BJAE IV, 2 (December 1981) 1-24

AGRICULTURAL RESEARCH ORGANIZATION AND POLICY IN BANGLADESH

M. Alauddin*

ABSTRACT

The deficiencies that epitomize the weakness of the Bangladesh agricultural research system are: (i) Organizational difficulties; (ii) Lack of physical facilities and inadequate funding ; (iii) Low level skill and ineffective training ; (iv) Insufficient linkage between research, extension and farmers. Agricultural research has experienced uneven and isolated advance and its limited achievements are confined to cereals. Research on jute and sugarcane remains neglected. Low research intensity and priority bear the mark of ill-conceived policy framework. "

For sustained agricultural productivity growth, the study suggests that agricultural research be made broadbased by:

{i) intensifying research on varietal improvement of jute, rice, wheat and sugarcane for wide scale adaptability.

(ii) extending the sphere of research activity to undertake research on end-use of jute, adaptation and indigenous development of mechanical and chemical innovation for effective realization of potential of biological innovations.

This would involve reorganization of the research system, well-defined priorities and substantial investment on research.

I. INTRODUCTION

Technological change in agriculture is a critical factor determining economic development which involves structural transformation and modernization. The real significance of technological change is that it is a vehicle for the application and substitution of knowledge for material resources or of a less expensive and abundant resource for the more expensive and scarce one. The purpose of introducing a technical innovation is to help release the constraints imposed on economic growth by the rigidities of resource supply. This involves the question of identifying the areas where rigidities in factor supply

---

*Assistant Professor, Department of Economics, Rajshahi University. The author expresses his gratitude to Professor F. G. Jarrett and Dr. T. J. Mules of the University of Adelaide, Australia; and Professor Vernon W. Ruttan and Dr. Carl E. Pray of the University of Minnesota, USA, for helpful comments on an earlier draft. Any remaining inadequacies are the author's own.

obtain and their relaxation is warranted. It is at this point that the consideration of factor endowment assumes critical significance.

To-day with persistent population pressure, there is growing land constraint in most developing countries particularly those of South and South East Asia. The prime need is to adopt technological strategy designed to release constraints on land resource. This raises the question of the sources from which technical innovations are to be generated. In this respect indigenous Research and Development (R and D) efforts play a critical part. This has two aspects : **First,** indigenous R and D efforts are needed for effectively adapting to local conditions and technological innovations embodying scientific knowledge and research findings that originate elsewhere. As a matter of fact, there exists a great deal of complementarity between domestic R and D and imported (or borrowed) technology as shown by Blumenthal (1976 ; 1979). **Second,** in view of the high degree of location specificity of agricultural technology, the extent of adaptation and returns thereto for the borrowing country are critically limited by ecological conditions. Also sustained technological progress necessity involves basic research findings. Historically, Japan and United States starting from entirely different factor endowments and factor supply conditions experienced comparable rates of growth of agricultural production and productivity over 1860-1960. Their success resulted primarily from the introduction of technological innovations consistent with their respective factor endowment patterns. Agricultural growth in both countries accompanied contrasting changes in land and labour price ratios. To offset the effect of relative prices it became imperative to introduce labour-saving mechanical innovations in the United States and yield increasing biological innovations in Japan. In both cases, a strong national agricultural research system played the most critical part.

The purpose of this paper is to attempt an appraisal of the Bangladesh agricultural research system as a net work meant to respond to the challenge of technology generation geared to the needs of the economy. Section II provides a brief history of the research system. Its organizational structure is discussed in Section III. This section also provides an analysis of some further aspects indicating intensity of agricultural research activity Section IV attempts a review of performance relating to technological change and research in Bangladesh agriculture. Section V presents concluding remarks and implications for policy.

II. A BRIEF HISTORY OF THE BANGLADESH AGRICULTURAL RESEARCH SYSTEM

Organized agricultural research in Bangladesh in its present form is of fairly recent origin. Although there existed an Agricultural Research Institute since 1909, a Livestock Directorate since 1932 and a Jute Research Institute established in 1950, it was not until the early sixties that agricultural research in an organized way received attention of any significance when institutionalization of agricultural research began to take root. This coincided with the establishment of the Agricultural University at Mymensingh and strengthening the research capacity of the Tea Research Institute which was set up in 1957. The creation of the Rice Research Institute, Sugarcane Research Institute and some other research institutes in the late sixties and early seventies followed the earlier efforts in this pursuit.

Faaland and Parkinson (1976, pp. 129-30) deal with those aspects that help explain the gradual shift of strategy for agricultural development over the years. Their approach to the problem leads to the eventual realization by the government of the need for strengthening indigenous R and D capacity for the generation of innovations and their adaptation to the ecological conditions of Bangladesh. The next few paragraphs which follow closely on the analysis of Faaland and Parkinson are an aid to the understanding of the causal interrelations implicit in the process of such development.

For centuries the fertility of the soil has been the critical factor determining the supply of foodgrains for the survival of the population. Over the years the pressure on land started mounting. The static nature of the technology of foodgrain production led to the failure of its supply to meet the growing demand. This turned the very strong balance of payments of the fifties into one registering increased deficits in the sixties. These dictated a two-pronged strategy during the fifties and sixties with the following two elements :

(a) "Large-scale efforts and investments to install irrigation and drainage and even to control the vast flow of the rivers themselves ;

(b) Allocation of foreign exchange for large and growing quantities of foodgrain imports financed through industrialization, import saving and export-earning developments and by foreign assistance" (ibid., p. 129).

While the above strategy was rational in conception, it was largely ignored in implementation—implemented only in part and often without persistence. Foodgrain production technology in the fifties and early sixties emphasized large scale irrigation efforts which were lumpy and indivisible. The other technologies like fertilizer, small scale irrigation and biological innovations had little place in the agricultural development strategy.

Closely interrelated with this strategy is the priority (or lack of it) accorded to agriculture in the successive development plans since the fifties. Agriculture, despite its overall importance in the economy of Bangladesh, has generally received disproportionately low allocation of development expenditure and experienced a historical decline in its share. Moreover, it has had to bear the brunt of shortfalls in regard to the utilization of allocated funds.

By the end of the sixties the backlog of the earlier neglect was beginning to emerge in serious proportions. This called for a strategy with different innovations adapted to rice cultivation. The late sixties witnessed an attempt to accelerate rice production and attain foodgrain self-sufficiney by 1970. The key elements of the food self sufficiency plan were the HYV seeds, chemical fertilizers and irrigation water. However, the plan targets appeared ambitious in relation to achievement as the critical inputs fell short in supply and finally the commitment and dedication needed for the plan to be implemented was simply not there.

In the early seventies, Bangladesh at her emergence as a new nation state opened her account in the development front with two liabilities, viz., crippling population pressure and serious balance of payments deficits. On the positive side of course, were the factors that "first, the country was on it's own, allowing its policies and future to be decided fully by its people, and secondly, traditional rice cultivation could be superseded by a whole range of dynamic technologies" Faaland and Parkinson, 1976 p. 130). This had important implications in terms of higher yields per unit area as well as greater choice and flexibility.

However, the fact of the matter is that while international efforts play a dominant part in the development of the basic technology, the national efforts are of critical importance in the specific development of the various seeds in accordance with the local environment. After the euphoria generated by the 'Green Revolution', the importance of the adaptation of technologies to specific ecological environments and supply of complementary inputs was beginning to be realized. Against this back ground, agricultural R and D efforts started receiving some attention. In 1973, Bangladesh Agricultural Research Council (BARC) was created to provide a "systematic approach to planning, coordination, direction and conduct a national agricultural research program and integrated research system" (BARC 1980, p. 1).

III. ORGANIZATIONAL STRUCTURE OF THE BANGLADESH AGRICULTURAL RESEARCH SYSTEM

Table 1 is employed as an aid to the understanding of the background and organizational set up under-lying the Bangladesh agricultural research system.

In respect of funding the growth of institutional research has taken place under government patronage. In essence, institutional agricultural research means public sector agricultural research in case of Bangladesh. The responsibility of determining priorities, guiding research efforts and establishing coordination is with the BARC while that of conducting research rests with the various research institutes. In addition of the institutions mentioned in Table 1, some amount of research is carried out in the Atomic Energy Centre and the Institutes of Nuclear Agriculture. The Bangladesh Agricultural University and the Bangladesh Agricultural College have the function of providing basic training to scientists. This is a very brief account of the Bangladesh agricultural research system.

However, no account of it can be meaningful unless the inadequacies inherent in the research system are identified. The remainder of this section is devoted to this.

TABLE I. AGRICULTURAL RESEARCH INSTITUTIONS, BACKGROUND AND ORGANISATION

Institution	No. of Directly Dependent Institutions Sub-stations 1	No. of Divisions Departments 2	Superior Institute and Supervisory Body 3	Background and General Field of Activity 4
Bangladesh Agricultural Research Council	-	-	Ministry of Agriculture	Established in 1973 ; it is a co-ordinating body of all agricultural research programmes undertaken by different research institute and financing of research projects on development.
Bangladesh Agricultural Research Institute	17	11	Bangladesh Agricultural Research Council and Ministry of Agriculture	Established in 1909 ; National Agricultural Research Centre serves a wide spectrum of basic, applied and adaptive research programmes with particular emphasis on problem orientation and solution.
Bangladesh Rice Research Institute	4	10	Bangladesh Agricultural Research Institute and Ministry of Agriculture	Established in 1970 to accelerate rice research in the then State of East Pakistan, granted full autonomy in June 1973. The Institute carries out research to improve land cultivation and production to develop improved varieties of rice and maters related thereto.
Bangladesh Forest Research Institute	5	-	Forest Directorate, Ministry of Forestry, Fesharies and Livestock	Established in 1954 to conduct research on forestry and forest products.
Directorate of Livestock Services		1	Ministry of Livestock Forestry and Fisheries	Originally an Animal Nutrition Division was created in 1932 and was under the Agricultural Directorate till 1950 when it was merged with Directorate of Livestock Services ; conducts research on nutrition research of livestock.

	1	2	3	4
Sugar cane Research Institute	-	-	Bangladesh Sugar Mills Corporation, Ministry of Industry	Established in July 1973, the institute functions as an independent autonomous unit within the policy directives of the Bangladesh Sugar Mills Corporation under the Ministry of Industry. A periodical evaluation will be made by the Bangladesh Agricultural Research Council. Development of high yielding varieties and introduction of improved method of sugar cane cultivation comprise its general fields of activity.
Bangladesh Tea **Research Institute**	2	-	Ministry of Commerce	Established in 1957 but not fully operational until 1961 when work began on definite programmes of short and long term projects and advisory work was started to solve the day-to-day problems of the tea estates. It is concerned with the overall development of tea.
Bangladesh Jute **Research Institute**	7	7	Jute Division ,Ministry of Jute, Bangladesh Agricultural Research Council.	Created in 1950, functions include agricultural, technological and economic research, to improve crop forecasting and statistics to produce, test and distribute improved seed and recommendations relating to banking and transport facilities, and to improve marketing in the interests of the jute industry in Bangladesh.
Bangladesh Agricultural University	1	20	Ministry of Education	Established in 1960, provides agricultural education and research.
Chittagong Uni-iversity, Department of Botany	-	-	Chittagong University and Ministry of Education	Established in 1973, functions include teaching and research.
Dacca University, **Department** of **Botany**, Soil **Science**, zoology, **Institution** of Nutrition and Food **Science**	-	-	University of Dacca	Established ; Botany : 1940 as part of Biology Dept., became an independent Dept. in 1949, Activities include Floistic Survey-Environmental Studies - Ecology, Hydrobiology - Limnology - Microbiology, plant physiology-Moleculat and general genetics. Soil Science : 1949 as an institution. Institute of Nutrition and Food Science : Food analysis for nutrient - Dietary and Anthropometry - Education and Extension Programmes.
Rajshahi University, **Depts.** of Botany **and** Zoology.	-	-	Rajshahi University and Bangladesh Agricultural Research Council.	Teaching, offering courses, degrees and research opportunities-Entomology, Ecology and Insect Control.

Source :- Compiled from Food and Agriculture Organisation (1978, pp. 23 ff).

"Three basic elements, namely : policy, planning and coordination, carrying out of research and training of research scientists" (FAO 1978, p. 23) constitute the keystone of the national agricultural research system. The problem that epitomizes the weakness of the Bangladesh agricultural research system is not the absence of these basic elements but the fact that they do not feature in a meaningful way.

Following the analysis of the Food and Agriculture Organization (FAO 1978, p. 23) the deficiencies of the Bangladesh agricultural research system can be presented as under the categories below :

(i) Organizational difficulties ;

(ii) Lack of physical facilities and inadequate training ;

(iii) Low level skill and ineffective training ;

(iv) Insufficient linkage between research, extension and farmers.

The reflection of organizational bottlenecks is found in the **mainly** uncoordinated way of research activities. Even though each of the existing research institutions, in its own way seeks to contribute to the advancement of agricultural science and technology, each is completely isolated. This situation has resulted in the work being carried out in an uncoordinated and piecemeal manner. The creation of the BARC had the fundamental objective of providing leadership in the coordination of research activities in agricultural science and technology. However, because of its **limited** mandate[2] it had not so far emerged as an effective organization in providing the leadership it sought to foster and catalyse the coordination so vital for the development of an infrastructure of agricultural research. What Albert H. Moseman observed a decade ago (Moseman 1970, p. 58) regarding the organization of agricultural research in developing nations, is also true for Bangladesh at present: "In general agricultural research in developing nations is more **personalized** than **organized** and depends largely upon the initiative and vigor and level of training of individual research workers" (emphasis added).

Level of scientific activity depends critically upon two interrelated variables, namely, the level of investment in research and the quality and quantity of scientific research workers on both counts, agricultural research activity in Bangladesh leaves much to be desired. Table 2 presents a picture of the growth of these two variables over the years to get an idea of the level of research activity.

Investment in agricultural research (col. 3, Table 2) shows an upward trend over the years. However,it shows a downward tendency for 1964-65 to 1966-67 and

Table-2. RESEARCH EXPENDITURE, AGRICULTURAL VALUE ADDED AND NUMBER OF RESEARCH WORKERS : 1960-77.

1 Year	2 Agricultural Value Added	3 Research Expenditure	4 No. of Research workers	5 Col. 3 ÷ Col. 2 %	6 (Col. 4 ÷ Col. 2) × 80	7 (Col. 3 ÷ Col. 4) ÷ 8
1960-61	24,933.5	1.88	104	0.0075	0.33	2,260
1961-62	26,212.9	3.83	121	0.0146	0.37	3,945
1962-63	25,477.9	5.77	171	0.0226	0.54	4,218
1963-64	27,601.1	9.55	192	0.0346	0.56	6,217
1964-65	27,982.2	5.54	219	0.0198	0.63	3,162
1965-66	28,798.8	1.76	273	0.0061	0.76	806
1966-67	28,799.0	2.85	282	0.0099	0.78	1,263
1967-68	31,466.3	11.00	310	0.0350	0.79	4,436
1968-69	30,976.4	11.51	333	0.0372	0.86	4,321
1969-70	31,847.4	12.50	354	0.0392	0.89	4,413
1970-71	30,404.7	11.67	360	0.0384	0.95	4,052
1971-72	27,138.4	12.59	369	0.0464	1.09	4,265
1972.73	27,220.0	5.95	387	0.0219	1.14	1,922
1973-74	30,295.9	21.37	449	0.0705	1.19	5,950
1974-75	29,697.0	24.14	522	0.0813	1.41	5,780
1975-76	32,636.8	40.89	585	0.1247	1.43	8,737
1976-77	32,473.5	42.60	657	0.1312	1.62	8,105

Notes : (1) Figures in columns 2 and 3 are in millions of Taka at 1972-73 constant prices.
(2) Column 5 represents research expenditure as percentage of agricultural value added.
(3) Column 6 represents research workers per $US 10 million of agricultural value added ($US 1=8 taka, 1972-73 prices). This constant exchange rate has been used throughout the period 1960-61 to 1976-77.
(4) Column 7 represents research expenditure per research worker in 1972-73 dollars (US $1= 8 Taka).

Source : Alauddin (1980, p. 202).

a sudden drop to 5.95 million Taka in 1972-73 from the previous year's level of 12·59 million Taka. It however, shows a steady increase since 1973-74. The number of research workers has registered a steady increase since the sixties (col. 4, Table 2).

To serve as meaningful indicators of the level of research activity, three more variables are derived. They are shown in columns 5, 6 and 7 of Table 2. They respectively represent research expenditure as a proportion of agricultural value added, number of research workers per $US 10 million of agricultural value added and research expenditure (US $) per research worker. All values are expressed in 1972-73 constant prices. These variables provide a measure of what Evenson and Kislev (1975) term **research intensity.** The figures in columns 5, 6 and 7 of Table 2 all hint at a very low **intensity of research** in Bangladesh agriculture. They stand in striking contrast to the corresponding figures (for a representative year, refer Tables 3a-c) of the developed countries of Western Europe, North America, Oceania and Japan. It has not even kept pace with the level of research activity of the group of countries with a similar per capita income level.

The intensity of research is much lower than that for the group of countries with similar per capita income level on the criteria of :

(i) Research Expenditure per scientist man year ;

(ii) Research Expenditure as a proportion of agricultural product value.

However, on the criterion of scientific manpower per $US 10 million of the value of agricultural produce, Bangladesh appears to compare favourably with the group of countries in question. But this conceals some important aspects because of which a substantial degree of over estimtion may have been implicit in the data provided in column 6 of Table 2. In the absence of any hard evidence, the extent of overestimation is difficult to ascertain precisely. However, some indication towards that direction can be had from the observations made in the following paragraphs.

In the first place, the number of research workers presented in column 4 of Table 2, contains a significant proportion (40 to 50 percent) of the "researchers" holding academic position in the Universities. As Moseman (1970, p. 58) observes "Research is not a major activity of the colleges or schools of Agriculture in many developing countries. These are basically training institutions with curricula and a procedure strongly guided by the universities to which they are affiliated." Moseman's observation is also true in case of Bangladesh.

TABLE 3

a. EXPENDITURE ON RESEARCH AS A PERCENTAGE OF THE VALUE OF AGRICULTURAL PRODUCT BY PER CAPITA INCOME GROUP 1974.

Income Group US $	Percentage Expended for Agricultural Research
I (>1750)	2.55
II (1001 - 1750)	2.34
III (<150)	0.67
Bangladesh	0.07

b. Research Expenditures per Manpower Unit by Income Level Group 1971.

Income Group US$		Public Research Expenditures per Scientific Manpower
I (>1750)	..	45,519
II (1001 - 1750)	..	15,884
III (<150)	..	10,442
Bangladesh	..	4,052

c. Research Manpower Resources Relative to the Value of Agricultural Product 1971.

Region		Scientist Man years per 10 Million Dollars of Agricultural Product
Western Europe	..	0.91
North America and Oceania	..	1.10
Africa	..	0.63
Asia	..	0.92
Bangladesh	..	0.95

Sources and Notes :

(i) Complied from Table 2 and Boyce and Evenson (1975, pp. 9-11).

(ii) For Bangladesh the dollar figures are in 1972-73 prices i.e., S I=Tk. 8 ; for other. countires they are in 1971 US dollars. For Bangladesh the years of reference in Tables 3a, 3b and 3c respectively are 1973-74. 1970-71 and 1970-71.

Secondly, although it is not possible to ascertain, it is widely believed that the research workers (refer col. 4, Table 2) have to devote a considerable proportion of their time to administrative work. In other words, the ratio of research workers to administrators is quite low. Noazesh Ahmed (1976, p. 136) discusses this point with regard to crop breeder administrator (general research and extension) ratio and suggest that this ratio could be as low as 1 : 10. In the absence of any concrete evidence, it is difficult to prove or disprove this contention. However, the following remark by Evenson and Kislev (1975, p. 509) tends to support the existence of a low researcher—administrative (technical) worker ratio in the research system of the developing countries in general : "It seems, however, that the LDC research systems have higher ratios of technical personnel to scientists than those in the developed countries," Perhaps Bangladesh is not an exception in this regard.

Another aspect of the Bangladesh agricultural research system is that it lacks close cooperation between agricultural research and education. The "trinity of education, extension and research" which features so prominently in the American agricultural research system and played a pivotal role in the technological transformation of agriculture, is conspicuous by its absence in Bangladesh.

As already mentioned, the agricultural institutions are primarily training institutions. The Bangladesh Agricultural University has little responsibility for the country's problem oriented research—nor has it really participated in the development programmes or the 'Green Revolution' as pointed out by Ahmed (1976, pp. 142-143). In his own words".. the University has been unable to expose its students and faculties to the grass root level of to-days's agriculture and thus has not created a body of scientists and technicians capable of understanding many aspects of practical problems. Such faculties, in the long run, cannot retain affinity for the land and they are not challenged by field problems. The movement of students and faculty into extension activities and a constant interchange with colleagues concerned with research and education could ensure a continous flow of science and technology into field practice."

IV. TECHNOLOGY AND RESEARCH : REVIEW OF PERFORMANCE

This section attempts to provide a brief review of performance relating to technological change and research in Bangladesh agriculture. In that pursuit we would sum up the composition and growth over the years of various components of agricultural technology. An attempt is also made to indicate the direction in which technological change has taken place.

1. Broadly speaking the present agricultural technology consists of both traditional and modern elements and is overwhelmingly dominated by the former. The modern technology in Bangladesh agriculture is a package of biological, chemical and mechanical innovations. The biological innovations consist mainly of High Yielding Varieties (HYV) of rice, wheat and to a much lesser extent, of HYV jute. Mechanical innovations take the form principally of irrigation machinery and equipment such as Low Lift Pump (LLP), Shallow Tubewells (STW) and Deep Tubewells (DTW), chemical innovations are in the form of chemical fectilizers, pesticides and insecticides.

2. Beginning from almost zero in 1967-68, HYV seeds at present cover about a fifth of the total rice acreage. The most significant aspect of this development is that since 1972-73, the proportion of HYV rice acreage has registered relatively slower increase. In 1967-68 HYV rice was confined to the **Boro** season ; by 1879-80, 60 percent of HYV rice was grown in the other two seasons viz., **Aus** and **Aman** seasons. There has been a phenomenal increase in the acreage and output of wheat. There has been a steady decline in the area under traditional variety over the years while the area under HYV wheat has increased drammatically (Alauddin 1980, p. 78 ; BBS 1981, pp. 49-53, p. 58 ; Clay 1978, p. 15).

3. The period 1962-63 to 1969-70 witnessed a spectacular increase in irrigated acreage from 133 thousand acres to 2,610 thousand acres, that is, an increase by a factor of twenty. The share of irrigated area in total cropped area during 1969-70 to 1978-79 virtually remained stagnant at around 10-11 percent. For the period 1969-70 to 1978-79 85 percent of the total irrigated acreage is confined to Boro rice cultivation. Another important feature of irrigation technology is that a significant proportion (over 40 percent) of irrigation practices is carried out by traditional methods and modern irrigation is overwhelmingly dominated by LLP irrigation (Alauddin 1980, p. 81 ; BBS, 1981, pp. 39, 43 ; Hamid 1981, p. 3 ; IBRD 1978, p. 97-98).

4. The use of chemical fertilizers has witnessed spectacular increase from about 50 tons in 1962-63 to about 842 thousand tons in 1979-80—a seventeenfold increase. The available information on pesticides and insecticides clearly indicates low level of the use of plant protection measures in Bangladesh (Alauddin 1980, pp. 80-85 ; BBS 1981, p. 72 ; BPC 1980, XXI-13).

5. All available evidence provides sufficient indication of the low level of agricultural technological innovations. Even the thin coverage of modern inputs reported

in this study might not have their potential fully realized in view of the bottlenecks arising from the possibilties as indicated by the following questions :

a. Whether fertilizer application is in right proportion, timely and in keeping with the need of the soil and plant types ;

b. Whether plant protection measures are disease specific and timely ;

c. Whether the areas under irrigation are adequately covered with regard to the required quantity of water and the timeliness of its application.

While there has not been any systematic study to investigate such possibilities and their likely effects on agricultural production, some flimsy evidence (see for example Alam 1974; 1975) ; Bari (1975) suggest their likely adverse effects.

6. The development of technology and its use has been confined mostly to food (cereals) production. This is the case with the biological innovations and other accompanying inputs in the package. Technology in other crops has made very little progress as there has been little or no varietal improvement in other important crops such as jute, sugarcane and pulses. The information provided by the Bangladesh Bureau of Statistics (BBS 1973, p. 35 ; 1979, p. 166 ; 1981, pp. 65-66) and the Bangladesh Planning Commission (BPC 1978, 1-21 ; 1980, pp. XII-29-30) suggests that commercially and nutritionally important crops e.g., jute, sugarcane and pulses have not been touched by technological change. Their acreage, output and yield (except the yield of jute) show steady decline since 1967-68. The per acre yield of jute, albeit year to year fluctuation shows some minor increase in recent years. This may have resulted from good weather rather than from any significant change in the technology of jute production.

7. Using the data provided by the Bangladesh Bureau of Statistics (BBS 1973, p. 35; 1979, p. 166, 1981, pp. 65-66) for the period 1967-68 to 1979-80, and the procedure by Venegas and Ruttan (1964) the relative roles of area and yield increases in output expansion of some major crops can been seen :

a. With the exception of jute, changes in area and yield have taken place in the same direction. For jute, the effect of decline in acreage on production has been partially offset by an increase in yield. For rice, the yield effect is the most dominant factor (94.2) percent) for increased output. The major cause of wheat production increase is attributable to area expansion (55.7) percent), but the yield effect is also quite significant (44.3 percent).

b. The decline in output of sugarcane has resulted mainly from decrease in acreage (63.7 percent) and to a lesser extent (36.3 percent) from decline in yield. The opposite is the case with pulses for which the main factor of output decline is decrease in yield (78.7 percent) while decrease in area accounts for only 21.3 percent of the decrease in production.

Against the background of the preceding discussion, we now turn to an analysis of the salient features of the improved biological innovations of foodgrain (rice and wheat) production which appear to have been the **pace setter** of techological change in Bangladesh agriculture.

1. Improved Varieties of Rice

a. Chandina (BR- 1)

It was released in 1970 for the **Aus** and **Boro** seasons. It is also suitable as a late transplant **Aman** crop. The variety is resistant to bacterial leaf blight and tungro and is moderately susceptible to backterial leaf steak and sheath rot. It takes 105-150 days to mature, the maturity period being the shortest in the **Aus** season while it is the longest in the **Boro** season. Yield varies from 30 to 70 **maunds** (1 **maund** 82 lbs) per acre. The highest yield is for the **Boro** season while the lowest is for the **Aman** season. This variety is about 31-33 inches tall.

b. Mala (BR- 2)

Mala was released in 1971 for the **Boro** and **Aus** seasons. It is 45-48 inches tall. Its quality is good with dense and big panicles but has considerable spikelet sterility and vigorous, seedling growth. It can be transplanted in deeper water to compete with weeds as upland broadcast crop in the **Aus** season. It takes 150-160 days and 120-125 days respectively in the **Boro** and **Aus** season to mature. The yield varies from 40 to 45 **maunds** an acre. It is resistant to tungro, moderately resistant to bacterial leaf blight, bacterial leaf streak and moderately susceptible to sheath rot.

c. Biplab (BR- 3)

Biplab was released in 1973 for the **Aus**, transplant **Aman** and **Boro** seasons. Under optimum condition, its yield potential may vary from 60 to 80 **maunds** an acre. The highest yield is obtained in the **Boro** season and the lowest in the **Aus**. Under upland rainfed conditions a broadcast crop may not yield more than 40 **maunds** an acre. But with at least one weeding and one ranking at appropriate times, yields easily reach 45 maunds an acre. **Biplab** is insensitive to photopheriod and can be sown from November to July regardless of day-length variation. It is thermosensitive, the higher the temperature at the seedling stage, the shorter is the maturity period which varies from 130 days to

170 days, depending on whether it is sown in the **Aus** or in the **Boro** season. It is resistant to bacterial leaf blight, foot rot, seedling blight, blast and leafscald and is moderately resistant to sheath blight, became, bacterial leaf streak and sheath rot and modereately susceptible to tungro. Because of its wider spectrum of disease resistance and adaptability in all the three rice seasons, this rice variety claims wider preference to others.

d. Brrisail (BR- 4)

Brrisàil was released as a variety for the transplant Aman season. BR-4, like BR-3 has a wide spectrum of disease resistance and yields 70 to 80 **maunds** an acre under optimum conditions. It can be transplanted in 6 to 7 inches of standing water and takes about 140-145 days to mature.

e. Purbachi

It was originated in China and was released in 1969 as a **Boro** variety. It is susceptible to tungro and bacterial leaf sheath. It takes 140-145 days to mature and yield 50 to 60 **maunds** an acre under optimum conditions. It is 34 inches tall.

f. IR- 5

It was released in 1969 as an early transplanted **Aman** crop. It is susceptible to cold at maturing time and is slightly photoperiod sensitive. It is 47 inches tall and yields 60 to 70 **maunds** an acre under optimum condition. IR- 5 matures in 135-145 days. It is susceptible to sheath rot and moderately susceptible to tungro and bacterial leaf. blight.

g. IR- 8

The variety was released in 1967 for the **Boro** and **Aus** seasons. It takes 130-135 days to mature and yields 60 to 70 **maunds** an acre in the **Aus** season. In the **Boro** season, it matures in 165-170 days and yields 80 to 90 **maunds** an acre. IR- 8 is susceptible to tungro and bacterial leaf blight.

h. Irrisail (IR- 20)

IR- 20 was released in 1969 as a transplant **Aman** crop. The variety matures in 130-140 days and yields about 80 **maunds** an acre. It is slightly photoperiod sensitive. Rice quality is good and is resistant to tungro and bacteciai leaf blight,moderately resistant to stem borers and moderately susceptible to bacterial leaf streak and sheath rot.

The above analysis reveals that the improved rice varieties have high yield potential under assured water supply. Most important is the fact that these modern varieties are susceptible to pests and diseases compared to the local varieties. A closer examination would reveal that some of the varieties are photoperiod sensitive and mature more quickly during the **Aus** season than during the **Boro** season. The conflict between higher yield potential and maturation period is of critical importance in increasing the cropping intensity while simultaneously increasing the productivity of land.

Since **Aman** is the most important rice crop in Bangladesh, the introduction of HYV sead-based technologies during this season is of critical importance for augmenting rice output. However, in this respect, the present technology is totally inadequate. **First,** these varieties are not suitable for 4 to 5 million acres of deep water rice that represent 20 percent of the total rice acreage (Ahmed and Husain 1977, p. 109). Average yields of deep-water rice are no more than 30 tons per acre as against the national average yield around 50 tons. **Second,** except BR- 5 these varieties cannot he transplanted for better yield in September when about 50 percent of transplant **Aman** (5 million acres) is transplanted. **Thrid,** they cannot be transplanted in more than 4 inches of water while one inch is considered optimum for these varieties. **Fourth,** none of these varieties (suitable for **Boro** and **Aus** seasons) can be transplanted in areas where water rises to more than 2 feet at the time of harvest.

Also they cannot be transplanted in the coastal areas where tidal water level rises several inches high after transplanting. In the vast majority of the **Aus** areas where drought prevails, none of these varieties can be grown for better performance. The present biological innovations, therefore, are only partially suitable for the ecological conditions of Bangladesh. It is no wonder, therefore, that modern varieties cover only about a fifth of the total rice areage. A significant proportion of the seed-based technologies is confined to the **Boro** season and their expansion is limited by the degree of certainty or otherwise, timeliness and adequacy of irrigation facilities. There are many other constraints associated with the inputs which directly or indirectly militate against the expansion of area under these varieties and thus against the increase in total output.

Improved Varieties of Wheat

The last decade has witnessed the development of a multidisciplinary wheat research programme involving different disciplines such as breeding, agronomy, soil fertility, chemistry, plant pathology and entomology within the Bangladesh aAgricultural Research Institute. During the last few years High Yielding Varieties of wheat viz., Sonorab 4, Mexipak 65, Norteno 67, Inia 66, Norteno 67, Sonalika Tanori 71 and Jupateco

73 were recommended and released for cultivation. Table 4 shows the average (potential) yields for 1968-69 to 1969-70 for 10 different varieties of wheat. The data contained in Table 4 show that Mexipak 65 was the highest yielding variety followed closely by Sonora 64, Inia 66 and Norteno 67. The trials also indicated that the varieties of Mexican origin higher yield potentials than those of local origin. Subsequent experiments on responsiveness to fertilizer, irrigation and date of sowing. The experiments indicated that Mexican varieties were more responsive to high fertility condition supplemented with full irrigation. Date of sowing had significant effect on yield at 1 percent level of probability. Among the dates of sowing between October 20 and December 18, November 9 proved to bring the highest yields for all varieties except Mexipak 65 for which December 9 proved to be the best. Varieties presently in use in Bangladesh have maturity period between 86 and 111 days and plant height 54 to 70 cms. The most important wheat disease in Bangladesh is leaf rust. Mexipak 65, Sonora 64 and to a lesser extent, Sonalika and Inia have become susceptible to this disease. Norteno, Tanori and Jupateco appear to be resistant to stem and leaf rust.

TABLE 4 : YIELD OF 10 VARIETIES OF MEXICAN ORIGIN AND LOCAL WHEAT.

Name of Variety		Average Yield (ton/acre)
Sonora 64	..	1.508
Mexipak 65	..	1.512
Inia 66	..	1.490
Norteno 67	..	1.336
Indus 66	..	1.483
L 50- L52XLR^3	..	1.186
(BXK 8) 5839	..	1.395
Pit G6 55xC 271	..	1.014
IP 52	..	1.018
Dirk	..	1.120

Source : Razzaque (1977, p. 62).

V. CONCLUDING REMARKS AND IMPLICATIONS FOR POLICY

a. Concluding Remarks

This paper has made an appraisal of the Bangladesh agricultural research system. It must, however, be pointed out that the present analysis is based on limited information from various scattered sources. However, the statistical quality of the data presented in the text would justify the observations made about the organization of the research system, level of research activity and the performance relating to technological change and research in Bangladesh agriculture.

The R and D efforts pertaining to agriculture may be considered to be still in their infancy. Within the research organizations created under different Ministries as supervisory bodies, there appears to be little understanding and coordination required to ensure the unimpeded flow of basic research findings into various stages of developmental research. The meagre resources allocated to agricultural research have been widely dispersed with little sense of priority. This has failed to create a strong and viable national infrastructure of agricultural research and has resulted in the allocation of relatively modest funds to short term and narrowly defined projects within special disciplines.

To-date agricultural research activity has experienced some very limited but isolated and uneven advance and the achievement can be said to be confined to cereals. This has taken the form of adaptation and indigenous development of HYV seeds of rice and wheat. But the cultivation of modern varieties of rice is confined primarily to the Boro season and they do not have the genetic qualities for cultivation for the bulk of the area during the main rice seasons, namely, Aus and Aman. The government's foodgrain production strategy to-date has laid primary emphasis on expanding foodgrain output through the expansion of irrigated Boro acreage. **Secondly,** have underestimated, if not ignored the limitations of the biological innovation in terms of their adaptability to ecological zones on a wider scale. **Thirdly,** it appears to have failed to give adequate consideration to the fact that high maturation period of crops is inimical to increased intensity of cropping. It is little or no wonder, therefore that the output of rice has registered an increase of only about 12 percent between the late sixties and late seventies. Wheat output has made substantial progress. But this growth in foodgrain production through expanded outputs of rice and wheat has been attained at the expense of reduced outputs of pulses. The substitution of cereals because of the improvement in the technology specific to them for some other crops e.g., pulses are a prominent source of protein in Bangladesh. The adoption of seed-fertilizer-irrigation technology requiring the application of various types of insecticides has severely affected the production of fish. A study by Hamid et al. (1978) shows that in the irrigated area (s) supply of fish has declined. This is likely to have resulted from the use of chemicals and germicides for protection of plants against locusts and pests proliferate with HYV crops. The decline in per capita supply of pulses and fish have unfavourable nutritional implications. This nutritional aspect of the food problems not too trivial to ignore.

Research on other important crops such as jute and sugarcane which have important implications in terms of export earnings and import substitution still remains a neglected field. The positive contribution of research and technology in the growth of cereals production has been partially offset by the declining output of other crops. The limited and uneven growth in research activity and technology thereof has failed to provide a sustained basis for agricultural productivity growth. Barely has there been any real attempt to broaden the technological base geared to the needs of the agrarian sector. Low research intensity and priority bear the mark of an ill-conceived policy framework. Thus agricultural research in Bangladesh is yet to make a "take-off" in any real sense.

B. IMPLICATIONS FOR POLICY

The final section is devoted to an analysis of the implications for policy in the light of the concluding remarks of the preceding sections.

For sustained agricultural productivity growth, research and technology need to rest on a broader base than at present. This would involve :

1. Intensification of R and D efforts ;
2. Extension of the sphere of research activity.

Intensification of research activity requires that R and D efforts be directed towards basic research to a far greater extent than at present. This implies that the present crop research programme take into consideration the following points which relate to the development of :

(i) Rice varietes with higher yield potential and suitable for cultivation in the deep-water-zones ;

(ii) Rice varleties with flood and drought resistant quality to withstand the uncertainties of water supply and disease resistant quality for adoption to wider ecological zones ;

(iii) Rice varieties with shorter matuıity period to allow for multiple cropping. This is to assign critical importance to another possible dimension—time. The present maturity period of crop varieties is an important factor that limits the possibility of raising more crops in a (crop) calender year.

(iv) High yielding varieties of jute adaptable to different ecological zones throughout Bangladesh. These varieties need to have the biological qualities of maturing early and disease resistance.

(v) Sugarcane varieties with higher yield potential, higher recovery rate (higher sugar content) and disease resistant qualities.

(vi) Wheat varieties with higher yield potential, drought and disease resistant qualities.

(vii) Improved grain qualities of rice and wheat.

The main thrust of the above argument is that the supply base of agriculture must shift from area increase to increases in yield and intensity of cropping. This would critically depend on wide scale adaptability of the improved biological innovations. The idea is to shift away from limiting their adaptability mainly to the winter season and to reduce dependence on irrigation water. The problem is not one of whether Bangladesh has the hydrological potential for winter irrigation, but one of feasibility of translating this potential into reality. Past performance does not lend support for the feasibility of meeting the massive irrigation requirements much beyond the irrigation coverage at present.

Extension of the sphere of research activity would require that R and D efforts be directed at :

(i) Enhancing the competitive power of jute vis-a-vis synthetics in terms of better use.

Jute at present faces stiff competition from synthetics. Mahmood's study (Mahmood 1981) shows that there is a long term switch away from jute usage in the developed countries of North America, Western Europe and Oceanea and Japan. The price elasticity of demand for jute ranges between 0.2 and 0.4 (ibid.) which are relatively low and it would take substantial favourable shifts in price relatives for jute to cause much effect on its consumption in importing areas.

The price of synthetic substitutes is a key determinant of the demand for jute and jute products in the non-producing areas. The prices of synthetics in turn depend on oil prices and technological change.In the short run the synthetic substitutes have quite a strong capacity to compete with jute. Profits have been abnormally high and there has been scope to absorb some cost increase out of profits (Faaland and Parkinson 1976, p. 178). Secondly, oilprice increase is unlikely to significantly increase the cost of synthetics particularly polypropylene for which oilcontent is very small. Another factor is that "a considerable proportion of the output of synthetics depends not on oil but on natural gas for its feed back and the increase in the price of the latter may well be much less than the increase in the price of oil" (**ibid.**).

The long term competitive balance is not certain to predict. However, the uncertainty over future oil prices may affect the competitive power of synthetics. But the effect may be less marked than might be anticipated because of the existence of excess capacity and nature of the market for synthetics (Mujeri 1978, pp. 48 ff). This could provide an opportunity to enhance the competitive power of jute in relation to its substitutes. The onus is on the products to evolve new varieties and introduce methods of cultivation to reduce cost. A collective effort on the part of the jute producers—mainly India and Bangladesh, is needed to initiate research on developing new varieties and better end use of jute.

(ii) Developing mechanical innovations aimed at moderating peaks in the demand for labour during specific times in year. This would allow timeliness and spread in operation like seed-bed preparation, land tilling, etc.

(iii) Chemical innovations designed for specific soil, plant, insect and disease type and for minimizing the destructive effects of chemicals on fish population.

Intensification of R and D efforts and extension of the sphere of research activity would involve substantial reorganization of the research system and well-defined priorities. Above all it needs substantially higher research investments. A recent study by Alauddin (1980) indicates high returns to investments in agricultural research in Bangladesh. A wide range of literature (see Arndt, et al. 1977, pp. 5-6) indicate that returns to a great deal of such investments throughout the world have been extra-ordinarily high and are in many cases far in excess of returns to other agricultural investments. The estimates, however, vary widely among themselves.

To sum up, the present study has attempted to identify the problems of agricultural research and technological change in Bangladesh. It has indicated the areas of deficiencies and further improvements in the process of institutionalization of agricultural research. This study emphasizes the need for a rationally coordinated system of policy measures involving agricultural researchers, planners and policy markers.

NOTES :

1. See Alauddin and Mujeri (1961) for an analysis of the priority which the agricultural sector in Bangladesh has received in the development plans since the early fifties.
2. See Badruddoza (1977) for a more detailed analysis of this point.
3. Venegas and Ruttan (1964) use the following procedure to determine the area and yield effects of output expansion.

   Let A Area (gross) under cultivation

   Y yield

   P output

   Since $P = AY$, $\frac{P_1}{P_0} = \frac{A_1Y_1}{A_0Y_0}$, taking logarithms and making slight rearrangements gives

   $$\frac{\log (Y_1/Y_0)}{\log (P_1/P_0)} + \frac{\text{Log } (A_1/A_0)}{\log (P_1/P_0)} = 1 \text{ (100 percent)}$$

   That is, effect of yield expansion (percentage)+effect of area expansion (percentage) =Output expansion (100 percent)

   '0' and '1' respectively refer to the averages of 1967-68 to 1969-70 and 1977-78 to 1979-80.
4. Draws heavily from BRRI (1975, 1976, 1977, undated).
5. Draws from Razzaque (1977).
6. This point has been very strongly made by Dalrymple (1975).
7. See Bangladesh Bureau of Statistics (BBS 1978, pp. 154-55) for overlapping crop seasons, particularly jute, Aus rice and Aman rice.

REFERENCES

Ahmad and Husain, 1977 — M. S. Ahmad and A. Husain ; "Strategy of Current Research on Varieties, Cultural Practices and Appied Research at BRRI", in BRRI (1977a).

Ahmed 1976 — N. Ahmed ; *Development Agriculture of Bangladesh,* Dacca : Bangladesh Books International, 1976.

Alam 1974 — M. Alam ; "*Capacity Utiization of Low Lift Pump Irrigation in Bangladesh,*" Research Report No. 17 (New Series) Dacca : Bangladesh Insititute of Development Studies, 1974.

Alam 1975	M. Alam : "Capacity Utilization of Deep Tubewell Irrigation in Bangladesh : A Time Series Analysis of Comilla Thana", *Bangladesh Development Studies* III, 4(1975).
Alauddin 1980	M. Alauddin : "Choice of Technology in Bangladesh Agriculture : An R and D Perspective", Unpublished Master's Thesis, University of Adelaide, Australia, 1980.
Alauddin and Mujeri 1981	M. Alauddin and M. K. Mujeri ; *The Strategy of Agricultural Development : Past and Present*, paper presnted at the conference of the Bangladesh Economic Association, Dacca : April 29-May 3, 1981.
Arndt, *et al.* 1977	T. M. Arndt, D. G. Dalrymple and V. W. Ruttan : *Resource Allocation and Productivity in National and International Agricultural Research*, Minneapolis : University of Minnesota Press, 1977.
Badruddoza 1977	K. M. Badruddoza ; *Organization and Accomplishment of Agricultural Research in Bangladesh*, paper presented at the Second FAO/SIDA seminar on Field Food Crops in Africa and the Near East, Lahore, Pakistan : 18 September --5 October, 1977.
BARC 1978	Bangladesh Agricultural Research Council : *This is BARC*, Dacca.
BBS 1973	Bangladesh Bureau of Statistics : *Statistical Digest of Bangladesh* 1972-73, Dacca : 1973.
BBS 1978	Bangladesh Bureau of Statistics : *Statistical Pocket Book of Bangladesh* 1978, Dacca.
BBS 1979	Bangladesh Bureau of Statistics : *Statistical Year Book of Bangladesh* 1979, Dacca : 1979.
BBS 1981	Bangladesh Bureau of Statistics : *Monthly Statistical Bulletin of Bangladesh*, March 1981, Dacca : 1981.
BPC 1979	Bangladesh Planning Commission : *Two Year Plan* 1978-80, Dacca : 1978.
BPC 1981	Bangladesh Planning Commission : *Second Five Year Plan* 1980-85, Dacca, 1980.
BRRI 1975	Bangladesh Rice Research Institute ; *Bangladesh Rice Research Institute*, Dacca : 1975.
BRRI 1976	Bangladesh Rice Research Institute : *Brrisail*, BR- 4, Dacca : 1976.
BRRI 1977	Bangladesh Rice Research Institutes : "*Workshop on Ten Years of Modern Rice and Wheat Cultivation in Bangladesh* : 7-10, 1977 Dacca : 1977.
BRRI (undated)	Bangladesh Rice Research Institute ; *Adhunik Dhaner Chash*, Dacca : (Undated).
Bari 1975	F. Bari : "*Causes and Consequences of Late Operation of Pumps and Tubewells in Comilla Kotwali Thana* (19-73-74)" Comilla : Bangladesh Academy for Rural Development, 1975.
Blumenthal 1976	T. Blumenthal ; "Japan's Technological Strategy", *Journal of Development Economics*, III, 3, (1976).

Blumenthal 1979	T. Blumenthal : "A Note on the Relationship between Domestic Research and Development and Imports of Technology", *Economic Development and Cultural Change*, XXVII, 2, (1979).
Boyce and Evenson 1975	J. K. Boyce & R. E. Evenson ; *National and International Research and Extension Programs*, New York : Agricultural Development Council, Inc. 1975.
Clay 1978	E. J. Clay : "Ten Years of Dwarf Wheat Production in Bangladesh", *Bangladesh Journal of Agricultural Economics*, I, 1, (1978).
Dalrymple 1975	Dana G. Dalrymple : "Multiple Cropping in Developing Countries", *Development Digest*, XIII, 1, (January, 1975).
Evenson and Kislev 1975	R. E. Evenson and Y. Kislev ; "Investment in Agricultural Research and Extension : A Survey of International Data' *Economic Development and Cultural Change*, XXIII, 2, (1975).
Faaland and Parkinson 1976	J. Faaland and J. R. Parkinson : *Bangladesh : The Test Case for Development*, London : C. Hurst & Co. 1976.
FAO 1978	Food and Agriculture Organization ; *Agricultural Research in Developing Countries, Vol.* 1 *Research Institutions*, Rome : 1978.
Hamid 1981	M. A. Hamid : *"Irrigation Techonology, Rural Institutions and the Rural Poor in Bangladesh"* A Paper presented at the seminar on *Rural Technology, Institutions and the Rural Poorest*, sposored by CIRDAP and IDS, Comilla : 2-5 February 1981.
Hamid *et al.* 1978	M. A. Hamid ; S.K. Saha, M.A. Rahman and A. J. Khan ; *Irrigation Technologies in Bangladesh , A Study in Some Selected Areas*, Rajshahi University : Department of Economics, 1978.
IBRD 1978	International Bank for Reconstruction and Development ; *Bangladesh, Current Trends and Development*, Dacca : 1978.
Mahmood 1981	M. Mahmood ; "World Trade in Jute", Paper presented at the conference of the Bangladesh Economic Association, Dacca : April 29-May 3, 1981.
Moseman 1970	A. H. Moseman : *Building Agricultural Research Systems in the Developing Nations* , New York : Agricultural Development Council, Inc. 1970.
Mujeri 1978	Mustafa K. Mujeri : *The World Market for Jute: An Economic Analysis*, Unpublished Ph. D. thesis, McMaster Unversity, Canada, 1978.
Razzaque 1977	M. A. Razzaque : "Review of Ten Years on Modern Wheat Research in Bangladesh", in BRRI (1977a).
Venegas and Ruttan 1964	E. C. Venegas & V.W. Ruttan : "An Analysis of Rice Production in the Philippines', *Economic Research journal*, 1964.