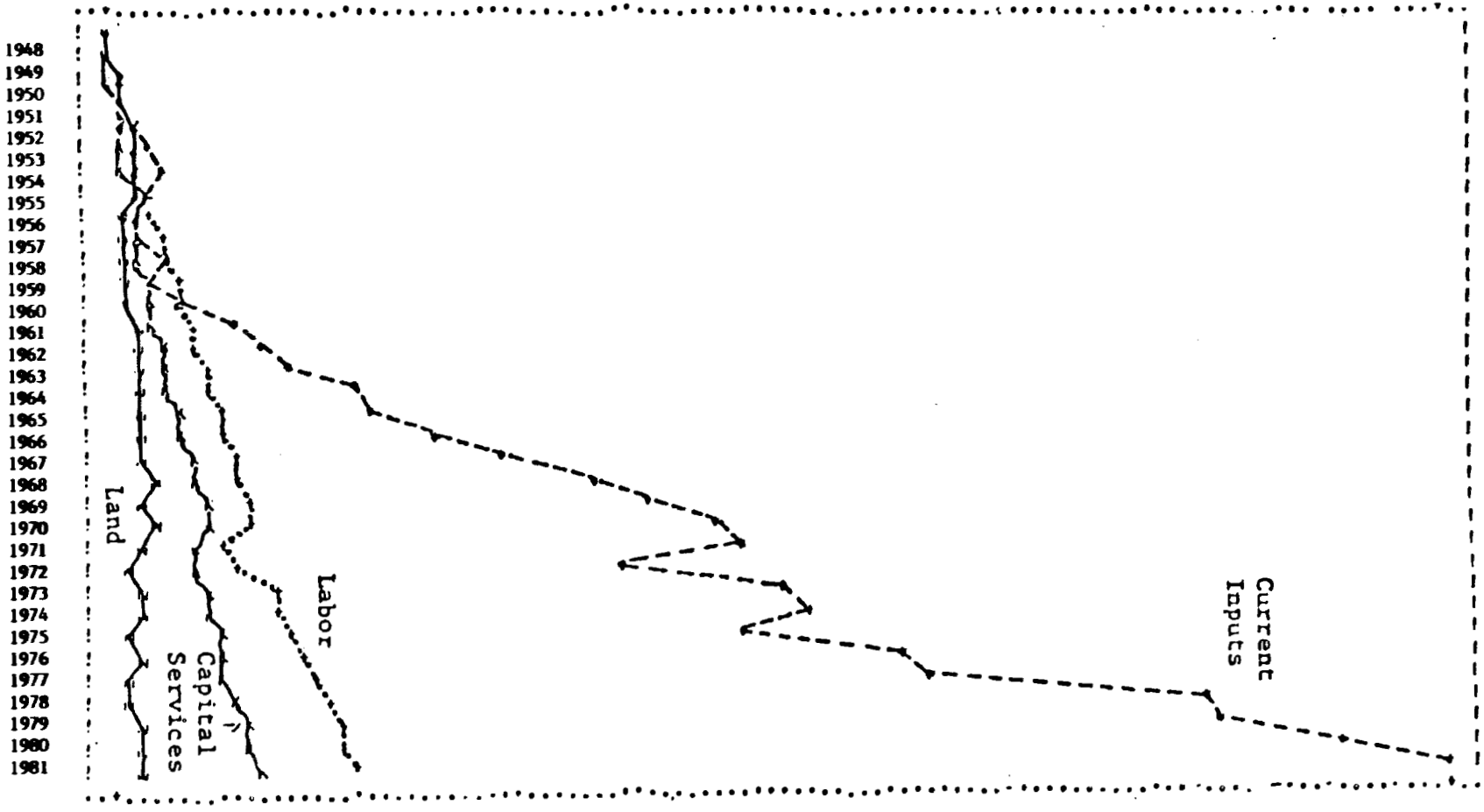


Figure 6.2 Indexes of Inputs Used in Agricultural Production
(Official Data)
(Base 1947/48 = 100)



Bangladesh

Table 6.2 Annual Rates of Growth of Major Crops: Production, Area, Yield

Crops	1947/48-1980/81	1947/48-1959/60	1959/60-1970/71	1970/71-1980/81
Rice Total				
Production	2.03	0.63	2.37	2.76
Area	.88	0.43	1.62	0.67
Yield	1.15	0.20	0.75	2.09
Aus Rice				
Production	2.39	3.18	2.73	2.46
Area	1.60	1.92	3.25	0.24
Yield	0.79	1.26	-0.52	2.22
Aman Rice				
Production	1.04	-0.20	0.17	3.27
Area	0.13	-0.13	0.09	0.71
Yield	0.91	-0.07	0.08	2.56
Boro Rice				
Production	7.98	1.42	16.06	1.54
Area	4.92	0.24	8.80	1.70
Yield	3.06	1.18	7.26	-0.16
Wheat				
Production	10.47	2.33	11.94	24.94
Area	6.82	2.53	7.53	14.63
Yield	3.65	-0.20	4.41	10.31
Pulses				
Production	-0.94	-2.21	2.55	-1.72
Area	-1.12	-2.12	0.39	0.29
Yield	0.18	-0.19	2.16	-2.01
Oilseeds				
Production	1.56	1.27	4.96	-0.39
Area	0.21	1.19	-0.03	0.09
Yield	1.35	0.08	4.99	0.48
Sugarcane				
Production	2.66	1.46	7.38	0.53
Area	1.85	1.72	4.02	0.23
Yield	0.81	-0.26	3.36	0.30
Potato				
Production	6.24	0.37	11.23	2.02
Area	4.18	0.52	5.43	2.18
Yield	2.06	-0.26	5.80	-0.16
Tobacco				
Production	0.08	-2.48	4.25	2.57
Area	-0.01	-1.69	0.68	2.52
Yield	0.09	-0.79	3.57	0.05
Jute				
Production	-0.06	0.14	1.40	-0.02
Area	-0.90	-2.76	.24	-1.58
Yield	.84	2.90	1.16	1.56
Tea				
Production	2.06	4.60	2.88	7.03
Area	1.58	0.54	3.57	-0.35
Yield	0.48	4.06	-0.69	7.38

Source: Pray and Ahmed (1985).

Table 6.3 Rice and Wheat Varieties from CIMMYT and IRRI

Variety	Pedigree	Parentage
Purbachi	Chen-chu-ai	
Pajam	(not ackowledged as official)	
IR8	IR8-288-3	Peta/Dee-gee-woo-gen
BR1 (Chandina)	IR532-1-176	Peta*3/TN1/TKM-6
BR-2(Mala)	IR272-4-1-2	CP-SLO*2/Sigadis
BR-3(Biplab)	BR27-10-1	IR506-1-133/Latisail
BR-6(IR28)	IR2061-214-3-8-2	IR833-6-2-1-1/IR156-149-1/IR737
BR-7(Brribalam)	IRR2053-87-3-1	IR1416-131-5/IR22//C4-63
BR-8(Asha)	BR167-2B-9	IR272-4-1-2/IR305-3-17-1-3
BR-9(Sufala)	BR169-1-1	IR27-4-1-2-3-10/IR8
IR-5	IR547-2	Peta/Tangkai Rotan
IR-20(Irrisail)	IR532-E-576	Peta*3/TN1/TEM-6
BR-4(Brrisail)	BR51-91-6	IR20/IR5-114-3-1
BR-5(Dulahhhog)		Pure line
BR-10(Progati)	BR51-46-5-HR65	IR20/IR5-114-3-1
BR-11(Mukta)	BR52-67-1-HR88	IR20/IR5-47-2

In addition, the following four varieties have been recommended by BRRI for release, but the recommendaion has not yet been acted on by seed authorities.

BR12(Moyna)	BR161-2B-58	Chandina/IR425-1-1-3-8-3
BR14(Gazi)	BR319-1-HR28	IR(d)/BR3
BR15(mohini)	IR2071-199-3-6	IR561-228-1-2/IR1737//CR94-13
BR16(Shahibalam)	IR2793-80-1	IR416-131-5/IR1364-37-3-1//IR1514A-E666

Variety	Mexican Designation
Mexicpak (Kalyansona)	Siete Cerros
Sonalika	(53-388-AN x Pi"S"-LR)(B4946-A4-18 x Y53)Y50[3]
Tanori 71 Jupataco 73 Norteno 67	
Balak	(selection from CIMMYT material)
Doel Inia 66 Akbar Anada Barkal Kanclam	(selection from CIMMYT material)

Sources: Rice varieties - personal communication, Clarence Miller, IRRI agricultural economist at BRRI.
Wheat: Dana Dalrymple and BARC

Table 6.4 Acres of Rice and Wheat Varieties

	Boro			Aman			Aus		All Seasons		Wheat	
	Total HYV	Pajam	BRRI	Total HYV	Pajam	BRRI	Total HYV	BRRI	All Rice	%BRRI	HYV	Total
1968	156		156					156	24427	1	3	192
1969	360		360	5		5	17	382	24568	2	13	290
1970	580	0	580	29	0	29	43	652	25486	3	23	296
1971	857	18	839	200	83	117	17	1028	24494	4	33	311
1972	795	35	760	428	167	262	96	1117	22975	5	43	314
1973	1088	53	1035	763	260	513	114	1663	23796	7	53	297
1974	1454	70	1084	1032	333	699	197	2280	24410	9	72	305
1975	1629	88	1541	1064	416	648	489	2678	24197	11	81	311
1976	1587	105	1482	1182	500	683	667	2831	25525	11	218	371
1977	1338	123	1215	1278	583	695	800	2710	24419	11	288	395
1978	1587	131	1456	1283	666	617	883	2956	24778	12	389	467
1979	1650	167	1483	1923	821	1112	1002	3597	24992	14	583	642
1980	1788	224	1564	2154	1028	1126	984	3684	25106	15	1015	1071
1981	1845	216	1629	2376	1183	1193	1200	4022	25474	16	1412	1461

Source: Bangladesh Bureau of Statistics, Agricultural Yearbook of Bangladesh, Dhaka. Various years. Ahmed and Pray 1980.

An appropriate costing of these related activities would somewhat inflate the rather low cost of research which has been attributed in attempts at evaluation of the net benefit of agricultural research (e.g., Gill 1982).

The earliest estimate of returns to research in Bangladesh (Pray 1979) found rates of return above 30 percent. The results of that work have been updated (by C. Pray) to include more recent data on the spread of HYVs and on the shift in the supply curve due to research. The more recent data on the shift of the supply curve come primarily from a study by IFDC and BARC (Sidphur, Boanante and Ahsan, 1984). In addition, more accurate research and extension expenditure data was refined and used.

The measure used in the process of computing rates of return is the total economic surplus from new technology, computed according to the framework and simplified parametic specifications by Hayami and Akino (1977). For brevity, these and other detailed assumptions reported by Pray (1979) are not repeated here. If it is assumed that research affects output with a 12-year lag, and that extension does not contribute to the spread of technology, the rates of return are between 31 and 37 percent. The fact that the important rice variety Pajam spread rapidly, despite the recommendations of extension that it should not be used, indicates that extension may not have had a great deal of influence in the adoption of at least some innovations. Alternatively, if it is assumed that both research in the previous 12 years, and extension expenditure in the previous year are influential in affecting output, the rate of return to research and extension expenditure falls to something between 23 and 32 percent.

About 60 percent of the observed variance in a time series of agricultural productivity since 1960 can be explained by simple regressions on HYV area (Pray and Ahmed 1985). Research expenditure itself can similarly explain over 70 percent of such variation. These associations are also supported by analyses of cross-sectional district-level data for 1977 and 1981 (Pray and Ahmed 1985). In short, from such statistical association as well as from casual empiricism, there seems little doubt that agricultural research,

especially through the success of modern cereal varieties, has indeed been a signficant engine of agricultural productivity and economic growth in Bangladesh.

The International Fertilizer Development Center (IFDC) and BARC conducted a study of about 2000 farmers in most districts of Bangladesh. In their study they estimated production functions for each crop season by variety. Their results (Table 6.5) show that, even at low levels of fertilizer use, HYVs give yields superior to the local varieties.

6.2 Income distribution effects of HYV technology

There has been considerable concern in Bangladesh about the distributional aspects of HYV adoption. In this section an attempt is made to piece together the available evidence on the contribution of HYVs to changes in the distribution of income in Bangladesh.

6.2.1 Long-run trends in rural income and asset distribution

By most indications, the per capita real income in rural areas has registered a decline over the past two decades, and the vast majority of the rural poor have been caught in the grip of increasing impoverishment. "....this process of impoverishment may, in part, be a reflection of growing inequality in rural Bangladesh" (Islam 1981).

In the late 1960s, Bose (1968) concluded that per capita agricultural income had declined over the entire period of the 50s and 60s except for 1963/64. More recently, Khan (1976), using energy requirements to define poverty, has shown that there was an increase in the incidence of poverty over the 15 years from 1960. Especially alarming was his finding that the "extremely poor" (those whose energy intake is only 80 percent or less of "requirements"), as a proportion of the rural population, increased eightfold over the period.

Table 6.5 Size of Holdings (acres)

	< 0.5	.5-1	1-1.5	1.5-2.5	< 2.5	2.5-7.5	7.5 >	Total
Area Under HYVs (1000s)	16	77	147	364	604	1079	531	2214
Percent of total gross cropped area under HYVs	10.2	10.5	9.8	9.1	9.4	6.8	5.7	7.0
Percent of total gross cropped area fertilized	34.2	35.8	34.6	31.9	33	25.8	22.9	26.4
Percent of total gross cropped area irrigated	9.9	10.2	9.8	8.9	9.3	7.2	7.3	7.6

Source: BBS (1980)

However, other empirical studies do not support the conclusion that inequality has increased. Alamgir (1974) found that, while the percentage and absolute sizes of the rural population in poverty increased between 1966/67 and 1973/74, the Gini coefficient showed little change. The Agricultural Censuses of 1977 and 1960 indicate that the major change has been a concentration of holdings in the medium size farm (2.5 to 7.5 acre) category (Table 6.6). In addition, the average size of the small holdings increased and the proportion of total area held by small farmers increased. At the same time, the proportion of land owned by "large"-scale farmers decreased from 38 to 32 percent. Thus, the Gini coefficient for land holdings indicated lessening inequality between 1960 and 1977.

The absolute number of landless is clearly increasing (Khan 1977, Singh 1979). There is also evidence that the percentage of landless households is increasing and that poorer farmers are selling their land (Alamagir 1976, Islam, 1981). Thus, although the distribution of land among landholders is less unequal, for the rural population as a whole, the distribution of the major asset in Bangladesh agriculture - land - may have worsened.

Several researchers (Bose 1968, Clay 1976, Khan 1977) have found that real wages in agriculture declined between the early 1960s and 1970s, with especially sharp declines for the post-liberation period. There is, however, some evidence that the decline may have stopped and perhaps even turned around slightly (IBRD 1984). Smaller farmers and landless laborers have a high dependence on wage incomes (Alamgir 1976, Islam 1981). Therefore the decline in real wages led most scholars to conclude that the living conditions of the landless and near-landless (about half the rural households) must have worsened in the face of small increases in employment opportunities. Further, some scholars suggest that the larger-scale farmers enjoyed a substantial improvement in their living conditions by selling surplus grain at prices that were increasing faster than the general cost of living and through greater access to subsidized credit and purchased inputs. They hypothesize that, since the HYV technology is of the land- augmenting type and land is very

Table 6.6 Distribution of Land 1960 and 1977

		0-2.5	2.5 - 7.5	7.5+	Total
Percent of farm holdings	1980	51.6	37.5	10.7	100
	1977	49.7	40.8	9.4	100
Percent of farm area	1960	16.2	45.7	38.1	100
	1977	18.7	48.9	32.4	100
Average farm size (acres)	1960	1.1	4.3	12.6	3.5
	1977	1.3	4.2	12.1	3.5

Source: BBS (1980).

unequally distributed, the benefits from increased output and efficiency must acrue mainly to those who control the land.

6.2.2 Large vs. small farmers vs. tenants

Several nationwide studies have been made of the use of new technology by farm size and tenancy status. The Agricultural Census showed (Table 6.6) that the proportion of cropped area under HYV paddy is inversely related to farm size. Thus, the farmer with less than an acre of land on average placed 10 percent under HYVs, while the large-scale farmers placed less than 6 percent of land under HYV paddy. The Agricultural Census data on fertilizer use show the same pattern - small-scale farmers fertilized one-third of their land compared to one-quarter by the medium and large-scale farmers. In 1979/80 the IFDC and BARC study (Sidhu, Baanante and Ahran 1982) indicated that the smallest-scale farmers on average used more fertilizer per acre than others (Table 6.7). More fertilizer per acre was used on sharecropped and rented land than on owner-operated land. For the nation as a whole, Januzzi and Peach (1980) found that owners, owners-cum-tenants and tenants all exhibited very similar rates of adoption of modern inputs - chemical fertilizers, pesticides, power irrigation, mechanical irrigation and other irrigation. Thus, there appears to be no overt disadvantage experienced by small holders or sharecroppers.

The majority of the scattered micro-studies indicate that small-scale farmers as well as the large-scale have been responsive to the new technology (Muqtada 1975, Bose 1974, Faidley and Esmay 1976, Asadussaman 1972). Asaduzzaman (1979) and Rahman (1981) found that, while the proportion of adopters is lower among the small-scale farmers, once they adopt, they devote proportionately larger areas to HYVs.

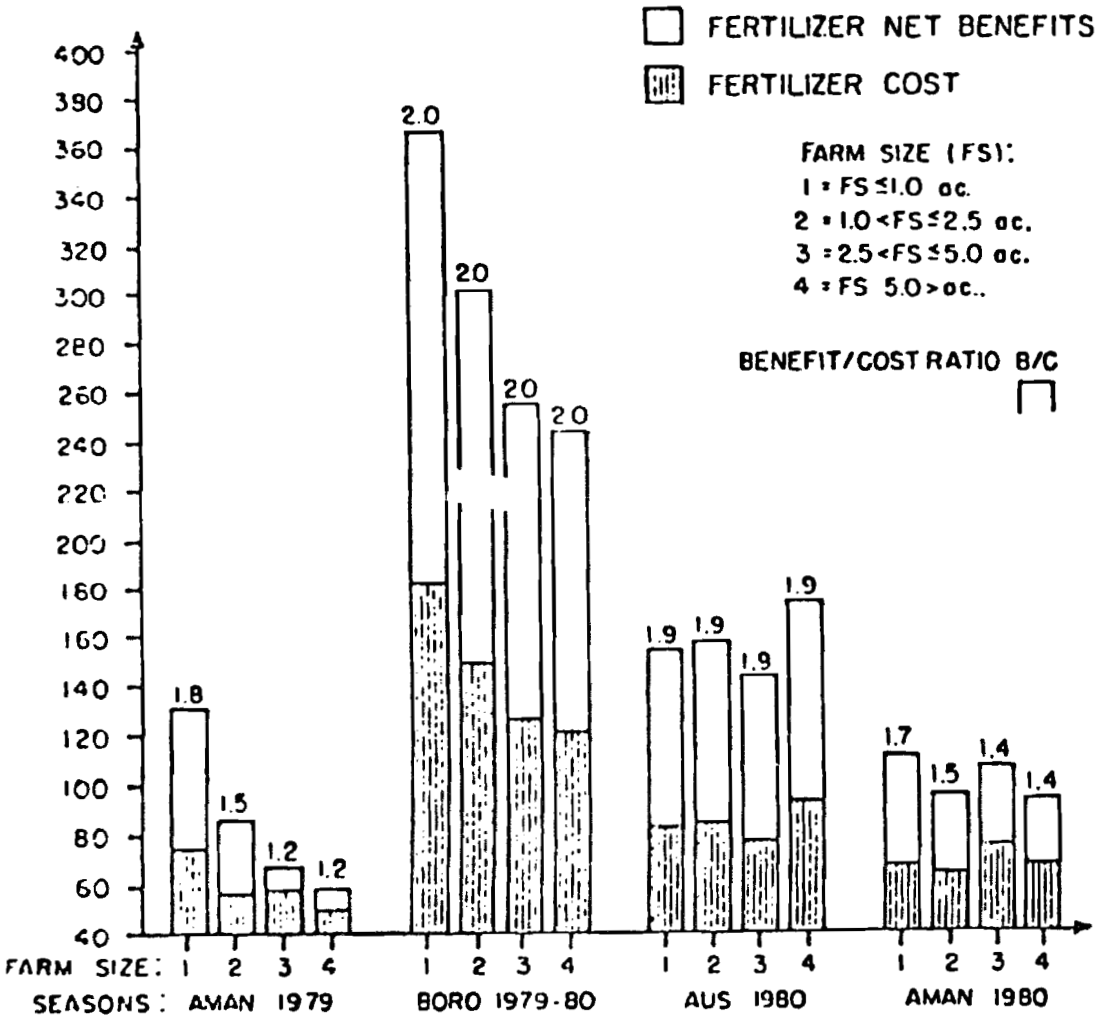
The IFDC/BARC study (Sidhu, Bannati and Ahaan 1982, 1984) is the only one available which estimates the impact of a "new" technology - in this case fertilizer - on the incomes of different farm size groups. The results (Figure 6.3) indicate that, with the exception of the aus season, small-scale farmers enjoyed more net benefits per unit area than others. It was also

Table 6.7 Average Levels of Use of Fertilizer(s) on Owner-Operated, Sharecropped, and Rented Land in Munds Per Acre of Cropped Land Per Farm by Farm Size and Season, 1979/80, Bangladesh

	On Owner-Operated Land			On Sharecropped Land			On Cash Rented-In Land		
Farm Size (FS)	Boro 1979/80	Aus 1980	Aman 1980	Boro 1979/80	Aus 1980	Aman 1980	Boro 1979/80	Aus 1980	Aman 1908
0 < FS < 1.0	1.23	0.83	0.79	1.41	0.68	0.77	2.67	1.78	1.26
1.0 < FS < 2.5	1.20	0.72	0.75	1.09	0.51	0.69	2.20	1.14	0.95
2.5 < FS < 5.0	0.93	0.68	0.85	1.04	0.57	0.68	2.55	1.87	0.96
FS > 5.0	1.12	0.78	0.79	0.95	0.77	0.74	0.75	0.97	0.93
All sample	1.13	0.74	0.80	1.23	0.61	0.74	2.66	1.60	0.95

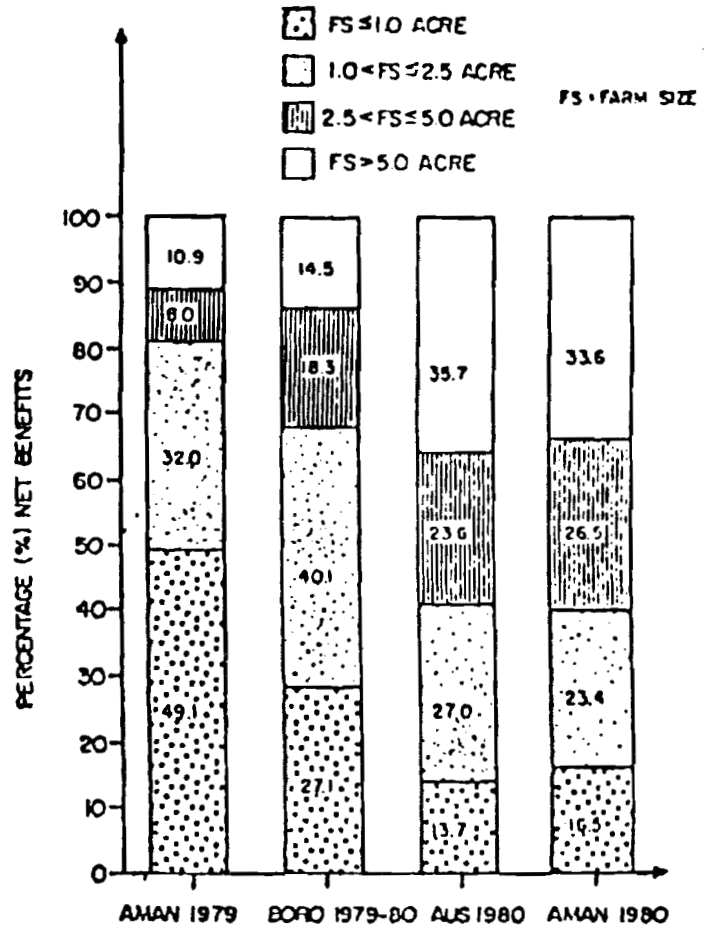
Source: Sidhu, Baanante and Ahsan (1982)

Figure 6.3 Farm-Level Average Benefits of Fertilizer Use by Farm Size by Season, 1979/80, Bangladesh.



Source: Sidhu, Baananti and Ahram (1982).

Figure 6.4 The Sample Distribution of Benefits of Fertilizer Use Among Farmers by Farm Size, 1979/80, Bangladesh.



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shown (Figure 6.4) that, by combining net benefits per unit area and farm size, more than half of the total net benefits from fertilizer use went to farmers with less than 2.5 acres in the 1979 aman and 1970-80 Aman crops, and about 40 percent in the 1980 aus and aman crops. Thus, fertilizer use did not worsen income distribution and, in the season when the most HYVs are used (boro), it actually improved the income distribution pattern among land owners.

6.2.3 Landless laborers

One of the major advantages of new HYV technology for a country with a growing labor force is its greater requirement of labor. It is hypothesized that, with the application of land-augmenting or yield-raising technology, labor requirements per unit area and the demand for labor will increase. Further, a rise in incomes as a result of the new technology will lead to some substitution of family labor by hired labor.

Until recently, the data on real agricultural wages indicated a decline from the level reached round 1964. Since this was the same time at which HYVs, the use of fertilizer and irrigation started to spread, some investigators concluded that the landless have failed to benefit from the increased productivity of the HYVs and that inequality in the countryside has increased (Islam 1981). However, this argument ignores the very large increase in the supply of labor due mainly to population growth. This large shift in supply during a time that demand for labor was growing (albeit slowly) due to modern technology, on balance pushed wages down. In the absence of HYVs, real wages would have fallen even farther than they did. Khan (1984) showed that real agricultural wages between 1949 and 1980 were positively related to agricultural productivity and the relative price index for agriculture, and negatively associated with the trend variable, which he associated with the rapid increase in supply of labor, the closed land frontier and slow growth in demand for labor.

The most recent data on real agricultural wages seem to indicate that wages reached their lowest level in the mid-1970s. Table 6.8 shows nominal

and real wage indices as calculated by the World Bank, using official government wage data. The average index for the years 1973/74 - 1977/78 was 70, and during the next five years 80, - a 15 percent increase. While seemingly no one has analyzed this phenomenon thoroughly, it is likely that modern agricultural technology was responsible for part of the increase.

The empirical evidence of increased demand for labor as a result of switching from the traditional varieties to the HYVs seems conclusive for Bangladesh. Virtually all micro studies found considerably higher labor requirements with the new technology: Muqtada (1975), Ahmad (1980), Ahmed (1976, 1977), Clay and Khan (1977), Hossain (1980), Faidley and Esmay (1976)), Sidhu, Baanante and Ahsan (1982) and Clay (1978). Ahmed (1983) found that the shift to HYVs not only increased hired laborers' real income but also increased their share of income, except where there was mechanized cultivation. It would seem that, with increased labor demand, the "trickle-down" effect of the HYV technology would be vindicated. However, there are several caveats.

First, Clay (1977), and Khan and Clay (1978) have warned that the previous reviews of agricultural employment may have been too optimistic in that the evidence does not support employment elasticities (the ratio of the percentage change in employment for a percentage change in productivity per unit area) of more than 0.5 for the switch to HYVs. More importantly, some changes in cropping patterns resulting from the introduction of HYVs may have actually decreased aggregate employment. There are some cropping patterns where the introduction of the new technology led to the substitution of one new HYV crop in place of two traditional crops, leading to a lower aggregate level of employment.

Second, the seasonal nature of employment in Bangladeshi agriculture may make some of the employment-generating effects of the new technology less beneficial for hired labor than the aggregate increase in demand for labor would seem to imply. It has been found (Hossain 1981) that, when the demand

for labor increases, only 50 percent of the increase will be provided by hired labor.

Clay (1978) noted "that most of the new rotations involve either a switch of activity into the winter months or substantial additional demand for labor during the winter months; but again, careful inspection shows that, in most cases, there is no marked increase in labor requirements during the slackest period (September-October). Intensification of crop rotation and the expansion of irrigated cultivation in Bangladesh in most cases significantly increases labor requirements, but does not remove the marked seasonality from crop production activity."

In contrast to the situation in India and Pakistan, where agricultural research and new technology have been associated with labor-saving mechanization, Bangladesh has largely avoided this problem. The one type of mechanization which has been adapted widely is mechanized irrigation. This has increased the demand for labor, and it comes in all sizes from various types of hand and foot operated tubewells, to small mechanically powered tubewells which can irrigate about 15 acres, to large tubewells which can irrigate up to 200 acres. It is not clear that the government has always encouraged the use of the type of tubewell with the most appropriate capital to labor ratio, but at least it has not encouraged mechanical cultivation which many studies have found decreases the demand for labor without increasing output per unit area. At the agricultural census of 1977, there were 3454 tractors and 738 power tillers in use compared to 58,844 power pumps for irrigation (BBS 1981). One type of mechanization that the government has encouraged is labor-displacing-rice milling. This is particularly devastating to poor women who do almost all of the hand milling. However, there is no obvious connection per se between HYVs and power mills (World Bank 1983).

6.2.4 Consumers vs. producers

In a closed economy with no government interference in grain markets, increased production of the main food grain due to new technology will push down real prices and pass a substantial portion of the benefits from research

to consumers. Bangladesh is not a closed economy and the government procures and sells grain each year. Thus, the actual impact of new technology on foodgrain prices and the distribution of income between producers and consumers will be determined in part by government decisions on (a) how much grain to procure internally, (b) how much to import, and (c) at the prices for both procurement and sale.

Throughout most of Bangladesh's history, the governments' primary concerns have been with keeping rice prices relatively low and stable and ensuring that certain politically important groups have assured supplies of basic commodities at reasonably low prices. The ration system provides inexpensive grain to the important groups. When threatened with a general price rise, the government reacts by importing grain by whatever means are available. However, until recently it has not shown much interest in using price supports and procurement as a means of providing farmers with production incentives. The downward shift in the supply curve for foodgrains due to the introduction of new varieties has not been offset by increased internal procurement. Continued imports have kept prices down. Procurement has been about 3 percent of total supply since 1975/76, with the exception of 1980/81 when it increased to 7.7 percent, and imports decreased to about one million tons (World Bank 1982).

Much of the benefit from the new technology has gone to consumers. The consumers who perhaps benefit most from new technology are those who do not have access to ration shops and who buy wheat and relatively low-quality rice. Most high yielding rice varieties grown in Bangladesh are considered low quality by Bangladeshis. Wheat is generally considered to be a grain inferior to any type of rice. The gains from changing technology are likely to go to the rural consumer who has to purchase grain in the market. This is reinforced by a procurement system which does not reach far into the countryside.

Another important impact of the new technology on consumers is that it has reduced the seasonal shortages of foodgrains and thus decreased some

seasonal price rises. The major impact of new technology has been the improvement in production in the winter rice crops, and the wheat crop which is also grown in the winter. Thus, more grain is coming to market in late spring and summer which was the traditional time of shortage before the aus harvest. This means lower prices for consumers and, as noted, the consumers who benefit most will be the rural consumers who do not have access to the ration system.

6.2.5 Women

Some concern has also been expressed about the possible effects of the new technology on a relatively under-privileged class of Bangladesh - namely, its women. Unfortunately, there are almost no data on the differential impact of HYVs on men and women. Traditionally, women have performed the bulk of the processing task for cereals. The fear is that their unequal status and seclusion will increase if labor-substituting technology, e.g., rice-milling, is widely available. Rice milling is spreading but research *per se* has done nothing to speed or to slow the spread. The rise in foodgrain production due to modern varieties should increase the scale of post-harvest operations (BARC 1975) and the demand for women's labor. However, this is a major gap in knowledge, and more research is needed on those and related issues.

Table 6.8

AVERAGE WAGE RATE INDICES BY SECTORS (SUMMARY), 1963/64 - 1982/83
(1969/70 = 100)

Year	Nominal Indices					COL Index of Industrial Workers	Rural COL Index	Real Indices /a				
	General	Manufacturing	Construction	Agriculture	Fisheries			General	Manufacturing	Construction	Agriculture	Fisheries
1963/64	83.54	78.68	95.00	84.39	80.94	76.74	71.80	108.86	102.53	123.79	117.54	112.73
1964/65	87.87	82.42	104.01	86.67	83.83	81.03	..	108.44	101.72	128.36	..	..
1965/66	88.12	83.52	100.42	83.95	89.20	82.45	..	106.88	101.30	121.80	..	..
1966/67	94.32	88.83	100.38	98.49	95.08	90.88	92.31	103.79	97.74	110.45	106.70	103.01
1967/68	94.61	88.62	99.80	98.53	97.47	92.84	..	101.91	95.45	107.50	..	..
1968/69	97.99	92.45	104.76	97.34	102.95	96.17	..	101.89	96.13	108.93	..	..
1969/70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1970/71	105.30	107.28	102.05	105.10	104.82	103.98	105.48	101.27	103.17	98.14	99.64	99.38
1971/72	106.50	109.56	108.37	99.72	105.30	108.12	124.32	98.50	101.33	100.23	80.22	84.71
1972/73	130.74	134.39	132.26	128.78	123.89	198.46	184.46	65.88	70.21	69.06	69.82	67.17
1973/74	173.07	161.23	201.10	185.61	156.18	268.03	259.91	64.57	60.95	76.18	71.42	60.10
1974/75	221.31	192.37	263.68	261.40	196.74	447.60	438.37	49.44	43.67	60.08	61.03	44.88
1975/76	243.97	204.90	305.31	279.17	225.56	364.60	381.60	66.91	56.71	84.78	73.16	59.11
1976/77	252.07	222.39	310.75	267.74	237.04	354.03	374.13	71.20	63.02	88.50	71.57	63.38
1977/78	279.81	251.30	333.89	311.63	250.95	419.27	434.38	66.74	59.94	76.64	71.75	57.78
1978/79	346.25	318.01	413.84	370.63	311.01	457.55	472.69	75.74	69.56	90.46	78.37	65.80
1979/80	432.90	389.04	491.69	443.31	451.43	525.68	548.71	82.45	74.10	93.63	80.80	82.28
1980/81	492.09	452.27	544.60	482.01	529.28	568.10	617.70	86.62	79.61	95.86	78.04	85.69
1981/82	566.16	515.25	616.30	566.88	617.15	656.15	696.61	86.35	78.56	93.98	81.38	88.59
1982/83	598.11	558.02	677.20	558.35	638.93	683.56	..	87.50	81.63	99.07	81.68	93.47

.. = not available.

/a The general, manufacturing and construction wage indices are deflated by the COL index for industrial workers, while the agriculture and fisheries wage indices are deflated by the rural COL index.

Source: World Bank (1984)

7 Future Impact of Collaborative Research

The most important yield increases from rice breeding will be in t.aman and aus. The new varieties BR-10 and BR-11, which were recently released for the t.aman season, have several characteristics that are popular with farmers and thus they appear to be spreading rather rapidly. Their main characteristic is that they can be transplanted several weeks later than BR-4 but still get produce high yields. This allows farmers to transplant aman rice following late floods, or jute and late aus rice. The main advantage of the local improved varieties has been their ability to outyield the BRRI varieties when planted later in the season. Now the local varieties will be replaced with BR-10 and BR-11 in several places. High yielding short-duration varieties for the aus and boro season have just been released and BRRI hopes to release its first improved variety for b.aman in 1985. (IRRI 1984).

The government is now making fertilizer with zinc and sulphur available. Gill (1983) reports that, in experiments in 18 districts during the 1981 aman season, sulphur in fertilizer increased yields of rice (BR-4) by over 400 kg/ha and zinc increased yields by nearly 400 kg/ha. He continues: "Informed but unofficial estimates suggest that around 3 million acres are potentially zinc-deficient and 2 million acres potentially sulphur deficient". This suggests that the potential increase in output in the aman season would be 800,000 tons. More recent experiments indicate that sulphur deficiency is more widespread and zinc deficiency less widespread than previously supposed. As of January 1984, both zinc and sulphur were available from BADC and their appropriate use was spreading slowly (IRRI 1984).

The growth of wheat production is slowing down but there is room for more production in less favored regions. Also more genetic diversity is being built up. The recently released varieties Balak and Doel have much more resistance to rust than Sonalika which currently is grown on about 70 percent of the wheat area.

There will be further reductions in imports of Dutch seed potatoes and increases in yield due to improved seed potato production. Disease-free seed is now being produced in Degibani in northern Bangladesh. This will allow the production of lower cost seed potatoes of the Dutch varieties. These seeds are free of diseases (mainly viral) and hence give higher yields. High-yielding varieties of local and exotic stock are in the pipeline which will increase yields of high quality and thus high-priced potatoes. The cost of storage is being substantially reduced through refinement of techniques in collaboration with CIP research staff.

8 Conclusion

The collaboration between the international agricultural research centers and the national agricultural research system of Bangladesh has been very important to the growth of agricultural research and agricultural productivity in Bangladesh. The collaboration started in 1966 with the beginning of IRRI's relationship with the Agricultural Research Institute. The number of collaboratively researched crops has expanded gradually to include wheat, maize, potatoes, some pulses and cassava. The most important types of contact included posting center researchers in Bangladesh to work with local researchers on local problems, regular visits by center staff, training programs at the centers or run by the centers, joint programs of germplasm testing, and publications.

These activities have influenced the size and direction of Bangladesh research. The well-publicized success of IRRI rice and CIMMYT wheat elsewhere in Asia made it easier for the national program to acquire budget allocations and resources from the East Pakistan and Bangladeshi governments and from the donors. The increases in funding have been most rapid in the foodgrains, potatoes, pulses and oilseeds, while the research on export crops has grown more slowly. The proportion spent on export crops has thus declined. Within the commodity programs, joint planning of research in on-farm research programs has influenced priorities toward farmers' needs. The institutional structure of research has been influenced by the centers' emphasis on multidisciplinary teams organized around a single commodity. The general efficiency of the research programs that are in touch with the centers seems to have improved - training at the centers has encouraged researchers to be more practical in outlook and work style. There is more incentive to perform vigorously with the prospect of wider recognition through participation in international yield trials or in international meetings. Center outposted (special project) staff have resources that must be helpful in overcoming crucial research bottlenecks.

The outcome of this collaboration has been more food production and probably improved income distribution. To quote Dr Kazi M. Badruddoza (1984, pp. 74-5):

> "The success of the rice research and production programs in Bangladesh was, among other things, due to a large number of trained scientists from IRRI. In fact, the establishment of BRRI in 1968 was considerably influenced by the collaboration of the local rice program with IRRI. Over the first decade of its existence, BRRI released 15 new varieties and the area under modern varieties grew from 271,000 to 1.78 million ha, a growth rate of 25 percent per annum. Varieties released by BRRI now cover an estimated 15 percent of the total rice production area and produce 31 percent of the total output."
>
> "...Credit for success of wheat cultivation goes to a few dedicated scientists of BARI, who were trained at CIMMYT and also to the persistent interests shown by the late Dr. Glenn Anderson of CIMMYT and follow-up visits and activities of CIMMYT staff... In the six years since 1975 and 1976, when the thrust on field-scale introduction of wheat started in a traditionally rice growing country, wheat production increased several fold. Bangladesh now produces about 1.4 million tons of wheat annually compared to 40 thousand tons in the early 1970s. This is a success story which is rare anywhere in crop production. It would not have been possible without the dedicated team of scientists trained at CIMMYT and continued interest by CIMMYT staff."

Modern varieties of rice and wheat have increased the demand for labor which benefits the landless laborers who are the poorest group in Bangladesh. Increased food production has reduced the real price of foodgrains, which primarily benefits poorer consumers both in the cities and the countryside. Thus the poor seem to have benefited significantly from the modern varieties. While still poor, they would be even worse off in their absence. At present there is insufficient evidence to say whether or not their relative position has improved due to these varieties.

Many aspects of institutional arrangements for agriculture research in Bangladesh reflect the influences of several international centers, ranging from the structure of the rice research institute to aspects of the ongoing debates on input and food pricing policies in the country. The centers are widely appreciated for their contributions.

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