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RICE RESEARCH PRIORITIES IN BANGLADESH: A QUANTITATIVE ANALYSIS

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ABSTRACT

The study prioritizes rice research problems by different ecosystems and research disciplines. Combination of economic surplus and scoring approach is used in setting rice research priority among different rice ecosystems, and only scoring approach is used to prioritize rice research problems by discipline. The study uses (a) information collected from agricultural research managers, rice scientists, extension workers and economist, and (b) different published data. Results show that rainfed lowland and irrigated ecosystems are top priority ecosystems as far as rice research in Bangladesh is concerned. Among different problem areas, Plant Breeding and Genetics, and Pest Management are two most high priority problem areas. Natural resource assessment and socio - economic analysis. two neglected fields in the Bangladesh Agricultural Research System, are also important research problem areas.

I. INTRODUCTION

Agricultural research funding is scarce in Bangladesh as in many other developing countries. The national agricultural research institutes are frequently forced to mediate conflicting demands of farmers, politicians, scientists and donor agencies. The presence of these conflicting demands reflects the fact that the demanders of new technologies and institutions may place different weights on national goals and objectives. In addition, farmers are the ones most aware of their own problems and constraints, but scientists are more knowledgeable about what can be achieved to solve their problems through research. Politicians must balance the needs of consumers and place demands on the research system in light of short-term crises. Thus, a formal priority setting analysis is necessary to help the National Agricultural Research System (NARS) reconcile demand for, and supplies of, new technologies and institutions in the light of relative weights placed on goals and objectives.

A study was undertaken during 1989-92 to provide information to Bangladesh Agricultural Research Council (BARC) and its individual agricultural research institutes to facilitate their assessments of research priorities. Research priority rankings were provided by commodity and by research problem areas for the system as a whole for 57 commodities and for the individual research institutes.

This paper discusses the results of the analysis on rice research priorities in Bangladesh. Rice researchers, research planners, and administrators continually face the question of how to allocate resources among different rice ecosystems and research disciplines. The purpose of the

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present study is to provide some information to research managers, planners and administrators to facilitate their decision regarding allocation of resources among different rice ecosystems and disciplines. The paper contains several parts. First, rice production and research systems in Bangladesh are briefly discussed. Second, methods used for assessing rice research priorities are discussed, including the procedures used in the current stud} . Third, the results of the analysis of the data are presented. Finally, conclusions, recommendations and suggestions for future studies are provided.

II. RICE PRODUCTION AND RESEARCH SYSTEM

Rice Production

In Bangladesh, rice is grown throughout the year on high to deeply flooded lowland in three seasons, namely: aus season (March-July), *aman* season (July-December), and *boro* season (January -June), with overlapping or short turnover periods. *Ainan* rice comprises two groups: broadcast *aman (B. aman)* and transplanted *anum (T. aman).* Broadcast *aman is* sown (sometimes mixed with *auc)* in the premonsoon period (March-May) and harvested in November-December. Table I shows the area and yield office in Bangladesh during the 1970s and 1980s. Area of *boro* rice has increased substantially over the last two decades. On the other hand, average area of *aus, T. Aman* and B. *aman* decreased during this period. Consequently, average total rice area has slightly decreased. Rice yield has remained more or less stagnant in spite of the expansion of modem varieties. In fact, yields of *T. aman* and B. *anuan* have even decreased.

T. Aman is the major rice crop in Bangladesh. During the 1970s, *T. aman* accounted for 40.6 percent of the rice area and 66.1 percent of the rice production. These shares decreased to 38.2 percent and 35.7 percent, respectively, during the 1980s. Share of boro in total rice area and yield have increased substantially over the last two decades. In the 1970's, *boro rice* accounted for 10.7 percent of the total rice area and 20.5 percent of the total rice production, and these shares have increased to 19.3 percent and 32.5 percent, respectively, in the 1980's.

Modem rice varieties were introduced in Bangladesh in 1966!67, 1967'68 and 1968i69 for the *boro, aus* and *amcun* seasons, respectively. At present around 89°jc of *born* area is covered by modem varieties (MN's) (Table 2). *Boro* rice is an irrigated crop in Bangladesh. Modern varieties cover around 41 percent of T. *aman* area and are grown mostly under rainfed condition. In the other seasons, MVs are also grown in transplanted conditions, except in a few high rainfall areas in the *am* season. At present, around 17 percent of *am* area is covered by MN's. The rest of the aus crop includes primarily local broadcast aus varieties. All the B. aman areas are covered by local varieties.

In Bangladesh, rice is grown in four different rice growing environments or ecosystems. *B. cnnan* and *B. aus* are grown in deepwater and upland rice ecosystems, respectively. *Boro* and *T. aus* are grown under the irrigated ecosystem. *T. aman is* grown primarily under rainfed lowland conditions. However, T. *aman* is also grown under deepwater environment where flood water exceeds 50 cm.

Rice Research

Research on rice in the geographic area now called Bangladesh started in a scientific manner in 1911 with the appointment of G.P. Hector as Economic Botanist of the Bengal Department of Agriculture (Great Britain 1928). By the early 1920s approximately 5 researchers worked entirely on rice (DOAB, 1925). Research expenditures were reduced in the early 1930s due to the great depression (DOAB 1935). However, the funding situation improved after 1935 as the Imperial Council of Agricultural Research began to fund rice research. In 1935, the Habigonj research station, now a regional station of the Bangladesh Rice Research Institute, was set up to conduct research on deepwater rice.

However, most research in this area stopped in 1942/43 due to the World War II. After the World war, research on rice began again. But, after the partition of British Bengal into The then East Pakistan and West Bengal in 1947, rice research again was hampered as many Hindu researchers migrated to India from East Pakistan. In the mid-1950s, rice research started to expand again. But rice research the suffered another set back in the early 1960's when the Pakistan government took over experimental rice fields to build second capital. "Thousands of germplasm collected during the last fifty years at a tremendous cost were lost forever" (Zairian 195).

Rice research was started again systematically in 1970 with the establishment of the Bangladesh Rice Research Institute (BRRI). During the 1960s, the academy of Rural Development at Comilla helped in disseminating varieties such as IR-8 and Pajam. At present, BRRI is the main research institute responsible for conducting research on rice. The Bangladesh Institute of Nuclear Agriculture (BINA) also conducts research on rice as well as on other commodities. A recent survey shows that 95% of BRRI'S scientific manpower and 31 IT' of BINA's manpower are devoted to rice research.(BARC 1990). In addition to these two research institutes, various universities are conducting research on rice in limited scale.

Table 3 Presents the names of rice varieties released by different research institutes. Table 3 reveals that most of the varieties are for *born* and T. *aus* rice (i.e. for the irrigated ecosystem). Only three MVs have been released so far for the upland rice ecosystem. As of now, no modem variety has been released for deepwater and tidal wetland ecosystems.

III. METHODS OF SETTING RESEARCH PRIORITIES

Several structured methods are available to assist the identification of rice research priorities. The most common methods used in similar previous studies are as follows:

1. **Scoring Model:** The scoring approach involves the identification and weighting of multiple objectives and criteria for ranking commodities and research areas. Application of this method are found in studies in the United States (Shumway and McCraken 1975), the Dominican Republic (Moscoso et. al. 1986), Ecuador (Espinosa et al. 1988), and

Uruguay (Ferreia, et al. 1987). A few studies have used congruence analysis, which is a special case of a scoring model with all weight placed on one criterion, usually value of production (Ruttan 1982; Ruttan 1983; Salmon 1983; Von Oppen and Ryan 1985).

2. **Economic Surplus Analysis:** The calculation of expected economic surplus to producers and consumers from conducting research uses benefit cost procedures to project the benefits and costs of research.Application of this approach are found in studies in Peru (Norton, et al. 1987) and in the Australian Center of International Agricultural Research (Davis, Oram and Ryan 1987).
3. **Mathematical Programming Model:** Mathematical Programming techniques apply mathematical optimization to choose a research portfolio through maximizing a multiple-goal objective function, given the resource constraints facing the system. An example of the use of this method is found in a study by Russell in the United Kingdom (Russell 1977). To date, mathematical programming models have not been used for research priority setting in developing countries.
4. **Econometric Models:** The estimation of econometric model involve the collection of historical data on production, inputs, prices, research expenditure, etc., to statistically assess the contribution of research to changes in production. Numerous studies have estimated these models (production functions, profit functions, supply functions and value added function) for ex-post evaluation of agricultural research.
5. **Simulation:** Simulation methods can be used to identify and select research priorities. Simulation models can be constructed as relatively simple or complex tools, can incorporate optimizing or ranking procedures, and can readily incorporate probabilistic information.

Method Used in the Present Study and the Rationale for its Selection

The method used in this priority setting study involved a combination of the scoring and economic surplus approaches. This combination method was chosen because it is the most conceptually defensible procedure for measuring the contributions of research given the time frame for completion, multiple objectives for research, data available, the need to rank different types of rice as well as research problem areas, and the need to build consensus among scientists and administrators on research priorities. The scoring component was chosen because it allows for weighting of multiple research objectives.

The scoring approach also was chosen for the research problem area as part of the priority setting procedure because it can be understood relatively easily by scientists and research managers. It involves them in its preparation and therefore facilitates building a consensus that the methods and results are valid. In addition, several of the research problem areas generate benefits which are difficult to quantity. The scoring approach facilitates ranking of those areas.

The economic surplus component of the priority setting procedures increases the accuracy of the calculations of efficiency and distribution of benefits from research. It provides for most detailed accounting of lags associated with research, adoption, and generation. It allows for discounting of future costs and benefits. The additional questions asked of scientists in order to add the economic surplus component to the scoring component to constitute a more refined priority setting procedure (and therefore more accurate and credible assessment of priorities) appears to be worth the additional effort.

Description of the Method Chosen for the Priority setting Analysis

Application of the combined scoring/economic surplus approach involves a series of steps including selecting a task force for the study, weighting objectives and criteria, defining requirements for data and other information needs, collecting published information, defining the market situation and government policies for different types of rice, developing a set of appropriate questionnaires and interviewing scientists and research managers, processing of the data and information collected with the computer, writing the report, and presenting, interpreting and revising results.

Objectives and Criteria

Objectives for the Bangladesh Agricultural Research System were identified by the task force and criteria employed to help measure how well research on various types of rice help attain those objectives are presented below. The first objective is to increase agricultural productivity and efficiency to produce more food, foreign exchange, and income related to the broad efficiency goal of improving the average level of well-being of all citizens. How well this first objective is attained by conducting research on different types of rice is measured by the expected net present value of economic gains. These gains in turn are based on the following criteria:

a) **Value of Production**: Value of production is a major determinant of research benefits because research costs are relatively unaffected by the number of units over which the results spread. Value of production is measured as the average gross value of rice for the preceding three years. Value of production is assumed to grow or contract for certain types of rice as new areas come into or leave production over time.

b) **Expected yield increase or per unit cost reduction**: The expected yield increase or per unit cost reduction, if research is successful, is an important determinant of productivity increase. Scientists were asked to estimate these changes on a percentage basis.

c) **Probability of Research Success**: It refers to the estimated probability of obtaining the yield increase or cost reduction indicated above by type of rice and by type of research. Scientists were asked how certain they were of obtaining the projected yield or cost changes.

d) **Adoption Rate** : Even if research is successful it has little value unless the results are adopted. Scientists were asked to predict the peak level of adoption and the year they estimate it will occur.

e) **Research Depreciation** : Certain types of research depreciate over time, particularly as insects and diseases evolve and attack new varieties. Scientists were asked to predict when their research results would begin to depreciate.

f) **Discount Rate**: Future research benefits are discounted with an annual discount rate (10%) to reflect the fact that benefits are worth less further they occur in future.

The distributional objectives relate the general goal of improving the well being of some groups in society more than others. The first distributional objective is to provide employment or improve the returns of labor more than land and capital. The number of people employed is used as a proxy measure of how well research on particular type of rice contributes to this objective. The second ditributional objective is conservation or increasing the sustainability of benefits for future generations. A discount rate (10%) which is two percent below the rate normally used to evaluate public investments in Bangladesh is used to give additional weight to future generations. The third distributional objective is to improve human nutrition by giving additional weight to the lowest income people. The proportion of calories in the diet is used as one measure of how a type of research contributes to nutritional well-being of the poor.

The fifth and final objective of the research system is to reduce the annual variation (risk) in production and income. A coefficient of variation in value of production is calculated for each type of rice to help measure its riskiness.

These five objectives for the research system were identified at the initiation of the study. Preliminary analysis of commodity priorities placed all weight on the efficiency objective and then explored the implications of placing additional weight on the other objectives.

The criteria corresponding to the five objectives listed above were used in subsequent analyses to derive commodity priority ranking. A second set of criteria were incorporated in a second model to derive priorities for research problem areas. A set of five criteria were developed to help measure the attainment of research problem areas to the efficiency objective. These were: (a) the number and severity of researchable problems, (b) effect of research on the need for capital, (c) complementarity with research which can be borrowed from other countries, (d) current manpower emphasis in research, and (e) research cost. An additional criterion of the effect of the research on quality of the natural resource environment was used as a measure of the distributional objective related to conservation. Finally, the effect of research on the annual variability of production was used as a measure of the stability objective.

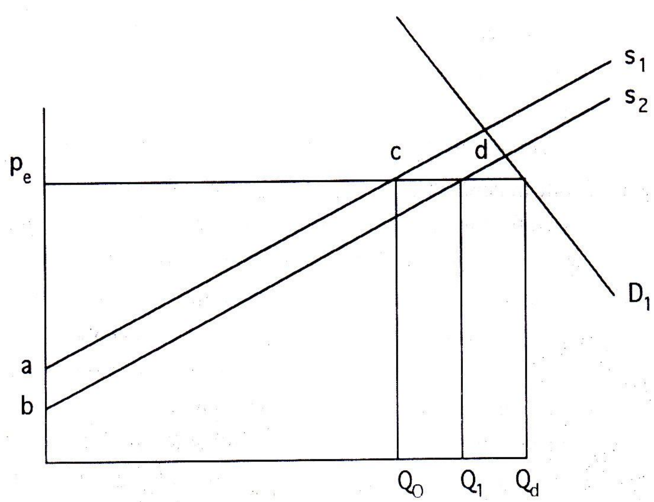
Data and Other Information Needs

Many types of data and other information were needed for the priority setting study. The data and information needs were grouped into: published data, information needed from research directors, information needed from scientists and extension workers, and information needed from economists. Published data include quantities of different types of rice produced and consumed, exports and imports, and price for each types of rice. Information from research directors include the list of types of rice to include in the study and the list of research problem areas. Information from scientists and extension workers include expected per unit cost reductions and yield increases, probabilities of research success, and expected level of adoption of research results. Information obtained from economists include prices, and income elasticities, and descriptions of government price policies. Published data were obtained from secondary government and international sources, and descriptions of the market and policy situation for each type of rice were obtained from published sources and from individuals knowledgeable about particular commodities. A set of questionnaires was developedand refined for use in interviewing scientists and extension workers. In addition, a worksheet was developed to facilitate questioning across different types of rice during the interviews. Interviews conducted with groups of scientists conducted over a three month period of time at the Bangladesh Rice Research Institute and the Bangladesh Institute of Nuclear Agriculture and the Bangladesh Agricultural University and at additional locations with extension workers. Data collected were then transferred to computer spreadsheets for analysis.

Processing of Data and Information

Once the basic information was collected and organized into series of tables, one procedure was used to arrive at a ranking of research priorities by type of rice. A second procedure resulted in lists of research priorities by research problem area. Microcomputer spreadsheet were used to facilitate the calculations.

Bangladesh is a net importer of rice, though in some years she also export very small quantity of fine grain rice. But the quantity of rice Bangladesh imports or exports can not affect the world price; as these quantities are very small compare to the total volume of world import or export. So, a shift out in the supply curve due to technological change will not change the market price, it will simply reduce the quantity of rice import. The effect of rice research in Bangladesh is illustrated in Figure 1.



[1]Which is implicitly equal to the "C and F" price minus the transportation and handling cost.

The original supply curve without technological change is represented by S_1 and the demand curve by D_1 in Figure 1. At domestic price P_e, the original quantity supplied is Q_o, quantity demanded is Q_d and imports are $Q_d - Q_o = Q_t$. If research generates new technology and farmers adopt them, then the supply curve will gradually shift from S_1 to S_2 due to lower unit (per ton) cost of production or due to a grater yield. The new quantity supplied after the research is Q_1 and imports are reduced to $Q^1{}_t = Q_d - Q_1$. As long as supply curve does not shift past Q_d, Bangladesh will remain an importer. Of course, Q_d can shifts out due to increase in population or income. A recent analysis (Dey 1993) shows that Bangladesh will remain a net importer of rice by the year 2005 if the present trend in investment in rice research and water resource development continue.

The gains to research for this type of market can be measured as the area bacd in Figure 1 unless the country increases supply enough to become an exporter. We have assumed parallel shift in supply curve in this study. The formula used in the calculations of changes in total economic surplus (CTS) and net present value (NPV) are as follows:

$$CTS_t = KP_e Q_o (1 + .5Ke)$$

$$NPV = \sum_{t=1}^{15} (CTS_t - RC_t)/(1 + r)^t$$

Where CTS_t = change in total economic surplus in time period t

P_e = domestic price

Q_o = initial quantity produced

e = price elasticity of supply

K = per unit cost reduction or yield increase due to research

r = discount rate

RC_t = research costs in the period t

Yearly values K for different types of rice were determined using the following formula:

K_t = (Projected percentage change in yield) * (Probability of research success in percentage) * (adoption rate in percentage in year t) * (Percent intensification).

Several steps were used for ranking priorities by type of rice. First, criterion related to the objective of improved agricultural productivity and efficiency was incorporated into economic surplus calculations. The net present values of these economic gains were used to rank the types of rice from highest to lowest. The types of rice were then ranked again based on the distribution and risk objectives. The implications of placing most of the weight in the first objective and small amounts on the other objectives were explored.

The steps involved in ranking the research problem areas were somewhat different. For each of the seven criteria for selecting research areas, a scoring of high, medium, or low was given based on information provided by the scientists. The responses which imply the greatest need for research were given a 2. The next greatest used a 1, and the least a 0. Therefore, each research problem area received a 2,1 or 0 for each criterion. The criteria were given weights of 0.7 for the number and severity of research problems, and 0 .05 for each of the other six criteria. The purpose of these weights is to reflect the relative importance of each criterion on efficiency gains and to give a small weight as well to the conservation and risk objectives.

IV. RESULTS OF THE ANALYSIS

The results of the analyses are divided into two parts. First, a summary of the basic data collected and the resulting priorities by type of rice are presented. Second, data collected and the resulting priorities by major research problem areas for rice are described.

A. Priorities by type of rice

A summary of responses from the scientist interviews is presented in Table 4. The projected percent change in yield (net of additional costs to achieve the yield), percent probability of research success, years until key research results are available, the peak adoption rate and the year it will occur, percent intensification and the values of "K" after 15 years are presented for each type rice. Key economic assumptions, including elasticities, initial prices and quantities, and estimates of average annual research expenditures are shown in Table 5. Information from Table 4 and 5, together with information on research depreciation were used to project the net economic benefits of research over the next 15 years for each of 4 types of rice. These benefits are shown in Table 6.

T. *aman* ranks first followed by *boro* and T. *aus*. In contrast, B. *aman* ranks last. *T. aman* ranks highest because of high total value of production and a high projected rate of yield increase (40%). B. *aman* rank lowest because of low total value of production and relatively low projected rate of yield increase (10%). Our ranking match well with the ranking of different of types of rice based on domestic resource cost coefficients (Table 7) calculated in a different study (Dey, 1991). Bangladesh has highest comparative advantage in growing HYV T. *aman* among various types of rice.

Different types of rice also were ranked based on their contribution to calorie intake and to employment as well as on annual variation in value of production. In Table 8, a weighted sum of the income (efficiency), nutrition, employment, and annual variation in income ranking are presented with 80 percent of the weight given to the income ranking as income or economic growth is also the major contributor to nutrition improvement and employment generation. A five percent weighting is given to the calorie and employment ranking each, and 10 percent to the stability.

A final ranking also shows that T. *aman* is the highest priority rice crop followed by *boro* and T. *aus* and B. *aus*. This ranking seems intuitively correct. In Bangladesh, *boro* rice cultivation has already reached a somewhat "stagnant" stage in terms of yield and HYV converge following the path of Japan and Thailand. On the other hand, only around 40 percent of T. *aman* area are under MVs. So far, only 9 varieties have been released in Bangladesh for

T. *aman* season whereas 22 varieties have been released for *boro* and T. *aus*. Development of technologies (including varieties) for T. *aman* (rainfed lowland season) will increase MV adoption, yield and, above all, total rice production in Bangladesh substantially.

B. **Research Problem Areas**

The results of the analysis of priorities by research problem area are shown in Table 9. Plant Breeding and Genetics, Pest Management, Water Control and Management and Soil Science receive high ranking. Socio-economics, Plant Production Practices and Natural Resource Assessment tend to be of intermediate importance. Research on Post Harvest Technologies and Agricultural Information systems tend to come low on the list.

Table 9 shows some discrepancies between current manpower emphasis and our priority ranking in the case of Socio-Economic Analysis and Natural Resource Assessment. At present, there are very few people at BRRI and BINA who are doing research in these two areas. Our priority ranking suggests that government may want to give some more emphasis in these two areas.

V. CONCLUSION, RECOMMENDATION FOR FUTURE RESEARCH

Results of this paper show that rainfed lowland and irrigation ecosystems are the top priority ecosystems as far as rice research in Bangladesh is concerned. T. *aman* rice is the single most important crop grown in the rainfed lowland ecosystem. Due to the ecological constraints, there are no suitable alternatives of T. *aman* crop.On the other hand, there are several alternatives to *boro* rice grown in irrigated ecosystem during the winter season. Among various types of rice, MV, T. *aman* can be grown most economically and Bangladesh has comparative advantage of growing MV, T. *aman* even as a exportable. But unfortunately, Bangladesh does not have technology to cover all the rainfed lowland ecosystem with MV T. *aman*. At present, only 41% of total T. *aman* areas are covered by modern technology. Existing varieties can not grown in areas where flooding depth exceeds 30 cm. With the withdrawal of subsidy from agricultural inputs, comparative advantage of growing MV *boro* , which is an input intensive crop, will decline further, and farmers may shift from *boro* rice to other crops. So, in order to meet the future rice demand for our fast growing population, more research efforts have to be given to develop suitable T. *aman* rice technology for rainfed lowland ecosystem.

Among different problem areas, Plant breeding and Genetics and Pest Management are the two highly priority problem areas. Natural Resource Assessment and Socio-economic Policy Analysis, two neglected fields in the Bangladesh Agricultural Research System, are also important research problem areas. Plant Breeding and Genetic research will be necessary to develop technology for unfavourable rainfed lowland ecosystem and to maintain the high yield of irrigated *boro* rice. Pest Management, Natural Resource Assessment and Socio-economic Policy Analysis research will help us to have a sustainable rice production system.

This paper however does not prioritize problem areas by more detailed ecosystems. Also this study does not prioritize rice research by agro-ecological zones. Future research should be done in this area. However, the task of priority setting is a continuous and interactive process. This paper is an intermediate step in that process. Perhaps the next step is a more detailed elicitation of potential research effects by rice agroecosystems and by research program areas simultaneously. Also, more detailed calculation of the distributed effects of research using economic surplus calculations as opposed to the rough proxy criteria used in this study are needed.

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Table 1. Yearly average area and yield of paddy in Bangladesh by type of rice, 1972-73 to 1990/91

By Type Of	AREA(in ha)		YIELD(m ton/ha)	
Rice	1972/73-1980/81	1981/82-1990/91	1972/73-1980/81	1981/82-1990/91
Aus	3151645	2797082	1.42	1.44
T.aman	4059788	3618658	2.00	1.80
B.aman	1714283	1219476	1.42	1.26
Boro	1074122	1823823	3.10	3.39
All paddy	9999838	9459039	1.84	1.96

Source: Calculate from BBS data.

Table 2. Proportion of rice area planted to modern varieties in Bangladesh by type of rice 1967-68 to 1990-91.

Year	Aus	Aman	T. Aman	Boro	All Rice
			(%)		
1967-68	0.00	0.00	0.00	10.17	0.64
1968-69	0.22	0.00	0.00	18.12	1.56
1969-70	0.51	0.20	0.30	26.55	2.56
1970-71	1.01	1.41	2.07	35.01	4.64
1971-72	1.63	4.71	7.04	36.40	6.74
1973-73	2.26	9.76	14.51	44.70	11.05
1974-75	8.87	9.20	13.15	56.77	14.73
1975-76	10.31	10.10	14.78	55.94	15.25
1976-77	11.35	7.29	10.40	63.35	13.46
1977-78	12.56	8.76	12.46	58.69	15.46
1978-79	12.56	11.98	16.86	62.24	17.41
1979-80	13.82	14.64	19.89	63.44	19.97
1980-81	15.41	15.90	21.51	64.35	21.18
1981-82	14.99	15.90	21.59	68.91	22.23
1982-83	15.76	17.94	24.18	75.37	25.04
1983-84	14.83	17.70	23.41	76.08	24.64
1984-85	16.45	18.90	24.12	78.13	27.29
1985-86	16.93	19.45	25.17	79.12	27.55
1986-87	18.70	20.62	26.54	80.14	29.47
1987-88	17.86	21.50	27.59	84.36	32.37
1988-89	15.56	26.54	32.78	84.72	38.18
1989-90	15.94	30.89	33.28	88.05	41.36
1990-91	17.42	34.02	40.62	88.93	44.07

Source: BBS (1978), BBS (1985), BBS (1989) and BBS (1993).

Table 3. Recommended modern varieties of rice in Bangladesh, by growing season.

Boro + T.aus		B.aus		T.aman	
Variety	Releasing Institute	Variety	Releasing Institute	Variety	Releasing Institute
BR-1	BRRI	BR-20	BRRI	BR-4	BRRI
BR-2	BRRI	BR-21	BRRI	BR-10	BRRI
BR-3	BRRI	BR-24	BRRI	BR-11	BRRI
BR-4	BRRI			BR-22	BRRI
BR-6	BRRI			BR-23	BRRI
BR-7	BRRI			IR-5	IRRI
BR-8	BRRI			IR-20	RRI
BR-9	BRRI			Binasail	BINA
BR-12	BRRI			BR-25	BRRI
BR-14	BRRI				
BR-15	BRRI				
BR-16	BRRI				
BR-17	BRRI				
BR-18	BRRI				
BR-19	BRRI				
IR-8	BRRI				
Purbachi	China				
Pajam	Malaysia				
BAU-63	BAU				
IRATOM-24	BINA				
IRATOM-38	BINA				
BR - 26	BRRI				

Table 4. Summary of Scientists Interview.

	TYPES OF RICE			
	Boro + T.aus	B.aus	B.aman	T.aman
Change in Yield (percent)	7.5	20	10	40
Probability of Success	85	85	85	85
Year to Results	1	3	2	2
Adoption Rate (percent)	20	10	20	16
Peak Year of Adoption	3	5	5	6
Percent Intensification	1	0	-1	0
"K" after 15 years	0.0148	0.0170	0.0146	0.0544

Source: Survey, 1989-90.

Table 5. Summary of key economic assumptions.

	TYPES OF RICE			
	Boro + T.aus	B.aus	B.aman	T.aman
Supply Elasticity	0.7	0.11	0.13	0.13
Initial Price (Tk/mt)	7364	7364	8484	8484
Initial Quantity (000 mt)	5503	2140	1070	6573
Estimated Average Annual Research Expenses (000 Tk)	44000	31000	31000	52500

Note: Initial price and initial quantity refer to the average of the period of 1985/86 to 1987/88.

Table 6. Projected Net Economic Benefits of Research by Type of Rice.

Type of Rice	Ecosystem	Net Present Value (000 Tk)	Rank
T. aman	Rainfed lowland	11691984	1
Boro + T.aus	Irrigated	3052679	2
B.aus	Upland	916144	3
B.aman	Deepwater	511205	4

Table 7. Domestic Resource Cost Coefficient of Different Types of Rice Grown in Bangladesh.

Crop	Land Type	Mode of Irrigation	Domestic Resource Cost: Yield ton/ha	Domestic Resource Cost: Import Substitute at Wholesale Level	Domestic Resource Cost: Export
B.aus	Highland	Rainfed	1.3-1.58	0.98-1.37	1.50-
B.aus	Medium Highland	Rainfed	1.36-1.70	0.71-1.21	1.08-1.62
MV T.aman	Medium Highland	Rainfed	2.66-3.18	0.54-0.73	0.87-1.13
MV Boro Lowland	Medium Low/	Irrigated	4.37	0.88	1.51

Source: Dey, M.M. 1990.

Table 8. Rice Research Priorities by ecosystem.

Types of Rice	Ecosystem	Net Economic Benefit Rank	Employment Rank	Calories Rank	Annual Variation Rank	Weighted Total
T. aman	Rainfed Lowland	1	1	1	2	1.1
Boro + T.aus	Irrigated	2	2	2	1	1.9
B.aus	Upland	3	3	3	3	3
B.aman	Deepwater	4	4	4	4	4

Table 9. Scoring Model to Help Assess Rice Research Priorities by Research Problem Area.

Research Problem Area	Number Problems	Capital Use	Borrow Research	Current Manpower	Research Cost	Environ Effect	Annual Variety	Weight Total
Plant Breeding and Genetic	2	0	2	2	0	1	1	1.5
Plant Pest Management	2	0	2	2	0	1	2	1.75
Soil Science	1.5	1	2	1.5	1	2	2	1.52
Water Control and Management	1.5	2	1	1.5	1	2	2	1.52
Socio-Economic	1.5	1	0	1	2	1	2	1.45
Plant Production Practices	1.5	2	1	1.5	0	1	2	1.42
Natural Resources Assessment	1	1	1	0	2	2	2	1.1
Mechanization	1	0	1	1	1	1	2	1
Plant Post Harvest Technologies	0.5	0	2	0	1	1	1	0.6
Extension Type Activities	0.5	1	0	1	1	1	1	0.6
Agricultural Information Systems	0	1	1	0	2	1	1	0.3
Weights =	0.1	0.05	0.05	0.05	0.05	0.05		