Ten Years of Agricultural Research in Bangladesh
Proceedings of the National Symposium on Agricultural Research

1985

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Foreword

The National Symposium on Agricultural Research on 22-23 December 1983 was a celebration of over a decade of scientific progress in Bangladesh. While our nation is young, our agricultural traditions are centuries old. The roots of our national agricultural research system go back more than 100 years, but our greatest accomplishments have come since our people achieved liberation in 1972.

The Symposium commemorated the ten year anniversary of the establishment of the Bangladesh Agricultural Research Council. Foremost, it was an opportunity to focus attention on the accomplishments of researchers, notably during the most recent decade. Secondly, it was an occasion for scientists of many disciplines and institutions to assemble together to report and evaluate their work, and to discuss plans for the future. In this sense, the Symposium served to build a co-operative spirit among our researchers that will strengthen their efforts for many years to come. And thirdly, there is a new awareness of the contributions of Bangladeshi research on the part of our national leaders and by the international agricultural research community.

The Symposium was organized around eleven topics that are central to agricultural research in this country: crops, fruits and vegetables, forests, livestock, fisheries, soils, on-farm water management, farming systems, nutrition, socio-economic, and communication. BARC invited an eminent Bangladesh scientist to present the keynote paper on each topic. These senior scientists have broad experience in their respective disciplines. Their papers are excellent statements of the contributions of agricultural research to the benefit of our people, thus they deserve thoughtful attention.

There were also 109 papers contributed for the Symposium; they are published here in abstract form. They introduce the reader to the variety of research that is conducted in our system as well as to the many methodologies and accomplishments. Increasingly, as these abstracts indicate, our emphasis is on research that is practical, which answers the questions asked by farmers, fishermen and foresters.

The Council believes the papers and abstracts published in these *Proceedings* constitute a significant contribution to the body of agricultural science literature of this region.

On behalf of BARC, I thank everyone who took part in the Symposium. We acknowledge the important contributions of the scientists and researchers who prepared the papers. And, we greatly appreciate the greetings and other messages of support received from the national leadership of Bangladesh and from agricultural leaders throughout the world.

I also acknowledge the institution-building grant of the U.S. Agency for International Development, the Agricultural Research Project–Phase II, which assisted BARC to sponsor the Symposium and to publish these proceedings.

The National Symposium on Agricultural Research was a proper commemoration of BARC's anniversary, but there is a continuing need for this kind of scientific interchange. The Council is planning to sponsor similar gatherings of our researchers every second year. In the interim, BARC dedicates this book (1) to the readers, with the desire that you will gain a better understanding of the importance of scientific research in a developing country, and (2) to the farmers of Bangladesh for whom we are seeking new technologies which will improve their agricultural productivity and overcome rural poverty.

Kazi M. Badruddoza
Chairman
Bangladesh Agricultural Research Council

Dhaka
December 1984

Preface

The National Symposium on Agricultural Research was an opportunity for scientists to demonstrate the broad scope and quality of agricultural science in Bangladesh. Papers were prepared by dozens of researchers representing 26 institutions. For these reasons, this publication is a useful cross-section of the multi-disciplinary, multi-institutional constituents of the national agricultural research system.

These papers and abstracts are the responsibility of their authors; they have not been subjected to peer review as would be the case for a scientific journal. They have been edited to meet international standards for agricultural research publications to increase their readability while maintaining their scientific validity. After editing, each paper and abstract has been checked for accuracy by the author(s).

The Organizing Committee for the Symposium placed no limit on the length of the documentation, thus some abstracts are concise while others provide considerable detail of the research results. Some of the abstracts are reports of original research and others are reviews of the achievements of Bangladesh researchers.

The basic references for language have been the *Oxford Advanced Learner's Dictionary of Current English* by A S Hornby, and the *Oxford Dictionary for Writers and Editors*, in order to favour the British usage which is the tradition in Bangladesh. *The Chicago Manual of Style* was the guide for production of the book, supplemented by several references for scientific editing. The *IRRI Style Manual* was very useful in resolving many of the agricultural research issues.

Each paper and abstract is a separate unit. No effort was made to reconcile apparent contradictions or inconsistencies. Readers desiring to pursue such matters should correspond with the authors. The goal has been to maintain the integrity and style of each researcher's work. Readers can sample the topics of interest without having to read the book in its entirety to become familiar with agricultural research in Bangladesh.

Both metric and English measures are used to describe the research. Though the metric system has been officially adopted for this country, much of the research was conducted prior to that decision and therefore is presented in the terms in use at the time. The only editorial conversion of measurements has been to use thousands and millions rather than the lakh (100,000) and crore (10 millions) commonly used on the Indian subcontinent.

The position titles and names of institutions have been retained as they were at the time of the Symposium in December 1983, even though there

have been many important changes in the organizational structure and individual postings in the national agricultural research system.

It is the desire of the Organizing Committee that this publication will provide the reader with an informative introduction to the accomplishments of the agricultural research system as well as to the many challenges it is facing to effectively meet the future needs of the people of this country.

Part I
Inauguration

Welcome Address

KAZI M. BADRUDDOZA

Executive Vice-Chairman
Bangladesh Agricultural Research Council

It is my proud privilege to welcome you all to the inaugural session of the Ten-Year Anniversary of the Bangladesh Agricultural Research Council. By accepting to inaugurate the opening session, the Minister for Agriculture and Water Resources of the People's Republic of Bangladesh has shown his commitment to the harnessing of agricultural science for national development. On behalf of the community of agricultural scientists, I thank him for his presence as the Honourable Chief Guest. I also thank the Secretary, Agriculture and Forests Division, for kindly agreeing to chair this session. I heartily welcome my scientist colleagues for their active participation and contribution to this meeting. In addition to critically reviewing the latest developments of various research disciplines, the purpose of this function is to direct the insights and skills of agricultural research toward the problems of rural development. The aim is to utilize the vast inter-disciplinary expertise present here for a deeper understanding of the central national problem–*rural development.*

The happy occasion of the ten-year anniversary of the Bangladesh Agricultural Research Council is a most appropriate time for us as a nation in which to take stock of the performance of our national agricultural research system. Twelve years after liberation we now have in place a set of research institutes covering rice, jute, tea, sugarcane, wheat, pulses, oilseeds, vegetables and other crops, as well as livestock, fisheries and forestry. At the apex of this network is BARC, whose function is to strengthen and co-ordinate the multifarious activities into a coherent, comprehensive and viable programme that is consistent with national goals and priorities in the vital agricultural sector.

There have been some remarkable developments in Bangladesh agriculture over the past ten years. The "wheat revolution" is one such change, with average yields that have more than doubled and a total production that has increased more than 16-fold. There also have been some impressive advances in the production of high yielding varieties of crops like rice, summer pulses and mustard seed. Much of the credit for these advances rightly belongs to the scientists of our agricultural research network. The productivity of this network has been consistently high and the payoff in some cases most impressive. Let us not forget, however, how much of the credit belongs to the millions of small farmers who are the final users of this new technology. Progress in the livestock, fisheries and forestry sectors also has been substantial.

The small farmers of Bangladesh are without question among the most intelligent and innovative in the world. What they often lack, however, is sufficient knowledge of and access to appropriate modern farming technology. When they have had such knowledge and access, and where the technology is appropriate to both local conditions and their own resources and needs, our small farmers have not merely adopted the technology but have experimented to better adapt it to their own circumstances. Every village in Bangladesh has its progressive small farmers whose fields are laboratories-in-miniature in which the last link in the process of scientific adaptation takes place.

Our best agricultural scientists have recognized this fact. All of our research in agriculture must start from the small farmer, his needs, resources and constraints–socio-economic, financial and physical. Our scientists must emphasize all aspects of farming systems, not only crop and livestock systems. Our scientists never forget that the ultimate purpose of their work is to raise the level of well-being of the entire community–of small farmers,of the rural landless who depend on them for employment, and of the urban customers who rely on them for food and clothing. A happy and prosperous small farm sector will be a happy and prosperous Bangladesh.

Once again, I most cordially welcome you to the decennial anniversary and confidently hope that your participation and contribution will help the deliberations in the various sessions.

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Inaugural Address

A. Z. M. OBAIDULLAH KHAN

Minister for Agriculture

I am delighted to attend this BARC tenth anniversary symposium. Dynamic agricultural research is a prerequisite for agricultural development. The Council's role in this regard is very important, especially for the national research policy, and for programme planning, publication and implementation.

Our agriculture has a special characteristic: most of the farms being small and marginal, the farmers not only produce many different crops but often they endeavour to produce cattle, poultry and fish. They have a variety of problems, unlike the situations of the Sri Lankan coconut farmer, the Malaysian oil palm farmer, and Hawaiian sugarcane farmer.

Even though the typical farm is small in Bangladesh agriculture, these farms are not meant only to produce rice, jute or milk. The agricultural process here is directed for the production of different types of crops, animal resources, fuel, animal feed and other commodities. Seeds, chemicals and fertilizers, animal power, water, labour, capital, and so forth are used to produce these things. In other words, a farm here is a production process; it can be called a small village workshop. Production planning, preparation and maximum utilization of scarce resources is equally applicable for the small workshop as for large scale industries. There has to be a co-ordination between research and numerous problems of the farmers who are operating these workshops. We should develop technology in such a way that it is easily adaptable by small farmers.

The scope of our agricultural research is pervasive. The objective of selecting new plant varieties should be to ensure better crops with higher production per acre under our agro-climatic conditions. The equipment required for modernizing our agriculture should be developed on the basis of pragmatic socio-economic needs.

Even today we see that local, low yielding varieties are used in most of our lands. We are yet to fully meet the demand for HYV wheat seed. We have not been able to overcome our dependence on foreign countries for improved potato seed. The same situation prevails in the case of improved seed of vegetables. No satisfactory progress has been achieved for deepwater rice.

Research should not be conducted for its own sake. I appeal to all of you to understand that research should improve the conditions of our farmers, for they are striving to overcome hunger, and upon their income all economic activities depend.

We should work hand in hand to improve the lot of the small and marginal farmers. Scientists should get away from their research institutions and learn about the farmers' problems. Our research has to be farmer-oriented. I am happy to know that on-farm research is being emphasized.

The exchange of theories and information among scientists is important. There should also be an easy flow of information among research organizations and throughout the research system. This relationship and sense of co-operation should exist as well within agricultural extension, the agencies supplying inputs, the national seed agencies, and the governmental policy-makers. Improved systems need to be developed to carry information to the general members of the public who ultimately bear the cost of the research system and to benefit such people from the research efforts.

There must be co-ordination in determining the present and future research priorities, and thus such different training programmes as in-service training and the education of future agricultural scientists are essential. The Government established BARC to fulfill this object to give assistance to the farmer communities. Above all, the flow of research should provide maximum benefit of the planned and integrated new technology to the people in general.

The Government has recently taken many steps to make it easy for agriculture to pass on from traditional to scientific agriculture. This includes the easy availability of long- and short-term credit programmes, irrigation equipment, and other facilities. It also includes the establishment of new institutions such as the College of Agricultural Sciences, and the transfer of BAU to the Ministry of Agriculture. There is now the Extension and Research Project to augment extension programmes. Through land reformation there is now more assurance of work for farmers and more opportunity for better distribution of the produce.

In view of these steps, the prospects are now brighter for rapid agricultural development. I believe the agricultural scientists can make remarkable contributions to the development of the nation through appropriately organized, disciplined, planned and integrated research.

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Chairman's Address

A. M. ANISUZZAMAN

Secretary, Agriculture and Forests

I consider it a privilege to preside over the inaugural session of the National Symposium on Agricultural Research, most especially as it is to commemorate the tenth anniversary of the establishment of the Bangladesh Agricultural Research Council.

Ten years after the birth of BARC is a good time to reflect on how the organization has developed.

- Has BARC lived up to the expectations of those who designed it?
- What has BARC achieved in these ten years that could not otherwise have been achieved?
- Have satisfactory foundations been laid in BARC for directing the future progress in national agricultural research?

To an administrator, these are important questions. BARC must stand for more than bricks and reinforced concrete. Institution-building must mean more than empire-building. Buildings and staff are important, but only when they provide the means to achieve productive ends.

What productive ends do I, as Secretary, look for from BARC? What I am looking for is a research system that will meet the country's agricultural development needs at the least cost in the shortest possible time. According to the Ordinance which established BARC, it is to help build and strengthen that system and to co-ordinate its activities. These activities must be mutually consistent, and thus consistent with the needs and priorities of the nation.

- What has BARC done over the past ten years to fulfill this role?
- Has it taken full measure of the agricultural sector's priorities stated in the five-year plans and translated them into researchable issues to be addressed by the agricultural research system?
- Has it formulated these issues into a properly integrated and consistent national plan of agricultural research?
- Has it assessed the capabilities of the research institutes for carrying out this plan?
- Has BARC taken a critical look at the way in which research programmes and projects are formulated and how research priorities are set?
- Are the criteria for project selection based on the agricultural needs of the nation or are they the research interests of individual scientists?

The whole basis for BARC's relationship with the constituent research institutes is a question which requires the most careful attention. It must be a relationship of mutual trust and support, for without this BARC cannot play its co-ordinating role.

- How does BARC approach a research institute, through its board of governors or through individual scientists who place research proposals before the Council?
- Who determines the areas for contract research, and how do these fit into the priorities of the research institutes?
- What has BARC done to find a mutually-acceptable demarcation line between its responsiblities and those of the constituent institutes?

BARC's most important role, undoubtedly, is that of co-ordinating, strengthening and, hence, planning the national agricultural research system–as a system. BARC's success or failure in this role will largely determine whether the agricultural research institutes will become such a system or remain as largely independent organizations, each pursuing its own independent programme.

- What steps has BARC taken to meet this objective?
- It has produced one National Agricultural Research Plan and it is in the process of formulating a second, but are these plans more than shopping lists of uncoordinated projects?
- Do they, in fact, translate national agricultural production priorities into researchable priorities ?
- Are the manpower, funding and physical requirements for each project carefully and precisely spelled out to ensure that the package is both desirable and realizable?
- Are the identified needs translated into concrete targets such as would be contained in a systems-based manpower development plan?
- Are the projects which are identified in the research plan set out in their order of priority? If so, how have these priorities been established?
- Have the projects and programmes of the plan been the subject of a rigorous cost-benefit analysis to determine their relative worth?
- Are the plans constructed in such a way as to maximize the returns to scarce resources?
- Do we have realistic contingency plans? For example, in the event of future budgetary or other constraints, can BARC advise the government as to which projects should be postponed and why?

Developing a research system, however, is more than just co-ordinating its various parts. These parts must be strengthened and made increasingly appropriate to the needs of the country and of the farmers. Far too many of our research scientists are research station-oriented. They regard the farmer as illiterate and, therefore, ignorant.

- Has BARC recognized this problem? If so,what has it done to correct it?
- What has it done to convince our scientists that they must respect the farmers as highly competent professionals?
- What has it done to encourage scientists to get into the farmers' fields to conduct farming systems research, and to take the farmers' needs, constraints and resources as the starting point of their research?

My final set of questions is concerned with BARC as an instituion.

- Has the Council ever taken a critical look at its own bureaucratic requirements?
- Has any attempt been made to streamline the procedures for processing, monitoring and reviewing the research projects supported by BARC so as to minimize the administrative load on the scientists?

I have a related set of issues concerning cost effectiveness. For example, a great deal of money is spent on study tours, fact-finding missions, short-term training, and other foreign travel by officials of BARC and of constituent bodies using BARC funding.

- Are such journeys necessary ?
- Is the information sought always needed? If so, is there an alternative means of acquiring it?
- When such journeys are considered necessary on defensible grounds, are they always taken by suitably qualified individuals?
- Are reports required?
- Are they reviewed?
- What impact do they have?

Perhaps by now I have said enough on this subject. I am not here to lecture BARC on what it should or should not do, nor am I here to question the hard work and dedication of the BARC staff. What I have aimed to do is to raise some searching issues and to voice my concern that research should be relevant for the country's pressing development needs—both social and economic—and to emphasize BARC's great responsibility for ensuring that an effective research effort is made to find early and practical solutions to the country's manifold agricultural, forestry, fisheries and livestock development problems.

To my mind, therefore, this tenth anniversary of BARC should not be the occasion for complacent self-congratulation and self-satisfaction. Rather, given the country's urgent development problems, let this anniversary be the occasion for re-dedication of our efforts to help the farmers, fishermen, and other rural communities to help themselves so that by the time of BARC's twentieth anniversary we may feel justifiably proud of our achievements in improving the quality of life of those whom we serve.

I want to avail myself of this opportunity to express on behalf of all of us our gratitude to those who were previously associated in building of BARC. Particularly, I gratefully remember the contributions of the pioneers like Dr. A. Islam and Dr. S.D. Chaudhuri. But for their dedicated efforts, BARC would not be what it is today. Their contributions will always offer guidance and strength for the present and future generations.

Vote of Thanks

M. A. MANNAN

Member-Director (Soils and Irrigation)
Bangladesh Agricultural Research Council

I consider it a pleasure and honour to offer the vote of thanks on behalf of the Bangladesh Agricultural Research Council.

After achieving independence, the Government of the People's Republic of Bangladesh realized the urgent need for an organized agricultural research system. A Presidential Order established the Bangladesh Agricultural Research Council in 1973 to undertake, aid, promote, co-ordinate and evaluate agricultural research throughout the country.

At the invitation of the Government, a number of teams of scientists of international repute visited Bangladesh to examine in great detail the various aspects of the Council. They made important recommendations. The reports submitted by these teams were examined by committees appointed by the Government and further modifications were made in the recommendations for taking the necessary action. Accordingly, the Presidential Order No. 32 of 1973 was amended in 1976 to strengthen the Council for the more effective discharge of its functions. Research institutes dealing with agriculture were spread over seven different Ministries. Recently a bold action of the Government has brought the major research institutes under the Ministry of Agriculture and made them constituent units of the Bangladesh Agricultural Research Council. This has definitely made the task of co-ordination and evaluation of the research activities of these institutes easier for BARC.

I am grateful to Mr. A.Z.M. Obaidullah Khan, Minister for Agriculture, who spared his valuable time to attend the inaugural session as the Chief Guest and to inaugurate the National Symposium on Agricultural Research in celebration of the ten-year anniversary of the Council.

I am thankful to Mr. A.M. Anisuzzaman, Secretary, Agriculture and Forests Division, who kindly agreed to chair the inaugural session.

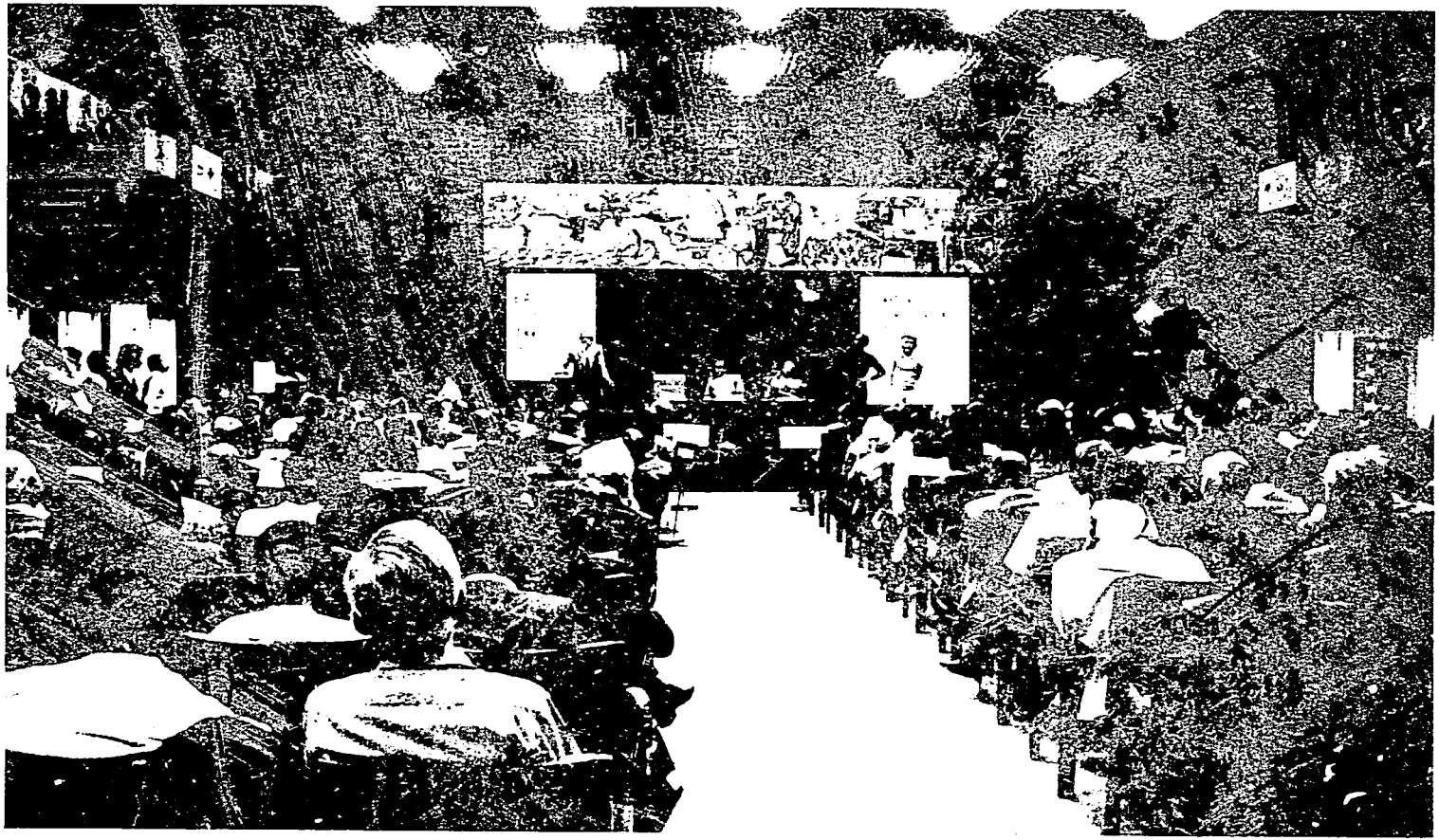
My thanks are extended to the distinguished guests who have kindly attended this session. I also express my thanks to the eminent scientists of Bangladesh for their active participation in the National Symposium on Agricultural Research of the Council.

I gratefully acknowledge the unstinted co-operation extended by the universities, and the research and extension organizations.

Lastly, I must extend my thanks to the national information media, representatives of which are here to disseminate reports of the activities of the Symposium.

Ladies and gentlemen, once again I thank you all.

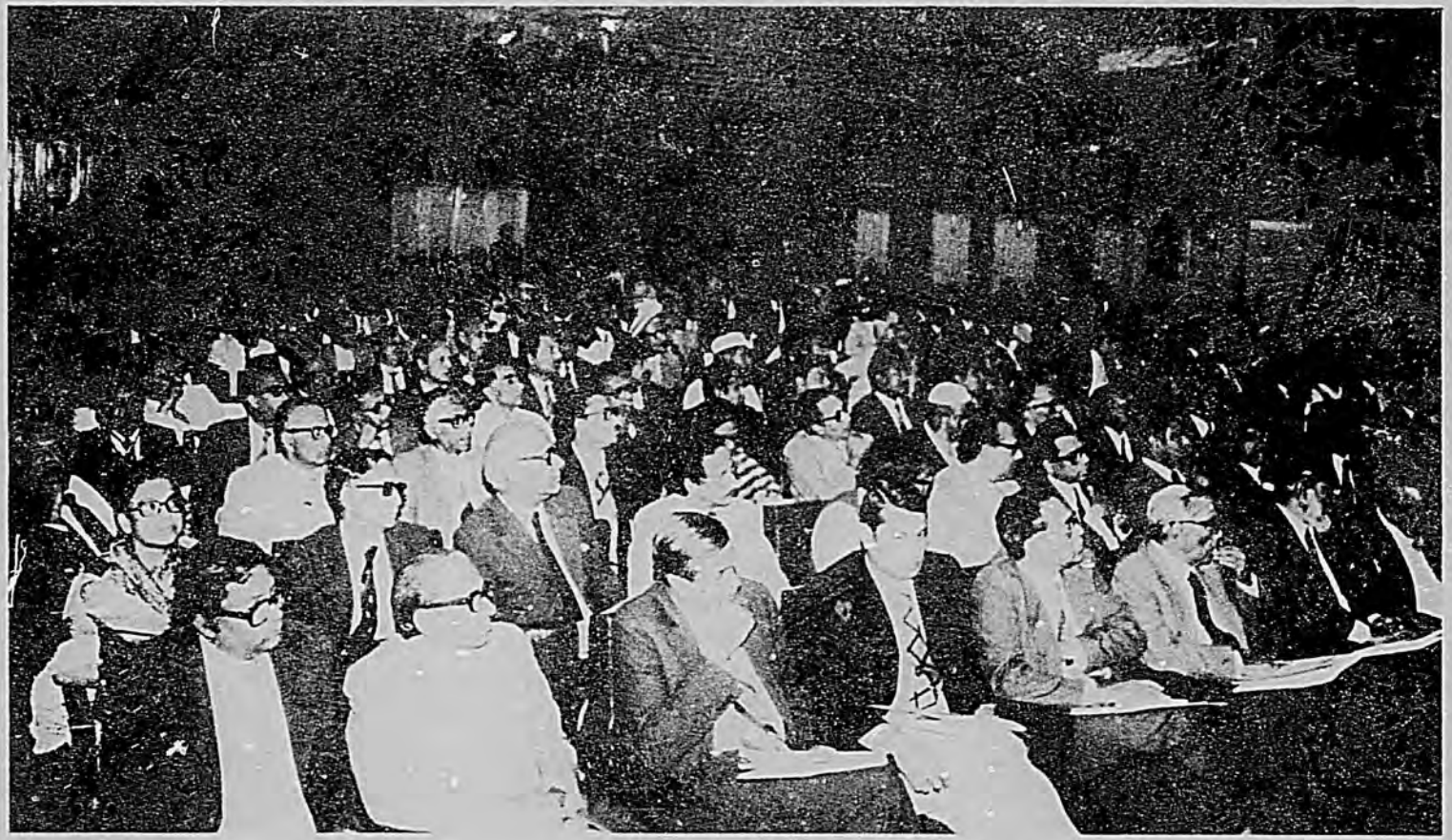
Part II
Photographs



Secretary of Agriculture A. M. Anisuzzaman presented the Chairman's Address.

The Minister for Agriculture, Mr. A. Z. M. Obaidullah Khan, inaugurated the National Symposium on Agricultural Research.

The Vote of Thanks was given by Dr. M. A. Mannan of BARC.



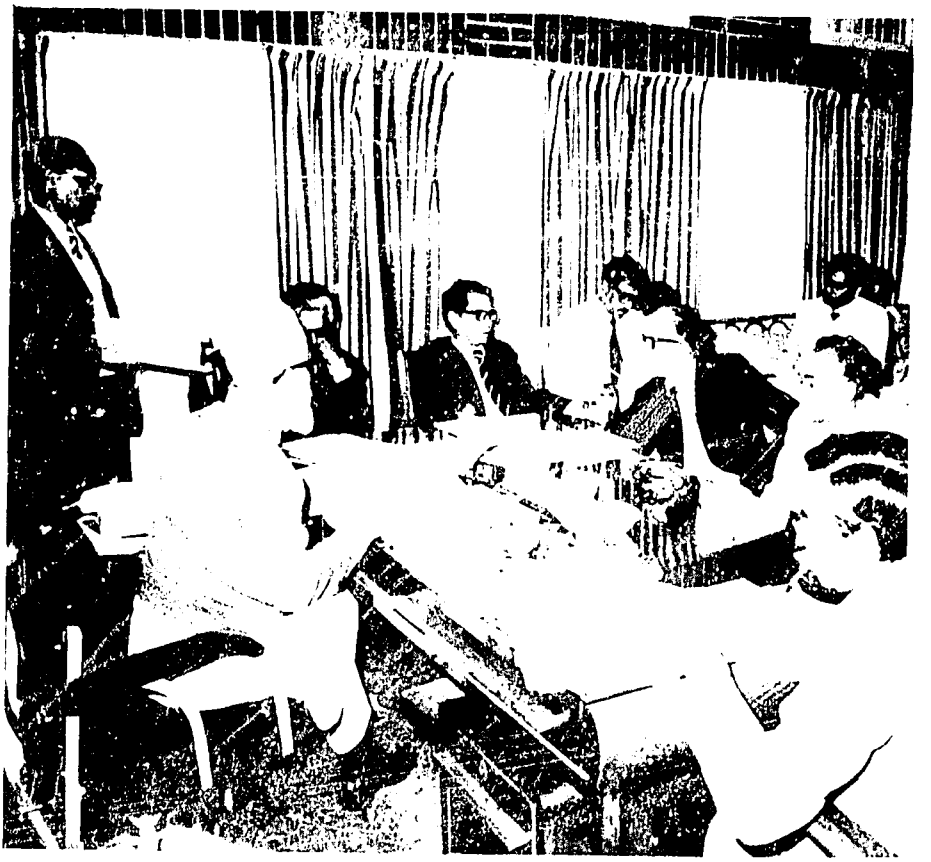
A distinguished audience assembled to commemorate BARC's ten year anniversary.

BARC staff members welcomed guests to the Symposium.

In his Welcome Address, Dr. Kazi M. Badruddoza of BARC spoke of the progressive small farmers of Bangladesh who need new technology to increase their agricultural productivity.

Dr. M. Omar Ali, Director, FRI, gave the keynote paper on Forest Research.

The keynote paper on Livestock Research was presented by Dr. Mirza A. Jalil, Director of Livestock Services. Dr. A. K. M. Aminul Haque, Vice Chancellor, BAU, was chairman of the session.



Bangladesh scientists contributed over 110 papers to the technical sessions.

Dr. M. U. Ahmed Chowdhury of BAU (left) and Dr. S. M. H. Zaman, Director, BRRI, were among the agricultural leaders who presided at Symposium sessions.

Mr. M. Z. Islam of NALDOC/BARC presented a paper to the technical session on Communication of Agricultural Research. Dr. S. G. Mahboob of BAU was in the chair.

A question and answer session was held during the technical session of Social and Economic Research.

Dr. M. M. Rahman, Director, BARI (left), gave the keynote paper on Farming Systems Research. Dr. Md. Ibrahim, President, Diabetes Association of Bangladesh, was chairman of the session, also shown below.

The Symposium was an opportunity for agricultural researchers to exchange ideas, as in this conversation with the BARC Executive Vice-Chairman.

Photographs by Mr. Sarkar Salahuddin, Scientific Officer, BARC.

Part III
Crops Research

KEYNOTE PAPER

Crops Research in Bangladesh

KAMAL UDDIN AHMAD

Member-Director (Crops and Forestry)
Bangladesh Agricultural Research Council

INTRODUCTION

Bangladesh is one of the most densely populated countries in the world. Our people have the distinction of being among the foremost cereal eaters as well as being the top rice-eating nation (Table 1). Another important food item is *daal* or pulses, eaten mainly as broth or soup to go with rice.

Wheat has come to be cultivated and eaten in larger quantities than ever before. This supplements the consumption of rice, the most expensive of all staple foods. The potato is the number one vegetable in the country. Sometimes in glut periods it is a staple food while at other times it has a place among the vegetables (Table 2). With improving cold storage facilities potatoes are available throughout the year.

While cereals and tuber crops supply carbohydrates, the pulses and oilseeds are treasured for their proteins and fats, respectively. The pity is that during the past 33 years, the production of pulses has not increased though the population has more than doubled. The per capita availability of pulses is now less than half what it was in 1947. Production has been reduced during the last decade due to smaller acreage, poor management, and the low productivity of local cultivars.[2] Of the daily per capita intake of about 12 gm of fat, 10 gm came from plant sources. It is imperative that oilseed production be doubled–if not trebled–to meet the fat requirement for a balanced diet.

The availability of vegetables is exceedingly low in Bangladesh. In most developed countries, more than 40% of the plant-based food comes from vegetables, including potatoes. Almost half of the plant-based food comes from those sources in Japan and the United Kingdom. Our neighbouring countries of Malaysia, Sri Lanka, Thailand and the Philippines get from 24 to 27% of their per capita supply of plant-based foods from vegetables and potatoes. Bangladesh's supply has been only 14% (Table 3). Our per capita consumption of fruit is now less than 40 gm per day. The Philippines and Thailand have more than triple that quantity, and some West European and North American countries have two to five times more.

Our situation with sugar is unsatisfactory. Our experts want to attain self-sufficiency in sugarcane production to help overcome our need to import sugar.

At one time Bangladesh had a virtual monopoly in jute, the world's most important fibre for the manufacture of sacks, cordage and carpet-backing. In 1947 we produced over 85% of the world production of 8.5 million bales.

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During the last three decades, world production has increased more than 2½ times but that of Bangladesh has decreased to only 4.6 million bales. India and China have emerged as the biggest producers, and Burma, Nepal and Brazil are now among the top group. We need to continue to earn foreign exchange through jute exports; this has been our largest single exchange earner.

We are self-sufficient in tea and tobacco, but also need to improve the quality and quantity of these crops to help earn foreign exchange.

Table 1. Production of rice in leading producing countries, 1979.

Country	Population (millions)	Rice production	
		million tons	kg/per capita/year
China	945	96.08	102
India	678	46.23	68
Indonesia	148	17.65	120
Bangladesh*	86	12.97	151
Thailand**	46	10.47	228
Japan	116	10.45	90
Vietnam	51	7.34	138
Burma**	34	6.70	197
Korea, Republic of	37	5.40	146
Brazil	122	5.08	42
Philippines	49	4.69	96
United States**	220	4.15	19

*Bangladesh imports rice

**Thailand, Burma and the United States export rice.

Table 2. Value of selected food crops, 1979. Value in US dollars/100 kg.

Rice		**Wheat**	
Thailand	33.4	United States	17.5
United States (Texas)	44.7	Denmark	18.9
		Sorghum	
Maize		United States	13.4
United States	13.8		
		Potato	
Barley (feed)		United States	7.3
Canada	9.6	Denmark	11.1
Cassava			
Thailand (Bangkok)	12.1		
Netherlands (Rotterdam)	16.4		

RESEARCH FOR VARIOUS CROPS

Rice

Rice research came into the limelight through the development of the high yielding *miracle rice*, the dwarf IR8. Bangladeshi farmers readily adopted it in the 1960s where irrigation was available. Several other high yielding varieties (HYVs) were subsequently introduced by the International Rice Research Institute plus a large number of new varieties by the Bangladesh Rice Research Institute. By 1982, 2.37 million ha were planted to the modern varieties which is about 23% of the rice growing area (Table 4). In 1970 only 2.7% of the rice area had been planted to these varieties. Now as much as 6 million tons of rice— 41% of the total harvest—Come from HYVs. Nearly one-third of the Bangladeshi population might have starved had we continued to depend on the conventional, low-yielding varieties of rice.

This large acreage has been achieved because scientists have provided farmers with both modern varieties and appropriate technologies. A static situation may be reached soon as the existing HYVs have inherent limitations and because of the constraints of the agro-ecological conditions. Some of the tasks for rice researchers seeking to expand the area planted to modern varieties are the (1) development of site-specific technologies,(2) reduction of the dependance on irrigation, (3) evolving HYVs suited to rainfed conditions, (4) fitting HYVs to the cropping systems in various regions of the country, (5) overcoming of micronutritional deficiencies, and (6) reductions of the costs of inputs and production. It is also important to improve long stemmed rice varieties and technology as these account for nearly the largest share of rice production during the rainy season. Otherwise, the average yield in Bangladesh may continue low compared with most of the leading rice producers of the world.

Only a little more than one-fifth of the total rice producing area of Bangladesh has been planted to the HYVs. The other four-fifths–about 20.1 million acres— is planted to the conventional, low-yielding varieties (Table 5). The average yield of HYV rice is nearly 1 t/A compared with 0.34 t/A for local aus, 0.39 t/A for broadcast aman, 0.50 t/A for local transplanted aman and 0.62 t/A for local boro. It is remarkable that Pajam, a variety not considered as high yielding, has been producing an average of 0.62 t/A in aus, 0.80 t/A in aman, and 0.93 t/A in boro seasons. This variety is being planted on 1.4 million acres. When a non-HYV can perform so well, we should try to find other varieties adapted to our conditions and which yield well using inputs equivalent to those of the HYVs. We need to develop HYVs that tolerate drought stress in the aus season, survive floods during the monsoon, and tolerate cold and moisture stress during the boro season.

Wheat

The history of wheat production in Bangladesh is unique for the world. Production has risen from a mere 100,000 tons in 1975 to as much as 1 million tons in 1982 (Table 6). It is important to recognize that almost the entire

Table 3. Per capita food supply from selected food groups in various countries, prior to 1970.

Country	Grams per person per day						Percentage of total from vegetables, roots and tubers
	Cereals	Veg., roots and tubers	Fruit	Sugars	Pulses	Total	
Japan	380	550	121	57	45	1153	48
United Kingdom	200	456	139	185	16	946	48
Netherlands	189	465	257	135	16	1062	44
United States	177	402	239	133	23	974	41
Lebanon	385	376	379	112	13	1263	30
Malaysia	392	210	71	80	23	776	72
United Arab Republic	551	330	230	49	35	1195	28
Sri Lanka	373	148	26	57	77	719	26
Thailand	412	199	128	29	52	820	24
Philippines	342	174	123	46	23	708	25
Bangladesh	528	104	63	80	37	762	14

Table 4. Area planted to HYV rice in Bangladesh, 1973–74 to 1980–81.

Season	Area planted to HYV rice (1,000 acres)							
	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79	1979–80	1980–81
Aus	329	699	872	901	953	1025	970	1179
Aman	2042	1239	1375	1046	1233	1695	2154	2375
Boro	1454	1629	1587	1337	1586	1649	1788	1847
Totals	3825	3567	3834	3284	3772	4369	4912	5401

Table 5. Area and yield of paddy in some leading rice-producing countries.

Country	Million hectares	tons/ha
India	40.00	1.98
China	37.29	3.53
Bangladesh	10.00	1.89
Indonesia	8.81	2.93
Thailand	8.29	2.05
Brazil	5.55	1.30
Burma	5.20	2.02
Vietnam	4.89	2.02
Philippines	3.76	1.84
Japan	2.56	6.25
United States	1.24	5.05
Korea, Republic of	1.23	6.55

Source: FAO, 1979.

wheat acreage is planted to HYVs. This is the result of the combined efforts of research at the Bangladesh Agricultural Research Institute, of extension organizations, and seed production and distribution by the Bangladesh Agricultural Development Corportion. After a phenomenal early rise, production has remained relatively stable. The Government has a task force investigating the matter. There were few shortcomings in research, but several were observed regarding irrigation facilities, seed production and distribution, and even pressure from potatoes, oilseeds and other competing crops in the rabi season. A potentially large wheat-producing area continues to be planted to boro rice despite the fact that rice consumes several times more water than does wheat.

The present need for HYVs of wheat has been met with Sonalika, which covers about 70% of the wheat area. Several others are widely grown. To attain varietal diversification and disease resistance, wheat scientists have released Balaka and Ananda with resistance to leaf rust; Kanchan, a semi-dwarf variety producing bold, white grains, which is adapted to late planting and produces higher yields than Sonalika; and two other semi-dwarf varieties, Akbar and Barkat, which also have produced higher than Sonalika. Since wheat needs to be planted late to follow aman rice and as much as 60% of wheat can be produced on land without irrigation, the main need now is for late varieties that can withstand drought conditions. The new varieties tend to perform well without irrigation. There also needs to be research on the post-harvest technology of wheat under Bangladesh conditions.

Maize and other cereals

Maize is an unconventional commodity/food crop that is relatively unknown and unacceptable to the local people. It has the capability to produce more food per acre than either rice or wheat at equivalent

production costs. Furthermore, it is a human food, an animal food, a fuel, and an important raw material for the starch and edible oil industries. This amazing maize is adapted to nearly all the seasonal, climatic and soil variations of the country. Being a year around crop it is suitable for intercropping and is adaptable to various cropping systems. Even backyards can accommodate maize for a variety of home uses. Efforts to introduce maize in the early 1960s were abortive. It has started to be established in Bangladesh due to recent attention by researchers of BARI and other enthusiasts. Two series of on-farm trials have indicated its fantastic potential: (1) an average yield of 5 t/ha from 65 on-farm trials in the rabi season, and (2) nearly 10 t/ha in 24 trials in 1980.

It may become the third ranking cereal food and an important poultry feed of the country if research, extension, and promotion of consumption and industrialization are continued. It is encouraging that more than 50% of the land planted to maize in the rabi season in five districts had previously been fallow. This indicates that maize need not encroach on other crops, though it may possibly replace some aus rice land. Maize is also a good companion or winter crop. We now need to find new open pollinated varieties as well as to popularize maize consumption.

Potatoes

After wheat, the Irish potato is the best example of the effectiveness of special crop initiatives. Concerted activities in research, seed production, extension and storage have increased potato cultivation from 724,000 tons in 1976–77 to 1.125 million tons in 1981–82 (Table 7). By way of contrast, sweet potato production remained static during the same period due to lack of institutional support.

HYVs were important to the spectacular achievements in potatoes. The Cardinal and Elvira varieties have very good yields, while Diamant, Multa, Patrones and Kufri Sindhari have also contributed to the big buildup of the annual tonnage. There have been important shifts in production patterns in recent years. Local varieties have decreased in area while HYVs have increased from 95,000 acres to 125,000 acres (Table 8). There were similar shifts in production. The average yield of HYVs in Dhaka, the leading potato-producing district, has gone up to as much as 6.85 t/A compared to the HYV national average of 5.25 t/A and the general national average of 4.3 t/A.

The main undertakings for potato research now are the (1) development and introduction of early varieties to escape viral and bacterial diseases, (2) improving local cultivars through positive selection, (3) producing the local foundation seed under expert supervision, (4) increasing the capability of storage, both long-term refrigerated and short-term non-refrigerated at the farmer-level, and, above all, (5) popularizing the consumption and values of the potato as a staple food for at least part of the year.

The sweet potato is more of a staple food than a vegetable, too. It is nutritionally good and is adapted to low input, low cost production technology. It should receive more research and extension attention to be

Table 6. Area and production of wheat in Bangladesh, 1973–74 to 1980–81.

Wheat production	1973–74	1974–75	1975–76	1976–77	1977–78	1978–79	1979–80	1980–81
Area (1,000 acres)	305	311	371	395	467	654	1070	1460
Production (1,000 tons)	109	115	215	255	343	486	810	1075

Table 7. Production of potatoes in Bangladesh, 1976–77 to 1981–82.

Potato production (1,000 tons)	1976–77	1977–78	1978–79	1979–80	1980–81	1981–82
Potato	724	899	895	983	983	1078
Sweet potato	744	770	782	779	693	681
Totals	1468	1669	1677	1682	1676	1759

Source : Bangladesh Bureau of Statistics, 1982 and 1983.

Table 8. Area and production of potatoes in Bangladesh, 1979–80 and 1980–81.

	Area (1,000 acres)		Yield		National production	
Year	Local	HYV	Local	HYV	Local	HYV
1979–80	143	95	3.86	4.81	494	409
1980–81	126	126	3.49	5.26	391	590

Source : Bangladesh Bureau of Statistics, 1982 and 1983.

established as a major food crop of the country. Fortunately, there is a ray of hope for locating the nutritionally-rich and high yielding varieties. TIS-2328 (purple flesh) and AIS-35-1 (orange flesh) are carotene-rich varieties with good dry matter contents and high yields.

Pulses

Pulses provide the better part of our daily protein requirement, but their production has almost declined (Table 9). Pulse scientists say the problem has accentuated with the increased emphasis on HYVs of rice and wheat. How can we meet the daily need of 65 gm of pulses per capita (many say the minimum is 15 gm) when only about 8 gm are available? It has been paradoxical that the need for pulses has increased while both the acreage and production were decreasing. No *miracle pulse* variety has been developed. The main pulse of the country, khesari, is accused of causing the crippling disease, lathyrites. Nothing remarkable has happened in lentils, the aristocrat among pulses, or chickpea, which originated in this part of the world. BARI has released the Mubarik mungbean which is suitable for the summer season. Though it does not produce high yields, this variety is a splendid discovery for its 60-days crop duration, with pods having synchronous maturing habits and photosensitivity. BARI now has the 3968 khesari which has only a 0.2% content of the neurotoxin BOAA. The Institute of Nuclear Agriculture has

Table 9. Production of pulses and oilseeds in Bangladesh, 1973–74 and 1980–81.

Crop	1,000 tons	
	1973–74	1980–81
Pulses		
Khesari	57.3	63.0
Lentil	42.5	48.7
Gram	39.6	37.0
Mashkalai	36.7	32.9
Motor	11.7	9.1
Mung	6.6	7.5
Arhar	2.2	2.6
Other rabi pulses	7.6	5.3
Other kharif pulses	3.0	2.0
Total pulses	207.2	208.1
Oilseeds		
Mustard	97.5	120.4
Coconut	56.8	75.5
Groundnut (rabi)	26.1	22.3
Til (kharit)	18.3	15.4
Linseed	6.0	7.2
Til (rabi)	6.8	3.9
Groundnut (kharif)	1.6	1.1
Castor	0.2	0.4
Other oilseeds	0.7	0.3
Total oilseeds	214.0	246.5

released a high protein mutant chickpea out of Faridpur-1 which yields about 45% protein. Some short-duration, photosensitive pigeon pea lines also are available. Some year-around blackgram lines have been identified. With the use of inoculum it is possible to reduce or even do away with the application of nitrogenous fertilizers in pulses cultivation.

How do we make a break-through? The conventional, low-to-medium yielding varieties are competing with wheat and boro rice, oilseeds and other rabi crops. To achieve the desired level of production and encourage farmers to bring more lands into pulses production it may be necessary to develop varieties which fit into cropping systems as catch crops, relay crops or intercrops. They should not be competing crops. The traditional varieties are highly susceptible to viral, bacterial and fungal diseases, and insects.[2] The yields are very poor, thus both short- and long-term research is imperative. Because pulses are a special part of our diet, Bangladesh may have to help itself by developing HYVs and the related production technologies. We cannot expect the developed world to be much interested in these crops.

Oilseeds

An astonishing 70% of the area planted to oilcrops is devoted to rape and mustard (Table 9). The Sonali Sharisha mustard is replacing the traditional varieties as it has the potential to achieve a two-fold increase in production. While mustard is the predominant oilseed, it is accused of containing a toxic compound that may have adverse effects on the stomach.

The groundnut (peanut) is a wonderful oilseed that is superior to mustard in its oil content, is about one-quarter protein, and unlike mustard can be grown in both kharif and rabi seasons. Farmers plant groundnuts in sandy, poor soil where nothing else grows. The traditional variety, DA-1, still produces good yields, but an improved variety is in the pipeline. Is it possible to popularize this outstanding oilseed for cooking food? Can suitable storehouses be built and subsidized for the farmers?

Research is also going on for sesame and other oilcrops, but coconut has received almost no attention though there is a Coconut Research Station and the Extension Department distributes a few thousand seedlings each year. The coconut is known on the Indian subcontinent as *kalpataru*, a tree that supplies everything one may desire from it. The production of 66,000 tons of dry coconut is minimal when one considers the potential of soil and climate. A tall, high yielding variety, CRIC-60, was introduced recently from Sri Lanka. About 10,000 seedlings of this variety are in the country waiting to be crossed with plants of a dwarf yet to be imported. Such an exercise deserves careful planning and prior trial of the germplasm.

One of the constraints in expanding oilseed production is the lack of effective technology for the extraction of the oil. The *ghani* is the local crushing unit, but it is very inefficient. There is an annual loss of 16,000 tons of oil using this method. Extraction efficiency needs to be increased by the use of expellers and solvent extraction methods, or other means that may be developed.

Table 10. Production of selected crops in Bangladesh, 1973–74 and 1980–81.

Crop	Annual production, 1,000 tons	
	1973–74	1980–81
Sugarcane	6342	6495
Jute (1,000 bales)	6000	4943
Date palm juice	437	372
Palmyra palm	100	82
Tobacco	41	47
Tea	27	39
Sunhemp	20	12
Cotton (100,000 bales)	6	10

Source: Bangladesh Bureau of Statistics, 1982.

Sugarcane

There has been no dramatic breakthrough in sugarcane though production technology has been improved and promises important dividends. However, sugarcane does profitably accommodate other crops between its rows when widely spaced. Interestingly, intercropping potato with sugarcane not only adds to the total volume of crop production but also increases the yield of sugarcane. Onion, mustard, soybean, brinjal, and several other crops also are compatible with sugarcane. Researchers are still looking for a sugarcane variety which is high yielding, has high sugar recovery, and is resistant to diseases. ISD-60 is a new variety that averages 92 t/ha of cane which is 10.2 tons of sugar. Another clone, I-60/74, is about to be released and several others are in the pipeline. There is a need to develop international collaboration to locate truly elite varieties as well as to improve other aspects of sugarcane research and development. The minimal need is to develop high sugar, disease resistant varieties, and to increase the crushing capacity of the mills.

Jute

As in most other crops, jute research has yet to produce a high yielding variety. Some new, improved varieties are now in use along with the conventional ones. Several new technologies have been generated. Row cropping can increase fibre yield by 10% and reduce the cost of weeding and thinning by 30%. The use of cuttings of the top and stem has been adopted to improve seed production. An improved method of retting has been introduced, too. Technological research brought to the forefront the diversified uses of the fibre, agricultural by-products and industrial wastes. Several products have been developed which blend jute with other fibres. The technology needs to be transferred to industrialists. As jute is facing tremendous competition from synthetic fibres, the producers should— to a considerable extent— also become users of its products. There has to be intensified research to reduce production costs, increase yields, and to find other uses for jute. These new uses may be unconventional but could well

lead to the ultimate survival of this valuable commodity which has given so much to our nation. It is encouraging that work is in progress on varieties that are less photosensitive, are early maturing, and flood tolerant.

Cotton

Our land had the distinction during the 18th century of producing the world's best fabric, the *muslin*. Now we are left with only the roughest fibre, the Comilla cotton, which is suitable for blending with wool. Bangladesh has recently gone into producing yarn. Nearly 25,000 bales of medium staple American Upland cotton were produced on about 19,000 ha in 1982 compared to a mere 36 ha in 1975. There are plans to considerably expand this acreage to meet a substantial part of the 600,000 bales required annually by the more than 1 million spindles of the country's 57 textile mills (Table 10). Those advocating increased cotton production look toward achieving self-sufficiency with an annual planting of 200,000 ha. They believe this will leave enough land for potential contending crops such as tobacco, potatoes, sugarcane, and wheat.

The advances in cotton production have been the result of support of the Government. There are doubts that cotton can continue to flourish should the subsidies be withdrawn. There is need to expand the limited research which is carried on by the small cell at BARI. New varieties and techniques are required to reduce production costs to levels where cotton is competitive with other crops. Much must be done in post-harvest technology, particularly to establish cotton as a multipurpose crop, and using the extracted oil for edible purposes and other commercial by-products such as oilcake which is a rich cattle feed with about 40% protein. It then may be possible to attain a substantial increase in cotton acreage, yield and total production.

Tobacco

It is amazing that the area devoted to cigarette tobacco cultivation grew from only 202 ha in 1971 to more than 20,000 ha in 1980–81. Not only has self-sufficiency been attained but there is an export of some 3.5 million pounds of tobacco leaves, which is a significant portion of the 51.5 million pounds produced (Table 11). Research is going on to develop higher yielding

Table 11. Tobacco production in Bangladesh, 1973–74 and 1980–81.

	Area (acres)		Production (tons)		Yield (t/a)	
Tobacco type	1973–74	1980–81	1973–74	1980–81	1973–74	1980–81
Virginia	15,575	49,985	6,473	22,720	0.43	0.45
Motihari	47,305	40,480	16,928	13,015	0.34	0.32
Jati	39,595	28,870	15,246	8,930	0.39	0.30
Others	12,165	7,645	2,995	1,965	0.25	0.26
Totals or average	114,640	126,980	41,642	46,630	0.36	0.37

Source : Bangladesh Bureau of Statistics, 1982 and 1983.

varieties. Two have been released, Arinco and Sesmaria. Another two, BAT-1 and BAT-2, have been evolved, and Sesmaria Gold is in the pipeline. Now research should seek varieties with higher quality, for that is the kind of tobacco which produces the cigarettes which capture the international market.

Tea

There has been much tea research and extension since the Bangladesh Tea Research Institute was established in 1957. Several clones have been developed which are high yielding and produce quality tea. The clone BT2 possesses a persistent flavour which is a unique characteristic for a low-elevation tea. There have been efforts to raise the yield of Bangladesh tea which at 820 pounds/A is the lowest in the world. A breakthrough may be near and in a few years the average yield in the country may be doubled. This requires a complete replacement of the low yielding clones and seed-stock with high yielding quality tea as well as the rehabilitation of old tea soils. If this is not done, there are many other ways for using the tea lands. One example is the suitability of many of the terrace and high lands for fruit production.

Farming systems

Farming systems is sometimes called *cropping systems* because the lion's share of the farmers' efforts are devoted to crop production. Livestock in most cases is limited to caring for draft animals which often are dual- or triple-purpose, first for milk then for draft and finally for meat. Cropping systems research started to receive attention with the initiation of the BRRI cropping systems research and development programme. Gradually, other organizations have followed suit. In Bangladesh, where every possible kind of crop is grown throughout the entire year, researchers in rice, jute, potatoes, wheat, pulses, oilseeds, sugarcane, vegetables and fruits must consider cropping systems as their meeting ground. Many cropping systems have been tested by BRRI, BARI, Bangladesh Jute Research Institute, Sugarcane Research and Training Institute, Bangladesh Agricultural University, Bangladesh Water Development Board and others, as well as in the extension and research project in the northwest devoted to adaptive research with multilocation testing of nationally-recommended technologies. It is time to pull all these results together and to pragmatically analyse and evaluate the applicability of the research. Then we can see how much more is needed and what can be extended to the end-users throughout the country.

Brammer[1] pointed out that (1) the introduction of HYVs, chemical fertilizers and irrigation, (2) the provision of rural development infrastructure, and (3) increasing population pressures have during the last two decades brought on the expansion of boro and transplanted aman rice, wheat and cash crops. This implies greater intensity and security of production and a reduction in pulses, oilseeds, broadcast aman rice, and jute. These changes, however, did not even slightly change the dominant position of rice in the

country. As stated by Kaul and Rahman,[11] rice will hold its key position in the farming system of Bangladesh as long as diversification fails to bring distinct advantages in terms of food quantity, cash returns, or both.

However, the cropping systems research should concentrate on crops and cropping patterns, and on alternative management practices in different environments and interactions between crops and between the farm household and environmental factors beyond the farmers' control. Obviously, the topographical and agro-ecological diversities, crop duration, socio-economic, management and employment constraints also have to be taken into account.

Post-harvest technology

Agricultural research is usually confined to production technology, thus the post-harvest matters such as processing, consumption, storage and marketing have been left alone. This is so true that the general impression is that the mandate of agricultural research is to care for production problems only. On the other hand, there have been no specific organizations or agencies responsible for such activities. The exception to this statement is with jute and the technology wing of BJRI and the Bangladesh Council of Scientific and Industrial Research laboratories. Many persons believe that similar post-harvest research should be conducted for other commodities, too.

There was a catastrophic situation in potatoes in 1981. After several years' activities in research, seed production and extension, potato production reached an all-time high of 1.2 million tons. This caused a slump in the market price which cut down potato farmers and cold storage owners. The situation developed because of the absence of promotional work on the consumption, transportation, short-term storage, and marketing of potatoes.

Groundnut, a highly desirable crop for Bangladesh, cannot maintain its present production level because of the lack of post-harvest technology. The example of maize was referred to early, too. The capacity of sugar mills is limited; so, nearly half of the 160,000 ha in sugarcane produce cane for making gur.[2]

There are other crops needing post-harvest attention, such as pineapple, tomato, coconut, guava, mango, and several acidic fruits. Something must be done institutionally to take care of these vital research and development needs. If we mean business, post-harvest matters—storage, processing, marketing, food habit changes and allied areas—must receive proper priority.

DISCUSSION

The national food deficiency gap rose from 1 million tons in the 1960s to an average of 1.6 million tons annually in the 1970s. Food-grain imports shot up to 2.7 million tons in 1980.[3] Vagaries of nature bring about great variations in the food grains production of our country, especially of rice.

As Islam and Ahsan put it,[10] the 1982—83 food grain requirement of Bangladesh of 17.7 million tons will swell to 26.8 million tons in 1999–2000 in

Table 12. Production and yield of HYV and local rice varieties in Bangladesh, 1971–72 and 1980–81.

Types of rice	Production (1,000 tons)		Yield (t/a)	
	1971–72	1980–81	1971–72	1980–81
Aus				
Local	2,212	2,179	0.30	0.34
HYV	129	1,048	1.07	0.89
Pajam	—	13	—	0.62
Aman				
Local (broadcast)	1,507	1,499	0.34	0.39
Local (transplanted)	3,492	4,310	0.36	0.50
HYV	690	1,084	1.11	0.91
Paijam	—	943	—	0.80
Boro				
Local	772	630	0.56	0.62
HYV	966	1,757	1.22	1.08
Pajam	—	201	—	0.93

Source : Bangladesh Bureau of Statistics, 1982.

order to feed the estimated population of 140 million persons. How much of this can be provided by rice? The previous nine years' growth rate of rice production has been less than 1.4%. The yield per acre of HYV rice has been reducing (Table 12). The increase in rice production has been possible by the expansion of the planting area.

It is quite obvious there is need for diversification in the rabi season to produce more wheat and potatoes. Potatoes must become a staple food. This may cause us to give away our place as the first ranking rice-eating country.

Further increases in rice production may have to be achieved through higher yields per acre, thus leaving the new areas which are suitable for boro rice to be used for wheat and rabi crops. It is noteworthy that boro rice alone took the major share of our scarce water to irrigate its 2.5 million acres in 1979–80. This is two-thirds of 3.9 million acres irrigated for all crops. If all the additional irrigation water beyond the present capacity is used for crops other than rice, it can mean a multiplication of three to five times the command area for each piece of water lifting equipment. Wheat requires 300 to 450 mm/ha and rice about 800 to 1600 mm/ha.[9] In other words, facilities developed for irrigating 1 million acres of rice should be adequate to irrigate 4 million tons of wheat compared to only 1 million tons of rice. In India, agricultural modernization and favourable weather achieved a surplus of 20 million tons of food grains by the end of the 1970s.[14] This was possible because of their using irrigation water mainly for wheat.

Thailand exported 1.7 million tons of rice because of the surplus it has produced.[13] Nepal exported about 200,000 tons of rice in 1975–76, the highest quantity in recent times.[12] Bangladesh might some day export rice whose price on the international market is more than double that of wheat. The

production and consumption of more wheat could mean supplying our malnourished population with more protein and fat per unit of land and per dish, and even earning foreign exchange through the export of surplus rice. Is this too ambitious a proposition?

Restricting the expansion of rice to new areas may pave the way for wheat, maize, roots and tubers, and rabi crops to flourish. Maize is the highest yielding food grain (Table 13). The potato is by far the highest yielding staple food crop in the world. Greatly increased production of these crops along with a diversification of our eating habit could generously support our dwindling livestock and poultry industry. There could be much more feed and fodder produced during the winter months once the irrigation water is brought to these crops. Fortunately, wheat, vegetables, pulses and oilseeds are increasingly popular with farmers due to appropriate policy measures.[1]

The unusually big acreages contemplated for wheat, potatoes and other crops due to the judicious use of irrigation water will require a large amount of quality seed. When crop diversification is adopted, this much-needed seed production can be accomplished by the farmers themselves. The technical know-how can be disseminated by extension agencies which are back-stopped by research institutions.

As BARC[1] reports, there was a steady growth in fertilizer use from the 1960s through to 1980. Then it stagnated in high use areas but picked up in some low use areas, mainly in the north where irrigation facilities were expanded. Fertilizer use went up from 719,000 tons in 1977–78 to 968 thousand tons five years later. While this growth is encouraging, the question of micronutrients is now coming up, particularly in rice fields. This seems to be partly because of the intensive culture and the non-use of organic manures. Could we not come back to making and using compost and farmyard manure? Researchers should find out about and extensionists should demonstrate the techniques for the maximum utilization of these traditional resources.

The amount of pesticides distributed in 1979–80 was 4.6 million pounds, down from 7 million pounds in 1976—77.[1] Perhaps this was because farmers had to buy them where previously these inputs had been provided free. This is

Table 13. World yield of selected foodgrains, roots and tubers.

Crop	Yield (t/ha)
Potato	15.50
Cassava	8.75
Sweet potato	8.36
Maize	3.27
Wheat	1.78
Barley	1.76
Rice	1.75
Oats	1.60
Sorghum	1.32

Source: FAO, 1979.

indicative of the previous misuse and present normal use of pesticides. An integrated pest management system, with proper pest surveillance and forecasting, may reduce the increase of pesticide application. It is a gigantic task for research and extension agencies to deliver the information of the proper technologies.

Although post-harvest technology follows pre-harvest technology, the two must run concurrently. Thailand increased its production of cassava more than 5½ times in only nine years because plans were made to put the produce to industrial use. In less than ten years Malaysia raised its palm oil production from 460,000 tons to 2.18 million tons. They accomplished this by giving priority to establishing oil palm plantations. In many cases there was complete replacement of the old plantations. They knew that oil palms are potentially 100% higher in yield, that the oil is nutritious, and that extraction facilities are prerequisites. It is no wonder that Malaysia now produces more than half of the world's palm oil.

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ABSTRACTS

Ten Years of Sugarcane Research in Bangladesh

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Sixteen sugarcane varieties have been released from the Sugarcane Research and Training Institute. Four are now in cultivation in the sugar mill zones. The recently released Isd-16 is the highest yielding and has the highest sugar content. It produces 6.42% more cane and 20.33% more sugar than the standard variety, Co. 1158. Another clone I-60/74, has received preliminary selection for release, and seven others are in the pipeline. Twenty-three imported varieties are now in selection trials, of which two to three are expected to be released within five years. A new 8-year breeding programme has eliminated unnecessary test stages.

Cultural practices recommended as a result of SRTI research are (1) November planting, (2) one meter row spacing, (3) the half overlapped and zig-zag method, (4) plough tillage and spade trenching, (5) spaced transplanting (single eye germinated bud), and (6) water shoots and top cutting as good seed materials. January is the best time to harvest regardless of the planting date. Recommendations have been developed for herbicides and fertilizers, including for organic manuring.

Intercrops have been recommended to be grown with sugarcane. Potatoes, onions, and garlic are excellent. Legumes are good companion crops when grown between the cane rows. Other research studies have developed procedures for (1) relay cropping, (2) defoliation and stalk binding of sugarcane, (3) reducing post-harvest losses, and (4) a resistance rating chart of disease in commercial and near-commercial sugarcane varieties and clones. There are also sett treatments and the control of pests and diseases (including several biological methods to control top shoot borers and chemical methods to control white grubs, nematodes, and borers, which are the most damaging pests of sugarcane). Other appropriate technologies on pest control have also been developed. Varietal recommendations for gurmaking also have been made and further work is in progress.

The SRTI has an active publication and training programme to disseminate its research results. One of the most innovative publications is a calendar to help plan effective control measures against major insects that damage sugarcane.

Dr. Shahjahan is Director, SRTI. Due to his illness, the paper was presented by Dr. M.A. Karim, Principal Cane Breeder, and Dr. A.B.M. Mafizur Rahman, Associate Cane Physiologist, SRTI.

A Review of the Entomology of the Sugarcane Top Shoot Borer, *Tryporyza Nivella* (F) (Pyrallidae: Lepidoptera) in Bangladesh

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The sugarcane top shoot borer, *Tryporyza nivella* (F) (Pyrallidae: Lepidoptera) causes severe damage to the sugarcane crop from the cane-forming stage through to harvesting affecting both the yield and recovery percentage. Research is being carried out in Bangladesh on different aspects of the problem: biology, incidence, varietal behaviour of the crop to the pest attack, extent of damage, yield and recovery percentage losses, economics, and different control measures. The paper reviews published research work on the pest that has been done in the country.

Mr. Khalequzzaman and Mr. Mannan are in the Department of Zoology, Rajshahi University.

Pod-Wall Strength as a Measure of Pod-Factor Resistance to Cowpea Curculio in Southern Pea (Cowpea)

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Twenty-four F_3 lines of southern pea (cowpea) were infested by cowpea curculios in field experiments of Auburn University, USA. This research was to find out the relationship between cowpea pod-wall strength and the cowpea curculio's damage. Pod-wall strength in the dry stage was highly correlated with pod-factor resistance (percent of unsuccessful pod-wall penetration). However, in comparing the pod-wall strength and the pod-factor resistance of F_3 lines, the correlation coefficients within the low and high groups were not significant in either the mature green or the dry stages of pod-wall development.

Dr. Hossain is Principal Scientific Officer (Maize), BARI, Joydebpur.

Genetic Improvement of Pulse Crops Through Nuclear and Conventional Techniques

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Mutation induction through chemical mutagens

The effective doses of sodium azide (NaN_3) on chickpea *(Cicer arietinum L)*, mungbean *(Vigna radiata L. Wilczek)* and lentil *(Lens culinaris* Medik) were worked out on the basis of height reduction of seedlings on specific days after seed treatment. The crops were treated with the effective doses of NaN_3 and a selection was carried out in the M_2 generation. The deviant types obtained were: chickpea 1.3%, mungbean 5.1%, and lentil 1.2%. Broad leaved and white flowered mutants were obtained in chickpea. In mungbean, the mutants were erect and synchronous in pod maturity. Late flowering mutants were obtained in lentil. The selected deviants and high yielding types are now being grown in the M_3 generation to develop mutants that are more desirable than the best existing varieties.

Mutation induction through gamma irradiation

Hyprosola is a chickpea mutant which has been developed through gamma irradation of the chickpea variety, Faridpur-1. It produces a 20% higher grain yield and 4% more protein than the parent. Hyprosola was released by the National Seed Board as a national variety in 1980 and is now cultivated by farmers in various parts of the country.

In 1978 the best existing varieties of chickpea and mungbean were irradiated separately for further improvement. Selections of desirable types were carried out through different generations. The M_6 generations of three mutants of chickpea and seven mutants of mungbean are now being grown in multilocational yield trials.

Exotic germplasm evaluation

Exotic germplasm of chickpea, mungbean and lentil have been collected from fourteen different countries. They have been evaluated every year since 1978. Some significantly higher yielding and earlier maturing types have been identified. Two strains of chickpea and three of mungbean are now in the advanced generation trials. In addition, five strains of mungbean have been identified for summer cultivation. These are under intensive trials along with Mubarik, the newly released summer mungbean variety developed by BARI. Some of these strains were superior to Mubarik in the 1982 trials. Fifteen strains of lentil have been selected from exotic collections on the basis of superior agronomic characters and are undergoing further trials.

This is a report of research conducted by the Plant Genetics Division, INA, of which Dr. Shaikh is the Head.

Innovative Approaches in Plant Breeding: Application of Anther Culture in Rice Improvement

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Innovative *in vitro* approaches that can be incorporated into plant breeding programmes include microspore culture, ovary culture, *in vitro* fertilization, embryo culture, chromosome elimination, and protoplast fusion.

The application of anther culture in rice breeding is a recent innovation. Callus induction ability through anther culture in rice was studied by employing two *indica* and two *japonica* parents, their F_1s (diallel matings), and twelve backcross/topcrosses. In addition, eleven doubled-haploid lines were evaluated for their breeding value.

Anthers of an appropriate stage were cultured on defined medium and then incubated for callus induction. Calli were transferred to a differentiation medium for plantlet development. Regenerated doubled-haploid plants were evaluated under field conditions in H_1 generation.

Significant genotypic differences were observed in callus induction by *indica* parents of 0 to 8.8% and *japonica* parents of 33.8 to 41.9%. Crosses F_1s with either of the *japonica* parents exhibited higher rates of 17.0 to 110.0% compared to 0.4 to 48.3% of callus induction than the corresponding F_1s.

The redifferentiation of plantlets from callus of different crosses was inconsistent. Individuals within each doubled-haploid line were uniform for the characters studied. There were, however, inter-line variations suggesting random participation of segregating gametes in callus induction.

Anther culture procedures offer a very good technique to achieve homozygous lines directly from F_1 hybrid in a single generation. This is in contrast to the conventional breeding method which usually requires more than five generations to accomplish desired results.

Dr. Miah is a Principal Scientific Officer, BRRI.

Breeding Improved Rice Varieties for Drought Prone Areas of Bangladesh

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About 30% of the rice production area of Bangladesh is planted to rainfed dryland, i.e., broadcast aus. Its successful production depends on the distribution and amount of rainfall. The low yield of aus rice is caused by high temperatures and low solar radiation, as well as unpredicted drought, poor nutrient uptake, and a lack of improved varieties. Drought resistance seems

to be the most important single limiting factor to increasing and stablizing of the production of the aus rice in the dryland area.

Traditional aus varieties of Bangladesh have the ability to compete with weeds, have a short growth duration, and other desired characters, but they do not always have drought resistance, and many are low yielders.

Drought resistance is a new breeding objective in rice. Progress has been limited because most past efforts have been directed to irrigated or transplanted rice where adequate water management is possible.

There are two breeding approaches: (1) the empirical or traditional approach where selection is made for desired agronomic characteristics such as modern plant types, short growth duration and high yields, and (2) the analytical approach where selection is made for a specific trait that will enable the plant to better withstand drought. Once identified the characteristics are introduced into the varieties with superior genetic backgrounds.

Dr. Nasiruddin is Principal Rice Breeder and Mr. Haq is a Rice Breeder, BRRI.

Conservation of Rice Germplasm in Bangladesh

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Variations in lands and seasons contribute to the varietal diversity and in the distribution of wild and weed races of rice in Bangladesh. There are four rice groups: aus (upland), transplant aman, broadcast aman (deepwater), and boro. With the introduction of modern rice varieties and the change in cropping patterns, traditional rice varieties are becoming extinct. A rice germplasm bank with a medium-term storage facility was established in 1974 by the Bangladesh Rice Research Institute to collect, conserve, evaluate, and utilize the genetic resources of rice to meet the increasing demand for food, to improve crop quality, and to stabilize rice yields.

Traditional rice varieties have outstanding characteristics such as aroma, grain and cooking qualities, disease and insect resistance, and drought, flood, cold, salinity, and submergence tolerance. Habiganj boro II, Heshikalmi, Kataktara, and Dular have 12% protein. Dular and Kataktara are resistant to blast. Soloi is resistant to rice tungro; Beto is resistant to stem rot; Saita and Saria are resistant to sheath blight; and Soite dhora, Lohatang, Kumri, and Kaliraj have tolerance to submergence.

A total of 4,000 rice varieties have been collected. There is a five-year plan for further collections. A national survey of varietal names, seasons, and locations was made and documented in the book, *Local Rice Varieties.* This book is a cross reference of existing collections and will help to indentify future acquisitions. A total of 12,479 names, including duplicates, are listed. Only the boro group has been analysed for duplicates so far. Of 1,200 boro

sample names, only 250 are not duplicated. The other seasonal groups are being analysed.

There are prospects for further collections in the remote, less accessible tribal areas, and for the collection of wild and weed races. Acquisitions from these areas are slow and difficult due to poor communications and transportation facilities, and the inadequate financial support available.

Dr. Nasiruddin is Principal Rice Breeder and Mr. Bashar a Rice Breeder, BRRI.

Varietal Screening of Rice Anthers for Culturability

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Anther culture is a method of haploid breeding for obtaining homozygous plants in a very short time. The prerequisite is the identification of genotypes having callusing ability in their anthers in culture medium. An initial screening was made for callusing ability of anthers of some of the germplasm materials, advance breeding lines, and some F_1, F_2, and F_3 generation plants. Of the 80 varieties and lines tested during the last boro and aus seasons, the anthers of 40% induced calli ranging from 0.4% to 37%. These 32 varieties and lines included 3 *japonicas*, 1 *japonica* × *indica*, and 28 *indica* types. The *japonicas* showed a higher response of 20.0% to 37.0% compared to 0.4% to 34.6% for the *indicas*. The N_6 medium developed for *japonica* and modified H_5 and SK-8 media for *indica* appeared to be good for induction of callus. In both types of materials, the regeneration into green plants was less than into albino plants. This aspect of anther culture technique needs further improvement.

This is a report of research by the Plant Pathology Division, BRRI, of which Dr. Miah is Head.

Reactions of Rice Varieties and Lines to Sheath Blight

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Bangladesh Rice Research Institute

Sheath blight caused by *Rhizoctonia solani (Thanatephorus cucumeris)* is one of the major rice diseases of Bangladesh. It is severe in the aus season. Most of the commercially-grown rice cultivars are susceptible. A total of 1156 aus and 1193 transplant aman rice germplasm materials and breeding lines were screened between 1978 and 1982 to identify sources of resistance to this disease. Of these materials, only 1.6% were moderately resistant during the aus season and 2.8% during the transplant aman season. Some of the

moderately resistant transplant aman varieties are: Chotamona Kunchi, Jatabashful, Kalamona, Kumragoir, Lohagor, Lotamona, Dudhkalam, Kalajira, Kurchimagi, and Urman Sardar; and aus varieties: Dudbajal, Bakiella, H_4, Pankhari 203, Suduwee, Murali, Kalamanik, and Saita.

Studies were made of the relationships of some of the plant characters and their reactions to sheath blight disease during the aus season. Susceptibility was associated with semi-dwarfness, high tillering ability, thick culms, erect flag leaf, absence of sheath hairiness, and late maturity. No relationship to disease reactions was found for culm strength and grain type. This indicates that the modern semi-dwarf, erect flag-leaved, high tillering and late varieties are more susceptible to sheath blight. However, there must be further study of the genetic relationships between these characters and the resistance or susceptiblity of various varieties to the disease.

This is a report of research of the Plant Pathology Division, BRRI.

Climatic Limitations in Rice Cultivation

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Grain yield of rice gradually decreased as the seeding dates were shifted from November to March. High mean temperatures during the vegetative stage and high minimum temperatures during the ripening stage affected the grain yield in rice during the boro season. Low light intensity during the productive and ripening stages severely affected the grain yield and yield components. Low yields in the aus season were due to high minimum temperatures accompanied by low solar radiation. Transplanting 30-day-old seedlings on August 15 gave the highest grain yield during the transplant aman season. Yields gradually decreased due to low temperatures.

This is a report of research of the Plant Physiology Division, BRRI, of which Mr. Haque is Head.

Submergence Tolerance in Rice

M. M. HOSSAIN AND M. Z. HAQUE
Bangladesh Rice Research Institute

Submergence tolerance in rice and the recovery from submergence have been identified as two different mechanisms. Three of eight varieties–BR4, Dudmona and Kumragoir—were found to be moderately tolerant to submergence. After two weeks of drainage, Dudmona and Kumragoir followed by BR4 were found to be highly tolerent in terms of dry matter and tiller production. The application of NPK fertilizers enhanced the plants' recovery ability from submergence damage. BR4, Dudmona and Kumragoir responded equally well to added NPK fertilizers in terms of dry matter and

tiller production during the two weeks recovery period after drainage. Seedling age increased the submergence tolerance and dry matter production in all the varieties expect BR8.

This is a report of research of the Plant Physiology Division, BRRI.

Photoperiodism in Rice

A. R. GOMOSTA, M. Z. HAQUE AND H. A. QUAYYUM
Bangladesh Rice Research Institute

Contrary to general belief, there was not good correlation between traditional plant type in rice with photoperiod sensitivity. Breeding lines were identified with modern plant type and photoperiod sensitivity. The basic vegetative phase was found to be negatively correlated with the photoperiod sensitive phase and the degree of sensitivity, but with a low R^2 value indicating the existence of photoperiod sensitive varieties with a long vegetative phase.

Development of a screening technique to isolate photoperiod sensitive materials from segregating population was in progress based on partial flowering behaviour due to increasing day length in the boro season.

This is a report of research conducted by the Plant Physiology Division, BRRI.

Different Mechanisms for Drought Resistance in Rice

M. S. ISLAM AND M. Z. HAQUE
Bangladesh Rice Research Institute

Characteristics have been identified as being important for drought resistance in rice, including the ability of the roots to penetrate through the high bulk density soil, the number of thick roots, deep rooting ability, low dry matter reduction under water stress, and the desiccation tolerance of the variety. Some traditional varieties were found to give positive responses to growth up to certain levels of water stress.

Deeper seeding is beneficial when the rice plant is subjected to water stress during seedling stage. Seedling emergence varied widely among the varieties; it decreased with the increase of seeding depth. Seedlings emerged from deep seeding through long mesocotyl alone or in combination with a second internode.

Polyethylene glycol '6000' and sucrose solutions can be used in screening materials for desiccation tolerance and recovery ability.

This research was conducted by the Plant Physiology Division, BRRI.

Studies on the Performance of Induced Mutants of Rice

A. J. MIAH, M. A. AZAM, L. HAKIM, M. A. MANSUR,
S. RAHMAN AND H. R. AKAND
Institute of Nuclear Agriculture

A rice mutation breeding programe was initiated in 1966 with the high yielding IR8 variety. Two mutant varieties with early maturing characteristics were developed, IRATOM 24 and IRATOM 38, which were released for commercial cultivation.

In a similar programme initiated in 1973, IR8 and a popular local variety, Nizersail, were subjected to mutagenic treatments. The promising mutants isolated in the M_2 generation were evaluated and characterized in the subsequent generations.

Three of the four Nizersail mutants had reduced plant height while the other was taller than the parent. The mutants matured 2 to 3 weeks earlier. Two of the four yielded more than the parent variety. Three had a higher protein content. All mutants behaved similarly to the parent variety with respect to insect pests and diseases.

The two mutants of IR8 matured about 2 to 3 weeks earlier. They possessed finer grains and better cooking quality than the parent. Both were more resistant to thrips and bacterial leaf blight.

Achievements in Blackgram and Grasspea Improvement Through Nuclear and Conventional Techniques

M. A. Q. SHAIKH, S. KHANUM, M. A. MAJID, C. S. SAHA, S. BEGUM, AND
M. S. ALI
Institute of Nuclear Agriculture

Two accessions of blackgram *(Vigna mungo)*, B-10 and B-23, were treated with various doses of 60 Co gamma rays in 1978. Genotypes with higher seed yield, erect plant types, and disease resistance were identified in the M_2 generation. True breeding lines were selected in the M_4 and preliminary yield assessments were made in M_4. In M_5, the mutants were put into microplot yield trials along with the mother varieties. Five mutants were significantly superior to the higher yielding mother variety, B-10. The mutant B-10(25) is the highest yielding and is moderately resistant to yellow mosaic and cercespora leaf spot. The mutant B-10(23) is erect, determinate and bears upright pods. It is compact so accommodates a higher number of plants/unit area.

A total of 68 visually deviant genotypes of blackgram were selected in 1981 from the M_2 populations following treatment with soduim azide (NaN_3) and ethyl methane sulphonate (EMS). The salient features of these putative mutants are: dwarf, bushy, trailing, erect, synchronous in pod maturity,

increased number of pods, and tiny leaves. Some showed field tolerance to cercospora leaf spot and powdery mildew. These are being grown in M_3 generation to identify true breeding lines.

The BINA Sl No. L-1 of grasspea *(Lathyrus sativus)* was treated with NaN_3 in 1981—82. In the M_2, 34 individual variants (putative mutants) were selected for leaf characteristics, plant types, pigmentation and flower colour. These are under further study in M_3.

Agronomic evaluation of 16 local and 8 exotic grasspea cultivars revealed a narrow range of variability for days to maturity and the number of seeds/pod. However, the variations for number of pods/plant,100-seed weight, and seed yield/plant were quite pronounced . Exotic cultivars were bold seeded. The local collections produced high seed yields. BINA Acc. No. L-6 and L-11 had the highest yield/plant.

There was a 25 to 34% variation in protein content while the neurotoxin BOAA content (the lathyrogen factor responsible for causing irrecoverable paralysis of the lower limbs) ranged from 0.22 to 2.08%. A few lines have been isolated with high seed yield and moderate amounts of BOAA.

This is a report of research conducted by the Plant Genetics Division, INA, as part of a BARC/BAU/BARI/INA co-ordinated scheme for the improvement of blackgram and grasspea in Bangladesh.

Physiology of Lentil: Productivity in Relation to Population Density and Nitrogen Availability

R. K. DUTTA, L. RAHMAN AND MUSLIMUDDIN
Institute of Nuclear Agriculture

Experiments with lentil cv. L 9-12 at population densities of 40, 80 and 120/m² and nitrogen supply rates of 0, 15, 30 and 45 kg/ha of urea revealed that nitrogen supply and population pressure had no significant effect on yield. The effect of population pressure was compensated for mainly by the number of branches. NO_3 assimilation efficiency— measured as the activity of nitrate reductase— was not affected significantly due to N treatments or population pressure. The study showed that NO_3 influx to the site of nitrate reduction was not limiting but rather that the efficiency of nitrate reductase was very poor. Soluble protein, chlorophyll and chlorophyll a/b ratio were not significantly affected due to the treatments. The result indicated that nitrogen supplementation and accurate manipulation of plant density are not important factors for increasing lentil yields. The highest nodulation was recorded at flowering and was not affected by the nitrogen treatments.

The soil moisture, plant moisture and relative growth rate showed a declining pattern during early stages of growth. The plant moisture and relative growth rate increased during flowering because of rainfall but soil moisture remained constant indicating a severe water deficit for physiological processes. The results suggest that the yield of lentil may not be remarkably

improved by nitrate-N supplements and population manipulation, and that an adequate water supply is necessary for optimum yield due to uncertainty of rainfall.

Screening of Some Pulses Against Major Diseases

M. JALALUDDIN
Institute of Nuclear Agriculture

Extensive screening programmes to identity sources of resistance to major diseases were initiated in the 1977–78 season with some local and exotic collections and induced mutants of mungbean *(Vigna radiata)*, blackgram *(V. mungo)*, and chickpea *(Cicer arietinum)*.

Two mungbean strains, MB-53 of Sri Lankan origin and Sl. No. 59 from Bangladesh, were highly resistant to cercospora leaf spot *(Cercospora cruenta)*, powdery mildew *(Erysiphe polygoni)*, and Mungbean Yellow Mosaic Virus (MYMV) under natural epiphytotic conditions. The MB-57, MB-58, MB-59, MB-114, MB-133, V-5197, and V-2272 strains were resistant to MYMV.

Blackgram strain B-34 from Sri Lanka was resistant to cercospora leaf spot while B-20 from Bangladesh was resistant to powdery mildew. The strain T-9 of blackgram was highly resistant to MYMV.

Four chickpea strains, G-5, CAT-12, G-96, and G-299 (induced mutant), were moderately resistant to foot and root rot *(Fusarium* spp. and *Sclerotium* spp). Three strains, G-77, G-96, and G-201, were moderately resistant to wilt *(F. oxysporum* f. sp. *Ciceri)*. Only the chickpea G-96 strain was moderately resistant to foot and root rot and wilt, and also to Ascochyta blight *(Ascochyta rabiei)*.

Mr. Jalaluddin is Senior Scientific Officer, Plant Pathology Division, INA.

Studies on Major Diseases of Cereals

M. JALALUDDIN, A. Q. M. BAZLUR RASHID AND A. R. HOWLIDER
Institute of Nuclear Agriculture

A number of experiments have been conducted since 1977–78 with local and exotic collections and induced mutants of rice and wheat. Some of the rice varieties and induced mutants obtained from gamma-ray treated seeds of Nizersail and IR8 ranged from moderately resistant to resistant to bacterial blight *(Xanthomonas oryzae)*, sheath-blight *(Rhizoctónia oryzae)*, and stem rot *(Sclerotium oryzae)*. Some local varieties were more resistant to bacterial blight than TKM-6 which is resistant to this disease. Host-pathogen interaction studies revealed that different races of *Xanthomonans oryzae* existed at the Mymensingh, Jamalpur, Kishoregonj, and Tangail areas.

Screening of M_2 seeds indicated that gamma irradiation could induce resistance to bacterial blight in rice. Cutting, pin-prick, and spraying methods of inoculation of rice plants with X. *oryzae* were tried, with the cutting method being the most suitable for mass screening purposes. Nitrogen fertilization caused no significant increase in bacterial blight severity from 0 to 100 kg/ha. However, the severity of the bacterial blight significantly increased due to the interaction effects of the applied nitrogen doses and the 10 × 20 cm plant spacings.

The pathogens *Drechslera sorokiniana*, *D. tritici-repentis*, *Alternaria triticina*, *Ascochyta tritici*, and *Pseudomonas syringae* are causing leaf blights of wheat in Bangladesh. *D. sorokiniana* is the most dominant and is most instrumental in lowering wheat yields. *P. syringae* appears to be a new record-causing leaf blight of wheat in Bangladesh. Some parasitic nematodes of economic importance are associated with wheat. Some lines of wheat are resistant to the blights.

This is a report of research conducted by the Plant Pathology Division, INA.

Meiotic and Agronomic Investigations in Six F_1 and F_2 Populations of Inter-Triticale Crosses

AJIT KUMAR BANIK AND A. S. ISLAM
University of Dhaka

Meiotic and agronomic characters were studied in six F_1 combinations and six F_2 populations of crosses between the three selected strains of hexaploid triticale. In all of the six F_1 combinations, meiosis was more irregular than that of the respective parents. Relatively large numbers of tillers were present in the hybrid plants but the rate of fertility was lower in the hybrids. In the F_2 populations, meiotic disturbances improved, showing a wide range. The number of tillers per plant, degree of seed fertility, and yield were higher in all the F_2s than their respective F_1s indicating the positive effect of selection and hybridization in hexaploid triticles.

This is a report of Ph.D. thesis research conducted at the Department of Botany, University of Dhaka. Dr. Banik is now Assistant Professor of Botany, Brahmanbaria Government College, Comilla.

Research Activities in Tea

S. H. CHAUDHURY
Bangladesh Tea Research Institute

Little attention was given to tea research for more than 100 years after the crop was introduced into what is now Bangladesh. The Bangladesh Tea Research Institute was established in 1957. It conducts major investigations in the chemistry of soils and fertilizers and their relationship to the growth of tea

plants, crop management including improvement of cultural practices, plant improvement, pest management, plant introdution, and crop diversification, tea processing, and technology transfer. The research is chiefly applied to conform to the needs of the industry.

The paper reviews the principal areas of research: selection of high yielding, high quality clones through breeding; vegetative propagation; formulation of fertilizer policy for tea and ancillary crops; soil-fertilizer relationships; soil rehabilitation; evolving suitable agro-techniques such as spacing, pruning, and vegetative propagation; screening and standardization of pesticides for control of insects, diseases and weeds; and manufacturing problems and improvement of factory machinery.

The yield of tea in Bangladesh is the lowest of the world's major producing countries— around 823 lb/A. The BTRI has developed modern production techniques that have raised the yield of seedling tea to 2,300 lb/A of made tea in the ninth year. The yield potential of outstanding released clones is 4,600 lb/A from BT1; and 3,870 lb/A from BT2 and 3,375 lb/A from BT3 in the sixth year.

The industry requires urgent attention to all fields of tea culture and production. The solution seems to require research that will lead to a consolidation of the tea areas by reducing the tea vacancies in plantings, increasing the yield and quality through introduction of high yielding clones and seedstock, an improved management and monitoring system, rehabilitation of old tea soils, and training the planters so that the transfer of technology is effective.

Dr. Chaudhury is Director, BTRI.

Progress of Tea Improvement in Bangladesh

A. RASHID
Bangladesh Tea Research Institute

Tea is an outbreeding perennial crop, thus is extremely heterozygous. Improvement through breeding, mutation, and polyploidization is slow and laborious. Nevertheless, there is a wide range of variability in the seedling population which can be profitably exploited by selection and vegetative propagation.

Through selection, the four outstanding clones BT1, BT2, BT3 and BT4 have been developed by the Bangladesh Tea Research Institute and released to the tea industry. BT2 possesses a touch of flavour which is unique for a low elevation tea such as is grown in Bangladesh.

In the field of seed improvement, the combination of BT1 and TV1 has been extremely useful in producing a more uniform seed population with the potential for both high yield and quality.

These improved plant materials play an important role in the improvement of yield and quality of Bangladesh tea.

Decade of Tea Pest Management Research

D. L. SANA
Bangladesh Tea Research Institute

Present day agriculture is the result of continuous and progressive research on crop husbandry. Man has been able to bring forth an idea of synergism of *production technology* and *protection technology*. In this context, the concept of *pest management* of any crop— cereal, fibre or a beverage crop like tea— is considered to be a technological bond between these ideas. The decade-long research on tea pest management has been aimed at synchronizing these technologies so that the tea industry of Bangladesh will be a viable productive sector in the future.

The paper describes major research activities conducted on tea pest management during the past decade. They embrace the bio-ecological relationship of pests, the assessment of crop losses, the evaluation of pesticidal efficacy, the economic valuation of various control methods, the evaluation of pest-succession, and the evolving of a pest monitoring system in tea.

Mr. Sana is Principal Scientific Officer, BRTI.

A Review on Soybean Entomology in Bangladesh

M. A. MANNAN AND M. KHALEQUZZAMAN
Rajshahi University

Attempts have been made to introduce and popularize soybean production into the cropping system of Bangladesh. However, the crop suffers from the attacks of different pests from the seedling stage to harvesting stage, and also while in storage. This paper includes a checklist of the soybean pests recorded so far in Bangladesh. It reviews the research conducted on the different aspects of soybean pests and the behaviour of the crop to attacks by pests.

This is a report of research conducted by the Department of Zoology, Rajshahi University.

Production Potential of Sunflower in Bangladesh: Its Constraints and Solutions

M. A. KHALEQUE AND MD. AHSANULLAH
Bangladesh Agricultural Research Institute

Sunflower is an important oilcrop in the world, standing third in production after soybean and cottonseed. It is largely grown in the USSR, Poland, Czechoslovakia, and Yugoslavia. Recently it has been increasing in the USA,

too. It has been grown for ornamental purposes in Bangladesh. Only recently attention has been given to its potential as a source of oil. It contains high quality oil which amounts to about 42% of the seed. Since Bangladesh is very deficient in edible oils, sunflower cultivation is a good prospect for minimizing this shortage. The dependence on one seasonal crop like mustard is not justified to ensure production for the whole year.

The sunflower grows well throughout the year in Bangladesh and yields 1500—1600 kg/ha. Many varieties and strains from the USSR, Poland, USA, Sweden, India and Bangladesh have been tested since 1976. The variety DS-1, popularly known as Kirani, has been selected and was released by the National Seed Board in 1982. It is being multiplied by the Bangladesh Agricultural Development Corporation and there are demonstrations at the BARI/RARS and some farmers' fields. According to the observations and studies, it is a productive and economic crop.

However, several production problems have been detected. These include (1) loss of viability of seed, (2) damage by birds, (3) difficulty in extraction of oil, and (4) sterile seeds. Suitable technology has been developed to solve each of these problems except that of bird damage. It is now possible to store seeds for long periods in polythene bags while maintaining a desirable germination level. Rural expellers easily extract 33% oil from the seed. Even the bullock-driven *ghany* can extract 28% oil. The bird damage and the sterility problems can be reduced by care and management, plus provision to increase pollination by bees. Sunflower cultivation, therefore, can help reduce the deficiency of cooking oil in Bangladesh.

Mr. Khaleque is Project Director (Oilseeds) and Mr. Ahsanullah is Senior Scientific Officer (Biochemistry), Oilseed Project, BARI, Joydebpur.

Prospective Selection of Groundnut Varieties

MD. FARIDUDDIN MIA, M. A. KHALEQUE AND MD. SULAIMAN KHAN
Bangladesh Agricultural Research Institute

The groundnut (peanut) is an important oil crop in the world as well as in Bangladesh. The BARI Oilseed Project has collected 255 varieties/strains from India, USA, Nigeria, Senegal, China, and the Philippines, as well as from within the country. These have been grown at BARI, Joydebpur in the 1980–82 rabi and kharif seasons. Seventeen strains were selected on the basis of their maturity, oil content, shelling percentage, and yield. These selections were grown in yield trials in the 1982–83 rabi season along with two local checks, DA-1 (Spanish group) and DG-2 (Virginia group).

The 17 selected strains showed statistically significant differences. The highest yield of 2748 kg/ha was obtained from the ICG-3100 strain. This compares to the check varieties of DA-1 with 1504 kg/ha and DG-2 with 2344 kg/ha. The second highest yield was 2205 kg/ha obtained from No. 5816. The strain ICG-3370 had the highest shelling percentage of 78.26% compared to

76.59% for the DA-1 and 61.66% for DG-2. The variety/strain No. 5816 had a 50.1% maximum oil content and was significantly different from all other varieties/strains. The varieties/strains ICG-3370, Gurgapur, OG-1-64, No. 5816 and DG-2 were statistically identical and were significantly different from other varieties/strains in respect of maturity period.

The selected varieties/strains ICG-3100 and No. 5816 are superior to all the varieties/strains, including the checks, in yield and oil content, respectively. The two varieties/strains have good prospects for the future as new varieties of groundnut for Bangladesh.

Mr. Mia is Senior Scientific Officer, Mr. Khaleque is Project Director and Mr. Khan is Principal Scientific Officer, Oilseeds Project, BARI.

Detection of Seed-borne *Alternaria Brassicae* from Oilseed Rape and Transmission of Fungus

MD. AMIN UDDIN MRIDHA
University of Chittagong

Seed-borne *Alternaria brassicae* from winter oilseed rape *(Brassica napus* L. spp. *oleifera)* can be detected satisfactorily by incubating seeds on wet blotting paper for 48 hours at 15°C. Light had little effect on sporulation of the fungus on seeds at the optimum temperature of 15°C but it causes inhibition at higher temperatures. The fungus occurs more abundantly in small, immature or shrivelled seed than in mature and apparently healthy seeds.

The transfer of *A. brassicae* from the infected seed to the developing seedling can readily be observed in the blotter test or by covering the seed with vermiculite, but cannot be seen in soil. The role of seed-borne *A. brassicae* inoculum in developing disease is discussed in the paper.

Dr. Mridha is Assistant Professor, Department of Botany, University of Chittagong.

Prospects and Possibilities of Interspecific Hybridization in the Genus *Brassica*

MD. WAHIDUZZAMAN
Bangladesh Agricultural Research Institute

The genus *Brassica* includes many species and sub-species; most oilseeds belong, such as mustard, cabbage, radish and cauliflower. Not all exhibit every character, but when carefully observed many of the desired traits may be found in some of the species. The intergenomic relations between some of the *Brassica* species present further scope and might succeed for reciprocal improvement through interspecific crossing.

The cross compatibility between different *Brassica* species and their reciprocals differed significantly. *B. napus* × *B. campestris* and *B. juncea* × *B. napus* produced hybrid seeds easily. *B. napus* × *B. carinata/B. alboglabra*, *B. carinata* × *B. campestris/B. alboglabra*, and *B. campestris* × *B. napus* produced hybrid seeds more or less without difficulty. *B. carinata* × *B. napus*, *B. napus* × *B. juncea*, *B. alboglabra* × *B. napus*, and *B. campestris* × *B. alboglabra* and its reciprocals were almost incompatible. However, a few hybrid seeds were produced even in incompatible crosses when environmental conditions were favourable, i.e., in temperatures about or below 20°C. The problem was much more intricate in the case of F_2 seed production. The exceptions were the crosses *B. napus* × *B. campestris* and its reciprocals, and *B. napus* × *B. alboglabra*. However, this problem appeared not to be a limiting factor as the advanced generations produced genotypes of clear breeding value.

Mr. Wahiduzzaman is Senior Scientific Officer (Oilseeds), BARI.

Improved Jute Seed Production Programme in Bangladesh

RAMENDRA CHOUDHURY AND M. KASEM ALI
Bangladesh Jute Research Institute

This paper describes the development, procedures, and benefits of the jute seed production programme of the Bangladesh Jute Research Institute. The programme started in the late 1960s and has gained popularity because improved seed is the cheapest input for increasing jute production. By adopting a package of improved practices, farmers can double their production of jute, currently averaging 1.4 t/ha. Improved seed is the basis for this technology package, contributing about 20% to the yield increase.

As jute is a partially cross pollinated crop, the seed degenerates over seasons of plantings. Producing certified seed of the recommended varieties is difficult as seed is neither the main product of the crop nor harvested at the same time as the main product. BJRI has correlated seed science disciplines along with managerial skills to develop a successful seed production programme to cater to the needs of the jute farmers of Bangladesh.

The development of the seed programme is described from its beginning in 1955. The entire responsibility was transferred to BJRI in 1972. The Jute Seed Division has the goal of supplying one-third of the country's jute seed requirement through the block farmers in the Intensive Jute Cultivation Scheme (IJCS).

The improved seeds of the recommended varieties of capsularis and olitorius are produced in three phases: (1) breeders seed is maintained at the BJRI experiment stations and supplied every year, (2) foundation seeds are produced at BJRI foundation seed farms, and (3) foundation seeds supplied to selected registered growers are multiplied in the fields for certified seed

production under guidance and supervision of BJRI personnel. The certified seed produced by the growers must pass the quality standards of the National Seed Board before it can be sold to farmers.

BJRI is expected to supply 2150 tons of certified seed of high yielding jute varieties for planting of 0.26 million ha of white and tossa jute in 1984. This will meet the goal of one-third of the nation's jute seed requirement. However, there are some persons urging that BJRI be geared up to produce at least one-half of the country's jute seed needs. It is claimed that the increased seed production would significantly increase the country's production of jute, thus be a nominal insurance premium to safeguard the national economy of Bangladesh.

Mr. Choudhury is Principal Scientific Officer and Dr. Ali is Executive Director, BJRI.

Genetic Improvement of Jute Through Nuclear Techniques

M. A. Q. SHAIKH AND M. M. MIA
Institute of Nuclear Agriculture

Jute is well known for its various uses. It is the most important foreign exchange earner for the country among the export goods. A continuous endeavour is needed to improve the varieties of jute for higher yield and better quality fibre.

Varietal improvement has been impaired by the limited variability in the population and also the probable complex genetic composition of the available stocks. In spite of many attempts, it hardly has been possible to make a breakthrough in the varietal improvement programme.

There are only a few cultivars used for commercial jute cultivation. Although both the species have an equal number of chromosomes and morphologically they are not very distinct from each other, yet they are sexually so much isolated that it has not been possible to have a hybrid incorporating desirable characters of both the species.

Various attempts have been made to evolve new genetic strains using the induced mutation technique. In almost all cases the seeds were treated with gamma rays. Selections of the desired types with definite genetic markers were made either in the M_2 or in M_3 generations. For hybridization, pollen grains were treated with different doses of gamma rays.

Following the described methods, a total of 50 genetic stocks were isolated and evaluated. Some were higher yielding than the mother varieties while some had other desirable agronomic characters. One high yielding mutant, Atompat-38, was released provisionally in 1981. A few others are in advanced stages of testing under field conditions.

A large number are of indirect type and through extensive hybridization the positive mutated characters can be incorporated into the cultivated types.

On the basis of this experimentation it can be said with considerable emphasis that induced mutation techniques using both physical and chemical agents have a definite role to play for the varietal improvement programme in jute. It is expected that mutation breeding will have to be further explored to evolve varieties with desirable agronomical characters such as high yield, disease resistance and better fibre quality.

This is a report of research conducted by the Plant Genetics Division, INA.

Genetic Resources of Jute and Mesta

M. A. SOBHAN AND M. HUSAIN
Bangladesh Jute Research Institute

Jute (*Corchorus* sp.) and mesta (*Hibiscus* sp.) account for about 3.3 million tons of long vegetable fibre that is produced in several developing countries and enters world trade. Jute and mesta plants are known primarily for their bast fibre. However, they are versatile in their utility, and contribute to some of mankind's needs for fuel, housing, paper pulp, vegetables, and medicines. A world survey of genetic resources of jute and mesta is yet to be made. The Gene Bank for Bast Fibre Crops in the Bangladesh Jute Research Institute was commissioned in 1982. There are 1090 entries of *C. capsularis*, and 524 of *C. olitorius*, 143 of *H. cannabinus*, 60 of *H. sabdariffa*, and 13 of wild and related species, covering a wide array of land races, obsolete cultivars, improved cultivars, exotic cultivars, genetic stock, cytogenetic stock, and induced mutants. Seeds of each entry are kept in sealed, laminated aluminum pouches in two cold rooms, one for medium term storage maintained at 4°C and the other at −20°C for long term preservation. A preliminary evaluation of the germplasm indicates the deversity of some traits as well as deficiencies of others. This limits genetic improvement and threatens the future existence of these plants. A global collection of germplasm— made possible through international collaboration— is needed to conserve the natural variability and help genetic improvement.

Mr. Sobhan is Senior Scientific Officer, and Dr. Husain is Director, Jute Research (Agricuture), BJRI.

Use of Early Flowering Mutants in Evaluating the Genetics of Flowering Behaviour in Jute (*C. capsularis* L.)

C. S. SAHA, S. BEGUM AND M. A. Q. SHAIKH
Institute of Nuclear Agriculture

A radiation-induced, early flowering mutant, C-5 of *C. capsularis*, was crossed with the mother variety, D-154, for evaluating the genetic mechanism involved in controlling flowering behaviour in jute. F_2 and F_3 data indicated

that this trait is governed by one pair of genes. The mutant character for earliness was inherited recessively, i.e., lateness is dominant over earliness. The alleles responsible for flowering in the mutant, C-5, is insensitive to environmental conditions, whereas the mother variety is highly sensitive. Induction of mutations for earliness of various categories—like early by 85–90 days, 30–35 days, and 25–30 days—indicates that there are many alleles involved in controlling the flowering behaviour and that the basic vegetative phase of jute is less than one month. Induction of different types of earliness and repetition of the same mutational types of earliness which simultaneously affected other characters — like plant height and base diameter— may be due to the pleiotropic nature of the genes.

This is a report of research conducted by the Plant Genetics Division, INA.

An Integrated Approach for Jute Insect Pest Control

A. K. M. F. KABIR
Bangladesh Jute Research Institute

Integrated pest management (IPM) is an applied system which combines and integrates biological and chemical measures with resistant varieties into a single unified pest control programme.

Some alternative approaches of jute pest control have been identified in the insect pest management research programme at BJRI. This information will contribute to better understanding and management of the key pests.

In a sophisticated IPM programme, biological control agents and resistant varieties are given appropriate consideration. Attempts should be made for the introduction of exotic parasites and predators to strengthen the biological control measures. The evaluation of germplasm for resistance to certain pest species also has been given priority. Close collaboration between entomologists and plant breeders is essential in the germplasm collection and evaluation work. The paper outlines the views on some of the most important aspects of integrated pest control.

Dr. Kabir is Chief Scientific Officer, Division of Entomology, BJRI.

Genetic Improvement of Jute Through Interspecific Hybridization

SADEKA ARANGZEB AND ASMA KHATUN
Bangladesh Jute Research Institute

Corchorus trilocularis and *C. capsularis* were crossed to produce a hybrid incorporating the desirable characters from wild sources of jute with those of commercial value. The F_1 plant was intermediate in most of the characters of

the male and female parents. F_2, and F_3 plants showed interesting segregations including the parental and hybrid types. Plant heights of 305 to 335 cm were observed in F_2, F_3, and backcrossing progenies. Under normal circumstances, the F_2, and F_3, populations were free from the leaf-mosaic disease of jute. Similarly, most of the lines of F_3 populations were not attacked with stem-rot disease. A preliminary test of eight lines of F_3 populations identified five as being free of leaf-mosaic disease of jute. Ten F_3 lines were found to be resistant to stem-rot disease. F_2, F_3, and backcross segregations indicated the possibilities of introgression of the desirable characters of *C. trilocularis* into the standard cultivated varieties without affecting their economic value.

Mrs. Arangzeb is Principal Scientific Officer and Miss Khatun is Scientific Officer, BJRI.

Potential Use of Tobacco Extracts for Controlling Insect Pests

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A material prepared with tobacco extract, oil, egg, and detergent is lethal to some insect pests. Doses of one part of the material mixed with 10, 20, 40, 75, and 150 parts of water were tested against cowpea aphids, bean aphids, groundnut leaf beetle, epilachna beetle, epilachna grub, and rice bug. All of the doses of the material were effective in controlling the cowpea and bean aphids. The other insects were largely resistant to the material.

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Part IV
Fruit and Vegetable Research

KEYNOTE PAPER

Fruit and Vegetable Research in Bangladesh

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Horticulture deals with crops that are intensively cultivated and of high enough value to warrant a large input of capital, labour, and technology per unit of land.

Bangladesh is a country where the daily per capita supply of calories, protein, and other important nutrients is extremely low. More than 75% of the people live below the poverty line. Most of them cannot afford meat, eggs, fish, and milk. In a country like this, fruits and vegetables can play a significant role in meeting the nutritional requirements of the people.

The supply of fruits and vegetables in Bangladesh is not sufficient to meet the demand. Fruit and vegetable farming have not been established as large scale commercial enterprises in the country. These are grown as subsidiaries to the major field crops, usually in and around the homesteads of the 68,000 villages. Only recently has a trend developed among some farmers near to towns and cities to engage exclusively in the commercial cultivation of fruits and vegetables.

The climate of Bangladesh is favourable for the production of such fruits as banana, pineapple, and papaya, and a number of summer and winter vegetables. The extensive cultivation of these crops could generate rural employment, stimulate urban employment, expand exports, improve the nutrition of the people, and increase the income of the farmers.

Fruit and vegetable research became established in the mid-1960s in the Bangladesh Agricultural Research Institute. There was modest early progress given by the Bangladesh Agricultural University, Bangladesh Agricultural Development Corporation, and the Bangladesh Academy for Rural Development.

The fruit and vegetable research activities have become better organized with the expansion of BARI and the establishment of the Bangladesh Agricultural Research Council. BARI now includes the Potato Research Centre and the Citrus and Vegetable Seed Research Centre. Research on other fruits and vegetables is being conducted by the Fruit and Vegetable Section, Division of Horticulture. Some investigations also are underway at research sub-stations located throughout the country.

Bangladesh produces a large number of fruit and vegetable crops, but these will not be individually considered in this paper. A few points on the important fruits and vegetables will be highlighted to provide some ideas of the development of this research in the country.

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FRUITS

Banana

Bananas contribute 42% of the country's total fruit production, estimated to be 1,424,000 tons. Naturally, the crop has attracted great attention from researchers. K. Ahmad made a detailed study of the morphological characters of edible banana cultivars of Bangladesh. He concluded that Amritasagar and Champa have higher yield potentials than do Sabri, Agniswar, and Dudshar. Studies were conducted for three years in the same land on perennial cropping of Amritasagar and an introduced variety, Basrai. Amritasagar yielded 15.99, 15.79, and 14.60 t/A in three successive years, whereas Basrai yielded 23.49, 21.44 and 21.61 t/A in the corresponding years. Varietial trials, cultural practices, and fertilizer requirements— especially for potash for Dhaka soil— also were investigated.

The BAU Department of Horticulture studied two wild species of banana, *Musa balbisiana* and *M. acuminata*. It was learned that Amritasagar is a triploid comprising AAA type of genomes contributed by *M. acuminata*. The vegetable banana Anaji is also a triploid (ABB), with genome BB contributed by *M.balbisiana* and the genome A contributed by *M. acuminata*. The study also indicated that Amritasagar, Anaji, and Sabri each have 33 chromosomes in somatic cells, whereas the seeded variety Atia has only 22 chromosomes. A study was undertaken in 1977 of the yield potential of the more commercial banana varieties, Robusta (Cavendish group), Lacatan, Basrai, Jahaji, Dwarf Cavendish, Amritasagar, and Sabri. It was concluded that Robusta is worth recommending to commercial growers due to its high yield and earliness. Its only disadvantage is that the fruit remains green when ripe and the pulp is a little softer.

A. Haque of BAU studied two planting times for commercial banana growing. He reported that in the Mymensingh area, September–October planting is better than February–March, and that clump planting has no advantage over single sucker planting.

The banana has potential for export. Investigation may be taken up to improve the Amritasagar variety for yield, arrangement of the fingers, and other characteristics by clonal selection from a big population of commercial crops. There also should be research conducted on post-harvest technology.

Mango

Mango contributes about 22% to the total production of fruit in Bangladesh. Production of good quality mangoes on a commercial basis is concentrated in the Chapai Nowabgonj area of Rajshahi. Quality mangoes are also grown in the districts of Dinajpur, Jessore, Kushtia, and Pabna, and in some areas of Khulna. These are the potential areas for the extension of quality mango growing in the country.

Though the total mango-growing area has been estimated to be about 10 million acres, only about 25,000 acres are planted to good quality grafted

varieties. The most common varieties are Fazli, Langra, Gopalbhog, Mohonbhog, Khirshapati, Khudi-khirsha, Bombay, and Aswini. Through research, the technologies of vegetative propagation of mango have been developed by many organizations like BARI, BAU, BADC, and the Bangladesh Horticultural Development Board.

The writer could not identify any research paper showing the comparative yield potential, regularity in bearing, time of blossoming, or ripening of the mango garden in the Chapai Nowabgobj area. As the trees are tall, control measures cannot be taken effectively. To overcome this, mango grafts in the nurseries and gardens are trained and pruned so the trees remain low headed, and they are planted with closer spacings. To develop suitable varieties for the southern region, attempts may be taken to select mother plants from the same areas having regular and heavy-bearing abilities with good quality fruit. The Government is actively considering the establishment of a mango research station in the Chapai Nowabgonj area to develop various aspects of mango. We should have it as early as possible.

Jackfruit

Jackfruit makes up about 14.6% of the fruit production in Bangladesh. Its bearing habit is regular, and pest and disease hazards are less.

Researchers should pay attention to the development of good quality, high yielding varieties. Investigation should seek early, medium, and late types. Such studies may not require the establishment of jackfruit orchards at the research stations as good public gardens may be used. A research programme can be developed by the relevant organizations.

Pineapple, papaya, jujube, guava and melon

Pineapple contributes 7.6% to the total fruit production of the country. There is an increasing trend in its cultivation. Some of the locations for growing pineapple on a commercial basis are the Madhupur area of the Tangail District, Sylhet, and the Chittagong Hill Tracts. Its importance has greatly increased with the establishment of a processing centre at Chittagong. Farmers have accepted the Giant Kew variety for their home and commercial gardens.

Investigations on pineapple production by BARI and other institutions include propagation techniques, fertilizer and irrigation requirements, planting times, and mulching practices. Future research programmes may be prepared after surveying the commercial growing areas. There is a possibility of using clonal selection to increase the production of the Giant Kew variety.

Papaya, jujube, guava, and melon together contribute 25.8% of the total fruit production of the country. Each of these has a special reason to receive attention from researchers as well as extension workers. Some are important home-yard fruits. The introduction of hybrid seeds in this decade has made watermelon a profitable industry with export potential. A substantial quantity of watermelon already is exported from Malaysia to Japan.

Cirtus fruits

The Citrus and Vegetable Seed Research Centre began operation at BARI in September 1977. Both Japanese and Bangladeshi scientists are involved with this research programme. The performances of a number of exotic varieties of mandarin orange, lime, lemon, pomelo, and sweet orange are under observation. Six different kinds of citrus rootstocks are being studied. Side by side, various local varieties of citrus fruits are also being collected, planted and studied. A citrus fruit improvement project has also been initiated by A.H. Md. Faruque at BAU.

In Bangladesh there are too many fruits for the researchers and extension workers to look after. Through the citrus research project at BARI, possibly 20 years' progress has been made. The Centre must remain active after the termination of the present contract period.

VEGETABLES

In general, vegetable production is much below the quantity required for the nation. About 68% of the production in 1977–78 was by the solanaceous vegetables, with potatoes contributing 53.4%, brinjal 10.7%, and tomatoes 3.8%. Roughly 80% of all vegetables grown in Bangladesh are produced in the winter season. Consequently, there is a shortage of fresh vegetables in the summer season, especially from July to November. Floods and rains often heavily damage the late summer and early winter vegetables.

Potato

The Potato Research Centre at BARI was established in 1977. Its scientists are working at Joydebpur and in various research sub-stations. The Centre is functioning quite satisfactorily. High yielding hybrid seed potatoes are imported every year from Holland and multiplied through the registered growers under strict supervision of the field staff of BADC. The multiplied seed is distributed to the growers the following year for large scale production. This policy should continue. The PRC research programme should be developed in close cooperation with BADC so the growers' problems may be tackled efficiently.

Brinjal

Superior quality brinjals are marketed in the winter season. Research studies so far have dealt primarily with the yield potential of different cultivars and of cultural management. Brinjal growers keep their own seeds.

There is no need for adaptation trials of exotic hybrid brinjal varieties. Improvement can be made with our own varieties. Pollination difficulties for summer and monsoon crops should be studied.

Tomato

The establishment of the Bangladesh Vegetable Research and Development Centre has intensified the research effort on tomato, cabbage, sweet potato, radish, and winged bean. The scheme was implemented with the

participation of BARI, BAU, BARD, and the University of Dhaka. The project was funded by BARC. High yielding tomato varieties identified have been Sanmarzano, Homestead, Marglobe, Floradel, Tropic Grow, Pink No. 12, and Pink No. 29.

Adaptability and yield potential tests for exotic tomato varieties were also conducted at BARI and BAU. However, it is suggested that without specific objectives, tomato varieties should not be indiscriminately imported only for yield tests. Production of open pollinated varieties should be encouraged so researchers and farmers can keep their seed for several generations.

Virus diseases, bacterial wilt, early blight, late blight, fusarium wilt, and root knot nematodes are the main handicaps in increasing tomato production. The Asian Vegetable Research and Development Center has the largest tomato breeding programme for the tropics. AVRDC resistant tomato lines can be obtained for research purposes through the USDA Regional Plant Introduction Center, Ames, Iowa, USA.

A processing centre for tomatoes and pineapple has been established near Chittagong. The tomato varieties suitable for processing are of determinate type. The fruits ripen almost simultaneously. There should be studies of the yield potential and other factors of the varieties developed by various tomato processing organizations of the world. Some of those processing varieties having wide adaptability are Campbell 34, Heinz 1350, Peto 80, and VF-65-433. Seeds of these varieties may be procured from Peto Seed Company, Box 4206, Saticoy, California 93303, USA. The AVRDC also is working with processing-type tomatoes.

Cruciferous vegetables

Cruciferous vegetables are grown mainly in the winter season. Cabbage, cauliflower, and radish are the most important in this group which contributes about 11% of the total vegetable production of the country. Research on these crops has been undertaken by BARI, BAU, and BVRDC. The CVSRC has also made substantial contributions on these vegetables. The following recommendations are made concerning the research and production of these vegetables:

1. Importation should be stopped of the exotic varieties of cabbage other than Hercules, Titan, Atlas, Leo-80 of the T. Sakata and Company of Japan, and the K-Y Cross and K-K Cross of the Takii & Company of Japan. The adaptability of these varieties has been tested in Bangladesh for a considerable time.

2. The CVSRC has made progress in the production of cabbage seeds from two lines, F-67-2-1 and K-24-1-31-1, both of which are from Taiwan. They were developed from the Yoshin group of cabbages.

3. There are open pollinated, acclimatised tropical-type cauliflowers in Bangladesh, including Patnal Early, Kartika, Poushali, Agrahyani, and Maghi. Experienced cauliflower growers in the areas of Tangail, Dhaka, Rajshahi, and Dinajpur keep their own seeds. Researchers should develop improved methods for large-scale production of seed of these variety. The

Takii company of Japan developed the open pollinated tropicalised cauliflower variety, Tropical cauliflower, which producess in 45 to 55 days. Efforts should be made of produce seeds of these types.

4. High yielding, biennial types of exotic radish varieties do not usually produce seeds under Bangladeshi conditions. CVSRC had some success in studying the effect of vernalization of germinating radish seeds on the production of seed. The study should be continued.

Cucurbitaceous vegetables

This is the largest group of summer vegetables; most of these have been grown in Bangladesh since ancient times. Researchers' attention has not been drawn to these vegetables as it should be. Farmers keep the seeds of these vegetables. Research work should be undertaken to develop high yielding varieties suitable for growing at different times of the year.

Leguminous vegetables

Though leguminous vegetables can decrease the protein deficiency of our people to some extent, we have done little to develop this group. The climate of Bangladesh favours the production of peas, beans, asparagus beans (barbati), cowpeas, and hyacinth beans (country bean). Generally, beans are produced during the winter season. Varieties of asparagus beans may be developed to grow in the summer season of Bangladesh.

Lady's finger

Lady's finger is another vegetable grown in the summer. It is very nutritious and is in great demand in city markets. Yellow mosaic disease, its main enemy, is prevalent in July and August. Researchers should develop resistant varieties and production technology to get rid of this disease problem.

Root crops

Sweet potato and aroids are playing an important role in meeting the vegetable needs of the country. The exotic types of sweet potato with yellow flesh are rich in carotene.

A project for "Development of Root Crops of Bangladesh with Particular Emphasis on Sweet Potato and Aroids" was undertaken by BARI and BAU between 1980 and June 1983. It was funded by BARC. A few cultivars of sweet potato have been identified which are rich in carotene content as well as high yielding. The selected varieties will now be tried in the farmers' fields through the extension machinery of the country. Through this project, both wet and dry cultivation aroids were collected from different places of Bangladesh and are under study. The project will continue from 1984 through 1988 with some new activites. Studies on the processing of sweet potato and aroids will be done by the food technology department of BAU.

Leafy vegetables

This report would be incomplete without mention of greens. Nutritionists advise than an adult should take 280 g of vegetables every day of which 110 g should be in the form of green leafy vegetables. Spinach, New Zealand spinach *(Tetragonia expansa)*, mustard, and radish for greens are the most popular greens produced in winter season. Amaranths and Indian spinach are also important greens in the country. There is ample scope for researchers to develop good varieties of these vegetables.

ESTABLISHMENT OF FRUIT AND VEGETABLE RESEARCH INSTITUTES AND DEVELOPMENT OF MANPOWER

This paper has discussed established research areas and their future with respect to some important fruits and vegetables. The research needs in some specific areas have been pointed out.

Fruits and vegetables are very sensitive crops. Successfully raising them requires highly specialized techniques. The number of vegetable and fruit crops commonly grown in Bangladesh is quite high, including about four dozen vegetable crops and more than one dozen fruit crops. The crops belong to a large number of families, and their growth habits and cultural management differ widely. Consequently, the problems associated with the production of these crops are complex and diversified. To make significant improvement in their production, the problems must be solved through proper planning and execution of research programmes. This necessitates (1) the establishment of fruit and vegetable research institutes, and (2) the development of appropriate manpower. To boost research activities, the following specific suggestions are made:

1. A tree fruit research institute should be established in the northern zone of the country.
2. A mango research institute should be established in the Chapai Nowabgonj area.
3. A quick-growing fruit research institute should be established in the southern zone of the country, but not at Dhaka.
4. A vegetable seed research institute should be established in the northern zone of the country, preferably in the northern part of Dinajpur where the winter season is long and the rainfall is low.

It is not an easy task to develop the required manpower for these proposed research institutes. It is not suggested that we are to immediately procure the land, and construct the buildings and residential houses for these institutes. It may be done gradually. In a few cases it has been mentioned that there is scope to conduct research in the farmers' fields. Nevertheless, the researchers should be given proper facilities and incentives. The researchers should not normally change their places of posting or the nature of their jobs. Introduction of time-scale in pay will help to solve the problem. The contributions of a research scientist should get due recognition.

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Performance of Vegetatively-Propagated Cabbage Varieties in Summer

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The total yield of cabbage was increased by 48% through a second, vegetatively-propagated planting. The average yield of four varieties grown from seed was 43 t/ha with an average maturity period of 150 days. Subsequent cabbage yields grown from those sprouts averaged 20 t/ha and matured in 111 days. The highest yield of 26 t/ha and the minimum period to maturity of 93 days was recorded from the variety K-K Cross through the vegetative propagation method. The varieties K-K Cross and K-Y Cross are recommended for vegetative cultivation of cabbage.

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Effect of Planting Dates on the Incidence of Tuber Rot of Potato in Natural Storage Conditions

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A study was conducted with two potato varieties, Lal Pakri (local) and Kufri Sindhuri (exotic), to determine the effect of the crop period on the incidence of tuber rot as caused by *Fusarium* spp. and bacterial soft rot organisms in natural storage conditions during the March to September 1983 period. They were planted on November 5 and 20 and December 5. The crop period was 110 days. The result was that the incidence of both *Fusarium* and bacterial tuber rot increased in the natural storage conditions in relation to the lateness of the crop period. In the early part of the storage period, the tuber rot was mainly due to *Fusarium* spp., whereas at the later stages the tubers were most vulnerable to the bacterial rottage. The increased bacterial rottage at the later stage may be due to the cumulative effect of the physiological aging of the tubers and the relatively high prevailing atmospheric humidity. The means of *Fusarium* rottage of the two varieties were 16.35% for the November 5 planting, 31.3% for November 20 planting, and 42.6%

for December 5 planting. The corresponding data for bacterial rottage were 17.05% for November 5 planting, 27.95% for November 20 planting, and 39.75% for December 5 planting. The local potato variety, Lal Pakri, is shown to be comparatively resistant to both types of rottage.

This is a report of research conducted by the Potato Research Centre, BARI, Joydebpur.

Potato Seed Production via True Potato Seed: An Alternative to Tuber Seed Production

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The use of true potato seed (TPS) seems to be a practical method for adopting potato cultivation to the lowland tropics where farmers' holdings are small and their resources are scarce. This technology has the potential to increase rural employment. Based on preliminary results, hybrid progenies gave significantly higher yields than open pollinated ones being comparable to yields obtained from crops raised asexually. Genetic engineering can go a long way in evolving commercially acceptable potato progenies with high yields and which combine resistances to the major diseases and pests of the tropics with reasonable uniformity in foliage and tuber characters.

The small size of the tubers from TPS is not a limitation in Bangladesh as the consumers prefer small potatoes. The traditional cultivars grown in the country produce tiny tubers which are not uniform in shape, colour or size.

Procedures are being investigated for a commercially viable system of using seedling tubers as a substitute for basic seed for subsequent clonal multiplication. This will help to provide a regular supply of clean seed at a cost the small farmers can afford.

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New Approaches to Potato Storage Technology in the Tropical Climates

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The potato is a semi-perishable commodity. A significant percentage of the production is lost during the post-harvest period due to high temperatures which cause several types of rots when the storage facilities are inadequate and inappropriate. Since mechanical cold storage facilities are costly, there is need to evaluate low-cost cool storage as an alternative for the protection of stored potatoes. Such a device should protect the potatoes from daytime heat and provide the cooling effect of the night air. The paper discusses proposed methods and construction designs for the storage of consumer potatoes in the natural ventilated stores and seed potatoes in the diffused light stores. Various technical aspects are suggested to improve the efficiency of these low-cost cool stores for short-term storage. The use of sprout suppressants is recommended when the storage is to be extended for more than 105 days, especially in central and southern Bangladesh. Potatoes can be stored for 150 to 160 days in northwest Bangladesh without the aid of sprout suppressants provided appropriate plant protection measures are adopted against tuber moth infestation.

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Principles of Scientific Potato Seed Production in the Tropics

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This paper discusses the complex problem of degeneration of potato seed stocks under tropical conditions caused by pathological, physiological and genetic factors. A procedure is outlined for the development and production of basic seed in a phased programme during the period of low aphid infestation in the tropical plains. Also discussed are aphid management and plant protection measures to minimize the incidence of soil and tuber-borne diseases to maintain healthy stocks. Agro-techniques are indicated for

increasing the efficiency of the seed programmes. The new technology envisages planting of initially pathogen-free stocks during vector free periods from mid–October to mid–January in northwest Bangladesh, timely roguing before arrival of aphids, killing the haulms before the aphids attain critical numbers, and keeping the regrowth of stumps under check. Aphids prefer young growth, so the killing of the haulms is defeated. Degeneration studies with six commercial varieties showed that initially high grade stocks could be reasonably maintained in their health and productivity for several clonal generations. The annual rate of virus incidence for severe mosaic and potato leaf roll virus is well below 1%.

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Present Status of Coconut Research and Development

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There are about 30,000 ha planted to coconuts in Bangladesh, mostly mixed plantings in homesteads. Though they are concentrated in the southern coastal districts there are scattered plantations in other districts. Certain unfavourable climatic conditions are serious limitations, including irregular distribution of rainfall causing serious drainage and irrigation problems, wide seasonal variations of temperatures, and occasional cyclones and floods. Other reasons for poor coconut production are the unsuitable planting sites and lands, genetic inferiority, the senility of many plants, and a serious disease of unknown etiology.

The BARI Coconut Research Station is conducting research on variety development through introduction, selection and hybridization, and on improved management practices. Seedlings for farmers are raised and distributed by the Food Crops Division of the Department of Agricultural Extension from its 55 nurseries.

The production of neglected coconut plantings can be significantly increased by improving the land with earthworks and removing excess shade, then applying regular fertilization and irrigation during the dry periods.

The very good performance of some new plantations indicates there are excellent prospects for extending coconut production to such areas as Chittagong, Chittagong Hill Tracts, Sylhet, Khulna, Jessore, Kushtia and Rangpur, and some of the northern districts. Coconut plantings may be further expanded in homesteads all over the country.

The production of coconut can be improved by using the latest management practices, and by planting suitable new areas of high quality seedlings of genetically superior varieties, including hybrids adapted to Bangladesh conditions. The variety development programme of BARI and the isolated seed production garden of DAE can play vital roles in increased national production.

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Prospects and Problems of Mango Production

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Mango yield is low in Bangladesh and continuing to decline despite the country's suitable agro-climate for this fruit. The reasons for this low productivity are that many trees have been maintained beyond their useful productive lives and farmers have relied on traditional practices.

A mango research and development programme has been suggested as one way to develop new cultural practices. The extension organization should be strengthened to motivate farmers to adopt modern cultural practices and to provide them with the necessary material inputs and technical know-how. More efficient and economic use can be made of the land by gradually replacing unproductive orchards with new plantations. Research organizations should collect germplasm, develop new varieties through clonal selection, develop appropriate production technology, and study post-harvest handling and processing.

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Utilization of Hills for Horticulture

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About 12% of the land of Bangladesh is hilly areas, mostly in the Chittagong Hill Tracts and the Chittagong and Sylhet districts. With an expanding population, increasing numbers of farmers have been moving into these hill areas. They are using improper farming practices which are causing massive erosion of hillsides resulting in land degradation in the lower

catchment areas. The paper gives a review of the farming practices in the hill areas. It also covers the soil erosion process and management short falls. Suggestions are made for proper farming practices with emphasis on horticultural crops, adequate soil conservation practices, and the development of research and extension capabilities for providing effective management and conservation of the hill areas.

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Banana Research and Development

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The banana is the most important fruit crop in Bangladesh in terms of acreage, production and year around availability. The paper reviews banana research and development from 1951–52 to 1980–81. There was little increase in either banana acreage or production during the period, but the human population of the country doubled. However, there was a change in the production pattern. In the past bananas were almost entirely a homestead crop; damage due to pests and diseases did not have significant impact on the national economy. Now bananas are being commercially grown in many areas, with bank loans and research back-up as indispensable for the success of these enterprises.

The average per plant yield is around 12–14 kg, which is about one-half that of major banana-producing countries. The paper suggests improving plant yield through clonal selection, introduction of exotic varieties and lines, and the manipulation of production practices. Serious diseases like Panama and Sigatoka and damage by the banana beetle have been observed in many plantations. For there to be successful commercial banana production, all the local banana varieties and lines must be screened to find their susceptibility and tolerances to serious pests and diseases, and then to develop a package of improved production practices for different agro-ecological regions of Bangladesh.

Dr. Hossain is Head and Mr. Ahmed is Senior Scientific Officer, Horticulture Division, BARI; and Mr. Islam is Senior Scientific Officer, BARC.

Research and Development of High Yielding and Nutritionally Rich Sweet Potatoes and Aroids

M. A. MANNAN AND ASIT KUMAR SARKER
Bangladesh Agricultural Research Institute

During the past three years, more than 100 cultivars of sweet potatoes from Bangladesh and abroad have been collected and evaluated in a joint research project of the Bangladesh Agricultural Research Institute and the Bangladesh Agricultural University. Five cultivars have been selected on the basis of their yields, keeping quality, and nutrient content. These give about four times higher yields than the local cultivars. They possess moderate to very high quantities of vitamin A.

About 150 cultivars of different species and genus of aroids have been collected. The Mukhi Kachu and Pani Kachu (both *Colocasia)* are under thorough study. It is hoped that high yielding cultivar of these two groups will soon be available.

Biochemical studies of these cultivars are being conducted. The final selections will be made on the basis of growers' yields and the nutrient contents.

Mr. Mannan and Mr. Sarker are Principal Scientific Officers (Root Crops), BARI.

Collection and Evaluation of Spices in Bangladesh

M. MAFIZUL HOQUE AND N. U. AHMED
Bangladesh Agricultural Research Institute

Spices and herbs are essential commodities of the culinary art in Bangladesh and most other countries of the world. They are valued for their medicinal properties and for contributing flavour and aroma to the otherwise insipid food.

Twenty-six spice crops are grown commercially or may be introduced into this country. Fourteen spices are in large scale production: chilli, onion, garlic, turmeric, ginger, bayleaf, coriander, fennel, anise, dill, fenugreek, black cumin, spearmint and sweet basil. Three other spice crops— black pepper, cinnamon and lemon grass— recently have been successfully introduced. The following spices and herbs are likely to be introduced: cardamon, clove, cumin, caraway, nutmeg, allspice, cassia, vanilla and peppermint.

Systematic research on spices started in Bangladesh in 1980. A country-wide survey gave a general picture of the production, marketing and use of these crops. Chilli, onion, garlic, turmeric, ginger and coriander were identified as the major spice crops and given research emphasis.

This is the status of the germplasm collections of the spice crops: chilli (hot)–99, onion (exotic)–31, garlic–24, turmeric–83, ginger–33, and coriander–8. These are being screened, classified and evaluated at the Spices Research Centre of BARI. The information gained through this organized experimentation will be a good source of technological information for increased spices production.

Mr. Hoque is Principal Scientific Officer, Vegetable Section, and Mr. Ahmed is Senior Scientific Officer, Horticulture Division, BARI.

Potentials and Prospects of Citrus

A. M. ABDULLAH, ABUL BASHAR AND ABDUL HOQUE
Bangladesh Agricultural Research Institute

The genus citrus comprises about 160 species which are divided into four horticultural groups: mandarin, orange, pomelo, and lime and lemon. The climate of Bangladesh is not congenial for mandarin and sweet oranges but it is quite suitable for the other two groups. Pomelo, lime and lemon are grown all over the country while mandarin cultivation is restricted to parts of Sylhet and the Chittagong Hill Tracts. These fruits are grown both in homesteads and commercial gardens. The top-most research priority is to develop high yielding and good quality pomelo, lime and lemon varieties by evaluating the local germplasm and exotic cultivars. There should be an intensive search to find mandarin and sweet orange varieties adaptable to Bangladeshi conditions.

Mr. Abdullah and Mr. Bashar are Principal Scientific Officers (Citrus) and Mr. Hoque is Senior Scientific Officer, Citrus and Vegetable Seed Research Centre, BARI.

Recent Developments of New Vegetables

M. A. RAZZAQUE, M. A. RASHID AND M. SALEH AHMED
Bangladesh Agricultural Research Institute

The Citrus and Vegetable Seed Research Centre was initiated by the Bangladesh Agricultural Research Institute and the Government of Japan to diversify Bangladesh's vegetable production by developing high yielding and disease resistant varieties which produce seeds locally. Another important objective is to devise improved seed production technologies. There has been intensive study in the 1980s on radish, cabbage, saishin, kuroba, kangkong, and watermelon.

A new radish variety, Tasaki San Mula-1, has been released. It produces seeds under field conditions, and has better root quality than that of the Red Bombay or other popular Japanese hybrid varieties.

Some new leafy vegetables of Southeast Asian origin have been successfully introduced. Three new lines have been developed: China Sak of saishin,

Bati Sak of kuroba, and Gima Kalmi of kangkong. All these varieties have been approved by the National Seed Board.

A new cabbage line has been developed from the F 67-1 maternal line of the Yoshin group. Unlike other cabbage cultivars, this has the potential to produce seed under farmers' conditions. It is awaiting national release.

Mr. Razzaque is Principal Scientific Officer (Citrus and Vegetables) and Head, Mr. Rashid is Senior Scientific Officer, and Mr. Ahmed is Scientific Officer, Citrus and Vegetable Seed Research Centre, BARI.

Black Pepper: A Promising Spice Crop

A. QUASEM, NAZIMUDDIN AHMED AND M. A. SHAKUR
Bangladesh Agricultural Research Institute

Black pepper cuttings were obtained from Malaysia and Sri Lanka in 1962 and planted at the horticultural research stations at Jaintiapur and Hathazari. They were trailed on jungle plants as well as on mango and jackfruit. Some of the vines started bearing from the third year but most took longer. Vine selection for growth and bearing habit started from the beginning of the research. Selected vines have been multiplied and their performances recorded. They have an annual yield range of 5 to 10 kg/vine. This is dependent on the bearing surface; otherwise the vines are similar in growing and bearing habits and in their tolerance to pests and diseases. These vines are to be released by the National Seed Board as a new black pepper cultivar for Bangladesh.

Dr. Quasem is Principal Scientific Officer, Regional Agricultural Research Station/Hathazari; Mr. Ahmed is Principal Scientific Officer, Jaintiapur Citrus Research Centre/Sylhet; and Mr. Shakur is Senior Scientific Officer, Regional Agricultural Research Station/Hathazari, BARI.

Performance of Local Papaya Lines

N. N. SHAHA AND AL-AMIN
Bangladesh Agricultural Research Institute

Five local papaya lines have been collected from different growing centres— one each from Barisal, Chittagong and Jessore, and two from Rajshahi. The Rajshahis are known locally by the colour of their flesh at maturity as Rajshahi Red and Rajshahi Yellow.

The five lines were planted in 1981–82 at the BARI horticultural research station at Rajshahi. Their yields were poor compared to that of many papaya-growing countries. However, Rajshahi Red was the top yielder of the five lines. It is very sweet and has a very attractive red flesh when ripe. This

can be recommended as a standard cultivar in the country provided seed production can be assured either through controlled pollination or proper isolation.

Mr. Shaha is Principal Scientific Officer (Fruit), and Mr. Al-Amin is Scientific Officer (Kazla Farm, Rajshahi), Fruit Section, Horticulture Division, BARI.

Performance of Tomatoes in Bangladesh

M. MAFIZUL HOQUE, M. MOZAMMEL HOQUE, A. R. CHOWDHURY, R. A. BEGUM AND M. A. J. BHUYAN
Bangladesh Agricultural Research Institute

The 101 accessions acquired in 1982 brought the total tomato germplasm collection to 310. The lines have been evaluated from time to time for yield, earliness, fruit characters, taste and disease incidence. These varieties have been provisionally recommended: Oxheart, L-7, and San-marzano in 1976; World Champion, Roma VF and Homestead-24 in 1978; and Money Maker and Pusha Early Dwarf in 1980. Although San-marzano and Roma VF are still the best, promising varieties such as C1-143-0-10-3, C1-1131 F_2-213, Monoprecos, SSD-29 and No. 8248 have been selected in recent advanced yield trials.

Experiments have shown the possibility of extending the growing period of tomatoes up to the dry summer with varieties like Hope-1 and Master-2. Encouraging results have been obtained in recent investigations with two heat-tolerant lines, No. 111 (a selection of C1-1d-0-1) and No. 367 (a selection of C1-143-0-10-3), that gave good yields up to early July, which is well within the wet summer.

A total of 31 crosses have been made to evolve better tomato varieties, concentrating on improving the wilt and virus resistance. Only one existing line, No. 108, has been found to be very promising for wilt resistance.

Mr. M. Mafizul Hoque is Principal Scientific Officer, Mr. M. Mozammel Hoque is Senior Scientific Officer, and R. A. Begum is Senior Scientific Officer (On Deputation), Vegetable Section, Horticulture Division; Mr. Chowdhury is Principal Scientific Officer (Vegetable), Citrus and Vegetable Seed Research Centre; and [illegible] is Senior Scientific Officer, Mango Research Project (Kallyanpur Farm), all of BARI.

Some Technological Aspects of the Commercial Production of Bananas

MD. AZIZUL HAQUE
Bangladesh Agricultural University

A study at the Bangladesh Agricultural University indicated that a gross income of Tk. 60,000 may be obtained with an investment of Tk. 16,000 for one acre of Amritasagar bananas. The experiment from 1978 to 1983 showed

that the planting time for commercial production should be limited to two periods: September to October and February to March, with the former preferred. Water suckers were not inferior as planting material to the sword suckers in relation to yield and quality. Sword suckers of the Amritasagar variety, aged 3–4 months, produced a crop in 10½ to 12 months. Flood irrigations three to five times between November and April were good enough at the BAU. Intercropping with winter vegetables, mustard and pulses was beneficial in keeping plots free of weeds and in making the soil loose and well aerated. Uniform suckers used from the ratoon crop reduced the crop period from 11 to 18 months down to 11 to 13 months. Clump planting was totally unsuitable for any normal crop as the plants were tall, weak, and produced small bunches. The tops of the plants moved toward more light due to phototropism, so the inflorescence fell on the side to which the plant inclined.

Dr. Haque is Associate Professor, Department of Horticulture, and Principal Investigator, Production Technology of Bananas, at BAU.

Part V
Forest Research

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KEYNOTE PAPER

Forest Research Objectives, Programmes and Priorities

M. OMAR ALI

Director
Forest Research Institute

INTRODUCTION

Bangladesh is one of the world's most densely populated countries. The population is increasing about 3% annually. As a result, there is great pressure to use forest land for agricultural and related purposes even though the country's forest resource is extremely limited. Only 9.2% of the land area is scientifically managed. However, about 20% of the land is capable of producing forest crops. This includes 1.8 million acres of Unclassed State Forests (USF) in the Chittagong Hill Tracts, 1.25 million acres of new land formation in the coastal belt, and 650,000 acres of village groves, denuded hills, marginal wasteland, roadsides, railways and embankments.

The forests are unevenly distributed. The central and northern districts, where the population growth is expected to be greatest, have the least forest resources. (Figure 1.) There is an acute shortage of fuelwood, so the wood resource of these areas must be rapidly increased through community forestry development programmes.

The hill forest in the east is low yielding and heterogenous. Only about 40 of the over 400 species growing there are commercially important. The others are not fully utilized because they are not available in sufficient quantities or are naturally not durable. They often are left as residue which may be as high as 40% of the total extracted volume of the forest. A loss of this magnitude cannot be justified. The forest management plan calls for clear felling and then replanting with selected, desirable timber species to convert the area into high yielding plantation forest.

Seventy-seven percent of the USF land is suitable for only forestry and specialized horticultural crops. The shifting cultivation of the tribal people has rapidly depleted the tree cover resulting in deterioration of soil fertility, accelerated soil erosion, and heavy siltation of Kaptai Lake. There needs to be an aggressive agro-forestry programme to settle the tribal population to permanent agriculture and specialized horticulture and thus bring the USF land to productive use.

The tidal forest accounts for nearly 50% of the total productive forest, but it is low yielding. This can be improved through better management and harvesting practices.

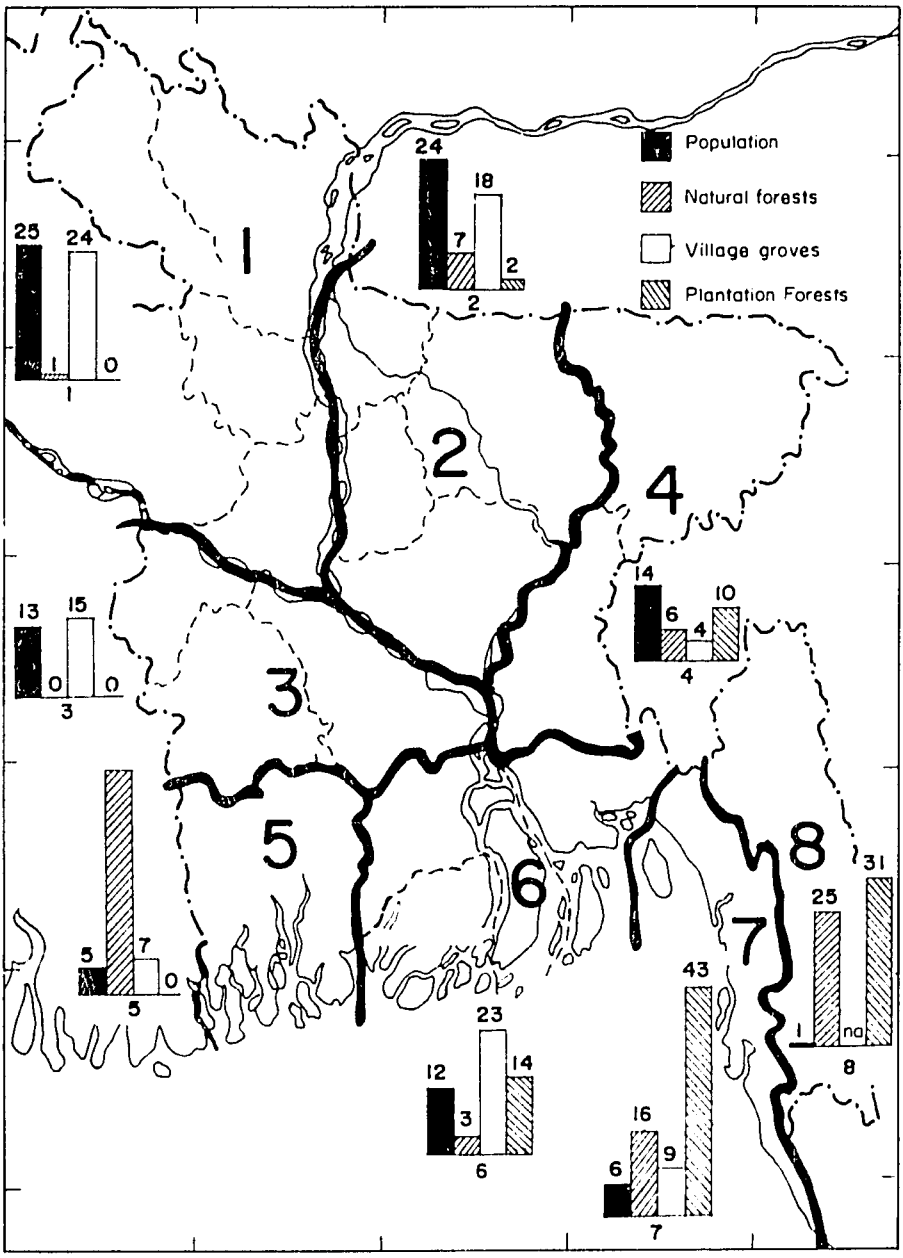

Figure 1. The regions of Bangladesh with the highest population have the least forest resources as illustrated in these bar charts indicating the percentages of population and forest resources.

The village groves are very important in supplementing the timber and fuelwood needs of the country, supplying about 85% of the national requirements. However, the rate of removal is two to three times the annual increment which means the village forest resource is likely to disappear unless immediate remedial measures are taken.

The demand for timber and fuelwood in the year 2000 is projected to be 115 million cubic feet (cft) of timber and 310 million cft of fuelwood at the current levels of consumption. (Figures 2 and 3.) This compares with the maximum probable supply of only 55 million cft of timber and 125 million cft of fuelwood. This leaves a deficit of 60 million cft of timber and 185 million cft fuelwood, over 90% of which will be needed in the central, northern and western parts of the country.

To overcome this gap, the productivity of the existing forests must be increased several fold. This calls for intensified forestry development programmes and goal-oriented forest research efforts.

FORESTRY SECTOR OBJECTIVES AND STRATEGIES

The extremely low level of exploitation of government managed forests and the rapid depletion of homestead tree cover demands that the forestry sector priorities of the Second Five Year Plan, and consequently the forest research programmes, need reorientation to meet the future demands for wood, wood products, and fuelwood.

The country's forest resource is limited yet there is increasing pressure to use forest land for agricultural purposes due to the rapid population growth, and the increasing demand for timber and fuelwood. These requirements, coupled with the social values of protection, conservation and recreational uses of forests have led to the development of five forest sector objectives and ten main forest sector strategies. These are expected to be valid to the year 2000 and possibly beyond.

Forest Sector Objectives

1. To maximize the production from existing growing stock of the forests.
2. To develop as quickly as possible the forest resources in the government forests and the private homesteads.
3. To provide protection against cyclones, tidal bores, and soil erosion.
4. To contribute to the national food production goal.
5. To provide outdoor recreation.

Forestry Sector Priorities

1. Acceleration of the cutting of the high forests in the hills.
2. Raising the plantations, afforestation and reforestation.
3. Replenishment of the homestead tree and bamboo wealth.
4. Introduction of agro-forestry practices and of forestry for rural community development.
5. Reduction of waste at all stages of production.
6. Preference of panel products to solid timber.

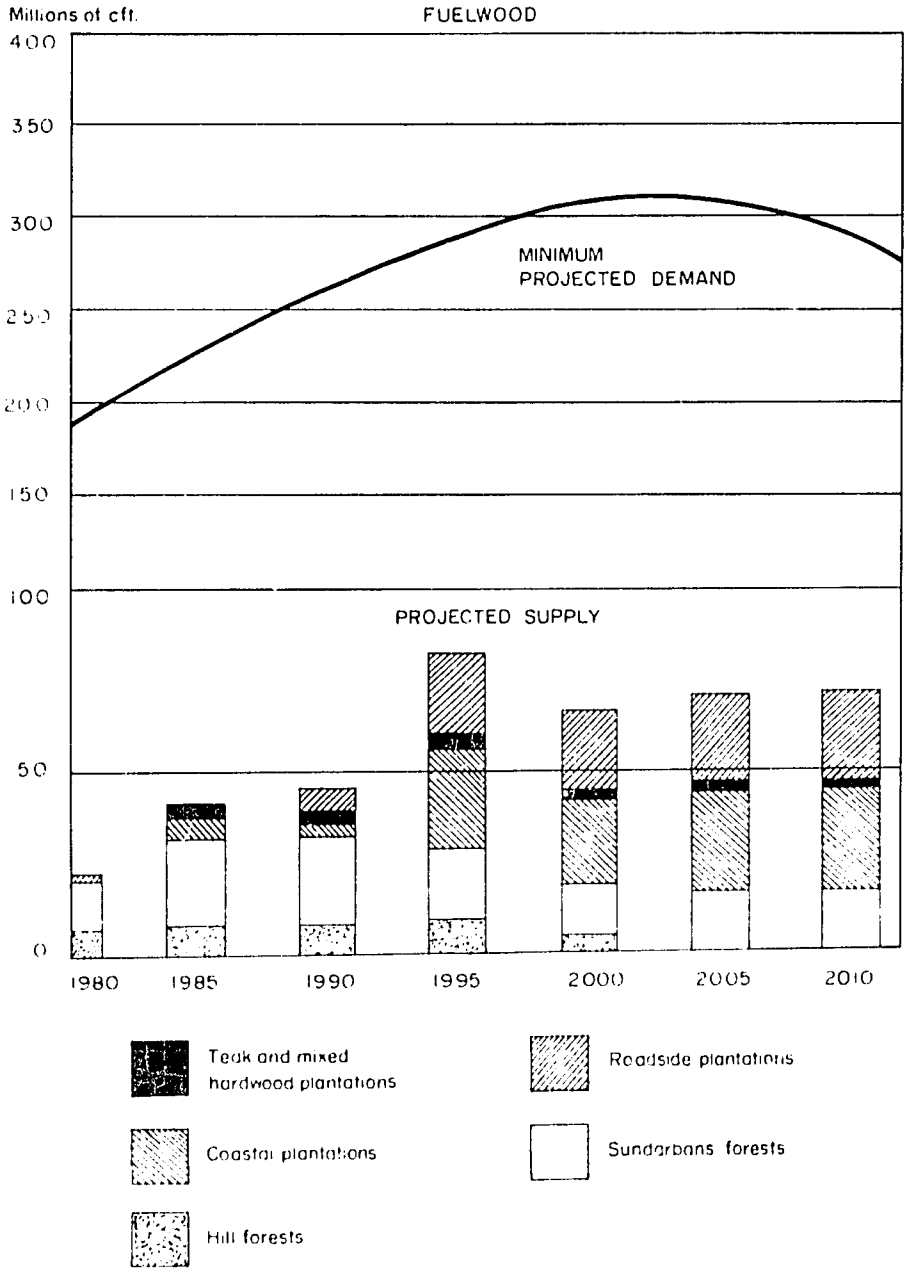

Figure 2. During the 1980s the huge gap between supply of fuelwood in Bangladesh and the demand is being filled by overcutting the village groves. Since this overcutting cannot continue, ways must be found to produce new fast-growing exotic woodlots and plantations.

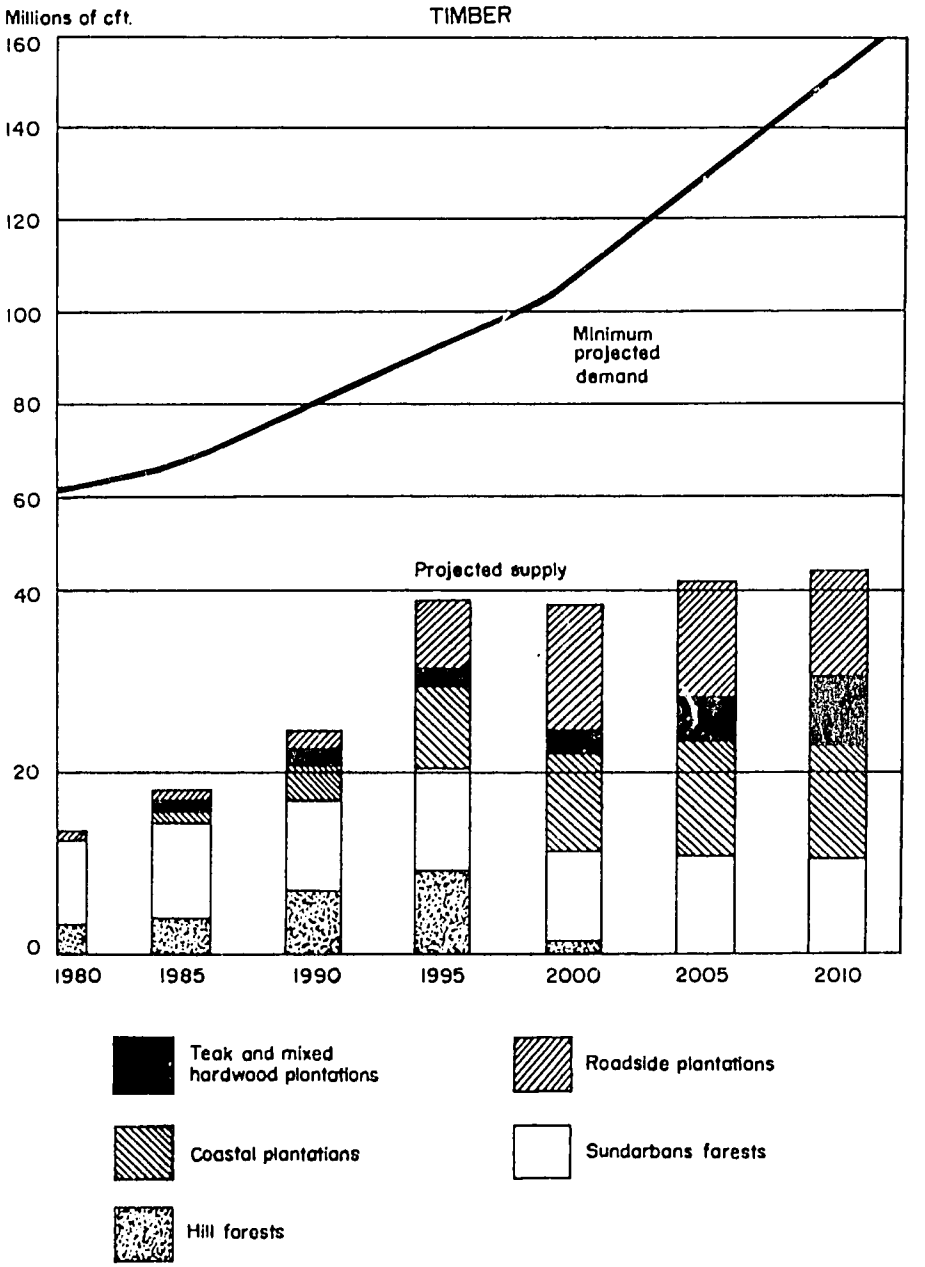

Figure 3. The overcutting of village groves and the illicit felling of government forests are two ways Bangladesh is filling the gap between supply and demand for timber (sawn wood, pulpwood, plywood and poles). New initiatives are required to overcome this problem, such as planting fast-growing exotic and indigenous species.

7. Strengthen wildlife management and develop outdoor recreation facilities.

8. Make optimum use of existing industrial capacity.

9. Training of personnel and reorganization of the forest services.

10. Undertaking goal-oriented research activities.

To overcome the critical shortage of timber and fuelwood supplies, the future forestry sector priorities must include:

1. The establishment of fast growing, coppicing tree species in plantations and community development schemes to provide fuelwood and roundwood.

2. Modification of the present plantation schemes to include a greater proportion of fast-growing species; careful site selection and matching species more exactly to sites; and planting compartments/blocks of single species rather than with mixed species.

3. Better use and less waste of existing timber resources.

FOREST RESEARCH OBJECTIVES

The objectives of forest research are formulated on the basis of the forestry sector strategies and priorities:

1. Increase the forest productivity in the reforestation programmes through the selection, evaluation and pilot plantation testing of fast growing and high yielding species, and provenance to meet the industrial and domestic requirements including fuelwood.

2. Develop nursery and plantation techniques to service large plantations.

3. Develop high quality seed resources for the large scale plantation programmes.

4. Prepare inventory and yield data for plantations and natural forests.

5. Select and evaluate species for afforestation of coastal embankments and new land formations in the coastal areas.

6. Improve the productivity of wood values and optimize other forest and site values in the tidal forests.

7. Investigate and promote control methods to minimize pest and disease destruction of forest crops and of forest products already in use.

8. Promote the multiple use of land in villages and homesteads and other public holdings to improve living conditions by using better agro-forest crops for producing forage, fuel, minor forest products, food and timber products.

9. Prepare management controls to minimize soil erosion in the USF and to protect the Kaptai watershed.

10. Improve knowledge of the costs and effects of various management practices of logging.

11. Develop wildlife management programmes.

12. Develop management techniques for the heavily cutover Sal Forests.

13. Collect, evaluate and disseminate statistics on forest products, industry and trade, and provide economic evaluation and forest industry information and forest management projects.

14. Provide information on the properties and uses of Bangladesh timbers.

15. Develop new products and processes and find out the optimum and most economical uses of forest products, including wood waste, with special reference to timber and non-timber species which are now unused. Prepare an end-use classification by species groups of the less used timbers.

These research objectives are the basis of the forest research programmes. The key programme areas are:

Programme 1: National forest seed centre
Objective: To set up a unified national system for the procurement, handling, storage, testing and distribution of the highest possible quality of tree seed and the seeds of other crops to be grown on forest land, such as bamboo, cane, oil palm, and ground cover legumes.

Programme 2: Exotic species introduction and testing
Objective: To co-ordinate and carry out the establishment of exotic tree species in Bangladesh, particularly very fast growing species for fuelwood, pulpwood, poles, sawn timber and other uses, through the mechanism of successive elimination, provenance, growth trials, and pilot plantations.

Programme 3: Tree breeding and seed orchard
Objectives: Establishment of seed orchards of improved varieties of trees to ensure the supply of quality seeds; to develop techniques for the breeding and improvement of forest tree species; and to conserve gene resources of forest species.

Programme 4: Nursery techniques
Objectives: To improve and modernize the existing nursery techniques for production of better and healthier seedlings to be used as planting material, especially for large scale afforestation programmes; and to standardize forest nursery practices in Bangladesh.

Programme 5: Land classification and evaluation, soil conservation, and watershed management
Objectives: To establish a system of forest land evaluation and classification; to develop simple methods of determining land capability and suitability for forestry purposes; and to conserve the natural fertility of forest soils and develop means for catchment protection and watershed-management.

Programme 6: Plantation growth and yield
Objectives: To have an inventory of the forest wealth of Bangladesh; to develop mensurational methods and formats for the compilation of data; and to study the growth rate of plantation and commercially-important species of managed forests in order to develop techniques for yield prediction and fixation of economic rotation on the basis of site quality.

Programme 7: Mangrove research
Objectives: To increase the productivity of mangrove forests through better

management and plantation techniques; to protect and expand the ecosystem to maintain its role in protection of the people and property in the coastal areas from cyclones and tidal bores; and to stabilize and improve for agricultural purposes the new lands appearing in the Bay of Bengal.

Programme 8: Bamboo research
Objectives: To prepare field identification guides; to determine the growth rates and yields of various species of village and forest bamboos; to develop techniques of mass propagation to improve growth and productivity; to safeguard against pests; and to develop sound management techniques for sustained yield.

Programme 9: Development of models for agro-forestry and forestry for community development
Objectives: To develop agro-forestry models by selecting the most suitable multiple-use trees, food crops and livestock, and study the production potential of the proposed systems; to assess the input requirements, management techniques and economic advantages of the systems; to evaluate the effect of all farming systems on soil fertility and conservation; and to demonstrate their feasibility and desirability in the context of the current practices leading to the settlement of shifting cultivators and improvement of their socio-economic conditions.

Programme 10: Plantation techniques and management
Objectives: To meet the growing demand for fuelwood and timber by improving the management systems for increasing the sustained yield of the natural forests; and to develop and standardize techniques for raising successful stands of high quality of both indigenous and exotic fast growing species to enrich and improve the potential timber resources of the country.

Programme 11: Forest protection
Objectives: To develop techniques to minimize the damage caused by pathogenic micro-organisms and insect pests to tree crops and forest products already in use; and to develop preventive and control measures against forest fires.

Programme 12: Non-timber economic crops
Objectives: To quantify and promote the growth of non-timber economic crops and products for optimum use in related industries, such as cane, patipata, medicinal plants, honey bees, and edible mushrooms.

Programme 13: Fuelwood plantations
Objectives: To raise fuelwood/energy plantations by the introduction of fast growing species to meet the increasing demand for domestic fuelwood on short coppice rotations (4–5 years) in rural areas, especially in the north, central and western districts.

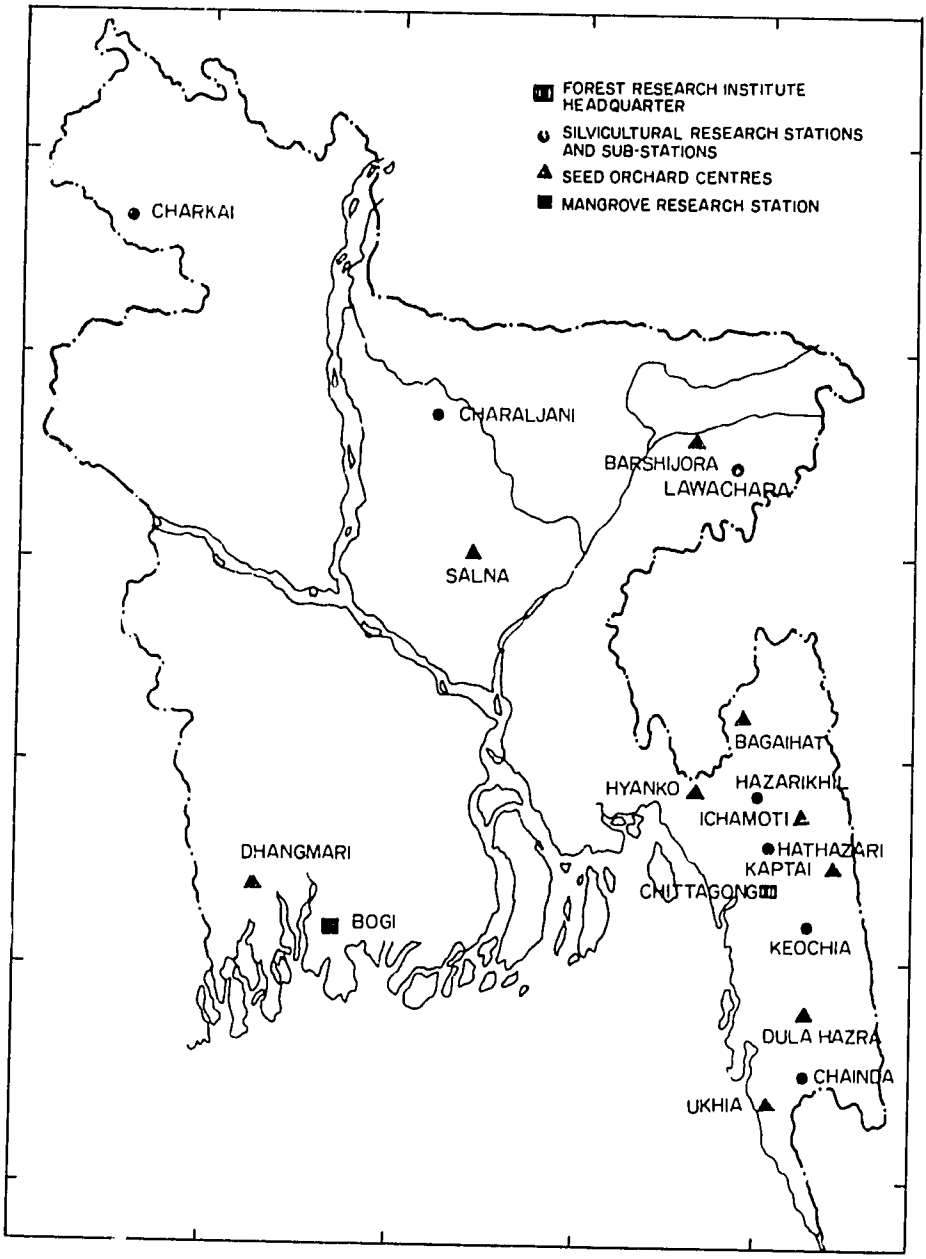

Figure 4. The facilities of the Forest Research Institute are located in the primary forestry areas of Bangladesh.

Programme 14: Plants, wood, fungi and insect archive collections
Objectives: To develop a National Reference Collection of plants, wood, and forest fungi and insects; to compile forest flora and fauna of Bangladesh; and to identify wood samples and plant specimens.

Programme 15: Wildlife management and conservation
Objectives: To develop a sound ecological and demographic basis for the management of the wildlife of Bangladesh as an economic enterprise; and to create facilities for human recreation and education, and for the protection of endangered wildlife species.

Programme 16: Sawmilling and woodworking
Objective: To reduce waste during primary conversion to ensure rational use of the sawn timber.

Programme 17: Composite wood products
Objective: To popularize composite wood products in order to minimize the use of solid woods and to improve the economic status of the plywood and particleboard industries.

Programme 18: Seasoning and mechanical properties
Objectives: To avoid seasoning defects and consequent timber losses, and to improve the quality of wooden furniture and other wood products; and to provide basic information on the physical and mechanical properties of timber.

Programme 19: Pulp and paper products
Objectives: To develop improved methods of using fibrous raw materials for pulp and fibreboard manufacture; and to find uses for lesser known species to augment raw material supplies in these industries.

Programme 20: Preservation of wood, bamboo and related materials used in rural housing
Objectives: To develop economic and effective methods of preservative treatments to increase the outdoor service life of wood, bamboo and thatching materials; and to popularize the use of the treated materials in rural housing.

Programme 21: Chemistry of forest products
Objective: To conduct studies of forest products to develop industrial chemicals from these locally available raw materials to avoid future importations.

Programme 22: Development of products and processes
Objective: To use smaller wood pieces and waste wood to develop special products which will promote small-scale industries.

Programme 23: End-use classification of lesser-used timber species
Objectives: To classify the lesser-known and –used species according to major end-use categories to ensure their optimum utilization.

Programme 24: Extension and training in forest product utilization
Objectives: To provide technical service to wood-based industries to motivate them to adopt improved methods and technologies; and to train industry personnel for higher productivity and quality control.

Each programme area has a number of research projects. These will be carried out in the 16 research divisions of the Forest Research Institute and its field stations and sub-stations. (Figure 4.)

The main objective of forestry research is to maximize the productivity of the forest land to meet the requirements of the people in general and the rural poor in particular, and to optimize the use of woods through improved processes and the application of the latest technology.

The FRI has the role to support the Government's plans of maintaining the current supply levels of wood and wood products, and also in looking ahead to increasing them in the future. Accordingly, the Institute has to keep abreast of both the present and future problems and must develop plans to quickly solve them.

The role of the local community for forestry development, the concept of multiple use of forest land, and the role of fast growing exotic tree species in plantation forestry have new importance in the reorientation of forest research priorities.

To introduce fast growing, exotic tree species, priority must be given to technology transfer for the adaptation of silviculture and management principles, especially for the species of eucalyptus, acacia, casuarina and pinus. For the indigenous wood and bamboo resources, greater emphasis needs to be placed on using lesser-known species, reducing waste, and extending the service life of materials by 4 to 5 times through preservative treatments. This will reduce the pressure on the rapidly diminishing natural forests and village groves.

Much of the applied research in forest management and silviculture must take place in the field. The Silvicultural Research Stations and Seed Orchard Centres of the FRI are located in various ecological zones to take greater responsibility in this task.

In the coming years, priority programme areas will receive new thrusts so as to fulfill the national objectives and commitments to bring goods and services to the doorsteps of the rural population to improve their quality of life.

Forestry Planning for Development

AFZALUR RAHMAN
Forest Research Institute

This paper attempts to analyse the major socio-economic considerations for an integrated approach to planning for the forestry sector in Bangladesh. It is argued that the proper intersectoral and intrasectoral co-ordination is indispensable for the systematic development of the sector.

Forestry planning is done both at national and regional levels in Bangladesh. At the national level some national targets are set up and financial allocations made regarding plantation and other related development activities. The regional planning is based on subdividing the whole forest area for proper management and administration. Working plans covering a period of 10 to 20 years are prepared for each region. They contain detailed management prescriptions for each region. The regional plans are reviewed so the management prescriptions of different regions are in harmony with each other and with the objectives of the national plan. However, the regional targets are not fully established on an analytical basis that would reflect the true behaviour of the economy.

The paper describes the main steps and basic principles of forestry planning in order to develop an operational basis for preparing a comprehensive land use plan for the sector. Given the resources and the view to make planning an efficient means of mobilizing forestry resources for the economic emancipation of the suffering people, it will be highly rewarding to weave financial, economic, organizational, social, technical and physical problems into a more rational perspective for making a maximum contribution to the society.

Mr. Rahman is a Senior Research Officer, FRI.

Entomo-Fauna in the Forests of Bangladesh Part I. Pieridae

MD. WAHED BAKSHA AND J. H. CHOUDHURY
Forest Research Institute

An extensive survey of the forest entomo-fauna of Bangladesh was made over a period of more than a decade. The objective was to establish a national reference collection. Insect specimens were collected, preserved, studied and identified along with the available literature. The paper deals only with members of the family Pieridae. A total of 17 species representing 9 genera have been identified: four for the genus *Delias*, three for both *Catopsilia* and

Appias, two for *Eurema* and one for each of *Leptosia*, *Anapheis*, *Valeria*, *Cepora* and *Pieris*. A key has been prepared for separating the available sub-families, genera and species. The host range and distribution of the species in different forests of Bangladesh also have been incorporated.

Mr. Baksha is Senior Research Officer (Entomology) and Dr. Choudhury is Divisional Officer, Forest Protection Service, of FRI.

Solar Drying Technique for Seasoning of Wood in Bangladesh

M. A. SATTAR
Forest Research Institute

The applicability of using the solar drying technique for seasoning timber in Bangladesh was studied in kilns developed at the Forest Research Institute. A series of charges were dried employing solar drying as well as the conventional air drying and steamheated kiln drying methods. Twenty different end-use timber species of various dimensions were used for this study. Solar and air drying were continued for three years during the entire drying seasons.

The results of the study suggest that the climatic conditions of the country are suitable for operating solar kilns throughout the year. Even refractory timbers of higher dimensions can be dried during the rainy season to a desired lower moisture content level. The quality of the solar dried timber is found to be superior to both air and kiln dried timber. The results further reveal that solar drying is significantly more efficient than air drying; it is undoubtedly a simpler and less expensive drying technique than kiln drying. For the effective utilization of Bangladeshi timber, it has been recommended that the solar drying technique be employed in wood-based industries for seasoning timber prior to use.

Mr. Sattar is a Divisional Officer, Seasoning and Timber Physics Division, FRI.

Distribution Factor Affecting the Performance of Water Repellents Applied to Wood

M. A. RAZZAQUE
Forest Research Institute

Resin/wax water repellents applied to wood under a vacuum through one open transverse end gives significant resistance to water entry into wood. A steep effectiveness gradient is formed inward from the treated end. This is probably due (1) to a decrease in the available flow paths with increasing distance penetrated, and (2) to the surface enrichment resulting from the solvent evaporation. A higher treatment level affords better water repellent

effectiveness. Rigorous simulated weathering causes a significant loss of the water repellency. However, the loss is confined to the exposed end and to the first few weathering cycles. A very high degree of effectiveness remains in the exposed end even after this loss, though this part becomes less water repellent than some parts of the interior. The between–cycles difference in the means of water absorption of the end specimens remains statistically insignificant. The between–species ariation depends to a large extent on the nature of the flow paths and the natural dimensional stability of the species. Loss of performance is associated with the deleterious effect of the water repellent deposit brought about by the breakdown of the specimens.

The exposed end specimens have physically more water repellents than the interior ones before simulated weathering cycles. This trend is maintained even after prolonged weathering, though with less steep gradients. The apparent incompatibility of the amount of water repellents present and the degree of effectiveness provided in the exposed end specimens after exposure show that it is not only the quantity of deposits at a particular location which determines the degree of water repellency afforded within that zone, but also the distribution at the cellular or subcellular level and/or the quality of bond between the deposit and cell wall. This lends support to the view that a chemical or hydrogen bond is much more effective than van der Waal's forces in water repellent-treated wood.

Dr. Razzaque is a Divisional Officer, Forest Chemistry Division, FRI.

Vegetative Propagation of Bamboos Through Branch Cutting

MD. SERAJUDDOULA
Forest Research Institute

Vegetative propagation of three commercially-important species of bamboo–*Bambusa vulgaris*, *Bambusa polymorpha*, and *Melocanna baccifera*–was carried out through branch cuttings in a semi-controlled propagator at 80° to 92°F temperature and a relative humidity of 93 to 95%. The branch cuttings were collected and planted in (1) the dry season of mid-October to mid-February and (2) the wet season of mid-March to mid-August. The *vulgaris* and *polymorpha* produced roots but the *baccifera* did not. The period of rooting and the time of collection differed significantly. *Vulgaris* rooted earlier than *polymorpha*, and the cuttings collected and planted in the wet season rooted earlier than those of the dry season. The rooted branch cuttings were planted in 12 × 18 inches polybags for rhizome development. These were produced within one year, averaging 93% development for the two species. About 96% of the *vulgaris* plantings took root and about 81% of the *polymorpha*. The rhizomes developed earlier in the *vulgaris* than in the *polymorpha*.

Mr. Serajuddoula is a Senior Research Officer, Silviculture Genetics Division, FRI.

Bamboo Blight with Particular Reference to *Acremonium strictum*

MOHAMMAD ABDUR RAHMAN AND SUDIBBYA KANTI KHISHA

Forest Research Institute

Bamboo produces new culms from buds on subterranean rhizomes during the monsoon rains generally from early June until late August. Expansion of the culms continues until October. Blight first significantly affects the culms in August, with disease having its maximum effect by mid-November. Subsequently, there is little or no increase in the number of blighted new culms.

Diagnostic symptoms of the blight are described. *Coniothyrium fuckelii* Sacc. and *Acremonium strictum* W. Gams (Herb.I.M.I.278366) were the two most commonly isolated fungi from blighted bamboos.

Artificial inoculation tests have established that *A. strictum* is pathogenic on new branches which developed from ground layered culm cuttings of *Bambusa balcooa* Roxb. at the Forest Research Institute campus and on naturally grown culm of *B. vulgaris* Scrad at Nawapara, Chittagong. The pathogenic ability of the fungus is discussed.

Dr. Rahman is a Divisional Officer, FRI.

Preliminary Studies on the Growth and Yield of *Albizia Moluccana* Miq

SOMESWAR DAS

Forest Research Institute

Albizia moluccana Miq is a fast-growing exotic tree species. It was introduced in Bangladesh as a shade tree in the tea gardens. The species went to the forest plantation in 1974. Its growth and yield had not been studied in Bangladesh, so a preliminary study of its growth and yield has been made in the Sylhet Forest Division.

The age–diameter, age–height, diameter–height relationships and the growth pattern have been worked out. At the end of the eighth year, the MAI was 443 cuft/A/year (31 m^3/ha/year). A proportion of the stems were eliminated naturally with age in the plantations where no thinning was carried out. The total merchantable timber yield at the end of the eighth year, excluding the branch wood and brush wood (2" top dia), was 3548 cuft/A, whereas data collected from the FRI campus showed the MAI to be 475 cuft/A/year (33 m^3/ha/year). The total yield for the same site was 4787 cuft at

the end of the tenth growing season. The growth curves indicate the rotation between 12 and 15 years should be fixed after a thorough study of the growth pattern and the consideration of other technical factors.

Mr. Das is Conservator of Forests and Chief Research Officer (Forest Management), FRI.

Role of Winged, Dewinged and Exposed Garjan (*Dipterocarpus turbinatus Gaertn.* F.) Seeds on Germination-Sowing in Three Different Directions

MD. ASHRAFUL HAQUE

Forest Research Institute

This experiment was conducted to observe the percentage of germination of winged, dewinged and exposed Garjan *(Dipterocarpus turbinatus Gaertn.* F.) seeds by sowing in three different directions. This was done in polythene bags and the nursery bed. The maximum germination of 89.00 to 94.00% was observed in the dewinged seeds with an upward direction of sowing. Dewinged seeds with a slanting direction had a similar germination of 87.00 to 92.50%. Very poor germination of 16.50 to 39.75% was observed in inverted direction. In the cases of upward and slanting directions, germination is initiated within 2 to 6 days, whereas it takes 11.25 to 16.50 days in the inverted direction. There is no significant variation in germination between winged and dewinged seeds.

Mr. Haque is Senior Research Officer, FRI.

Taxonomy and a Critical Review on the Biology and Control of Loranthaceae With Particular Reference to Bangladesh

MD. KHAIRUL ALAM

Forest Research Institute

Loranthaceae includes semiparasitic plants which are popularly known as mistletoe. They cause more world-wide economic loss than any other family of parasitic angiosperms. In Bangladesh mistletoe attacks a large number of hosts namely gamar *(Gmelina arborea* Roxb.), teak *(Tectona grandis* Linn.), sal *(Shorea robusta* Gaertn.f.), mango *(Mangifera indica* Linn.), jackfruit *(Artocarpus heterophyllus* Lamk.). and many ornamental plants. Fifteen species under 7 genera of Loranthaceae have been recorded in Bangladesh, and their taxonomy and distribution discussed, and the important hosts are listed. The paper presents a critical review of the biology and control of mistletoe to draw attention to the need for adequate studies which can lead to appropriate control of the parasites in the Bangladeshi context.

Mr. Alam is Senior Research Officer, FRI.

A Preliminary Observation on the Incidence of Top Shoot Borer on Cane

MD. WAHED BAKSHA
Forest Research Institute

A preliminary survey was conducted on the incidence of top shoot borer, *Ommatolapus haemorrhoidalis* (Wiedemann) (Curculionidae: Coleoptera) on four cultivars of cane grown in the Cane Arboretum of the Forest Research Institute, Chittagong, from July to September 1983. The cultivars were Jai or Jali bet *(Calamus guruba* Ham.); Karak, Kiring or Baro bet *(Calamus viminalis* Willd. var. *fasciculata* Becc.); Bhudum bet *(Calamus latifolius* Roxb.); and Golak or Golla bet *(Demonorops jenkinsianus* Mart.). The data were recorded during the peak infestation period under natural field conditions. The results revealed that Jali bet, with a 64.26% shoot infestation, was highly susceptible to the attack of the pest whereas other cultivars showed no sign of shoot infestation. Therefore, the pest was found to be species-specific as far as the available cane cultivars were concerned.

Mr. Baksha is Senior Research Officer (Entomology), Forest Protection Division, FRI.

Part VI
Livestock Research

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KEYNOTE PAPER

Livestock Research in Bangladesh

MIRZA ABDUL JALIL

Director
Livestock Services
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The important impact of livestock resources on the subsistence agricultural economy of rural Bangladesh deserves to be mentioned afresh.

The most important function of domestic animals is providing the draft power necessary for ploughing, road and farm transport, threshing, and crushing. This represents fron. 20 to 40% of the total cost of producing major crops in Bangladesh.

Another valuable contribution of livestock to crop production is the dung produced by cattle and buffaloes. About half of the dung is used as fertilizer, either left directly on the fields or spread after collection. This is equivalent to 200,000 tons of chemical fertilizer or about Tk. 900 million at the present subsidized retail prices. Or to describe it another way, this amount of cow dung annually generates some 600,000 tons of rice valued at about Tk. 4 million at the current official procurement price.

Using the present prevailing retail price for firewood as a standard, the cow dung used for fuel represents between Tk. 5 and 7 million per year. This 6.7 to 7 million tons of dung is approximately equivalent to 1.5 million tons of crude oil.

This data describes only one aspect of the livestock resource of Bangladesh. The following are ten other economic measures of the importance of livestock to our national life:

- Livestock contributes 8.7% to the gross domestic product (GDP) of Bangladesh.
- The country earns a significant amount of foreign exchange by exporting hides and skins, bones, wool and other an mal products.
- Animals are an important source of protein for the physical and mental development of children.
- Livestock provides employment to the otherwise jobless youth; 14% of the people depend on livestock for their livelihood.
- Twenty percent of the inputs for crop production are from animals draft power.
- Ninety-nine percent of the land is ploughed by bullock power.
- An additional 2.58 million tons of food grains are produced every year by using 1.770 million tons of cow dung as manure.
- The country saves about Tk. 225,450 million per year of foreign exchange by using 835 million tons of cow dung as fuel.
- Livestock provides cash income to the rural people.

- Livestock provides transportation in the rural areas.

Obviously, there is considerable potential for increasing the livestock sector's contribution to the GDP. Research to improve animal health and production can pave the way to attaining the goal. Improved animal health care will bring immediate gains (1) in the efficiency of fodder utilization by animals, (2) reducing the mortality rate caused by diseases, (3) increasing the weight and strength of draft animals, (4) higher milk yields, and (5) increasing the number and weight of animals available for slaughter for meat and by-product. Research in animal production is essential for developing a wide variety of fodder and methods of using various non-traditional feeds, agricultural waste, and by-products. Upgrading the genetic quality of the national cattle herd will gradually increase the average weight and strength, the relative feed utilization effeciency, and the overall yields of milk, meat and eggs.

Quickly implementing these measures will provent a further decline in the per capita supply of animal protein for consumers. It may even achieve a modest increase in the availability of goat and poultry meat and of eggs.

The livestock sector has not been among the priority areas of governmental development efforts or of financial resource allocations. Most of the reasons for this will continue to hold for some time. Relatively unsatisfactory performances of livestock planners have not been able to develop a reasonable, well-conceived, convincingly justified programme. These problems need to be overcome very soon for real improvements to be achieved.

There is practically no livestock research infrastructure in the country. From the research point of view, livestock is a neglected sector. Some piecemeal studies are being conducted by the Bangladesh Agricultutal University, Bangladesh Council for Scientific and Industrial Research, Livestock Research Institute, Central Cattle Breeding Station at Savar, and some voluntry agencies. Most of these are ad hoc projects which are not properly followed up. The research often deals only with intensive livestock breeding and cultivation and related matters of interest primarily to researchers,but not to the 6 million farmers owning cattle,goats and poultry.

The Department of Livestock Services has these research organizations:

- Dhaka: The Veterinary Research Institute and the Livestock Research Institute, both in Mohakhali, have the following sections:
  - — Goat tissue vaccine production.
  - — Ranikhet disease vaccine production.
  - — Fowl pox vaccine production.
  - — Duck plague vaccine production.
  - — Foot-and-mouth disease vaccine production.
  - — Single dose rabies vaccine (Pirbright) production.
  - — Disease investigation.
  - — Parasitic disease investigation.
  - — Animal nutritution.
  - — Artificial insemination.

— Central Cattle Breeding Station, Savar.
— Central Poultry Breeding Station, Savar.

- Comilla: The Animal Husbandry Research Institute has these activities:
  — Investigation into the epidemiology of parastic disease.
  — Bacterial disease (investigation and vaccine production).
  — Animal breeding and genetics.
- Field disease investigation laboratories now operating at Manikganj, Feni, Joypurhat, Barisal, Gaibandha, Sylhet and Mymenshingh.
- Central Diesease Investigation Laboratory under construction at Dhaka.
- Sheep Development Farm, Sonagazi, Noakhali.

There is a lack of co-ordination among these institutions in the absence of a research focus on the problems of the village livestock economy as it is now and is likely to exist for years to come.

The National Agricultural Research Plan formulated in 1979 was the first attempt made at a comprehensive framework for all agriculturtal research conducted in the country under the auspices of the Bangladesh Agricultural Research Council.This plan clearly points out that the livestock sector did not receive the attention appropriate to its importance. It is one of the weakest sectors of Bangladesh agriculture. No visible improvement could be made because of the lack of urgency and poor investment in research. The livestock breeds are poor and unhealthy. Animal nutrition is insufficient and treatments of diseases are inadequate. There are so many problems of livestock improvement that a thorough assessment is needed to determine the research priorities.

Rightly, the 1979 Plan identified four priority areas for research on ruminant livestock:

1. Nutrition improvement as a general approach to increasing animal productivity and better use of available animal resources.
2. Improve the reproductive efficiency of available breeds which now are limited by poor nutrition, diseases and inadequate genetics and management.
3. Improve livestock management systems, ranging from production to marketing to consumption of livestock products.
4. Animal disease control.

AREAS FOR LIVESTOCK RESEARCH

The following have been suggested as probable research topics for Bangladesh, but studies are not limited to these.

Animal health

1. Survey of infectious diseases, including tuberculosis, among different species of animals and fowls in various regions of Bangladesh.
2. Survey of the parasitic worm burden of cattle, sheep, goats and fowls.

3. Etiological and epidemiological studies of duck plague.

4. Epidemiological studies of foot-and-mouth disease and typification of the viruses found in various outbreaks.

5. Studies in the antigenicity of various isolates of the genus *Pasteurella* for use in vaccine production.

6. Studies on the epidemiology of rabies.

7. Studies on the pathogenicity and antigenicity of various field strains of Newcastle disease virus.

8. Serological survey of pullorum disease.

9. Serological survey of brucellosis in cattle and buffaloes.

10. Research survey on calf mortality in different areas with reference to (a) incidence, (b) etiology, (c) environmental management factors, and (d) significance and financial quantification.

11. Bionomics of the snail host *Fasciola* spp.

12. Studies on rota virus incidence in animals in Bangladesh.

13. Studies on salmonella infections in different species of animals in Bangladesh with particular reference to its public health significance.

14. Studies on the epidemiological features of newly emerging animal infections in the country with the development of biologics of their control.

15. Incidence and etiological studies of mastitis in cattle and goats.

16. Studies into the nutritional and metabolic diseases of ruminants and fowls.

17. Studies on colibacillosis of calves and goats.

18. Studies on the treatment and prevention of rumpsore of cattle.

19. Studies on listeriosis in animals.

20. Studies on so-called viral diarrhoea of goats.

21. Survey on the prevalence of *Cornurus coebralis* in goats.

22. Studies on mucosal disease in ruminants.

23. Studies on the epidemiology of nasal schistosomiasis in cattle.

24. Studies on the prevalence of Mareks' disease in poultry.

25. Survey of the incidence and epidemiological pattern of clostridial infection in Bangladesh.

Public health

This research concerns diseases of animals that can affect humans. Four of the topics in the Animal Health section above belong to this group, i.e., items 12, 13, 15 and 17. Other infectious diseases of livestock included are anthrax and parasitism such as cysticeroosis.

Livestock production

1. Field studies and evaluations of upgrading cattle through artificial insemination and bull distribution under various ecological conditions.

2. Characterization of the types and genetic composition of cattle in various regions.

3. Selection and development of the indigenious cattle as breeding or upgrading stock for increased draft power and milk production.

4. Characterization of the Bangladesh Black Bengal as a goat breed.
5. Histological studies of the skin and hide of the Bangladesh Black Bengal goat.
6. Selection and breed improvement of the Bangladesh Black Bengal goat by inbred lines.
7. Village level evaluation of the cockerel exchange programme in terms of breed preference for upgrading and productivity.
8. Studies in different regions on replacing cows with buffaloes for draft power.
9. Selection and upgrading of local water buffaloes for draft power and milk.
10. Search for an all-seasons or legume forage that can be grown on roadsides, bunds and pond banks for cattle feeding, and then its genetic improvement.
11. Agronomic studies of *Leucaena leucocaphala* under different ecological conditions.
12. Studies on the feedstuff values of non-conventional, indigenious crops and plants for improved nutrition of cattle and poultry.
13. Feasibility studies on the industrial processing of local agricultural residues which are of potential importance as feedstuffs, e.g., cottonseed oil meal and mango seed oil meal.
14. Designing and testing the adaptability of improved harnesses, yokes and ploughes for draft animals.
15. Studies on conserving and using of sugarcane tops as fodder for draft and milk animals in the villages.
16. Survey on unconventional sources of feedstuffs.
17. Study on the critical amount of by-pass protein required for ruminants as supplement in the feeding of ammonia urea-treated straw.
18. Studies on the use of bio-gas effluent as a feed supplement.
19. Studies on the different hybrid combinations and deshi cattle to determine the interactions between environmental stress under different ecological and farming conditions in Bangladesh.

Production economics

1. Studies on the popularization of bio-gas technology with reference to the economics of plant construction, e.g., individual ownership compared with a communal undertaking.
2. Studies of the socio-economic patterns of livestock farming in different districts of the country.
3. Surveys of the marketing networks of livestock and livestock products.
4. Studies on the economics of scale in integrated farm operations with particular reference to the size of the livestock component.
5. Economic analysis and quantification of the losses in livestock and poultry for morbidity and mortality due to diseases and parasites.

The financial resources available for agricultural research are extremely limited in Bangladesh. In the mid-1970s this amounted to only 0.023% of the

total gross value of agricultural production. This may be compared to 0.044% in Pakistan, 0.097% in India, 0.207% in Thailand, 0.275% in the Philippines, 1.34% in Japan, and 1.73% in the United States. Of course, the share available for livestock research is much smaller. We cannot afford to spread these meager resources too thinly over too many projects, a magnificant number of which may never bring results applicable to the country's livestock economy. Our efforts must be concentrated on a few selected projects which are of the highest priority and promise the quickest pay-offs in the smallholder farm economy.

It has been pointed out that research efforts have been limited, scattered and uncoordinated due to the absence of a national livestock research agency. There has been no institutional arrangement for continuity of livestock research to backstop the national development programme.

Given this situation, the creation of the Bangladesh Livestock Research Institute deserves prompt consideration for maintaining livestock research that will satisfy the technological needs of the national livestock development programme. It is of great satisfaction that the World Bank has come up with proposals to assist the establishment of the Bangladesh Livestock Research Institute at the Central Cattle Breeding Station at Savar. The project documents are prepared and under active consideration by the Government. It is hoped that with the establishment of this Institute the constraints limiting livestock research will be removed.

ABSTRACTS

Studies on Poultry Breeding in Bangladesh

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The objective of poultry breeders today is to develop birds that will produce the most eggs and meat at the least cost and in the shortest possible time.

Chicken

The three breeds of Single Comb White Leghorns, Rhode Island Reds and White Plymouth Rocks account for more than 80% of the world's chicken production. The paper describes the trends in poultry breeding objectives, and the sophisticated technology devoted to this scientific work. It is argued that Bangladesh and other developing countries should take advantage of the existing technology in advanced countries and apply it to their own situations.

The priority of the BAU poultry development programme is to improve production in the villages where most poultry is reared. Attempts were made in the 1960s to upgrade the local (deshi) stock by crossing with exotic breeds under farm conditions. The results of this upgrading were encouraging but the process was lengthy, time-consuming and expensive.

In 1976 a method of short-term upgrading of poultry was adapted from a scheme developed by FAO. The method is to cross local hens with hybrid exotic cocks, after first removing the local cocks from the villages. An evaluation of this process after three years indicated that the annual production of eggs increased 35%, from 30 to 70 eggs per hen during the project period. Egg size increased significantly, the offspring were heavier, the mortality rates reduced substantially, and villagers' poultry income increased by about 50% annually. The paper reports on the details of this process as well as plans being made to improve upon the system. The goal is to produce a variety/cross/hybrid chicken suitable to Bangladesh's tropical conditions which produces eggs at a satisfactory rate with expected gain in body weight, has disease resistance and heat tolerance, and a uniform colour (prefer red).

Ducks

There are no high yielding breeds of ducks native to Bangladesh. Farmers depend on Khaki Campbells and Indian Runners for egg production in the limited market. These ducks, perfectly a cross with local ducks, can be profitably raised in riverine and low-lying areas where they can collect most of their feed from the water. Muscovy or Pekin are the best breeds for meat production, but a cross with local or Khaki Campbell may be more suitable for Bangladesh. A short-term upgrading programme as described for chickens is needed to improve duck production.

Other poultry

A flock of Japanese quail may be imported to see if they thrive under Bangladesh conditions. This is a popular game bird in many countries. Turkeys do not thrive in the hot, humid climate of Bangladesh. Heavier breeds of pigeon, such as White Kings, can be bred profitably for squab production.

The paper recommends (1) collaboration with poultry breeders in advanced countries to secure replacement and breeder stocks, (2) adding a poultry geneticist to the BAU faculty and quite a few to the Livestock Department, (3) inserting a large amount of capital in a poultry breeding programme, and (4) developing a programme of technology transfer to Bangladesh from advanced countries so poultry development can advance at a high rate.

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Poultry Nutrition Research in Bangladesh

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Q. M. E. HUQUE

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Giving proper nutrition to poultry is necessary to produce the meat and eggs needed for the people of Bangladesh, especially those persons who are inadequately fed. Feed costs are 60 to 65% of the total expense of producing poultry meat and eggs, so nutrition constitutes a major part of poultry production.

There is no systematic research on poultry nutrition in this country. The sporadic nutrition studies have been inadequate and of little application to poultry production. Constraints to this research include the (1) competition between humans and poultry for cereal grains, (2) poor exploitation of available feed resources, particularly unconventional feed, (3) lack of facilities for systematic research, (4) lack of standard mixed feeds in the country, (5) absence of feeding standards for Bangladesh, (6) lack of sound governmental policy for the import and export of poultry feed ingredients, (7) lack of poultry extension activities, (8) lack of co-ordination between researchers and the extension organization, (9) lack of input supplies to the farmers, (10) lack of honour, dignity and remuneration for the researchers, and (11) lack of funds and the multitude of administrative complexities. There should be increased poultry research which is aimed at greatly expanding the production of meat and eggs so as to reduce the country's shortage of animal protein.

Dr. Bulbul and Mr. Chowdhury are members of the Department of Poultry Science, BAU; Dr. Huque is a Senior Scientific Officer, BARC.

Studies of the Diseases of Cattle

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There is no accurate and reliable information on the prevalance and distribution of diseases of cattle in Bangladesh. It appears that some of the major infectious diseases have existed since the introduction of cattle into the Indo — Bangladesh region by Central and West Asian migrants and invaders. The earliest report on the prevalence of foot-and-mouth disease, rinderpest, and septicaemic pasteurellosis in the cattle of Bengal (now Bangladesh) was by Dr. K. Palmer in 1867.

During the twelve years since independence, studies on the diseases of cattle have not been promising. Anthrax, septicaemic pasteurellosis, black-leg, mastitis, tuberculosis, colibacillosis, Johne's disease, tetanus and listeriosis were recorded earlier.

Brucellosis, caused by *Brucella abortus*, was found to be more prevalent in organized dairy farms than in rural areas. In rural areas, pockets of brucellosis exist in certain herds and villages; under such situations the rate of infection may reach 63%. Abortion due to brucellosis is not yet documented in Bangladesh, but the brucella infection is present in 60 to 80% of the aborted cows, retained placenta and genital complications. The presence of sub-clinical mastitis due to brucellosis poses a great concern to human health in this country. Milkers, dairy workers and agricultural workers were found to be serologically positive to brucellosis.

Bovine tuberculosis is present in both farm and rural cattle. A higher prevalence was observed in crossbreed cattle than in indigenous breeds. Mastitis due to *Streptococcus agalactiae*, *Staphylococcus aureus*, *Streptococcus uberis* and *Corynebacterium pyogenes*, respectively, was more prevalent than *Staphyloccus albus*, *Streptococcus dysgalactiae*, *Streptococcus uberis*, *Streptococcus pyogenes*, *Pseudomonas* sp., *Brucella* sp., and *Coli-form* sp.

Septicaemic pasteurellosis caused by *Pasteurella multocida* is found in coastal and low-lying areas, especially in the summer and monsoon months between April and September.

Salmonella blockley from the intestinal contents and feces of cattle has been recorded for the first time in Bangladesh. Its pathogenic role has not yet been ascertained.

Viral diseases like foot-and-mouth, rinderpest, rabies, virus diarrhoea, and papillomatosis are present in the country. Blue tongue, infectious bovine rhinotracheitis and para-influenza 3 have been detected for the first time. Ephemeral fever is fairly common in this country. An outbreak of it during April–May 1980 was reported in Pabna.

Clinical parasitosis is not frequently encountered in the veterinary clinics, but sub-clinical and low levels of parasitic infestation cause a chronic and debilitating effect on the working efficiency and productivity of animals in the country. Humpsore caused by *Stephanofilaria assamensis* is a major problem

yet the mode of transmission of this disease is not known. It is reported that bacteria produce local suppuration and breakage of the superficial layer of the skin. Fly vectors then bring microfilariae to the area to cause humpsore. Schistosomiasis is widely prevalent. Nasal schistosomiasis is endemic in coastal regions. Sub-clinical nasal schistosomiasis with no clinical symptoms has been recorded for the first time in the cattle of Bangladesh.

Reproductive diseases are associated with tritrichomonas infection. Moneiziasis can cause a clinical disease in calves and produce symptoms of profuse watery diarrhoea, dehydration, and decreases of plasma and total blood volume. In clinically-affected cattle, *Balantidium coli* can cause marked emaciation, weakness and anorexia, and the rate of infection may go up to 13.6%. Gastrointestinal parasitosis is a problem of magnitude. It is reported that it is not a problem of significance in the cattle raised in native pasture land in Pabna.

Diseases due to toxic materials include those of *Abrus pricatorius*, the aqueous extract of seed which can produce a severe systemic reaction and often is used by the cobblers to maliciously kill animals. Rakta-karabi leaves *(Nerium indicum)* are often encountered as a source of poisoning. A large death loss occurred in 1980 in Pabna and Faridpur districts due to nitrate poisoning caused by eating shyma and pahari kalmi. Cyanide poisoning also has been observed in cattle that have eaten tishi plants.

The most common systemic diseases were tympanitis, pharyngeal paralysis, yoke-gall, myiasis due to *Crysomyia bezziana*, lameness, congenital tendon contraction, umbilical hernia, congenital artesia ani, ascitis due to pyometra, bovine posthitis due to *Corynebacterium* sp. and *E. coli*. Infertility poses a great problem for cattle raisers in this country. Repeat-breeding syndrome is very often associated with infertile cows. *Corynebacterium pyogenes*, *Streptococcus pyogenes* and *Staphylococcus aureus* were isolated from the genetial tract of repeat-breeding cows.

Detailed epidemiological studies are necessary to get a comprehensive picture of the diseases of cattle in Bangladesh.

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Parasitic Diseases of Cattle in Bangladesh

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Investigation on the parasitic diseases of cattle revealed the presence of the following species of parasites in Bangladesh: *Pseudasthemia* sp., *Fasciola gigantica*, *Paramphistomum explanatum*, *Gastrothylax crumenifer*, *Cotylophoron cotylophorum*, *Paramphistomum scoliocoelium*, *Homalogaster paloniae*, *Eurytrema coelomaticum*, *Schistosoma nasalis*, *Schistosoma indicum*, *Schistosoma spindalis*, *Moniezia expansa*, *Neoascaris vitulorum*,

Strongyloides papillosus, Oesophagostomum radiatum, Oesophagostomum venulosum, Agriostomum vryburgi, Bunostomum bovis, Bunostomum phlebotomum, Trichostrongylus axei, Osterlagia trifurcate, Cooperia punctata, Cooperia pectinata, Haemonchus contortus, Haemonchus similis, Mecistocirrus digitatus, Dictyocaulus viviparus, Thelazia rhodesi, Gongylenoma ingluvicola, Setaria digitata, Stephanofilaria assamensis, Capillaria bilobata, Babesia bigemina, Theileria mutans, Trypanosoma evansi, Eimeria zurnii, Eimeria bovis, Trichomonas foetus, and *Tabanas* sp., *Demodex bovis, Boophilus microphilus, Haemophysalis bispinosa, Rhipicephalus sanguineus, Hyalemma anatolicum, Damalina bovis, Haematopinus eurysternus, Haematopinus tuberculatus, Haematopinus quadripertusus, Stomoxys calcitrans, Musca conducens, Chrysomea bezziana,* and *Collitroge americana.*

The general incidence of infestations by these parasites is very high. Most animals are infested with more than one species of parasite. The parasitic load is always high among calves. The calves and young adults of exotic and crossbred animals are severely affected due to heavy infestations of parasites. Mortality of calves and morbidity in adults is estimated to cause very high economic losses.

Most mortality among calves is caused by *Neoascaris vitulorum, Haemonchus* spp., *Mecistocirrus digitatus, Bunostomum* spp., *Fasciola gigantica* and *Moniezia expansa.* Morbidity in terms of reduced meat and milk production and the loss of draft power is also significantly high due to the chronic and insidious effects of parasites like *Stephanofilaria assamensis, Schistosoma* spp., hydatid cysts, immature paramphistomes, *Boophilus microplus, Haemaphysalis bispinosa* and *Haematopinus* spp.

In view of the significant economic losses caused by these parasites, there is emphasis on the prevention and control of the most harmful parasitic diseases. The available information is insufficient, thus further studies are suggested on the epidemiology, bionomics, seasonal variations, and population dynamics of the concerned parasites. Such research may help develop effective prevention and control of parasitic diseases and thus lead the way to successful cattle development programmes.

Dr. Rahman is Associate Professor, Department of Parasitology, BAU.

Incidence of Parasitic Diseases in Bangladesh

A. K. NAZIRUDDIN AHMED

Livestock Research Institute

The Directorate of Livestock Services began the investigation of the incidence of the parasitic diseases of domesticated animals in 1956. Approximately 90% of the cattle, buffaloes, sheep and goats of Bangladesh are infected with helminth parasites in varying degrees. The parasitic load in the rumen is 69%, abomasum is 80%, intestine is 84%, and liver is 51%. The

hydatid cyst in ruminants is found in 21% of cattle and 32% of buffaloes. The incidence of schistosomiasis in cattle is 83%, in buffaloes is 88%, in sheep is 18%, and in goats is 21%. Protozoan parasites and arthroped vectors of diseases also have been recorded.

Mr. Ahmed is Principal Scientific Officer, Endo Parasites Section, LRI.

Incidence and Control of Ranikhet (Newcastle) Disease in Bangladesh

MD. MANSURUL AMIN
Bangladesh Agricultural University

The paper reports on the incidence of Ranikhet (Newcastle) disease (RD) in Bangladesh and its severity. It was found that 67.4% of 660 respiratory and brain tissue samples collected from chickens in 150 localities covering 19 districts of Bangladesh yielded the Newcastle Disease Virus (NDV).

The paper presents a brief review of the part played by NDV in mixed infections in chickens involving other respiratory pathogens and management factors, although no research on this subject has been conducted in Bangladesh.

The paper discusses the current immunization procedure followed in Bangladesh to protect chickens against RD and the comparative efficacy of some vaccinal strains. A research study determined that maternal antibodies transferred to chicks from vaccinated parents did not exert any depressive effect on immune response following primary (initial) vaccination against NDV. The period from 1 to 12 days of age is an optimum time for primary vaccination of chicks with lentogenic strain of NDV.

A programme of vaccination using eye-drop administration of live B1 vaccines during the first two weeks of hatch followed by intra-muscular inoculation of live vaccines of Komarov (K) strain at 10-12 weeks of age produced sufficient immunity in chickens against RD virus to protect birds for at least seven months.

The estimated total annual requirement of RD vaccines needed for baby chicks, growing and adult birds is approximately 160 million doses. In contrast to this, the Directorate of Livestock Services produces 70 million doses. The pilot project for development, production and studies on poultry vaccines at the Bangladesh Agricultural University can produce an additional 10 million doses of such vaccines. Thus, only 50% of the total annual requirement of RD vaccines is currently available in Bangladesh. It appears that almost 70% of total population of chickens remains unprotected against RD.

The paper describes the difficulties for effective control measures including the absence of a Disease Control Act, type of rearing of birds in Bangladesh, sanitation and hygiene, inadequency of the cold-chain system which is recommended to be ideal, maintenance of the requisite stability of vaccine titre at the time of use (particularly at the remote areas), vaccination at the

stipulated intervals, and the information lacking in these subjects that is needed to identify the future trends and areas of research in the Bangladesh context.

Dr. Amin is Associate Professor, Department of Microbiology and Hygiene, BAU.

Enzyme-linked Immunosorbent Assay (ELISA) And Its Application in Diagnostic Virology

MUZAHED UDDIN AHMED
Bangladesh Agricultural University
JOHN ASKAA
National Institutes of Health

The use of enzyme-linked immunosorbent assay (ELISA) has been introduced in the detection and quantitation of antigen and antibodies. Varieties of ELISA systems are being applied in the diagnosis of bacterial, viral and parasitic infections.

In this review some important features of the double antibody sandwich ELISA system are discussed with particular reference to those elements which are most important in determining the specificity, sensitivity, safety, inexpensiveness and relative ease of performance of the assay.

Dr. Ahmed is in the Department of Medicine, BAU, and Dr. Askaa in the Laboratory of Infectious Diseases, National Institute of Allergy and Infectious Diseases, National Institutes of Health, USA.

Utilization of Straw Treated with Urea As Source of Ammonia in Bangladesh

M. SAADULLAH AND MOZAMMEL HAQUE
Bangladesh Agricultural University

This paper reviews some of the experimental information available from the DANIDA/BAU straw treatment project. It focuses attention on methods of treating the straw with urea and the production responses from the treated-straw based ration with calves and dairy cattle. It is concluded that the urea treatment of straw increases the nitrogen content of straw and the digestibility of nutrients, and promotes better growth responses with calves and increased milk production in dairy cows. The spraying of fibrous materials with urea and then storing is technologically simple and easy for small farmers to follow. The practice should be tried by farmers in their village homesteads with improvements and alterations in the method made according to their needs.

The authors are in the Department of General Animal Science, BAU, of which Dr. Saadullah is Associate Professor and Head.

Performance of Cattle Fed Paddy Straw Treated with Animal Urine as a Source of Ammonia

MOZAMMEL HAQUE

Bangladesh Agricultural University

CHARLES DAVIS

DANIDA

M. SAADULLAH

Bangladesh Agricultural University

FRANDS DOLBERG

DANIDA

Twelve local male calves were used to test the health aspects of using animal urine as a source of ammonia for treatment of straw. The trial lasted 105 days and showed no negative effects of using animal urine in this way. The performance of animals fed on urine-treated straw was not different from that observed on animals fed straw treated with urea as a source of ammonia. Both performed significantly better than the untreated control group.

Mr. Haque and Dr. Saadullah are in the Department of General Animal Science, BAU, and Mr. Davis and Mr. Dolberg are advisers, DANIDA projects in Bangladesh.

Study of the Cost of Producing Cross-Bred Broilers Up to 12 Weeks of Age

MD. MUJAFFAR HOSSAIN AND SHAFIUDDIN AHMED

Bangladesh Agricultural University

The experiment was conducted for 12 weeks on two groups of cross-bred chicks: Aseel × Australorp and Australorp × New Hampshire. They were fed a ration containing 23% protein. The average body weight gain per chick was 90.01 g in T1(Aseel × Australorp) and 92.89 g in T2 (Australorp × New Hampshire). Average mortality of each treatment was 15%. It was found that feed and chick costs are the two major expenditures in producing broilers. Feed cost was 53.99% and the chick cost was 23.29%. The average body weight at 12 weeks was 1.76 pounds for T1 and 1.68 pounds for T2. The cost of production per pound of broiler was Tk. 8.61 in T1 and Tk. 9.02 in T2.The feed conversion ratios were 3.36:1 and 2.71:1 in T1 and T2, respectively. It appears that broiler production can be profitable when they are sold at a market price of Tk. 12. However, it is suggested that the cost of producing

broilers may be reduced by genetic improvement in the growth and feed conversion rates by continuous selection and breeding, and keeping market and management factors constant and correct.

Mr. Hossain is Lecturer, Department of General Animal Science, and Dr. Ahmed is Associate Professor, Department of Poultry Science, BAU.

Part VII
Fisheries Research

KEYNOTE PAPER

Fisheries Research

A. Q. CHOWDHURY

Director of Fisheries
Ministry of Agriculture

INTRODUCTION

Fish are a source of animal protein, and fill a vital role in meeting the nutritional needs of the people of Bangladesh. Fish are the second most important staple in the diet, accounting for 80% of the intake of animal protein. Before World War II there was an abundant supply of fish and they were common for human consumption, but the need for fish culture or fisheries management did not occur. However, as time passed the population increased. There were several natural calamities that resulted in famine conditions due to the scarcity of rice. This encouraged planners to look for ways of augmenting agricultural production.

As a consequence of several agricultural and water development projects, there have been far reaching changes in the fish habitat. The construction of irrigation and flood control structures, and the use of inorganic fertilizers and pesticides with modern varieties of rice have had a cumulative effect on aquatic life. The rural people also encroached on fish habitats by using water to irrigate rice fields and converted waterways into agricultural land for crop production. These steps are detrimental to the fish life in both open and impounded waters.

As could be expected, these adverse conditions caused the fish production to decrease. At the same time, the demand for fish increased several times with the increase of population. The country now produces approximately 700,000 tons of fish whereas there is annual demand for nearly 1.1 million tons. It is encouraging to note that the authorities have recently recognized the need for increasing the production of fish in the country.

PROGRESS OF RESEARCH

Research undertaken in the past by the Directorate of Fisheries was restricted to the implementation of some development schemes such as (1) control of aquatic vegetation, (2) culture of prawn in fresh water, (3) paper mills' pollution, (4) fish parasites and diseases, (5) freshwater pink pearls, and (6) paddy rice with fish culture. There was no plan for guiding a purposeful research programme for the development of fish culture or the management of fisheries. This was also because qualified manpower and facilities for research work were not available. Late in the 1960s the Government organized research in a more co-ordinated manner, and the fisheries complex at Chandpur was established. This facility included the Freshwater Fisheries

Research Station, the Fisheries Technological Laboratory, and the Fisheries Training Institute.

The establishment of the new complex encouraged the consolidation of research work, but there still were not sufficient facilities and manpower for the appropriate development of the fisheries of the country. The fragmentary nature of the research did not provide the needed information. However, the development of the technique of induced breeding of carp at Chandpur has had a far reaching impact on aquaculture activities by way of the establishment of fish seed farms. In the late 1970s there was need for an Aquaculture Experiment Station which is being established on the campus of the Bangladesh Agricultural University at Mymensingh.

During this period big hatcheries have been or are in the process of being established for large scale production of fish fry and fingerlings, which are the main input of fish culture. The problems of fish culture and fisheries management are receiving more attention with the increased demand for fish and fish products. It is imperative there be a national plan for the development of fisheries so research and development can be directed toward achieving the target of fish production.

Recently the Government has taken several steps to co-ordinate and expand fisheries research. One of the major steps is the proposal to establish a National Institute of Fisheries Research which is necessary to execute a plan and programme that has autonomy and flexibility.

RESEARCH NEEDS

The supply of protein is inadequate to meet the requirements of our expanding population. The need is to increase the supply of cheap protein from underutilized fisheries resources, extend the fisheries boundary further from the coasts, develop the artisanal fisheries, mechanize the fishing fleet, and improve the fishing gear. The Government sets annual targets to rapidly increase fish production to compensate for the protein gap. However, expanding the fishing beyond an optimum limit may lead to catches that fall to uneconomic levels.

There are two distinct needs in the development of open water or capture fisheries that deserve the attention of research. First, it is necessary to know the potential stocks of fish that are capable of yielding the quantity required under the development programme. It is essential to have an evaluation of the fisheries resources and the degree to which the potential yield of fish and shellfish are being exploited. This data will indicate where future development programmes will be successful and where they will not, so are essential for planning. Other information also is needed to make the best use of the fisheries resources which are under exploitation and those approaching full exploitation or which are already overfished. One of the most important items of information needed is the amount of fishing that will provide maximum yield.

A second important role of capture fisheries research is to monitor the effects of the development projects. Fisheries are a renewable resource, so do

not often lend themselves to experimentation. A great deal can be learned about fisheries dynamics and planning the future development programmes by carefully monitoring the number of boats in a fishing fleet, the fishing methods, and the size of the catch.

The position of culture fisheries is different and is comparable to some extent with agriculture. As in capture fisheries, the limit for development is not bounded by the size of the natural fish stocks but depends on suitable areas for aquaculture, technical information on the local conditions which can be readily understood and used, and the amount of investment available. The objective of aquaculture research is to determine the suitable areas, the best culture systems that have been successful in other countries, and then to adapt these to the local conditions. A further step is to devise and develop new systems for cultured species and for wild indigenous species that might be brought under culture.

Aquaculture involving fish or shellfish culture in cages, net pens or ponds and molluscs in open waters requires the production or collection of juveniles and providing conditions for their fast growth with a minimum of mortalities. The research involves the rearing of the young, the study of food and environmental conditions required throughout their lives, and the development of systems that will provide these conditions. This requires experimentation on a pilot scale in the laboratory which leads to trials on a commercial scale. Aquaculture research also involves the control of diseases and predators.

Aquaculture development must bring suitable information on culture systems to those who are in a position to use it. This is followed by the continuous improvement of the existing systems. This information is communicated by both technical and non-technical manuals and reports, technical advice, and by demonstration farms which are operated on a commercial basis.

The research and its application always should be closely integrated by use of a two-way flow of information and experience between the research workers and the producers.

ROLE OF UNIVERSITIES IN FISHERIES RESEARCH

This discussion has pointed out that research undertaken by the Government will be applied and field-oriented to provide technical information for fisheries development and management.

The primary contribution of the universities will be to provide courses in fisheries to train biologists with a basic understanding of biology, ecology, statistics, and other branches of fisheries science. The universities involved in research should be specialized and develop a school concentrating in a particular field of fisheries research depending on the scope and facilities available. It cannot be said precisely what the universities should investigate. Experience in other countries is that fisheries research in the universities can be devoted to the more long-term, basic and background problems which have a secondary priority in the Government fisheries research programme.

Aquaculture Management Programme in Bangladesh

KAZI AZIZUL HAQUE

Directorate of Fisheries

The cultivable waters of Bangladesh include 336,000 acres of ponds, 40,000 acres of oxbow lakes, 7 million acres of paddy fields, and 15,530,866 acres of mangrove and tidal flats. The paper discusses the status of aquaculture in the inland and coastal waters. While 1.5 metric tons of fish have been produced from some well-cared ponds, the average production is still only about 75 kg/A/year. The highest production obtained in oxbow lakes is 168 kg/A/year with the average about 10 kg/A/year. Production of fish and shrimp from coastal water is also low, only about 125 to 200 kg/A/year.

The paper discusses the polyculture method adopted by pond culturists using the species *Catla catla, Labeo rohita, Cirrhinus mrigala* and *Labeo calbasu.* There is a recent trend of composite fish culture with the exotic species *Hypophthalmichthys molitrix, Ctenopharyngodon idella, Cyprinus carpio* and *Aristichthys nobililis.* Experimentation is underway for production of seed and rearing of catfish *Clarius batrachus.* Pilot operation of pen and cage culture is encouraging.

Important species for coastal aquaculture are *Penaeus monodon, P.indicus, P. semisulcatus, Metapenaeus brevicornis, M. monoceros, Macrobrachium rosenbergii, Lates calcarifer,* and *Mugil* Sp. While 'Bhericulture' is a traditional practice in the Khulna region, aquaculture is a relatively new practice in the Chittagong area. Coastal aquaculture is expanding fast. In 1979-80, the area under culture was about 65,000 acres while now it is more than 101,000 acres.

The problems and constraints of aquaculture in inland waters include (1) large scale dereliction of ponds, (2) general lack of appreciation, (3) multiple ownership of private ponds, (4) lack of effective demonstration farms, (5) lack of adequate organization, and (6) lack of finance. In coastal aquaculture, the main constraint is the lack of technical know-how. The acquisition of knowledge in pond layout, identification of fish and shrimp larvae, water control management, fertilization, and feeding have been stressed. Land use policies, investment needs, and inadequate facilities for ice, transport and cold-storage are other problems.

Giving encouragement to the private sector through physical and financial incentives is a strategy for the development of aquaculture. The paper describes facilities of training; the supply of inputs, especially fish seed; and the extension service offered by the Directorate of Fisheries. Twenty-eight carp hatcheries have been built to supply fish seed. Work on 67 more is progressing. Ninety-seven fish seed multiplication farms are distributing fry and fingerlings to pond culturists. The extension service has one fishery

officer aided by two field assistants in each upazila. They use the T and V method. Important aquaculture development projects of the Directorate of Fisheries rendering demonstration and extension services are: (1) oxbow lake fishery development, (2) Raipur Fish Hatchery Complex, (3) development of fish seed multiplication farms, (4) Fisheries Training and Extension Centre at Faridpur, (5) Demonstration Shrimp Farm at Satkhira, (6) fish and shrimp demonstration farms in coastal districts, (7) shrimp and fish culture at Chakaria Sundarban, (8) pilot pen and cage culture, (9) establishment of mini-hatcheries in rural areas,(10) rehabilitation of derelict tanks at Nimgachi, Nandigram and Dinajpur, (11) intensive fish culture in 500 village ponds, and (12) the pilot project for edible mussel culture at Cox's Bazar.

There is a growing awareness among the pond culturists. The responsibility of the researchers is to feed the people with the technical know-how they need for proper utilization of the fisheries resources.

Mr. Haque is Project Director, Aquaculture Development Project.

Study on Exotic Fishes in Bangladesh

A. K. ATAUR RAHMAN

Aquaculture Experiment Station

A list is provided of the fishes transplanted in Bangladesh for culture and other purposes. A short history of these introductions is appended as far as is available. There is a discussion of the principal biological characteristics and adaptability of the species to local environmental conditions and their advantages and disadvantages in aquaculture in respect of Chinese silver carp, grass carp, black carp, common carp and big-head carp as well as African cichlids of the genus *Tilapia*. To avoid any future complications, it is suggested that the biology and other parameters of the introduced species be studied in depth under controlled conditions before these are extensively used in the aquaculture programme of the country.

Mr. Rahman is Project Director, Aquaculture Experiment Station, Mymensingh.

Prawn Fisheries Research in Brackish Water

A. L. BHUIYAN

University of Chittagong

About 30 species of prawn have been identified in the waters of Bangladesh. As many as 23 are found in brackish water. Some species have migratory habits.

Of the brackish water prawns, Bagda *(Penaeus monodon)* and Galda *(Macrobrachium rosenbergii)* are important in the national economy as a

supply of fine food and for earning foreign exchange through exports.

In 1975–76, the seeds of *Penaeus monodon* were collected from the Karnaphuli estuary and reared in low saline water (S 2.0 to 7.4%) of the Coastal Defence Battery pond of the Bangladesh Navy. The seeds grew to as long as 246 mm in one year. People of the coastal areas of Chittagong and Khulna have now started to produce this prawn on a large scale.

The ablation method was followed to obtain seeds in the laboratory. Though the results were satisfactory, the project was terminated and this hatching of the eggs was stopped.

A study of the breeding and migratory biology of the Galda [giant prawn] was undertaken to produce seeds for distribution to prawn farmers. Eggs from berried females were collected from the Karnaphuli and Halda Rivers (S up to 5.0%) and hatched in the aquaria (S 12.0 to 15.0%) at the field station near Patenga Sea Beach of the Institute of Marine Sciences. The rearing technique of I to XI stages of zoea (larvae) has been developed for production of culturable seeds (juveniles) of this species. The larvae are reared to juveniles in 38 days then released in a small pond for growing to adulthood.

There has been limited investigation of the migration of the larvae of the *Macrobrachius rosenbergii* from the offshore spawning areas to the inshore nursery grounds. The broodstocks migrate for spawning at the start of the monsoon runoff, going from the river to the offshore (S 12.0 to 15.0%) where they start to release their eggs from pleopods. The hatched larvae float as plankters, moving randomly day after day toward the river mouth. They are moved as juveniles to the nursery grounds by the diurnal tidal currents where they feed, grow, develop and spread along the river from September to December in various salinities of up to 5.0%. The young and the adults also are found along the rivers and in those linked canals having tidal currents.

The paper reports the preliminary diagrams of the probable route of migration (salinity, berried females, larvae and juveniles). The methodology is described for the collection of seeds (juveniles and young) from nursery grounds for distribution to prawn farmers of neighbouring districts.

Field data suggests that berried females are most abundant from May to July; juveniles and larvae from June to August; and adults from August to November. The commercial harvesting of adults and juveniles is made with 'Behundi jal' and 'Peloin jal', respectively.

Additional investigation is recommeded to foster the production, development and distribution of seeds of those prawns of economic significance.

Dr. Bhuiyan is Professor, Institute of Marine Sciences, University of Chittagong.

Studies on the Culture of Fisheries Organisms Under Different Limnological Conditions

MD AMINUL ISLAM

Bangladesh Agricultural University

Bangladesh possesses extensive inland water resources. The total area of perennial waters is estimated at 1.6 million ha. An estimated 3.1 million ha of land remains under water for four to six months. This situation makes the water–land ratio of Bangladesh one of the highest in the world. The broad objectives of limnological studies are described in the paper.

Extensive research is needed to determine such things as the physico-chemical status of a particular habitat, its fertilizer requirements, and its suitability for fish culture. The paper describes the problems and constraints of limnological research, including physical facilities, lack of funds, and insufficient co-ordination among the scientists working in different research organizations. It also includes thirteen recommendations for the development of fisheries research in the country.

Dr. Islam is Head, Department of Fisheries Biology and Limnology, and Dean, Faculty of Fisheries, BAU.

Review of the Exploratory Surveys Undertaken to Assess the Marine Fisheries Resources of Bangladesh and the Present Status of Exploitation

MD. SHAHIDULLAH

Marine Fisheries Department

The Bay of Bengal has the potential to be a plentiful source of fish for Bangladesh. Several surveys have been conducted since 1958 with the assistance of foreign countries and international agencies to explore the possibilities of commercial exploitation and to assess and estimate the potential resources of marine fisheries. This paper gives a short account of those surveys.

On the basis of earlier surveys, West (1973) estimated the standing stock of demersal fish in the Bangladesh continental shelf to be 264,000 to 373,000 tons, and the maximum sustained harvestable stock to be 132,000 to 186,000 tons. He also estimated the standing stock of shrimp at 9,000 tons.

Based on further surveys up to 1979–80 and on the analysis and interpretation of actual catch statistics from the commercial landing of trawlers operated during 1979–1982, Penn revised the estimate as follows:

Varieties	Standing stock tons	Maximum annual harvestable stock tons
Demersal fish	200,000-250,000	100,000-125,000
Pelagic fish	160,000-200,000	30,000-60,000
Shrimp	4,000-6,000	2,000-3,000

For harvesting these resources, the following fishing efforts were employed during 1982–83:

Deep sea trawlers:	Fish trawlers	25
	Shrimp trawlers	21
Mechanized boat (Operating gill nets and encircled nets)		3,000
Sailboat (operating (1) set bag nets, (2) long line (3) beach seine net, (4) other nets).		9,000

Mr. Shahidullah is Deputy Director, Marine Fisheries Department, Chittagong.

Marine Fisheries Research in Bangladesh

MD. MOHSIN ALI

Marine Fisheries Research Management and Development Project

The paper reviews research conducted intermittently from 1958 to 1980 in the Bay of Bengal. Most studies have observed the species composition and catch rate along with such oceanographic parameters as temperature, salinity, dissolved oxyzen, and the bottom condition of limited fishing areas. The average catch rate of fin fish by trawling varies from 40 to 1600 kg/ha. The catch composition varied widely at different depths in terms of species and quantity. The surface salinity varied from 10 to 29 ppt, the temperature from 28 to 29° C, and the dissolved oxyzen from 4.5 to 5.0 ml/l. At about 500 m depth, the salinity was recorded at 35 ppt, the temperature at 11° C, and the dissolved oxyzen at 0.2 ml/l.

The Government has decided to start survey investigation and research for the development and management of marine fisheries and mariculture in the coastal district. A group has been formed and will be trained in the Marine Fisheries Research, Management and Development Project to conduct this work.

Dr. Ali is Project Director (In Charge), Marine Fisheries Research, Management and Development Project, Chittagong.

Prawn Fisheries Research in Bangladesh

GOLAM KIBRIA AND M. KABIR AHMED
Directorate of Fisheries

This is a comprehensive review of prawn fisheries research that has been conducted in Bangladesh. A total of 63 species of prawn has been identified. Information has been incorporated on the abundance and distribution, biology of some important species, fishery and management, culture, reproduction and larval rearing of prawn. Finally, recommendations and suggestions are made for the development, improvement and management of the prawn fisheries of the country.

Mr. Kibria is Senior Scientific Officer, Shrimp Culture Project, Satkhira, Khulna, and Mr. Ahmed was Research Officer (Shrimp Biology), Fisheries Research Station, Chandpur, Comilla, Directorate of Fisheries.

Post-Harvest Technology of Fish

S. B. BHATTACHARJEE
Directorate of Fisheries

Bangladesh produces about 650,000 tons of fish annually. The production is much less than what is required. The post-harvest loss of fish further increases the protein deficiency. Improved techniques can minimize the post-harvest protein loss. Fish flesh contains four basic ingredients: water, protein, fat and minerals.

Fish is an extremely perishable foodstuff. Spoilage results from a series of complicated changes brought about in the dead tissues by enzymes and bacteria. Preservation is an interruption of the natural changes which occur; these processing methods include chilling, freezing, drying, salting and canning.

Chilling is the storage of fish at or slightly above 0°C. This is done by ice and is a short-term storage method. Freezing is a long-term method at a temperature of −30°C.

When the moisture content of dry fish is kept around 20%, bacteria cannot multiply. Salted dried fish have better keeping quality.

The quality of mechanically dried fish is much better than the sun dried product, but the process is expensive. About 30% of the Bangladeshi production of fish is sun dried.

Hilsa is salted in Bangladesh when there is an excessive supply. Pickling is a better salting method than brine or kench salting.

Canning is a relatively modern technology to preserve fish but is not yet popular in Bangladesh. The process involves hermetically sealing the fish in a container, heat sterilizing the sealed unit and then cooling to the ambient

temperature. Sterilization is done at 121°C for 20 to 30 minutes. Canning of hilsa is a good prospect for fish processing in Bangladesh.

Care should be taken when handling fish that normal spoilage is slowed down and contamination is minimized. The purpose of good handling is to keep the fish cool, undamaged and clean. Good handling will help to minimize the post-harvest loss of fish protein.

Mr. Bhattacharjee is Deputy Director, Directorate of Fisheries, located at the Fisheries Technological Research Station, Chandpur

Notes on Intensive Fish Culture in Bangladesh

M. A. MAZID

Bangladesh Agricultural University

Fish were abundant in this country during the British rule, therefore fish culture was not a necessity. Neither were food and nutrition a problem during that period as most diseases were caused by poor hygiene, unsanitary conditions, and inadequate medical facilities. Most of the diseases of the Third World countries are known to be caused by malnutrition. Food and nutrition are not only problems for our human population but also for our aquatic and land animals.

Our present system of fish culture is not a true culture, but rather is the natural rearing of fish without employing any food or care. Natural foods, such as plankton, are not abundant in the water so can support only a small population of fish. They cannot provide normal growth as well. Nutrition thus remains a problem for fisheries growth.

Additionally, there is irrigation, construction of dams and barrages, irrational uses of pesticides, interference with the ecology, and the application of other agricultural inputs that pose serious and continuous threats to the growth and survival of fish as they exist in nature. These problems are unlikely to diminish in the near future; rather, they may be accelerated. As a result, the availability of fish has decreased markedly over the last few years so that it is highly insufficient to meet our normal requirements. Consequently, the cost of fish is increasing day-by-day at an alarming rate which is beyond our purchasing capacity. Our population has nearly doubled since achieving national independence. The supply of fish should have been increased proportionately with the increase of population. We must increase our fish production as this is the chief source for our demand for animal protein.

To increase yields, the natural rearing of fish should be replaced by intensive culture. Management is not a problem in this procedure. Fish can be grown in high densities under intensive cultural techniques by employing supplemental feed. The result is that the yield per unit of water volume is increased. The success of intensive fish culture depends to a large extent on supplemental feeding. Nutritional studies are essential for the formulation of well-balanced artificial diets for economical feeding. Unfortunately, no

balanced dietary formula has been established for any local species that could be developed from the locally available raw materials, and so that those species could be brought under successful aquaculture. The following are suggested for priority research topics for the development of intensive fish culture in Bangladesh,

1. Nutritional studies of local species:
   a. Requirements of major nutrients:
      Proteins and amino acids
      Fats and fatty acids
      Carbohydrates
   b. Requirements of minor nutrients:
      Vitamins
      Minerals
2. Nutritive values of locally available waste materials for possible use in the manufacture of supplemental feeds.
3. Fish breeding, genetics and hatching development.
4. Control of diseases and parasites.
5. Physiology and behaviour of fish.
6. Effects of limnological factors on growth and survival.

Dr. Mazid is Assistant Professor and Head, Department of Fisheries Technology, BAU.

Part VIII
Soils Research

KEYNOTE PAPER

Soils Research in Bangladesh

M. AMIRUL ISLAM

Former Executive Vice-Chairman
Bangladesh Agricultural Research Council

I thank the Bangladesh Agricultural Research Council for inviting me to present this keynote speech in the National Symposium on Agricultural Research to observe the tenth anniversary of the establishment of BARC. I have reason to be happy on this occasion, for among others, I had some part in the formation of BARC.

Since the theme of the Symposium is "Ten Years of Agricultural Research in Bangladesh," it is an occasion to review and evaluate the progress in soil research during this period. For a better understanding of the accomplishments it is helpful to give a resume of the development of soil research in the geographical area now under Bangladesh during the British India and Pakistan periods.

SOIL RESEARCH DURING THE BRITISH INDIA PERIOD

During the British India period, soil investigations were carried out in the Agricultural Chemistry Section of the Agricultural Research Laboratory under the Directorate of Agriculture. The laboratory building is still standing in its place at Farm Gate as historical evidence. Dr. M. A. Quader, Dr. Sulaiman, and Mr. Wahidul Islam are some of the living scientists who worked in this laboratory during that time. Soil samples were collected from different parts of the province, then chemical analyses were meticulously carried out in the laboratory, presumably for assessing the nutrient content and fertilizer needs of the soil. Fertilizer trials used to be conducted in government experiment stations with chemical fertilizers and organic manures, including both the bulky types such as cowdung, compost and green manuring, and the concentrates such as oilcakes, bonemeals and fishmeals. There was practically no use of chemical fertilizers in those days, and fertilizer recommendations were hardly known to the farmers and district level agricultural officers.

When I joined as an agricultural chemist in January 1950 I found a large quantity of soil analysis data scattered over many notebooks and files. I had all the data compiled and used them in preparing the *Nutrient Status of East Pakistan Soils*. The *Soil Tract Map of East Pakistan*, with information on nutrient status and fertilizer requirements, was a valuable document at that time.

One long-term experiment began during the British India period under the auspices of the Imperial Council of Agricultural Research. It was on the

"Effect of continous application of sulphate of ammonia on the yield of rice and soil condition". It was started in 1945-46 at Dacca Farm and in 1946-47 at Rajshahi Farm. These experiments were continued under the author for a long time during the Pakistan period. There were some very important conclusions on the dose of nitrogen, and on the use of cowdung and lime along with chemical fertilizers, and their effects on calcareous and non-calcareous soils.

In the Chemistry Department of the University of Dacca, some important investigations were carried out on clay colloids, lateritic soils, methods of mechanical analysis of soils, and nitrogen transformation under different soil conditions. The identification and isolation of nitrogen fixing blue green algae (BGA) by Dr. P. K. De was an outstanding contribution during those days.

SOIL RESEARCH AND DEVELOPMENT DURING THE PAKISTAN PERIOD

An important development during the early Pakistan period was the creation in 1949 of the Soil Science Department of the University of Dacca. It quickly started producing graduates and post-graduates in soil science and was regarded as the pioneering soil science department in the subcontinent. The establishment of the Agricultural University of Mymenshingh with a soil science department gave another stimulus for the production of soil scientists in the country. A soils division was added to all the research laboratories and establishments connected with agriculture. A Soil Science Society of Pakistan was started in 1958 with its headquarters at Dacca, and with a large membership from both East and West Pakistan. The Society started regular publication of the *Pakistan Journal of Soil Science*.

The most important research activity during this time was the start of fertilizer trials in farmers' fields. The scheme for this was repeatedly turned down by the Food and Agriculture Council of Pakistan. The greatest opposition came from Dr. A. D. Shaik, at one time Agricultural Chemist of Sind and subsequently Director of Agriculture of that province. Scientists of that time could not accept the idea that scientific experiments could be conducted in the farmers' fields instead of in the government experiment stations where the conditions could be rigidly controlled. Without going into the arguments of advantages and disadvantages, we were ultimately successful in starting such experiments in the project supported by the Food and Agriculture Organization of the UN and United Nations Development Programme. The results helped to prepare the fertilizer recommendations for the important crops of the country. Fertilizer use then started to rise steeply. The finding that urea was as good a nitrogenous fertilizer as ammonium phosphate — in some cases even better — helped the authorities to establish a urea factory in East Pakistan.

Encouraged by the results, the Government of East Pakistan became enthusiastic to have the project cover every thana and union. However, the enthusiasm was restrained and action concentrated on starting the Soil

Fertility and Soil Testing Institute, with provisions for regional laboratories. Ultimately, West Pakistan followed suit and started fertilizer trials in farmers' fields on a much larger scale.

During this period there was further development in the soil survey. Originally there was a small soil survey unit of three or four persons. The author started a bigger soil scheme in 1951 with one Class I officer, four Class II officers, ten research assistants, and a large number of laboratory and field assistants and other personnel. In 1961, a Directorate of Soil Survey was started with assistance from FAO and which was converted into the Department of Soil Survey. Recently it was renamed the Soil Resources and Development Institute and has more than 450 staff members. More than 70% of the country was covered by reconnaissance soil survey before the independence of Bangladesh.

During this period a committee was constituted to co-ordinate all soil research activities in the country with the Secretary of Agriculture as chairm 1. A book on the soils of East Pakistan was prepared and sent to the government press for printing. Due to the unfortunate negligence of some officers, the book did not see the light of day.

In the 1960s high yielding varieties of rice were introduced in East Pakistan with great enthusiasm. Fertilizer recommendations were worked out along with variety trials for the *miracle* rices.

SOIL RESEARCH UNDER THE INDEPENDENT BANGLADESH

Many of the activities described under the Pakistan period have continued under the independent Bangladesh, though in somewhat moribund conditions in some organizations. However, new hope and enthusiasm were created, and exitedly good research work was conducted in the new nation of Bangladesh after the establishment of several research institutions:

- Bangladesh Rice Research Institute, with a soils division.
- Bangladesh Agricultural Research Council, with responsibility to give co-ordination and leadership to the national agricultural research system.
- Bangladesh Agricultural Research Institute, with a soils division into which has been merged the agricultural chemistry section of the former Agriculture Department.
- Bangladesh Jute Research Institute was reorganized with a soils division.
- Institute of Nuclear Agriculture.
- Sugarcane Research and Training Institute, with a soils division.
- Bangladesh Tea Research Institute, also with a soils division.

The Soils Division of BRRI is well-equipped with modern scientific instruments. The scientists are properly trained with high academic degrees. They have access to recent advances and research facilities developed by the International Rice Research Institute. They have joint, co-operative and collaborative research programmes with IRRI. The initial soil fertility research at BRRI was aimed at fertilizer response and efficiency studies with

local and modern varieties of rice, and at organic manures as a supplement of chemical fertilizers. They found that due to residual effects, phosphorus and potassium fertilizers can be applied in alternate crops or every third crop rather than each year. They also found that the productive efficiency of applied nitrogen was considerably improved due to modified 3-split applications in contrast to the conventional 2-split applications.

BRRI has been a co-operator of the International Network on Soil Fertility and Fertilizer Evaluation (INSFFER) which is co-ordinated by IRRI to increase the fertilizer efficiency in transplanted rice. They found that sulphur-coated urea and urea super granules are better than ordinary prilled urea applied as either basal or split doses.

BRRI was the first research institute in Bangladesh to discover and identify zinc and sulphur deficiencies in the wet paddy fields, first in some plots at Joydebpur and subsequently in many places over the country. In trials conducted at the Institute farm and in nearby farmers' fields, the sulphur deficiency was corrected by the application of either gypsum or ammonium sulphate. In trials at Tebnia and Gournadi, considerable increases in both grain and straw yields were achieved by the application of zinc sulphate at the rate of 10-12 kg/ha or by dipping seedling roots in a 2% zinc oxide suspension.

Superimposed fertilizer trials were conducted during 1981 on boro and aman rice to identify zinc and sulphur deficient areas. These were on a co-operative basis with the Directorate of Agriculture (E&M), Bangladesh Water Development Board, BARI, BAU, and some voluntary organizations. In almost all instances, the application of zinc and sulphur produced good responses. The FAO/Norway Fertilizer Project found that low fertilizer efficiency was due mainly to sulphur and zinc deficiencies caused by intensive cropping under irrigated conditions.

BAU has made good progress in the field of biological nitrogen fixation (BNF). Bhuiyan and others have separated 24 strains of *Rhizobium japonicum*. Local strains of Gi-5, Gii-7 and Gii-13 performed better than others. Pilot-scale inoculum production has been started by the University. They have also isolated *Rhizobium* strains from mashkalai and kheshari collected from pulse-growing areas of Bangladesh.

Research on rhizobial strains also is in progress in the microbiological section of the BARI Soil Science Division. After isolating and screening a large number of strains, ICARDA-5 and a local strain from Dinajpur were found effective on chickpea. In a field experiment, an inoculation with ICARDA-5 increased the yield of chickpea by 18%, and with a dose of 20 kg/ha of nitrogen increased the yield by 70%. In comparison, a dose of 20 kg/ha of nitrogen without the inoculum produced only a 20% yield increase.

BAU scientists have identified and isolated nine species of BGA from different soil types of Bangladesh. They found that the yield increases due to BGA inoculation varied from 15 to 22%. They showed that BGA can be multiplied on a large scale in shallow galvanized iron trays by using soil media, and that sun dried algal material can be stored for long periods without losing its viability. The sun dried algal material can be supplied to

farmers if they can be motivated by extension workers.

Azolla research in Bangladesh is still in its early stage; the right strain suitable for this country is yet to be found. BAU scientists have collected four strains of azolla and studied their life cycles in earthen pots under nethouse conditions. Islam of BRRI obtained maximum growth of azolla in September followed by February and then August. Normal growth of azolla in Bangladesh is inhibited by environmental stress and extremes of temperatures.

In this resume I have given just the highlights of the current position of soil research in Bangladesh. I have not written a detailed account of the soil analysis and fertilizer trials to prepare fertilizer recommendations conducted by the On-Farm Research Division of BARI, by BJRI, SRTI, BTRI and the soils laboratories of the BWDB. Nor have I tried to present an account of the basic research for student thesis projects at the soil science departments of BAU and the University of Dhaka.

I have, however, conducted a survey of soil research facilities in Bangladesh, compiling information on the existing institutions, the number of soil scientists in each and their qualifications, the laboratory space and special equipment, and foreign assistance and technical cooperation. Thus I have my own impressions about the institutes and scientists, and their capabilities, failures and successes. I also have my recollections as to who helped the development of soil science in the country, who caused great disservices to progress, and who were anxious to hold important positions in the Soil Science Society without giving any service to the Society. This may be true for many other organizations in the country as well.

RESEARCH AIMS AND PRIORITIES NEEDED FOR THE NEXT DECADE

The aim of agricultural research — of which soil research is one of the components — should be to increase food production to meet the requirements of the nearly 140 million people expected to be in Bangladesh by the year 2000. More specifically, there is an urgent need to deal with soil constraints which are preventing new high-potential crop varieties from producing to their full genetic capabilities. It will be necessary to modify farming systems to maintain the ability of soils to produce good crops far into the future. There are many forms of soil degradation, such as the erosion of top soil, salinization, waterlogging, and loss of nutrients by intensive cropping. The processes of soil degradation must be corrected and controlled.

Attaining these objectives requires serious attention to the following five issues.

Improve fertilizer use efficiency. Barely 30% of the added nitrogen and less than 10% of the added phosphorus are utilized by plants; the rest is either lost from the soil or retained in a fixed form that is unavailable to the standing crops. Scientific research effecting at least a 20% more efficient use of fertilizer can mean a saving of that additional amount of fertilizer, and a similar monetary saving for the farmers. The return can be gigantic in terms of farmers' savings and in the value of additional produce.

Exploit biological nitrogen fixation. We have not taken advantage of biological nitrogen fixation processes. Here is an opportunity to improve soil fertility and increase crop production by reducing our dependence on the production of energy-intensive chemical fertilizer. We can use BGA and azolla as fertilizer supplements in our paddy fields, and *Rhizobium* species for non-rice crops. Work has been started by BAU but more is necessary for the practical exploitation of BNF. Public administrators and extension workers are not fully aware of this technology. Bangladesh should follow the example of India of educating the farmers and training the administrators and extensionists. BGA is used on 2 million ha of rice in seven provinces of India, particularly in the south. Modern, high yielding varieties of rice are particularly sensitive to the availability of nitrogen fertilizers. BGA allows the farmers to get good results from such varieties without spending a fortune on nitrogen.

The use of green manures also is a part of the BNF process.

Use of micronutrients and secondary nutrients. The deficiencies of zinc and sulphur on many soils have been established as constraints on rice production in Bangladesh. More investigation is necessary to establish the micronutrient requirements for other crops on different soil types. The application of appropriate micronutrients should be a regular feature of fertilizer recommendations.

Alleviation of soil constraints for fertilizer use and crop production. The total area of Bangladesh is 35 million acres, of which the net cropped area is 20.8 million acres with a cropping intensity of 153%. There is hardly any unused land for increasing the agricultural area. On the other hand, there is encroachment on agricultural land for more housing, urban development, industrial growth, and the transport system. With such limited cropland resources, Bangladesh cannot allow large tracts to remain unproductive, underutilized, and beset with problems restricting the production of crops. Adequate actions have not been taken to alleviate the soil constraints that prevent the application of fertilizer for higher yields. This is a brief account of the problems soils of Bangladesh:

- Saline and alkali soils occupy 7.5 million acres, mostly in Khulna district, excluding the calcareous, acid sulphate, and grey flood plain non-saline soils; Mathbaria Police Station of Barisal district; Barguna, Amtali, Kalapara, Galachipa, and Patharghata Police Stations of Patuakhali district; and parts of Hatiya, Ramgati, Sudharam, Companyganj, and Sonagazi Police Stations of Noakhali district. Patches of alkali soils occur in the Jessore district.
- Acid sulphate soils comprise an area of 1.75 million acres, mostly in the Sundarbans of Khulna district, parts of Chakaria Sundarbans of Chakaria Police Station of Chittagong district, and of the Sundarban forests along small rivers in Cox's Bazar and Chittagong Sadar South. The main agricultural problems are the extreme acidity, salinity, and heavy consistency of the cleared soils. These soils are tidally flooded with occasional cyclones and storm surges.
- Peat soils occupy 2 million acres in south Faridpur, northwest Barisal,

and northwest Khulna, and locally in haors, hills and hilly valleys. Although rice is the crop best suited to these soils, the yields are poor. Methods must be developed to increase the yield of rice by the application of the right fertilizers and other soil amendments, and to make them suitable for other crops.

- Steepland soils, roughly about 80,000 acres, occur extensively in the Chittagong Hill Tracts where shifting cultivation is practised. These soils also are in Sylhet, Comilla and Mymensingh districts. The major requirement to obtain higher yields by the application of fertilizers is improved management to conserve the soil resource base and to protect the adjacent lower lands.
- Deeply flooded soils occupy about 4 million acres to different depths, mostly in the districts of Sylhet, Comilla, Noakhali, Dhaka, Faridpur, Mymensingh, Tangail, Pabna and Rajshahi. To obtain higher yields by the application of fertilizers, the major requirement is the improvement of practices for good seedling stands in the dry season, and slow or controlled rise of flood water to save the seedlings from submergence and damage in the monsoon season. The main problems of such soils are related to water management — too much water in the monsoon and too little in the dry season — making dryland cropping as hazardous as the monsoon season wetland cropping.

Integrated plant nutrition. There is no research work in progress in Bangladesh on integrated plant nutrition (IPN). The system aims at maintaining soil fertility and sustaining increased agricultural production through efficient use of organic manures, chemical fertilizers, and BNF.

The concept of an IPN system took shape in deliberations between the Indian Council of Agricultural Research and the Fertilizer Association of India in 1975. The concept involves the preparation of an account sheet of (1) the amount of nutrients removed by crops, (2) the amount added to the soil through fertilizers, organic manures and BNF, and (3) the balance of nutrients left in the soil. The preparation of a balance sheet involves a cropping system rather than a single crop; for example, a rice-based cropping system. The soils and crops from farmers' fields are chemically analysed to determine the nutrient removal and to estimate the fertilizer requirement and residual soil fertility. The nutrient balance sheet makes farmers aware that they are using less fertilizer than what is being removed by the crops and thus depleting the soil for sustained, increased production.

Implementation of the IPN supply system in selected villages of India — with guidance of experienced agricultural graduates — resulted in farmers being interested to conserve organic manures, adopting new high yielding crop varieties, a dramatic rise in the use of organic manures and chemical fertilizers, the maintenance of increased productivity, and the improvement of economic conditions and the general standards of living in the villages.

To make the issue clear, think of the existing cropping patterns of Bangladesh: for example, the most important cropping pattern is an aus rice or jute crop followed by transplanted aman rice. In developing an IPN system for this cropping pattern, all of the organic manures and kitchen ashes accumulated for the year should be applied on the aus rice or jute crop along

with the recommended dose of chemical fertilizer. Though BGA and azolla can fix atmospheric nitrogen and thus supplement the nitrogen from chemical fertilizers, it is not advisable to depend upon BNF for aus rice because of the uncertainty of rainfall and frequent droughts.

When the recommended dose of chemical fertilizer is applied on the aus rice crop, the subsequent aman rice crop benefits from the residual effect of phosphate and potassic fertilizers. A small portion of the applied nitrogen will be used by the aus rice or jute crop, but there will be no residual effect on the following aman rice crop. It will be necessary to apply an adequate dose of nitrogen for aman paddy. To supplement the nitrogenous fertilizers, BGA and azolla can be cultivated in the aman paddy fields. This will require identifying the correct strains of these nitrogen fixing organisms and learning their cultivation techniques. At the end of the year, a balance sheet can be prepared by estimating the amounts of nutrients added and those nutrients removed by the two crops, and then determining whether the soil has been depleted or left fit for sustained, increased production.

A similar IPN system can be worked out for other cropping patterns. With the increased irrigation coverage, this system is particularly important for production of irrigated boro or aus rice followed by transplanted rainfed aman rice. High yielding varieties of rice under irrigated conditions require higher doses of chemical fertilizers. Under irrigated conditions it might be possible to grow BGA or azolla as a supplement to chemical fertilizers. When used in adequate quantities, both chemical and biological fertilizers will leave sufficient amounts of residual material for use of the subsequent aman rice crop, thereby reducing the quantity of additional chemical fertilizer required.

I earnestly hope our scientists will start research work on IPN. It is a system study, not the study of a single crop. Our scientists are acquainted with integrated pest management, so the concept of integrated management of plant nutrition is not new.

Finally, I want to say that I have not exhausted the list of priority areas for the next decade. I sincerely hope our brilliant and promising soil scientists will add more issues in the priority list and continue their top quality research in earnest.

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Use of Bacterial Fertilizers in Agriculture

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The application to seed or soil of preparations containing specialized live bacteria can enhance the soil fertility and the yields of crops by rendering unavailable sources of elemental nitrogen, bound phosphates and cellulose-containing plant residues into available forms so that the root system of the plants can absorb the nutrients. In recent years, the shortage of expensive nitrogenous and phosphatic fertilizers has placed emphasis on the bacterial fertilization of the soil. Such preparations are already available in Europe. There are about seven commercial concerns in the United States producing legume inoculants. Bacterial fertilizers and soil conditioners are available in India.

Promising strains of peat-based rhizobial inoculum have been successfully prepared at the Bangladesh Agricultural University, Bangladesh Agricultural Research Institute, and Institute of Nuclear Agriculture, and field tests have been conducted in different regions of the country. Soil-based algal inoculant has been prepared at BAU for use in wetland rice cultivation. The technology is now available to produce viable inoculants or bacterial fertilizers. Research is needed to develop formulations that will protect the bacteria from adverse environmental conditions.

A study was conducted to investigate ways of increasing the frequency of soybean (*Glycine max* L. Merrill) nodulation by *Rhizobium japonicum*, and to seek means for increasing the colonization by *R. japonicum* of the spermosphere and rhizosphere of soybean.

The inoculation of benomyl-treated seeds with *R. japonicum* SEB-5 resulted in a 16% increase in dry weight and a 21% increase of total nitrogen content.

The number of nodules containing *R. japonicum* SEB-5 was also significantly increased, especially at the 0–5 cm depth. A 2 to 11% increase in pod dry weight and 3 to 10% increase in grain dry weight were obtained in different soils by the treatment of seed with benomyl.

The inoculation of oxamyl-treated seeds with *R. japonicum* SEO-3 resulted in an increase in nodule numbers (18–53%), pod weights (15–23%) and grain weights (12–16%). A foliar spray with an oxamyl solution on soybeans caused an increase of 18% in nodule numbers, 21% in root plus shoot weights, 11% total nitrogen content, 15% pod weights, and 6% grain weights compared to an oxamyl-free solution.

The data did not suggest a role for *Bdellovibrio*, bacteriophages, lytic bacteria, antibiotic producers and myxobacteria in the suppression of the *R,*

japonicum population, and the suppression was not related to toxin production in the rhizosphere.

The colonization by *R. japonicum* was improved when seeds were treated with benomyl, oxamyl or antibiotics; the numbers of rhizobia were several order of magnitude higher. The extent of colonization of soil by *R. japonicum* was inversely related to the high numbers of soil bacteria and protozoa. These data suggest that competition by bacteria and predation by protozoa can limit the colonization by *Rhizobium* of the soybean rhizosphere. It is suggested that benomyl or oxamyl treatment of seeds inoculated with a benomyl-resistant or an oxamyl-resistant mutant of *R. japonicum* might result in an increased yield of soybean especially when the foliage is sprayed with the same pesticide.

The experimental approach to increase the bacterial colonization of the rhizosphere can be used not only to increase the benefits of the legume *Rhizobium* symbiosis, but also to increase the colonization by free-living nitrogen fixers in association with the rhizosphere of tropical grasses. This approach can be extended to enhance the rhizosphere colonization by bacteria antagonistic to soil-borne plant pathogens as a means of biological control that may complement the toxic effects to pathogens of fungicides applied to the seeds. The introduction of pesticides that move down the leaves to control root pathogens or other harmful populations in the rhizosphere has great potential to eliminate the antagonism between rhizosphere microorganisms and inoculated *Rhizobium* for better plant growth, nodulation and N_2 fixation in cultivated legumes.

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Research on Trace Elements in Bangladesh Soils

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The beginning of micronutrient research in this country dates back to 1958. Glasshouse and field experiments conducted by the Agricultural Chemist, BARI, showed varied responses to micronutrient fertilization of rice, jute, sugarcane and wheat. A detailed survey of soils and rice leaves by INA at Mymensingh revealed that most parts of the country are deficient in available zinc. The status of plant zinc also was deficient. The status of copper, manganese and iron in soils and plants was also assessed, and deficiencies in one or other micronutrient elements were found at some locations. Based on pot and field experiments using the radioisotopic technique, 5 kg/ha of zinc were recommended by INA for application in rice cultivation. In a collaborative programme, BARC reported varied effects of zinc along with NPKS applications on growth and yield using several crop plants. In

consideration of the importance of micronutrients in crop nutrition, BARC initiated a programme on micronutrients in several crop plants, the findings of which have yet to be assessed. The results of work done in this country on micronutrients are reviewed in this paper.

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Problem Soils of Bangladesh

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Soil is a dynamic natural medium for plant growth. It is comprised of multiple phases: solids, liquids and gases. An unproductive soil is generally known as a problem soil. A soil is unproductive due to problems which include mineral and water stresses, sodicity, acidity, and adverse physical conditions. The following major problem soils are recognized in Bangladesh as constraints to agricultural expansion and intensive farming: degraded soils, saline soils, organic-matter depleted soils, eroded soils, acid brown hill soils, acid sulphate soils, ploughpan-formed soils, peat, waterlogged soils,and acid basin clay soils. The paper describes the problems of each of these and suggests possible extensions.

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Soil Erosion and Conservation in Hilly Areas of Bangladesh

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Soil conservation methods are almost non-existent in Bangladesh, even in the vast hilly areas of heavy and intense rains where the cycle of shifting cultivation (called "jhum") is short. The soil lost in a year on a 50% slope was 30 t/ha with hemp on the contour during rainfall of 2000 mm. The result was the same with paddy and maize. But in bare soil with sparse weeds, differing from near 10% slope to above 30%, the soil erosion is profound. Pegs showed the removal of 4 cm of top soil in 50% slope; the magnitude of loss was the same after years. During 15 days of rainfall in May – June with beans, cotton, soybeans and cowpeas, the least soil lost was soybeans at 5% slope with a multidivisor system.

Yearly rain average shows 2500 mm with the least being 1700 mm. Monthly fluctuations in two consecutive years showed less than 125 to 500 mm in May, and 30 to 200 mm in October. Humidity was lowest in January at 20%, 80% in the monsoon season, and daily temperature fluctuations were uniform throughout being above 60° F, less in 2 months only. Thus high temperatures

for continuous long periods disintegrate the humus, and the nitrogen content is low and less organic matter is present. The soil in these hills is acidic and there are differences in content, e.g., foothills at 1.1% nitrogen, less in terraces on high slopes. Moisture content under trees in winter dry periods is 15%, and when bare more than 2% in 1970 and now it is 1.7%.

With such parameters on soil conser-- tion methods that are by and for limited agriculture in hillocks, studies on commodities are going on and the results being disseminated among the hilly farmers. Generally crops are studied with factors of topography, varieties, time of sowing, depth of cultivation, and cultivation after top soil is removed. Soil conserving crops are advocated, yet depleting ones creep into the recommendations but with more population/closer spacing and invariable on the contours. Pineapples, fruit trees, ginger, turmeric, soybeans, maize, vegetables and sugarcane in trenches on the contours are advocated. The general emphasis is on less dependence on fertilizers and more on organic matter.

Hills should be used less for major agricultural practices. In order to attain anti-erosion measures, basic requirements of contouring in any slope and damming of gullies are essential.

Numerous field studies with appropriate equipment and structures are needed for the development of the soil loss equation.

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Nitrogen Fertilizer Management in Waterland Rice

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Experiments to determine the management needs for increasing nitrogen fertilizer efficiency in wetland rice were conducted from 1977 to 1983 at the Bangladesh Rice Research Institute, Joydebpur, and in adjoining farmers' fields. The response of rice to nitrogen applied as urea supergranule(USG)was better than prilled urea (PU) in some cases with respect to grain yield. Sulphur coated urea (SCU) appeared to be somewhat better than USG in improving the yield of rice. However, PU, ammonium sulfate, diammonium phosphate, and USG had little differential effect on grain yield. Complex and straight fertilizers at equivalent ratios of N, P_2O_5 and K_2O provided similar grain yields. Fertilizer rates and times of application depend on soil fertility, crop variety used, and the time of transplantation. The basal application of nitrogen can be eliminated or considerably reduced especially in the boro season. Two to three splits of urea were better depending on the life cycle of the crops, one at active and/or at maximum tillering and the rest about 4 to 5 days before panicle initiation stage.

Manipulation of plant spacing between maximum and minimum limits did not cause any significant yield difference at a high fertility level of soil. But at low fertility level, the close spacing was advantageous, especially during the boro season. Deficiency of one element—such as sulphur—probably inhibits the uptake of other elements—such as nitrogen—which drastically reduces grain yield.

The mixture of prilled urea and fresh organic manure or compost can be used as an important nitrogen source to obtain high grain yield and increase nitrogen use efficiency in wetland rice. Nitrogen recovery from azolla compost was increased from 25 to 56% by the addition of triple superphosphate during composting.

The authors are in the Agronomy Division, BRRI, of which Mr. Islam is Chief Scientist; Dr. M. Abdur Rahman, Mr. Mazid and Mr. Sattar are Senior Scientific Officers; and Mr. M. Bazlur Rahman and Mr. Harun-Ar-Rashid are Scientific Officers.

Vertical Distribution of Trace Elements and Their Significance in Some Forest Soils of Bangladesh

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Forests of Bangladesh occur on three distinctly different land types: the tidal swamps, the high terraces and the tertiary hills. Soil samples were collected for this study from the genetic horizons of three soil profiles representing the three land types. Trace elements in soil and in leaf samples were determined spectrometrically.

It was observed that the vertical distribution of trace elements is related with the amount of clay rather than with the genetic soil horizons. The clay content of these profiles is the attribute of the alluvial parent material; it is clear, therefore, that the redistribution of trace elements is not pedogenetically affected.

However, as the clay fraction contains higher amounts of trace elements, it can be assumed that the topsoil may deplete in trace elements content with the translocation of clay by elluviation. To verify this assumption the trace element/iron oxide ratio was studied for several soil samples. It can be postulated from the results that the effect of pedogenesis on the vertical distribution of trace elements in the studied profiles is not recognizable.

It is observed that in the studied profiles the molybdenum and cadmium contents are higher whereas the content of other trace elements is lower compared to the FAO's prescribed levels of total content of trace elements in soil.

Leaf samples of several tree species exhibit variable trace contents and are unrelated with the trace element content of soils on which they grow.

Zinc Deficiency in Soil and Plant Enhances Rice Ufra Disease

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Soil samples known to be deficient in zinc were collected from an ufra endemic area of Dhaka-Narayanganj-Demra project. They were placed in 16 pots and fertilized with 200, 150 and 100 ppm N, P_2O_5 and K_2O, respectively. Zinc at 50 ppm was added to 8 pots as zinc sulphate. Seedlings of the BR3 rice variety, which is susceptible to both zinc deficiency and ufra, were planted at the rate of 4 seedlings per pot in all the 16 pots. After the appearance of zinc deficiency symptoms, the seedlings of 4 pots from each group, i.e., zinc added and zinc not added, were inoculated with ufra nematode at 200 nematodes per plant following the seedling base and sheath inoculation methods. Significantly more of the most acute type of ufra symptom, i.e., UI (75.74%), was found on those plants grown in soil without added zinc and inoculated with ufra nematode than on those grown in soil with added zinc and also inoculated (62.69%). The average fertile tillers per plant was 13.38% less, average filled grains per plant was 21.25% less and the yield per pot was 1.4 g less in the former group of plants than in the latter group. The multiplication rates of the nematodes were 1:14 in the former plants compared to 1:12 in the latter plants. The zinc contents of the soil without added zinc and of the rice plants grown in it were 0.53 ppm and 25.25 ppm, respectively, which were lower than the critical levels of 1 ppm for soil and 27 ppm for rice plants.

This is a report of research of the Plant Pathology Division, BRRI, of which Dr. Miah is Head.

Fertilizer Management Practices for Multiple Cropping Systems Using Tracer Techniques

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In multiple cropping systems where crops of dissimilar nutrient requirement are grown together, it becomes operationally difficult to simultaneously meet the needs of the two crops. The legume can supply a part or most of its own nitrogen by dinitrogen fixation but has a high phosphorus requirement. The cereal, on the other hand, generally requires less phosphorus but is dependent on soil or fertilizer nitrogen. Tracer techniques are a uniquely useful tool for studying such systems.

With these views in mind, a series of experiments were conducted in Brahmaputra floodplain soil at the BAU farm, Mymensingh, during the

1981-82 and 1982-83 rabi seasons. These were to compare the efficiency of different methods of nitrogen and phosphorus fertilizer applications in maize, chickpea and wheat/chickpea intercropping systems. Experiments were also conducted to evaluate the beneficial residual effect of legumes for subsequent cereal crops for different intercropping systems.

The split application of nitrogen as basal and side-dressed to maize in a maize/chickpea intercropping system gave the highest efficiency of nitrogen utilization (21%) and produced an average maize grain yield of 1165 kg/ha under rainfed conditions. In a wheat/chickpea intercropping system, split application of nitrogen as basal and side-dressed to wheat also showed the highest efficiency of nitrogen utilization (44%) and produced an average wheat grain yield of 4920 kg/ha when given irrigation up to field capacity at crop reproductive initiation stage

The results from phosphorus efficiency studies with a maize/chickpea intercropping system showed that band application of phosphorus near each row of both the crops or near chickpea rows was highly significant compared to other treatments.

The results from the experiment on the role of preceding legume crops on grain yield of rice showed a significant contribution to grain yield as there was no significant yield difference between 50 and 100 kg/ha nitrogen. New experiments were set up in two different locations, Jamalpur and Kishoreganj, to confirm these results.

This is a report of research conducted by the Soil Science Division. INA.

Studies to Determine the Efficiency of Nitrogen Fertilizer in Wheat Cultivation in Some Soils of Bangladesh Using ^{15}N-Labelled Urea

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Institute of Nuclear Agriculture

Field experiments were conducted to find the efficiency of nitrogen fertilizer in wheat cultivation by using ^{15}N-labelled urea. The experiments were during the rabi seasons in the Brahmaputra grey floodplain in 1978 – 79 and the calcareous dark grey floodplain soils in 1981 – 82. The tests were made under rainfed and irrigated conditions. Nitrogen was applied at 100 kg/ha in single doses and two and three splits in the trials.

The highest grain yield of 2.5 t/ha was obtained in Brahmaputra grey floodplain soils under rainfed conditions by the application of the nitrogen in two splits, half at sowing and the other half at active tillering stage. The utilization of fertilizer nitrogen varied between 6 and 9% for different methods of application. This low yield and utilization was caused by poor tillering and growth which is attributed to the lack of moisture under rainfed conditions.

Applying the nitrogen in two splits — half at seeding and half at active tillering stage—under irrigated conditions increased the grain yield from 3.8 t/ha in the control to 5.5 t/ha in the calcareous dark grey floodplain soils of the Regional Agricultural Research Station at Ishurdi. Using ^{15}N-labelled urea, the utilization of the nitrogen by the wheat crop was 14.1% when applied at seeding and 11.2% when in two splits — seeding and active tillering stages.

The utilization efficiency of the applied fertilizer nitrogen by wheat was low under both rainfed and irrigated conditions. This topic warrants further experimentation with ^{15}N-labelled urea under Bangladesh conditions to determine the constraints to high utilization.

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Effect of Land Preparation on Rice Production

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Wetland tillage practices have their greatest effects on rice growth during seedling and stand establishment periods. Studies during 1976 to 1981 in silty clay soil at the Bangladesh Rice Research Institute, Joydebpur, indicate that land preparation for cultivating lowland rice does not affect rice yield directly but rather it reduces the cost of post-planting management. The degree and frequency of ploughing keeps the rice field almost weed-free during the entire critical period of crop-weed competition. Killing of preplanting weeds by herbicides made early transplanting possible but encouraged regrowth of weeds when there was no follow-up ploughing. The higher degree of puddling obtained with a power tiller reduced the hydraulic conductivity and increased grain yield in some cases. The turn-around time following the harvest of the aus rice crop and start of the aman season can be reduced to less than a week without affecting the growth of seedlings and the grain yield of transplant aman rice.

This is a report of research of the Agronomy Division, BRRI, of which Mr. Sattar and Mr. Rahman are Senior Scientific Officers and Mr. Harun-Ar-Rashid is Scientific Officer.

Response of Wheat to Fertilization on Four Major Soils of Bangladesh

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Institute of Nuclear Agriculture

The response of Sonalika wheat to the addition of nitrogen, phosphorous, potassium, sulphur and zinc fertilizer nutrients was evaluated in a series of field trials during the 1980–81 and 1981–82 seasons at Mymenshingh,

Jamalpur, Madhupur and Ishurdi. The wheat crop had significant responses to nitrogen applications at all the locations. At Ishurdi, the addition of only nitrogen at the rate of 120 kg/ha brought about a 113% increase in grain yield and a 104% increase in straw. The increase in the grain yields due to nitrogen application alone was 68% at Mymenshingh, 84% at Jamalpur, and 35% at Madhupur.

In Mymenshingh and Madhupur, the addition of phosphorous to the nitrogen did not significantly improve the wheat yield, but was significant when sulphur was also added. In Jamalpur there was a very sharp response to phosphorous; this brought a 143% increase over the control as compared to the increase of 84% brought about by nitrogen application alone. The yields of straw followed a similar trend. The application of potassium and zinc fertilizers was not significant in the production of wheat. The maximum average grain yields obtained due to the highest treatment $N_{120}P_{80}K_{60}S_{30}Zn_{8}$ were 3202 kg/ha at Mymenshingh, 3330 kg/ha at Jamalpur, 2687 kg/ha at Madhupur, and 4063 kg/ha at Ishurdi.

This is report of research by the Soil Science Division, INA.

A Decade of Research on Tea Soil

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The trend of research on tea soils during last decades is outlined in the paper. The outcome of this research may be viewed in the perspective of earmarking or consolidation of suitable land and formulation of fertilizer policy such as the economic use of fertilizers for successful cultivation of tea in Bangladesh. The paper discusses the theme of keeping up the marginal land resources for tea cultivation to a state of an optimum fertility level and motivation of the tea planters towards modern tea husbandry.

Dr. Chaudhury is Director, BTRI.

Part IX
On-Farm Water Management Research

KEYNOTE PAPER

On-Farm Water Management Research

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INTRODUCTION

Irrigation systems extend from the capture of the water supply on to its use on the farm. Historically, government-developed schemes were hydrologic-hydraulic systems which emphasized moving the water in primary canals. Now the agricultural utility of water has become an essential component of system design and operation. There is increasing recognition of the roles of the farmer and user, and of the need to utilize farmers' knowledge and skills.

The projects are considered in two parts: the main system and the on-farm portion. "On-farm" means "beyond the turnout" point when the water is no longer under the control of the governmental authority. This frequently includes a significant portion of the distribution system, may include part of the conveyance system, and includes all activities which occur on the agricultural holdings.

In Bangladesh, irrigation is provided by large project, low-lift pumps (LLP), deep and shallow tubewells (DTW and STW) and manual water lifting devices. On-farm water management is an integral part of the equipment used for pumping.

BACKGROUND ISSUES IN WATER MANAGEMENT

Bangladesh has a short history of irrigation development. There is little experience on which to draw when proposing water management programmes. This is as true for government agencies as it is for farmers.

Minor irrigation facilities like tubewells and LLPs provide access to irrigation for many farmers whose only experience may have been with dhones and swing baskets. Tubewell technology is totally new to Bangladesh, in contrast to other countries where water management focuses on upgrading of existing gravity-fed systems.

There is little chance in most gravity-fed systems of a total failure such as a breach of a reservoir. However poorly these are maintained and operated, some farmers will be able to get enough water to grow crops. With pump and engine-based irrigation, system failure is inevitable and frequent. The area affected is small, but the effects for the individual can be catastrophic. The failure of a single component can cause the loss of an entire crop. A pump and engine-based irrigation system creates an important and total dependence on service agencies, a complete contrast to gravity-fed systems. Surely there will be some lessening of this reliance as users improve their maintenance and repair skills, but they will always be dependent on the wholesalers of parts and operating inputs.

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Bangladesh has several agencies responsible for irrigation. Their activities overlap and they compete for the same audience. An added complication is that none of the implementing agencies for tubewell development has any real responsibility or is accountable for ensuring that equipment is maintained. While Bangladesh is by no means unique in this respect, it is critical because the vast majority of irrigation projects are formed of very small and isolated user groups. In discrete small-scale irrigation development programmes, each tubewell represents a special case and needs to have careful monitoring by service agencies to ensure inputs are readily available.

Bangladesh has little capacity to expand its cultivable area. As the country becomes increasingly dependent on groundwater for food grain production, the need for careful husbandry of that resource will grow. Failure to conserve this most important resource could lead to total disaster. Food grain production is more dependent on the proper functioning of thousands of pumps and engines, so their maintenance and management is important.

These factors make a water management programme in Bangladesh more complex and challenging than in most countries. Mistakes will be made because the situation is unique and the pace of growth is outstripping the growth rate of knowledge and understanding of these problems. A programme that installs 100,000 tubewells per year means that on average a new tubewell is installed every five minutes (Rust, 1983). It is important to ensure that no irreversible mistakes are made that can upset the critical balance of water and land resource.

ROLES OF IRRIGATION WATER IN AGRICULTURAL PRODUCTION

A common problem of research programmes in water management is their failure to give adequate attention to the many beneficial roles of water in the production process. It is assumed that the only beneficial use of irrigation water occurs inside the growing plants, and that which is not used by the plants is an undesirable loss. The result is a tendency to focus on water requirements in the design and operation of irrigation systems. This fails to give adequate attention to many of the benefits of irrigation water, so is likely to lead to inappropriate design and management decisions.

Traditionally, plant physiologists identify four major roles for water (1) as a component of plant tissues, (2) as a substance in chemical reactions, (3) as a medium for translocation of chemicals within the plant, and (4) as a source of mehanical strength through the maintenance of plant turgidity (Kramer, 1969).

In addition, water plays at least six roles associated with external biological and physical processes important to the production of wetland rice (Small, 1983).

First, the flooding of the fields influences the physical and chemical properties of the soil, and of the fertilizers and pesticides incorporated into the soil. Flooding increases the availability of certain nutrients (De Datta, 1981). It may also promote the development of toxic conditions, particularly when organic matter is rapidly decomposing. Downward percolation of water

through the soil or drainage in mid-season may correct this. The continuous flow of irrigation water through the field may have the desirable effect of keeping the soil surface oxidized. It may also increase the availability of soil nutrients where the irrigation water is quite cold or hot (De Datta, 1981). It is clear that production management techniques that may be desirable for their effects on the physical and chemical properties of the soil — which influence plant growth and yield -- may result in increased water use.

Second, water may play an external role in effecting the depth of flooding on the physical character of the plants. Both plant height and tiller numbers are affected by the depth of the water standing on the field. With increasing water depth, plants tend to grow taller which makes them more subject to lodging; while the number of tillers tends to decrease. When the water is too deep, yield may be depressed although this depends on the variety grown.

A third external role for water is as a mechanism to influence the temperature of the soil. Continuously flowing irrigation water may reduce soil temperature in hot areas, thus leading to higher yields (De Datta, 1981).

Fourth, water standing on a field can be an important weed control mechanism if the water depth is appropriate (De Datta, 1981). In this role, water can be a substitute for weeding by manual, mechanical or chemical means.

Fifth, water can be a pest control mechanism. It has been reported that keeping fields flooded reduces rat damage (De Datta, 1981). Continuous flooding of rice fields was a highly effective substitute for chemical control of root-knot nematodes in Vietnam (IRRI, 1982).

Finally, water plays an important role in land preparation. Water effectively substitutes for mechanical power by softening soils which have hardened during the dry season. Water is also necessary for puddling the soil, an important step in creating physical conditions conducive to the retention of standing water during the period of crop growth. It is noteworthy that the water used for land preparation frequently accounts for about 40% of the total amount used to produce an irrigated rice crop (IRRI, 1978; Wickham and Sen, 1978). In this sense water can be considered a partial substitute for mechanical power.

Unlike the roles that water plays internally in the plant, in these external roles water is not esential to plant growth. In some cases the primary concern is less with the volume of water than with other management aspects, such as the timing or temperature, while in other cases water is at least partially a substitute for some other production input or process.

PERFORMANCE OF IRRIGATION EQUIPMENT

How many acres of land can be irrigated per cubic feet per second (cfs) of installed pump capacity? There are considerable differences of opinion. For example, a World Bank report identified potential command areas of 30 to 50 acres per cfs of nominal installed capacity, depending on cropping patterns and soil types (World Bank, 1982). On the other hand, in a report prepared for USAID, the comparable figures were 40 to 80 acres per cfs (Keller et al.,

1980). The Bangladesh Agricultural Development Corporation stated there are tubewells in Mymensingh irrigating more than 70 acres per cfs.

The fundamental problem is the inherent technical bias involved. It is presumed that technical capability determines the optimal utilization of the capital equipment. But there is no more reason to presume it is economically desirable to use equipment to its technical capacity than to presume that it is economic to use land to its productive capacity for maximum yields per acre. Just as there are costs associated with achieving maximum yields which may be greater than the value of the increased production, so too there are costs in achieving maximum utilization of equipment which may be greater than the increased benefits. The optimal use of irrigation equipment should be studied in technical, economic and social terms rather than purely technical terms.

For a substantial time, farmers have been using irrigation equipment at levels considerably below the expectations of national irrigation sector planners. The issue is to identify whether or not the conditions creating this farm-level optimum imply a divergence from the optimal situation for the nation. To the extent there is divergence, questions need to be asked about how to bring the national and individual perspectives more in line. If there is no divergence, an understanding must be developed of the conditions which result in the current optimal — but low — levels of productivity. When this has been achieved, it may be possible to identify activities to change conditions that limit the productivity of the investments being made in irrigation.

Consider the factors associated with an increase in the command area. A larger irrigated area for a unit of equipment will normally mean lower cost per acre. Actually, it will also mean longer operating hours for the equipment and hence more frequent failures and shorter life. When repairs are slow and difficult to obtain, it may be more economical to keep the area served lower than would otherwise be optimal. There are great risks of yield loss or crop failure due to mechanical breakdowns. A large command area may need additional investments for linings, bigger canals, and more than one operator.

Given the small average farm size in Bangladesh, expanding the command area requires dealing with a larger number of individuals. Not only is this time-consuming, but there is a greater likelihood for serious conflicts stemming from both irrigation-related and other matters. Negotiations over the location, increased number, and length of water channels will be more difficult. The pattern of land-holding boundaries may increase costs by making it difficult or impossible to lay out straight channels. As the number of farmers and the size of the area expands, the complexity of the management input increases. Communication is a greater problem as distances increase and more farmers must be reached. These hidden costs generally are not included in financial projections. Studies are needed to better understand the system and to make better decisions about the size of the command area.

It is important to determine from the perspectives of the individual farmer and from the nation whether there are actual substantial cost savings to be made by using irrigation equipment at a level approaching its technical

capacity. If expanding command areas from their current typical levels will not achieve cost savings then substantial expenditures for this purpose are ill-advised. There are great needs for further investigations.

RESOURCE ASSESSMENT

In any programme of resource development, there has to be an understanding of the finite limits of growth for the resource to be conserved for future generations (Rust, 1983). To gain this understanding there must be good information about the potential reserves of the resource and its capacity for replenishment. Only when this data is available can a rational resource development programme be established. A fundamental weakness of the tubewell development programme in Bangladesh is that almost all this information is anecdotal. Nobody knows for sure how much water is available, how rapidly it can be extracted from auqifers without damaging recharge capabilities, how the availability varies from year to year, and how much it varies spatially.

The implications of an incomplete data base are obvious. In addressing the issues of tubewell density and spacing, planners have had to rely on very limited data collected in only a few areas. There is no indication of the reliability of the initial data, and in some cases there are only extrapolations based on assumptions; change the assumptions and the data will change.

This is best exemplified by looking at plans to introduce spacing legislation. The spacing of tubewells is determined by supply and demand. Supply is the total volume of water available in an aquifer during the pumping season. Groundwater storage in the aquifer is the major source but may be supplemented by lateral recharge due to groundwater flowing horizontally through the aquifer, and vertical recharge from rainfall and deep percolation of irrigation water. The supply will vary from place to place depending on aquifer and groundwater conditons, and on the efficiency of water use by farmers. Given this, there is a finite amount that can be extrated in any given season without permanently lowering the water table. However, the extractions can take place in any one of a number of combinations of tubewells and discharges up to the limit of the supply.

If it is assumed that a shallow tubewell will irrigate 20 acres, then it is possible to determine their spacing. But if they actually irrigate only 10 acres and use only half the water, then spacing can be much closer. While it may be desirable to have spacing criteria, they cannot be followed unless both the supply and demand conditions are known. Knowledge of demand is as poor as knowledge of supply. Very few tubewell discharges are known and none measured with different water table conditions at various times of the year. There are few reliable measurements of how much water is used to irrigate given areas of land, nor what are the actual tubewell command areas. And, very little is known about the probable impact of economic changes on command area and water use efficiencies.

Another issue that has not been adequately addressed in Bangladesh is whether groundwater development should be regulated from above or be

self-regulated. Opponents of self-regulation argue that the net result might be anarchy with the creation of water lords and over extraction of groundwater. The proponents counter that with little capability to enforce existing and proposed regulations, the results will be similar however well-intentioned and suitable the rules might be.

Self-regulation can work well when the technology being introduced will not permanently damage the resource base nor deprive large numbers of other users of access to water. If this logic is correct, it supports the present STW development programme and strongly discourages the installation of additional DTWs unless it can be demonstrated that the site is totally unsuitable for shallow or manual tubewells. Evidence from parts of India with similar environmental and social conditions indicates the probable success of a policy of STW saturation. Far from creating water lords, it inhibits their development because command areas are small and many farmers can obtain water from more than one well. An interesting feature of this study is that many more wells were sunk than pumps purchased. Non-pump owners hired pumps on a regular basis from their neighbours or from landless groups. This is the oposite to the Bangladesh situation where well and pump numbers are equal. As the cost of well drilling and installation is relatively cheap, this strategy would be successful in Bangladesh (Chambers and Joshi, 1983).

Such a programme is in contrast with efforts to regulate development from above. Proposed regulations have to allow flexibility to account for local conditions for it is almost impossible to predict tubewell densities and spacings. It is better to approach the problem empirically by monitoring and identifying problems as they arise, and only bring of regulatory efforts to play when needed. The danger of inappropriate or untimately regulation is that it becomes a license to extract informal benefits from potential installers of tubewells who wish to circumvent the regulations

DEVELOPMENT OF APPROPRIATE PUMPS AND ENGINES

It is extremely important to match engines and pumps. The key pump component is the impeller in centrifugal pumps and the turbine blades in turbine pumps. Pumps will perform much differently by slightly modifying the shapes of their impellers and turbines. The aim of impeller design is to make the pump efficient over the normal operating range, this being a function of changes in the groundwater table during the pumping season. In this respect, Bangladesh faces some difficult problems.

It is likely that the groundwater level for most parts of the country will fluctuate by about 20 feet from start to finish of the dry season. The designs of impellers and turbines to pump over this range are different from those which pump under more constant conditions. In specifying pump designs, BADC and the Bangladesh Water Development Board identify a single operating point. This is expressed as a desired discharge to be achieved against a specific head and with a certain efficiency. Manufacturers do not have to provide pump characteristic curves to describe expected pump performance nor do there seem to be efforts to test sample pumps to assure that they meet

specifications. A lot of work needs to be done on modifying pump impeller designs to match them to the variations in groundwater conditions.

The International Development Association Shallow Tubewell Project specified the use of a single cylinder four-stroke diesel engine developing 6 brake horspower (bhp) at 1500 rpm driving a centrifugal pump with 4-inch suction and delivery diameters. The static suction head was expected to be 12–15 feet and it was anticipated that the pump would deliver 0.75 cfs. Allowing for friction in the screen, the pressure drop in the well pipe, losses at bends and velocity head at exit, the total head might be 30 feet. Assuming a pump efficiency of 60% this would need 4.25 bhp so that the engine would be running at 70% load, an almost ideal condition.

But engines were purchased which would produce 9 bhp at 2200 rpm to drive the original 1500 rpm pumps. No reduction gear was proposed. What might happen for such speeding up of pumps? The discharge will increase causing greater drawdown and higher static suction head. The increased discharge will mean increased velocity in the pipe and increased friction losses. This also suggests a much higher fuel consumption per unit of water pumped so the efficiency of the pump will undoubtedly deteriorate as the higher speeds cause wear on the impeller, causing further increases in fuel consumption. It is useful to stress the importance of matching pump and engine because of the rising fuel prices.

Centrifugal pumps are efficient for higher heads while the mix-flow types are best at lower heads. It may not be proper to use centrifugal pumps throughout Bangladesh. We need pumps which will perform reasonably well throughout the 20 feet fluctions of the groundwater level over a dry season.

ON-FARM WATER DISTRIBUTION

There are at least four possibilities for improving on-farm distribution of irrigation water: (1) seepage reduction, (2) underground distribution system, (3) use of simple farm structures, and (4) rotational system of water supply.

The canal should be designed for the tubewell discharge. The clearing and compaction of the bed and banks will greatly reduce seepage.

Lining is expensive and requires maintanance. These costs are great because of typical Bangladesh conditions–humans and animals walking on canal beds and banks; carts crossing canals. Lining is not recommended unless the soil is very light. An underground distribution system (UDS) is expensive, too, but it saves land. The cost of UDSs can be reduced by using concrete pipes. We need research to determine the popularity of UDSs with farmers and their appropriateness under Bangladeshi conditions.

UDSs–even experimental ones–should be planned, designed and laid out mainly by the farmers. Stronger farmer organizations will be needed. A DTW with a UDS could be expected to irrigate at least 150 acres involving about 300 farmer plots. The initial investment would be high which will mean a greater effort to mobilize funds.

We need to know whether the farmers will make a long-term commitment to the system. Less than half of the lands are farmed by owners. Are the

majority landless farmers in a position to decide about committing lands to UDSs? It may not be economically justifiable for farmers to participate in the system for only one crop per year. Will the farmers agree to by water in the aus and aman seasons as well as in the dry period? How much can the cost be reduced by using concrete pipes? It can be difficult to transport pipes in remote areas. We will not know the answers to these and related questions until several systems are installed and studied.

Using simple farm structures will improve the efficiency of the water distribution system. Simple and inexpensive check structures will reduce the waste of water.

A rotational supply system also reduces conveyance loss of water. The Bangladesh Rural Development Board, through its Irrigation Management Programme (IMP), is mobilizing farmers to adopt such methods.

GROUNDWATER MODELLING

From what little information is available, it appears that the actual discharges of many pumps are considerably below the rated amounts.

- Thana reports on the CARE projects for the 1981–82 boro crop report the average discharges of nominally 2 cusecs (cusec = one cubic foot per second) DTWs was 1.66 cusecs for 75 DTWs in Dhamrai; 1.53 cusecs for 51 DTWs in Joydebpur; 2.11 cusecs for 10 DTWs in Rajshahi; and 1.61 cusecs for 44 DTWs in Parbatipur (Small, 1983).
- Researchers of Bangladesh Rice Research Institute measured the discharge of 5 DTWs in the Joydebpur area in the 1978–79 boro season. Though each had a 2 cusecs rated capacity, they averaged 1.39 cusecs at the time of the study (BRRI, 1982).
- BRRI measured a single DTW in the 1979–80 boro season with a discharge of 1.2 cusecs for a pump nominally rated at 2 cusecs (BRRI, 1982).
- The average discharge of 11 DTWs in Dhamrai measured by Islam in the 1978–79 season was 1.74 cusecs (Islam, 1980).
- A recent Diagnostic Analysis Training Course measured the discharges of 5 DTWs with a nominal rating of 2 cusecs. They actually ranged from 1.0 to 1.3 cusecs (Water Management Synthesis Project, 1983).

It is not clear why the discharges are low relative to the rated capacity, nor is it known whether it would be economically feasible to take action to bring the descharges closer to the rated levels.

Some of these measurements were taken early in the dry season. They would be reduced later in the season when the water table is lowest. Normally the irrigation demand is highest in March and April. A programme needs to be developed to measure the discharge from these units and the total extraction of groundwater. Water table lowering depends on the volume of extraction. Reduced recharges may be due to one or a combination of these reasons: (1) an excessive pumping rate lowered the groundwater table below the limits of centrifugal pumps, (2) reduced recharge in certain localities, (3) locally poor aquifer conditions, and (4) poor design and construction of wells.

Interference among tubewells depends on the rate of extraction, transmis-

sivity and storage coefficient of the aquifer, and lateral recharge from surface water sources. Extraction and withdrawal from the aquifer is controlled by tubewell discharge and spacing. It would be useful to identify the causes of the reduced discharges in order to evaluate the nature and cost of possible remedies.

As we do not have accurate information on the volume of extracted groundwater and the area irrigated, it is difficult to assess the impact of fielding of additional STWs and DTWs. There are about 110,000 STWs, 15,000 DTWs, more than 1 million hand pumps, and a large number of dugwelis with pumping at rates varying from zero—meaning they are not working—to about 50% above their rated capacities. We do not have information on how many are not working nor how many are pumping at 25%, 50% and 75% of their rated capacities.

Groundwater is a major source of irrigation. With the existing STWs and DTWs, it is possible to withdraw 85,000 cfs water to irrigate about 2.25 million acres, which is more than 12% of the cultivable area. With the 250,000 STWs and 20,000 DTWs proposed to be in place in 1985, it will be possible to withdraw 165,000 cfs to irrigate 4.95 million acres, which is 24% of the cultivable area. About 45,000 LLPs can be operated with the available surface water sources. Assuming an average discharge of 1.5 cfs each, these will irrigate about 2.02 million acres, about 10% of the cultivable area. Most drinking water is drawn from groundwater, too. Most of the irrigation wells are in the northwest, and in the Mymensingh, Tangail, Jamalpur, Dhaka and Comilla districts. We have great withdrawal rates in certain areas of the country.

All STWs are fitted with centrifugal pumps. These can suck in from a maximum depth of about 22 feet. When the water table goes below this limit, some farmers have been observed digging a hole 6 to 7 feet deep and lowering the STWs. They are lifted up again during the monsoon season. This lowering of the water table could dry up all sources of domestic water—hand pumps, ponds and tanks, and small rivers and *khals* (drainage channels). How could rural people get their drinking water under those conditions? Water from DTWs can be used for drinking purposes. Normally these are spaced about 2,000 feet apart, which is a long walk for people living between them. Reciprocating hand pumps can be replaced by deep-set hand pumps which can bring water up from great depths. However, it would be a major task to replace the more than 1 million reciprocating pumps. We should give careful and intensive study to such a sensitive system. Mathematical models are good tools. We need a model relating water table elevation changes to water withdrawal, river levels, aquifer conditions, and rainfall. These models could be helpful in locating appropriate pumps and engines in various parts of the country, provide information about the effects on domestic sources of water, and give warnings about crisis situations such as excessive lowering of the water table.

Adequate information is not available about the volume of surface water in beels, haors and oxbow lakes. The amount of water in beels depends on

rainfall and river flooding. The control embankments eliminated flooding of many beels and changed cropping patterns in some areas. The once famous Chalan Beel in Natore is now almost floodfree. In July 1983 I saw farmers using STWs for land preparation for the aman season in areas where in previous years there had been 4 to 5 feet of flooding during the monsoon which would have given a very good boro and reasonable aus crops. How have the flood control projects affected recharge?

FARMERS' INVOLVEMENT

A basic criticism of most development projects to assist farmers is that there is inadequate understanding of the factors which influence farmers' behaviour. This is certainly true for water management, and particularly true in Bangladesh. In the absence of good information, it is inevitable that outside intervention is based on assumptions and generalizations about field conditions and the rationality of farmers' actions. The few research studies that exist indicate that many farmer groups are probably doing a better job than they are normally given credit for. If this is so, the utility of outside intervention has to be seriously questioned.

Farmers are the ultimate users of irrigation water and the results of research for agricultural production. In spite of this critical role, it is common to find farmers excluded from most aspects of preparing recommendations developed for them. Irrigation agencies and researchers frequently state a desire for 'positive participation' by farmers. In practice this usually means farmers are asked to take part in a water-users' association to ensure that they contribute labour to the maintenance of the field channels and pay the irrigation fees charged by the government agency. It is not surprising that farmers are frequently less-than-enthusiastic about such limited roles.

There is an increasing body of evidence, particularly from Asia, of the value of giving farmers an expanded role in irrigation systems. One major benefit is that it uses the experiential knowledge of farmers, a significant resource that is too often overlooked in irrigation planning and development. Giving farmers an expanded role can mean a reduction in the total cost of the project, or an improvement in the design, or in the operating performance of the system.

A study from the Philippines gives an example of the potential for improved field channel construction through an expanded role for farmers (Moya, 1981). The study covered three tertiary units—ranging from 30 to 50 ha—in a large gravity irrigation system that had been operating for several years. Records were obtained of the original layout of the field channels as prepared by the irrigation agency. The researcher recorded the layouts of the field channels in existence at the time of his study, which indicated considerable changes made by farmers in the original system. He then conducted detailed topographic surveys which were given to an engineer who was asked to design systems of field channels. These designs closely matched the existing network of channels as adapted by the farmers in the area. The

implication is that while the farmers were able to use detailed experiental knowledge about local topography in the development of field channels, the irrigation agency could not design as effective a system without prohibitively expensive studies.

Another example comes from a joint project of the National Irrigation Administration of the Philippines with the International Rice Research Institute. The project investigated alternative approaches to the improvement of on-farm facilities. In several cases, substantial changes in the engineering designs were made on the basis of farmers' information. Farmers generally preferred to have direct access to water. Their knowledge of the land ownership patterns and of local topography made it possible for them to suggest acceptable alternative designs which significantly increased the number of farmers with direct access to water.

So, agricultural research results should be thoroughly tested to determine their acceptability by farmers.

CONCLUSION

It is necessary to understand some of the characteristics of Bangladesh that make it a rather special case in water management.

All benefits of water should be considered when identifying research projects. Unlike the roles that water plays internally in the plant, its external roles are not required in the sense of being essential to plant growth.

There are considerable differences in opinions about the area of land that can be irrigated per cfs of installed pump capacity. The optimum utilization of irrigation equipment does not depend on technical factors alone; it should be studied in technical, economic and social terms. This should be investigated urgently and thoroughly. If there are no substantial cost savings in expanding the command areas from their current typical levels, then the major expenditures being made in this direction may be ill-advised.

Are we using pumps and engines which perform satisfactorily under typical Bangladesh conditions? Most probably not; we should look into it.

Groundwater has become a major source of irrigation and drinking water in Bangladesh. Water is withdrawn by large numbers of STWs, DTWs, hand pumps and dugwells. Most recharge is by rain water. Some of our pumps are discharging at rates significantly lower than their rated capacities. Why? Are we over-exploiting the groundwater? We need further investigation. How are our pumps performing? Is it possible to decide the additional number of pumps on the basis of the present pumping rate? We need more studies.

We need mathematical models for various regions of Bangladesh which relate lowering of groundwater levels to extraction rates, river levels, rainfall in the previous monsoon season, and aquifer characteristics. Such models will allow us to carefully study our very sensitive groundwater system.

On-farm distribution is important. Seepage loss can be significantly reduced by excavating canals of proper size and gradient. Lining is not recommended unless soils are very light. Underground distribution systems

are expensive. Several such systems should be tested under farmers' field conditions. Simple farm water-control structures will be able to reduce water loss.

All research results must be tested for farmers' acceptability. They are the users of all the recommendations which are developed from research results.

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ARSTRACTS

Irrigation Equipment and its Performance

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Agricultural production in Bangladesh can be increased by intensive cultivation that gives importance to irrigation, fertilizer, improved types of seeds, and related practices. The existing irrigation methods and their performances are described in the paper. Both manual and power irrigation methods are widely used in Bangladesh. Most of the manual methods consuming sweat-energy show inefficient power performance. From the energy and discharge viewpoint, three manually driven pumps–the UNICEF pump, the MCC rower pump, and the diaphragm pump–can be considered for further improvement and subsequent standardization.

The electric motor or engine-driven pumps used in irrigation gave a reasonable performance under laboratory conditions, but this standard was not attainable under all field conditions. Sufficient information is necessary for choosing the pump and engine set to reproduce the rated head, discharge and efficiency in the field.

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Research and Development in Irrigation and Water Management at INA

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Institute of Nuclear Agriculture

Water Management in Crop Field

1. Compact layers have been formed at shallow depths in Bangladesh soils due to continuous rice cultivation. These are likely to affect water transmission through the profiles and root penetration into the deeper layers, but this effect had not been previously investigated. This study reports the effect of such a compact layer in a sandy loam soil on the water transmission and root development with and without its breaking by deep tillage.

The compact layer impeded infiltration and caused unsaturated flow in the lower layers and thus retarded the recharge of the profile. Where the compact layer was broken by deep tillage, the roots of 27-day maize plants had extended down to 30 cm compared to 8 cm in a 7 cm deep - tilled plot. After 49 days, the average height of the maize was 15 cm more in the deep-tilled plots compared to the shallow-tilled. There also was a marked increase in the dry matter yield on the deep-tilled plot.

2. A split-plot design experiment was conducted with nitrogen at rates of 0, 40, 80 and 120 kg/ha to study the effect of fertilizer rate on the water-use pattern of mustard under non-irrigated, partially irrigated and adequately irrigated conditions.

The results were that 80 kg/ha nitrogen with one irrigation of 6 cm at 20-25 days after sowing (vegetative stage) was suitable for optimum yield of mustard in the Mymensingh area. Field water use efficiency was also highest for this irrigation and significant at $p=0.01$.

Farm-Irrigation Structures

1. A closed form implicit equation for factor of safety of a simple homogeneous earth dam has been obtained by integration and using Bishop's simplified method. Being a closed form equation, it does not require a determination of the optimum slice width. The iterative procedure yields a factor of safety in a few cycles. The minimum factor of safety has been found by varying the trial slip circles through a grid search algorithm. By obtaining results for a wide variety of data, an empirical equation has been obtained for factor of safety as a function of slope, top width and height of dam, effective angle of internal friction, effective cohesion and unit weight of soil with no pore water pressure. The equation can be utilized to rapidly analyse the slope stability of a homogeneous earth dam.

2. An experiment was conducted with different discharge measuring structures to find the most economical water control structure for optimal use of water by the farmers.

It was found that the spile method of water control is easy and convenient for farmers' use but the problem lies with the variable heads for constant discharge measurement. The farmer can roughly estimate the desired depth of water reached in the field with the use of soil probe.

Drainage of Agricultural Lands

Summer groundnut cultivation in different areas of Bangladesh is a great problem because of excess water or the water-logged condition of the soil. This was studied to determine the effect of surface drainage on the summer groundnut cultivation and to recommend moisture distribution for groundnut cultivation having surface drainage facilities. The soil moisture distribution was monitored under different field drainage conditions with a neutron-moisture probe.

A 31.5% yield increase was obtained where the crop bed was raised with surface drains of 15 cm depth compared to the natural flat bed. Improved drainage practices were evident in such yield-attributing characters as plant height, matured pod number, and seed weight, and were significant at $p=0.01$ for different characters. Land having no drainage facilities had reduced pod formation and resulted in poor quality seeds. Groundnut yield and pod quality can be improved in medium or high lands having surface drainage facilities.

Hydrology

Analyses have been performed to study the geomorphological characteristics of four Himalayan and five non-Himalayan river basins. The study included stream orders, stream lengths, stream density and drainage density. The general conclusions have been drawn through a curve fitting for discharge measurement as a function of other geomorphological parameters.

Mr. Hassan and Mr. Basak are in the Irrigation and Water Management Division, INA.

Part

Farming Systems Resear

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KEYNOTE PAPER

Farming Systems Research

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There has been frequent debate going on for some time about the concept of *farming systems research*. People define farming systems research (FSR) in different ways; many FSR models have been suggested. Still, our understanding of the FSR concept is not clear. This creates difficulties in the operation of an FSR programme. This paper discusses some of the issues of the FSR programme in Bangladesh with emphasis on the concepts and operation.

Traditional ways of farming have evolved throughout the world over the centuries. The farmers have applied their innovative minds to selecting and adopting profitable practices within given sets of farming conditions that match with their requirements and resources. The following are some typical examples of farming systems that have evolved over time:

- Deep-water rice cultivation in Bangladesh.
- Cassava plantation in Africa.
- Maize and cotton belts in America.
- Commercialized shifting rice cultivation in the Magdalena Valley of Colombia.
- Shifting cultivation combined with lowland rice in Sierra Leone and Liberia.
- Bush fallow system in the humid tropical lowland of eastern Nigeria.
- Fallow system in the derived savannah:
  - Tobacco - millet holdings in Uganda.
  - Cotton - sorghum holdings in Sukumaland and Tanzania.
  - Groundnut - millet holdings in Mali.
- Small - scale ley farming with dairy cattle in Kenya.
- Dairy-coffee farming in Sao Paulo State, Brazil.

Each of these farming systems is the result of the knowledge and wisdom that have been accumulated by generations of farmers as to how they can best utilize the resources and opportunities available to them.

The evolution of farming systems is greatly influenced by social, economic and political factors.

- At one time indigo and barley cultivation were among the dominant farming systems in what is now Bangladesh. With the partition of British India, the cultivation of indigo and barley disappeared because these

Dr. Rahman, formerly Member-Director (Crops and Forests), BARC, is national co-ordinator of farming systems research. This paper was developed from remarks presented to the Symposium.

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commodities lost their access to the markets provided by the chemical dyes industry and the Robinson Barley Factory.

- Wheat was not an important crop of Bangladesh. Now it is the country's second major cereal crop and occupies an important place in the farming system. This is due to changes in social and economic situations.
- The potato was not an important crop for Brazil. With the establishment of the potato chip industry, potato cultivation became a part of the most stable farming systems in the country. Today it is going out of cultivation due to serious disease problems.
- In Hawaii, pineapple and sugarcane farming expanded rapidly due to the growth of the canning factories and sugar mills. Now this system is seriously threatened by the rising costs of sugar production which make it difficult to compete at the price paid on the international market.

Natural factors like floods, droughts, salinity and cyclonic disasters also have great influence on farming patterns. Agroclimatic variations can also give rise to an enormous range of cropping patterns and other production activities. The farmers adjust their practices to these odds and opportunities.

The role of agricultural scientists in this process has been to provide the farmers with alternative technologies that minimize their risks and maximize their production.

Agricultural scientists have been playing this role through commodity-oriented research. Great contributions have been made, such as with high yielding rice and wheat varieties and the complementary technologies that have been adopted in Bangladesh and in other countries. Major changes also have taken place in recent years in farming patterns due to the introduction of HYV technologies and the use of modern inputs, such as fertilizers, water and pesticides. This has been most successful in the developed countries. In developing countries like Bangladesh, the adoption of HYV technology has not been as successful. No doubt, productivity has increased significantly but the potential of the HYV technology has not been realized. There is still a very wide gap between the potential yields and the farmers' actual yields. In all too many cases, farmers have not adopted the new technologies.

Crop-oriented research has been most successful in countries which practice extensive agriculture. There the farmers are very specialized, controlling vast resources and often concentrating on commercial production of a single crop, such as wheat, maize or soybeans. Agriculture in Bangladesh is subsistance farming. It is characterized by millions of farmers cultivating very small plots which require an intensive supply of labour. They must maintain a careful balance of the technology, capital, labour and management components of the physical and biological inputs to optimize production for a reasonable economic return. Their primary goal is to produce enough to feed and care for their families, and only then to provide an extra quantity for the market.

Most Bangladesh farmers can produce two and even three crops annually, but their limited resources do not usually provide the reserves needed to overcome the emergencies caused by floods, droughts and other natural

disasters. However, the farmers through years of experience have developed their own strategies and devised means to manage the risks. They have the grasp of different situations and accordingly decide on their on- and off-farm activities to be undertaken for particular situations. In this business, they take into account their requirements, the resources of land, labour and capital available to them, the physical and biological conditions in their farming environments, the technology available to them, and their access to inputs, credit and markets.

Crop-oriented scientists working within the ideal conditions of the experimental stations have been isolated from the real farming life of the small farmers. These researchers have not appreciated fully what types of technologies are required for different socio-economic groups of farmers who belong to varying agroecological situations in order to achieve higher productivity with minimum risks.

This is the primary reason for the slow spread of HYV technologies which were not adaptable under many conditions. Technology generation through crop-oriented research is useful but it can be made far more beneficial when it is directed to addressing farmers' problems through the farming systems approach. This has not been happening because scientists have not had direct contact with farmers at any stage of their research activities. Therefore, they have not been adequately exposed to the local farming environments.

There are many reasons why farmers do not adopt the new technologies that researchers have developed for them. (1) Often they are uninformed and reluctant to try new ideas. (2) There may be a failure in the mechanisms and institutions that are to inform farmers of the new methods. (3) There may be unwise governmental policies which constrain the farmers. (4) There may be lack of incentives. (5) Farmers certainly have an aversion to risks that threaten their basic security.

The fundamental reason for the failure to adopt the new technologies is that they often fail to meet the farmers' needs. Researchers often do not consider farmers' limited financial, labour and environmental resources. The small farmers of Bangladesh can be excellent managers of their scarce resources, especially capital and labour, under a given set of environmental conditions. But they were never considered a part of the research team. A small farm is a family enterprise. Production of the families' food supply and other necessities is more important than profitability. Decisions are generally made on this basis rather than whether or not they are economically rational. It is important for 'professional' researchers to appreciate these values. Unfortunately, this appreciation was not there. As a result, the traditional crop-oriented on-station research alone could not fully respond to the needs of all groups of farmers operating under varying farming conditions.

The process of designing and testing improved practices requires involvement of physical and biological scientists who must join with socio-economists to develop systems that are based not only on their physical and biological potential, but also on their social and economic acceptability to the farmers. This means that the on-station and on-farm research must begin with an

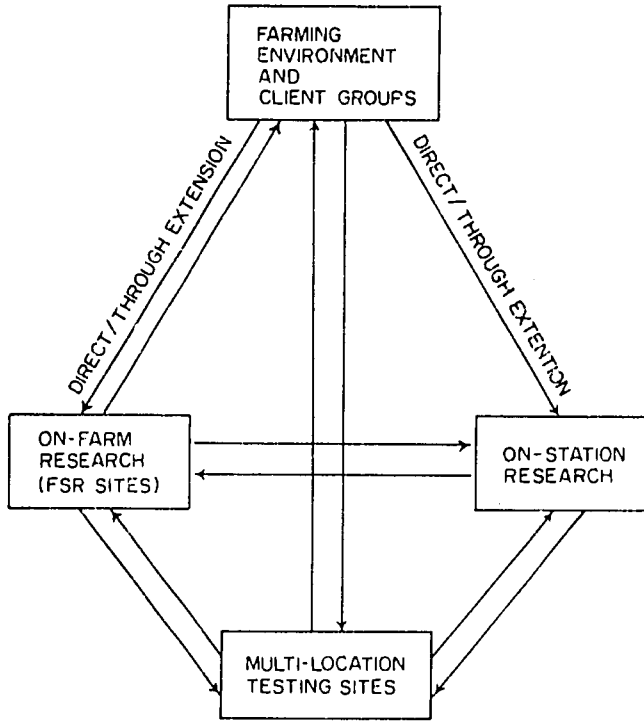

Figure 1. The farming systems research approach.

assessment of the farming environment which includes the climate, soil, water and other physical and biological factors, as well as the socio-economic conditions of different client groups. This requires on-station research to be organically linked with on-farm research, and the total research effort is then geared to a systems approach called *farming systems research* (Figure 1). This does not demand a specific model. FSR follows the rules of what the farmers do under a given set of farming conditions, be it crop farming or livestock farming or a combination of the two. The distinctive features of FSR should be that:

- It puts the farmers in a central role; they are a part of the research team.
- It ties on-station with on-farm research by bringing together the traditional scientists and on-farm scientists to work for a common goal.
- It involves economists to determine the technological changes brought about by the biological scientists.
- It brings the extension workers to work as equal partners with the researchers and the farmers.
- It begins research with the analyses of social, economic, political, institutional, physical, biological and environmental conditions under which each client group operates.

In the past, agricultural research was confined to the experimental station. Research was first taken to the farmers' fields by the Bangladesh Agricultural

Research Institute in the 1960s through some fertilizer trial programmes. Scientific research on the farming systems concept only began in the 1970s. The Bangladesh Rice Research Institute started cropping systems research in 1974 as a participant in the Asian Cropping Systems Programme established by the International Rice Research Institute. In the same year, the Sugarcane Research and Training Institute started its cropping systems research programme in the farmers' fields. Subsequently, other research institutes saw the need and initiated limited site-specific studies on cropping systems. These efforts were brought together in 1980 in the National Cropping Systems Research Programme organized and co-ordinated by the Bangladesh Agricultural Research Council. The partners in this programme are BARI, BRRI, BJRI, BAU, BWDB and the MCC. The introduction of the T&V system through the Extension and Research Project has added a new dimension to the FSR approach by organically linking research with the extension workers and the farmers. This has led quite logically to the broader scope of FSR. But the FSR programme could not be operated in a truly functional setting due to the lack of a clear understanding of the concept and the absence of a proper institutional arrangement.

For the system to become operational, the country's research programme must be reoriented to a farming systems approach. This requires restructuring the institutional set-up and realigning the 'traditional' and 'on-farm' research groups. A recommended institutional mechanism is illustrated in the accompanying figures. In this new approach, particular attention is given to:

- Establishment of a network of FSR and multilocation testing (MLT) sites in the farmers' fields.
- Linking these sites with the experimental stations (Figure 2).
- Testing of technology generated at the research stations for its applicability to actual farming conditions.

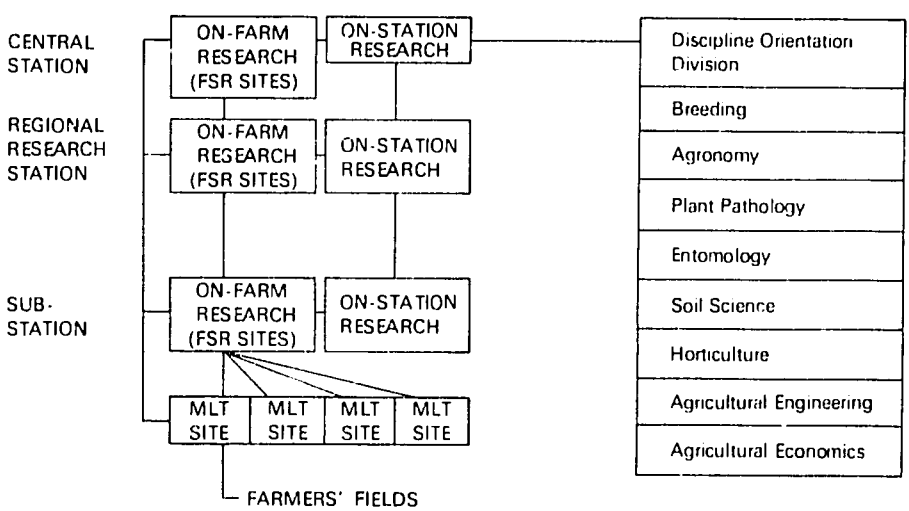

Figure 2. A diagram of the reorientation of research.

- Associating extension workers, other development forces, and farmers in identifying production problems, and the review and evaluation of test results.
- Feedback to the research stations of the production problems that need immediate attention and which cannot be solved at the site level.

The strength of this approach lies in the decentralization of research efforts through improving the regional and sub-regional research stations and of the on-farm research sites.

The ad hoc contract research projects under the National Co-ordinated Cropping Systems Research Programme and the E&RP have been an important input to the establishment of an FSR programme. The initial thrust of these programmes was to test cropping patterns and component technology, and their respective economic profitability. In this effort, least attention was given to critical analysis of why and under what circumstances the farmers adopt certain practices, how they allocate their resources and time to different on- and off-farm activities to maximize their incomes, and how external factors influence the farmers in making certain decisions. In any future FSR work these issues must be addressed before designing the trials. Groundwork for the FSR programme has been done and from this effort it can be possible to evolve an integrated FSR programme with the gradual inclusion of other component studies under a specific agro-socio-ecological context.

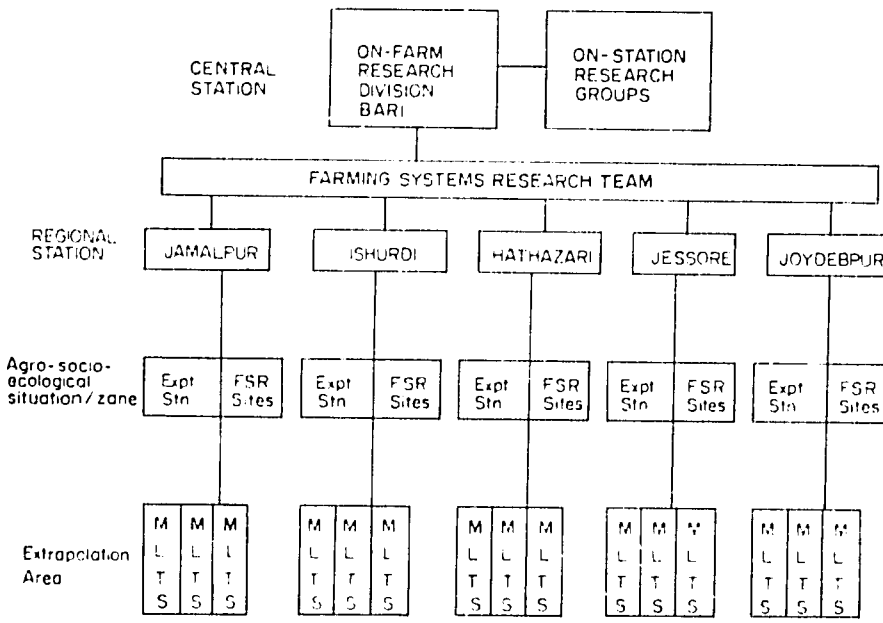

Figure 3. The farming systems research (FSR) set-up of the Bangladesh Agricultural Research Institute (MLTS = multilocation test sites).

BARI has initiated this process. It has redirected its crop-oriented research to an FSR approach based on the institutional concept shown in Figure 1. The BARI structure has been reorganized to create an On-Farm Research Division with a network of FSR and MLT sites which are being established in representative agro-socio-ecological zones.These sites have been organically linked with the experimental stations at the central, regional and sub-regional levels (Figure 2). This will facilitate continuous dialogue between on-station and on-farm research groups, and bring the traditional on-station scientists close to the rural farming environments so they do not lose sight of the farmers' requirements when the research objectives are set. As a key element to strengthening the system, the research planning process has been taken to the regional level where both on-station and on-farm research groups, extension agents, farmers and other agricultural development workers meet in workshops to identify local crop production problems and determine research priorities. They also meet periodically to review research programmes and evaluate the results. Scientists from other research institutes also are involved in this process, such as from BRRI and BJRI.

The FSR structure of BARI is illustrated in Figure 3. The on-farm part of the FSR programme is organized as a two-tiered activity: (1) farmers' field trials at representative FSR sites, and (2) cross-country testing at the MLT sites of the technologies generated at the experimental stations or by innovative farmers. The FSR and MLT sites will be the primary contact points for the researchers, extension workers and farmers. They will be the major source of extension messages for the subject matter officers (SMO) and subject matter specialists (SMS), as well as the information source to the researchers of production problems. As FSR team members, economists will use these sites for analysing farmers' situations, and for monitoring and evaluating the acceptability and impact of the new technologies.

The FSR team is composed of scientists drawn from the relevant disciplines and institutions, depending on the components of the programme. FSR programmes with only crop components have been reactivated along with the new approach in the existing CSR sites. It is proposed that in two to three of these sites that livestock and forestry components be tried as well. As we learn from these selected pilot sites, methodologies for integrated FSR will be standardized to extend these activities to other CSR sites, if feasible.

The FSR programme is being dove-tailed with the T&V system by expanding the Regional and District Technical Committees to include personnel from other institutes and organizations as they take part in FSR in a given area or region.

In conclusion it may be recorded that too many agricultural development programmes are still HYV-oriented. It is time that initiatives are taken by all concerned to shift the direction of agricultural research from crop-oriented to a systems-oriented approach, and let the farming systems research approach be a strategy for the future.

ABSTRACT

Current Status of Vertebrate Pest Management in Field Crops in Bangladesh

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The paper reviews the vertebrate pest research carried out by the Vertebrate Pest Section of Bangladesh Agricultural Research Institute from 1979 to the present. The research activities are in five categories: (1) basic studies of the biology, movements, and food habits of pest species, (2) laboratory evaluations of chemical control agents (rodenticides and bird repellents), (3) field trials of control methods, (4) damage assessments in field crops (damage estimates and evaluation of damage assessment methods), and (5) recommendations and training.

A 1979 survey of 303 wheat fields in four districts of Bangladesh indicated a 12.1% loss of the mature wheat crop due to rat damage. This represents approximately 77,000 tons of wheat per year in Bangladesh. The lesser bandicoot rat *(Bandicota bengalensis)* was responsible for the most damage to wheat.Surveys in six districts of Bangladesh in 1982 indicated an average of 8.4% damage to the mature wheat crop. There was higher damage in the non-irrigated fields than in the irrigated fields. Though laboratory and field trials show greater efficacy of the anti-coagulant rodenticides over zinc phosphide against the bandicoot rat, the zinc phosphide bait is recommended for wheat field rat control in Bangladesh on an ad hoc basis for reasons of past standardization and its present avaliability at a lower price in the country rather than the non-standardized new anti-coagulant baits.

Simulated rat damage studies in transplanted aman rice and wheat crops showed significant yield reductions for damage levels of more than 10% plants after the booting stage. Rat damage control is, therefore, recommended from the booting stage of these crops. A radio-telemetry study in one wheat field showed that the bandicoot rats spent most of their time in wheat fields with an average of 18 m^2 home range in mature wheat fields. Such home range data indicated effectiveness of rodenticide bait applications directly in rat burrows or within 2 m of these burrows.

Studies in deepwater aman rice areas indicated different species composition of rodents in island households and in surrounding deepwater rice fields. The roof rat *(Rattus rattus)* was the predominant rat species in island households before the peak flooding of surrounding rice fields. The

population of the lesser bandicoot rat increased in the islands during the peak flooding of rice fields probably because of migration of rats from the flooded fields. Damage to deepwater rice plants before maturity was caused by the greater bandicoot rat *(Bandicota indica)* and the lesser bandicoot rat *(B. bengalensis)* with higher abundance of the former species, but the most rat burrows in harvested fields were of lesser bandicoot rats. Effective rodent control in island households can be achieved by baiting with both 2% zinc phosphide and 0.005% brodifacoum after peak flooding of the surrounding rice fields. Three rounds of baiting in island households and in deepwater rice fields with 0.005% brodifacoum bait during peak flood period reduced rat activities and crop damage in both locations. In deepwater rice fields, a 1.8% yield loss was estimated by considering quantities of hoarded rice panicles in rat burrows in harvested fields. Less than 1.0% rat damage of sugarcane plants was recorded during the first six months of the crop cycle in the North Bengal Sugar Mills zone due to Indian mole rat *(Nesokia indica)*.

Seed treatments with 0.25% and 0.50% concentrations of methiocarb and 1.2% concentration of copper oxychloride were found to be effective in reducing bird damage to sprouting wheat seeds after sowing. Though methiocarb is superior to copper oxychloride as a bird repellent in most trials, its higher cost, toxicity to birds, and the unavailability in Bangladesh necessitated further trials of copper oxychloride as it is of lower cost, safe to humans and is available. Another bird repellent chemical, Avitrol, is effective in reducing bird damage to maize cobs by selective treatment of a few cobs in each row after the milk stage.

In 1983 the Vertebrate Pest Section participated in a nationwide rat control campaign in wheat fields that was organized in co-operation with the Directorate of Plant Protection and the German—Bangladesh Plant Protection Programme (GTZ). The VPS scientists trained plant protection assistants, distributed information materials, and prepared and distributed 19,600 zinc phosphide bait packets in Bogra, Dinajpur, and Rangpur districts during the campaign.

Mr. Karim, Mr. Haque, Mr. Mian and Mr. Sultana are researchers in the Vertebrate Pest Section, BARI. Mr. Brooks is a Pest Control Specialist, Denver Wildlife Center, assigned to the VPS.

Part XI
Research on Nutrition and Agriculture

KEYNOTE PAPER

Nutrition Research Needs in Agriculture

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Nutrition is multi-disciplinary in the sense that everything in heaven and on earth seems to affect nutrition in a varying measure–directly or indirectly. overtly or covertly. The principal determinant is food. However, all foods are not equal in their nutrient values. People need varying amounts of nutrients according to their age, sex, occupation, and the environment in which they live. Agriculture produces food to deliver nutrition to the human population, so must conduct research on as many aspects of nutrition as possible.

Nutrition stands for the output of most activities in agriculture. Nutrition research in agriculture may include studies on the following dozen topics as well as others:

- Nutrient contents and their biological availability of various foods that we now grow or may grow in the future.
- Requirements of various nutrients by the people living in our environment, categorized by sex, age and occupation.
- Various socio-economic and ecological factors guiding the distribution of food among communities of the country, and among individuals in a community.
- Anti-nutrient and toxic factors in food grown in Bangladesh and how to eliminate them.
- Anthropological studies on eating habits and food prejudices that considerably affect the pattern of food consumption.
- Nutritional status of the population as it relates to the consumption pattern of foodstuffs.
- Food consumption as it relates to physical and mental development and work performance of the people.
- Nutritional deficiencies in the people of Bangladesh.
- Nutritional survey and surveillance to observe changes in the nutritional status of the population.
- Agricultural policy and related options concerned with food production and consumption.
- Studies on the marketing of foodstuffs.
- Home and commercial processing and preservation of foodstuffs.

Inasmuch as the advancement of nutrition is the *raison d'etre* of agriculture, it is important to know the present nutritional status of our people. Surveys carried out by the Institute of Nutrition and Food Science in 1962 - 64 and since have documented that inadequate caloric intake is our

country's principal nutritional handicap. The average intake of energy is summarized below in kilocalories.

Year	Daily caloric intake per person	
	Actual average	Requirement
1962 - 64	2301	-
1975 - 76	2094	2248
1981 - 82	1943	2273

But averages conceal the inside situation—the maldistribution between the rich and the poor as well as within a given family where the disadvantaged are the females and the children. INFS studied the food intake of households according to the socio-economic classification of the union parishad. The caloric distribution among the sample households went from 1802 for the poorest union parishad up to 2191 for the richest. The study examined the distribution of calories among the male, female, expectant and nursing mothers, and children of the families. (See Table 1.)

Maldistribution is a matter of much concern for all people who are involved in the production of food, either through their sweat on the farm or in the laboratory.

There are serious deficiencies of many micronutrients, specifically of vitamins A, B_2 (riboflavin), and ascorbic acid.

Table 1. Comparative caloric intake for family members by economic status of the union parishad.

	Calories			
	Poorest ← Union Parishad → Richest			
	A	B	C	D
Adult males, 20 years and over				
Requirement	3278	3002	2749	2636
Intake	2969	2883	2894	3320
Adult females, 20 years and over				
Requirement	2128	2132	2129	2044
Intake	2072	2277	2079	2336
Expectant mothers				
Requirement	2277	2353	2359	2261
Intake	1883	1743	1677	2447
Nursing mothers				
Requirement	2544	2553	2604	2517
Intake	2273	2323	2243	2402
Children, under 10 years				
Requirement	1765	1789	1788	1805
Intake	1112	1203	1102	1219

Research is needed regarding the content of vitamin A or its precursors among the common animal and plant foodstuffs. Not only must there be an adequate amount of vitamin A in our diet but we have to know its biological availability through research.

The Bangladesh diet has only a scant amount of fat, little of animal food, but a very high carbohydrate content. Intestinal parasites and associated pathogens must be curtailing the physiological efficiency of people's digestive tracts. Vitamin A has a multiple role. At the molecular level, we only understand its action in the visual process. It is not understood how vitamin A promotes growth nor its role in hematopoiesis. The recent discovery that two small fishes, mola *(Amblypharyngodon mola)* and dhela *(Rohte cotio)* are extremely rich sources of vitamins A_1 and A_2 calls for investigations of other fish species, too. It is important to study why these two species of freshwater fishes are so very rich in vitamin A.

The search for improved nutrition requires research leading to local sources of oil. Efforts must continue to increase the production of common oilseeds. At the same time, we must search in rural areas and forests for as yet unrecognized sources of fat that are suitable for edible fat and have other useful physico-chemical characteristics. Fish and other aquatic animals should be investigated in the same manner.

Though most protein deficiencies of the Bangladeshi population are caused by a lack of energy in their diets, it is essential that we conduct studies on the quality of the protein from our common foodstuffs. Protein quality depends on (1) its ease of hydrolysis during digestion, (2) the amino acid make-up, and (3) the presence of deleterious substances which render protein or its hydrolysates unavailable, such as anti-enzyme substances, and tannic acid and polyphenols. The Bangladeshi diet consists almost entirely of plant products so tends to be of low biological value, due especially to the deficiencies of lysine and sulphur amino acid.

The protein value of foodstuffs, especially lysine, is often affected by the mode of cooking. Lysine is affected by heat. There needs to be research on the biological availability of protein as eaten in the usual Bangladeshi diets.

During earlier studies by the INFS, thiamine did not appear to be greatly deficient in Bangladeshi diets. However, it now has become a risk area due to (1) the proliferation of rice mills and (2) the growing practice in rural areas of consuming raw rather than parboiled rice. The widespread deficiency of riboflavin has been documented in various nutrition surveys. While the diseases due to the deficiency of this nutrient may appear trivial, its catalytic role is of paramount nutritional importance in the overall biochemistry of living organisms, especially in protein metabolism and energy-yielding reactions, for example the TCA cycle. This requires investigation as to how this deficiency in the diet affects the metabolism of protein and the energy output from food.

The availability of various nutrients from our foodstuffs, especially vitamins and minerals, is an important area of investigation. Nutritionists are very concerned with the anti-nutritional factors and toxic substances that may

be present in food through both endogenous and exogenous sources. The presence of neurotoxin in one of the most important legumes, khesari (*L. sativus*), is a case in point. Because of the toxin this legume may be used only for animal feed. A means of detoxifying the plant would be of great economic value. Various other legumes also have deleterious factors such as trypsin inhibitors, cyanoglycosides, and antithyroid substances. There are recent reports from West African countries that cassava may lead to injury to the pancreas and cause diabetes. We use great quantities of roots and tubers which probably contain harmful substances. Aflatoxins and other mycotoxins are almost constant companions of our foodstuffs and pose a great danger to human health. The development of suitable methods for detoxification of infected foodstuffs seems to be of great importance.

It is within the competence of the nutritionists in agriculture to find or create species of plants and animals to provide the adequate amounts of nutrients needed by the human species. Laudable attempts have been made with respect to the lysine enrichment in maize. We need cereals richer in riboflavin as this seems to be the micronutrient not abundantly available in most of the inexpensive foodstuffs. We have a widespread deficiency of riboflavin.

Nutrition is a multi-disciplinary branch of knowledge. To tackle nutritional problems there needs to be co-operative research with participation of experts in health, agriculture and the basic sciences. Without a thorough understanding of the basic sciences, no substantial progress can be made in any branch of agricultural research. And again, if we do not understand the various socio-economic and cultural factors and forces which determine how we eat, live, and treat each other, we will not be able to solve our nutritional problems no matter how much food we produce.

ABSTRACTS

Functional Role of Zinc in Insulin and Diabetes Mellitus

ABDUR RAHIM AND KAMAL FARUQUE

Bangladesh Agricultural Research Council

Insulin has been reported to be synthesized in the rough endoplasmic reticulum of the beta-cells of the pancreas as a single chain polypeptide of amino acid residues. This molecule, termed pro-insulin, is obtained when there is rapid removal of an N-terminal extension of about 25 amino acids, which is responsible for binding newly synthesized pro-insulin molecules with ribosomes. The pro-insulin monomer then polymerizes to form the pro-insulin hexamer. The pro-insulin hexamer is soluble and is reported to have the capacity to fold and attain spontaneously a three-dimensional configuration. The pro-insulin hexamer is then converted by proteolytic cleavage into the biologically-active form of insulin hexamer.

The microelement zinc has been implicated in insulin biosynthesis. It is reported that pro-insulin binds with zinc during its polymerization. Molecular organization in zinc pro-insulin hexamer is maintained through all three subsequent steps of insulin biosynthesis. The pro-insulin hexamer, and thus the mature insulin hexamer, contains two or four zinc atoms centrally co-ordinated in the molecule, hence the names 2-zinc and 4-zinc insulins. The solubility of pro-insulin decreases as it is converted into insulin and insulin crystals are deposited in the cells. One purpose of this crystallization is probably to reduce the rate of proteolysis by the converting enzymes residing on the inner side of the plasma membrane.

The role of zinc in insulin biosynthesis—pro-insulin hexamerization, insulin crystallization, or in both—is also indicated by the levels of zinc in the islet tissue of a variety of species. Interestingly, two distinct ranges of zinc levels are reported. A lower level of 2 - 3 mg/100 g tissue is found in animals in which insulins are not crystallized or aggregated to hexamer, and a higher level of 10 - 12 mg/100 g is found in species where the insulins have a specific zinc-binding and co-ordina ity and are crystallized.

In vitro studies have shown that zinc induces pro-insulin hexamerization. It lends support to the proposition that pro-insulin monomers aggregate into hexamers in beta-cells rich in zinc.

Insulin contains zinc and, interestingly, a diabetic pancreas contains about half the normal amount of zinc. The pancreatic acina cells of zinc-deficient rats show cellular alteration, a reduction in zymogen granules, rupture of zymogen granules and basal accumulation of lipid droplets. The rate of insulin secretion in response to a glucose stimulation is reduced in zinc deficiency. Moreover, the zinc-depleted animals are less sensitive to coma and convulsions when soluble zinc-free insulin is injected intraperetoneally. Since it can be assumed that zinc participates in the synthesis and storage of

insulin in the beta-cells, it is plausible that the amount of insulin stored during zinc deficiency is lower.

Diabetic children have been shown to have low hair zinc levels which return to normal after insulin administration. Zinc deficient animals have reduced glucose tolerance, lowered serum insulin content, and elevated total insulin-like activity after glucose stimulation. The insulin-like effects of Zn^{++} in adipocytes are not caused only by direct effects of ion on intracellular metabolism but also by indirect effects related to hydrogen peroxide generation.

To our knowledge, the etiology of diabetes mellitus and foods of diabetics has not been investigated in terms of zinc and related elements like copper, calcium, cobalt, and cadmium which are interrelated with the absorption, metabolism and biochemical functions of zinc.

The study deals with the compilation of information relating to the functional role of zinc in insulin and diabetes mellitus.

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Nutritive Value of Rice

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Bangladesh Rice Research Institute

Rice is a cereal grain and starch is its principal component. The starch content of milled rice varies from 84 – 93% on a dry weight basis, averaging 89.8%. The second highest componenent is protein which varies from 4.5 – 14.3% averaging 8.4%. Rice has the lowest but nutritionally most balanced protein among cereal grains. Lysine and threonine are the two limiting amino acids in rice protein. It is rich in sulphur-containing amino acids. It has 2.3 – 6.8 g lysine, 2.3 – 5.7 g threonine, 0.9 – 5.1 g methionine and 1.6 – 2.2 g cystine per 16 g/N. Lysine content has a negative correlation with protein content if the content does not exceed 10%. High protein rice tends to have better lysine content.

Milled rice has a low fat content. It is also low in thiamine and riboflavin and has a high niacin content. Phosphorous, calcium, magnasium, iron and zinc in milled rice fall far short of the nutrient requirement. The calcium/phosphorous ratio is also highly unfavourable, and the fiber and tannin contents are low in milled rice.

The nutrients in the rice grain are not evenly distributed. Non-starch constituents decrease from the surface to the centre of the grain. The outer bran layer is rich in protein, vitamins and minerals. High protein rices have more even distribution of protein.

Rice starch has 96.4% digestibility in rat and protein has 99.5%. The biological value (BV) for rice protein is 74% and utilizable protein (UP) is

6.3%. The high BV is because of the comparatively high lysine content and low UP value is for low protein content. The net protein utilization (NPU) value is 73.8%. This means that about 26% of the ingested nitrogen is lost in the urine and feces. The digestibility for high protein rice is lower than for the low protein rice, but the apparent relation of nitrogen for the two rices is similar. An increase in protein content of milled rice results in only a slight decrease in its protein quality.

The nutrient content of rice is decreased during milling. A major portion of the fat, ash, and B vitamins are removed with the bran. Calories in the form of starch and protein are fairly well retained. Parboiling allows some of the vitamins and minerals in the bran to diffuse into the endosperm as the heat treatment coagulates the protein. Thus, losses of vitamins and protein are reduced by parboiling during milling.

The digestibility of rice protein is reduced by cooking, but this has no adverse effect on the NPU as it increases the BV. Cooking does not affect the amino acid composition but it has a selective effect on the digestibility of individual amino acids. The digestibility of some amino acids may be decreased by 20%. Lysine digestibility is the least affected and cystine suffers the most. Cooking may denature specific proteins in the protein bodies and it results in a significant loss of B vitamins.

The food value of rice can be improved by supplements. Supplementing rice-based food with amino acids, lysine and theonine, fish powder, chicken, meat and pulses increases the PER value. Zinc supplementation to food based on high protein rice results in faster height and weight gains in growing children.

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Non-Formal Nutrition Education

M. KABIRULLAH

Bangladesh Institute of Research and Training on Applied Nutrition

Nutritional problems of Bangladesh have been analysed by a number of authors seeking to specify the causes. There is now a consensus that poverty together with lack of nutrition education are basically responsible for virtually every case of malnutrition. Many cases of kwashiorkor, xerophalmia and many other problems could be prevented when mothers know how to make the best use of the food they have in their kitchens. Moreover, an enormous amount of food is lost during processing and cooking due to lack of knowledge. Available foods are not used efficiently. Food selection, preparation, and serving, and feeding practices are strongly influenced by custom, habit, religion and prejudice. People living in a cash-earning

economy do not always know how best to utilize their family budgets. They do not know how to buy foods that will provide them the nutrients required to prepare balanced diets for their families. Even a farmer does not know to plan his farming according to the nutrient needs of his family. All this indicates that non-formal nutrition education is indispensible everywhere and in all social strata.

Non-formal nutrition education is within the scope of all workers who have direct contact with families including agriculturists, home economists, dietitians, health workers, social workers, and many others. People in rural areas have to be shown not only what to eat but also how to grow the right kinds of food. In urban areas they have to learn how to balance their family budgets to get the best diets within their limited resources. Non-formal nutrition education is not just a question of giving information but it involves active and direct participation, and learning by doing.

Bangladesh Institute of Research and Training on Applied Nutrition has been working on non-formal nutrition education with the objective of the "solution of nutritional problems with self help" and could effectively improve the nutritional status of the people in the experimental area.

Dr. Kabirullah is Director, BIRTAN.

Protein Concentrate from Jute and Mesta Leaves

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Bangladesh Jute Research Institute

Although jute is mainly a fibre crop, the young leaves are also used as vegetables. The jute leaves are picked for vegetables several times during the growing phase as well as during the thinning of the jute plant. In Bangladesh 1.4 to 1.6 million acres are used for jute cultivation which is 4.32% of the total cropped area. Preliminary investigation has revealed that the dry basis amount of jute and mesta leaves is almost equal to their fibre content. It has also been observed that jute leaves contain 18 - 22% protein. No experiment has yet been done with the mesta leaves to determine their protein content, but from the results with jute leaves it appears that this source alone can supply about 2×10^8 kg of protein. This is about 10% of the total protein requirement of the country calculated at the rate of 58 g per person per day. Jute and mesta leaves remain unutilized during the time of harvesting. As a result, a huge quantity of this national resource is lost every year. On the other hand, the people suffer from protein calorie malnutrition. This calls for giving research emphasis to the isolation, purification and preservation of jute and mesta leaf proteins to solve the nutritional problem of the country.

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Zinc in Nutrition

ABDUR RAHIM AND KAMAL FARUQUE

Bangladesh Agricultural Research Council

The nutritional deficiency of zinc has been reported to cause a large number of anomalies in man. These include (1) severe growth retardation, (2) abnormal growth of hair and nails, (3) deformed bone formation, (4) defective and delayed wound healing, (5) decreased pancreatic enzyme synthesis, (6) decreased peptide hormone synthesis, (7) sterility, (8) anemia, (9) night blindness, (10) alopecia, (11) abnormal serum protein pattern, (12) altered phosphate metabolism, (13) decreased proteolysis, (14) decreased ethanol tolerance, (15) imbalance between aerobic and anarobic metabolism, (16) acid–base imbalance, (17) diabetes mellitus, (18) diarrhoea, and (19) acrodermatitis enteropathica.

The most frequently reported deficiency symptoms are the (1) loss of appetite, (2) retardation or even cessation of growth, (3) anorexia, (4) jitteriness, (5) altered behaviour, (6) mental and cerebellar disturbance,(7) testicular atrophy, and (8) skin defects including parakeratatic lesions.

Zinc deficiency has been widely investigated, and the causes are reported to be due to (1) inadequate dietary intake, (2) protein calorie deficiency, (3) synthetic diets, (4) vegetarianism, (5) dietary phytate, (6) fibre malabsorption, and (7) immaturity of absorptive systems. It can also result from conditioning factors other than a primary lack of the metal in the diet. Some important factors are:

- Polyphosphates, clay and laundry starch cause chelation of zinc.
- Alcohol causes increased urinary excretion of zinc.
- Pancreatic insufficiency causes steatorrhea and lack of zinc binding factor.
- Cirrhosis of the liver and other liver diseases cause increased urinary zinc loss.
- Renal tubular disease causes failure of tubular reabsorption of zinc.
- Hemolytic anaemia causes urinary excretion of red blood corpuscle (RBC) zinc.
- Burns cause exudation and catabolism of zinc complexes.
- Parasitic infection with hookworm causes chronic blood zinc loss and steatorrhea.
- Antimetabolite drugs cause catabolism of zinc complexes.
- Pregnancy causes fetal uptake of zinc.
- Acrodermatitis enteropathica causes impaired intestinal absorption of zinc.
- Malabsorption syndrome causes intestinal loss of zinc.
- Diabetes mellitus causes increased urinary excretion of zinc.
- Infectious diseases cause mobilization of zinc by leukocytic endogenous mediator (LEM) and subsequent urinary excretion.

Intravenous feeding may cause zinc deficiency due to excessive urinary

losses of zinc when complexed with carbohydrates or amino acids, particularly in an anabolic phase.

Zinc plays a part in metalloenzymes including carbonic anhydrase, peptidases (carboxy-, ammino-), alkaline phosphatase, dehydrogenases (alcohol-, retinal-, lactate-, glutamate-, 3-phosphoglyceraldehyde-), polymerases (DNA-, RNA-), thymidine kinase, delta-ALA dehydratase, mannose-p-isomerase, pyruvate carboxylase, and thermolysin.

The daily dietary allowances of zinc, as recommended by the Expert Committee of the World Health Organization are: 10–15 mg for males, 8–13 mg for females, 20–25 mg for pregnant women, 27 mg for lactating mothers, and 3–6 mg for infants. Men and animals have to depend on plants to meet this requirement. Plants get the metal from the soil. The average zinc content of soil ranges from 10–300 ppm; under normal conditions only a small fraction of this is available to plants. This rate of uptake is generally adequate for growth and to cater to the various biological functions. Recent studies on rice cultivation in various soils of Bangladesh have shown growth failure, poor yield, and other deficiency symptoms. Similar deficiencies are likely to be found in fruits, vegetables, grains, grasses, and fodder crops. If this is so, it raises the question as to whether or not our food has adequate amounts of zinc, and whether the whole amount of dietary zinc is available.

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Seasonal Pattern of Within-Family Energy Distribution

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A study was conducted in a central–west Bangladesh village in 1981 to assess the pattern of within-family allocations of available energy in different seasons of the year. This was done by weighing individual food intakes for three consecutive days at four different seasons, and covering periods of normal and relatively short and abundant food availability. Detailed information on socio-economic parameters was also collected to categorize the households into 'poor' and 'better off' groups.

The findings revealed highly significant seasonal differences in energy intake of the adult working population but a lack of consistent socio-economic differential. A widely-held notion that the intra-household allocation of food discriminates against women and children, particularly at times of food shortages, was not demonstrated. On the contarary the findings suggest that seasonal food shortages affect every member in the family and the impact of the shortage is largely absorbed by adults, particularly the adult males, rather than being transferred to children.

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Extraction of Oil from Groundnut Kernels and Use of Cake for Preparing Human food

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Roasting groundnuts (peanuts) will partially or fully damage the oil content. Extracting oil from unshelled nuts spoils the cake and makes it unfit for human consumption. The prospect of the groundnut becoming an economically important oil crop in Bangladesh depends on the efficient extraction of the oil and the use of the cake for human food.

Trials were initiated early in 1982 to use a local expeller to extract oil from the groundnut kernels. Paste and groundnut flour were obtained by using kernels in normal or super-dried condition. Oil cakes in a 1:2 mixture with the kernels gave 40% oil. Sesame/groundnut cake was suitable for using with flour to prepare edible local sweets (pitha) and biscuits in 1:1 and 1:9 ratios. The cake smells like Ovaltine when it has been fried to completely remove the oil content. Successful attempts have been made to remove the black colour of the cake by mixing the kernels with wheat bran at a 16:5 ratio, with ata (flour with whole wheat) at 6:1 ratio, and maida (wheat flour with the bran removed) at a 6:1 ratio. Cakes made of the white ata or maida mixtures were roasted and ground, then biscuits were prepared in 1:3 and 1:2 ratios with the maida. These biscuits had 13.15% and 15.80% protein, respectively, which contrasts with the 9.75% protein content of normal biscuits in the market. In feeding trials people of different age groups found the biscuits were tasteful and they experienced no digestion problems.

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Research on Nutritional Quality Characteristics in Rice, Legumes and Tomatoes

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Rice

Sixty local cultivars of rice were evaluated for their nutritional characteristics. Their protein ranged from 6.1 to 12.8%. Hbj. B. VI, a boro rice variety, contained the most seed protein. Amino acid pattern did not show any

deterioration in the quality of protein with increase in total crude protein. Fine rices were found to have inferior nutritional quality to bolder rices.

In another study, 2556 rice cultivars from the BRRI Germplasm Bank were analyzed for quality. These covered all seasons and were collected from all over the country. Their protein content ranged from 4.6 to 14.2%. Boro rice varieties were superior in nutritional quality. Cultivation of high protein boro cultivars can be encouraged in suitable areas. Broadcast aman rice varieties collected from Munshiganj and Manikganj areas had more protein. More basic work is called for on protein characterization and for finding the mechanism of protein synthesis. Various techniques for protein determination—Kjeldahl, DBC, Alkaliphenate and Biuret—were compared using rice as the test material. DBC technique was the most suitable because of its simplicity and lower cost.

Legumes

Considerable variation for protein content was found within and among the germplasm of chickpea, mungbean, grasspea and lentil maintained at the Institute of Nuclear Agriculture. Some high protein types have been identified. Hyprosola, a chickpea mutant with more protein than the mother variety Faridpur-1, is now available for cultivation. New protein fractions in cowpea, CP-I and CP-II, have been reported. The homology between various sub-units of cowpea storage protein has been found. Further work on these protein characteristics along with their genetic information, might be helpful in framing the technology for protein improvement in pulses.

Tomatoes

The Anobik tomato mutant and the Oxneart variety, their F_1s, F_2s and backcrosses were studied for the inheritance pattern of vitamin C content. The increase of vitamin C content in the selected F_2 fruits was higher than for the F_1 fruits; the former was two to three times that of the parents. Correlation studies indicated the vitamin C content per fruit increased with the increase of weight of the fruit. The per plant increase of vitamin C over the parents for the fruits harvested was 165% in the F_2, 92% in the backcrosses, and 53% in the F_1 plants. The selected F_2 plants showed better yield and more vitamin C content, which is of commercial value.

Mr. Khan, Mr. Munir, Dr. Shaikh and Mr. Dutta are researchers at INA. Dr. Kaul, formerly at INA, is a Crops Specialist, International Agricultural Development Service, BARC.

Part XII
Social and Economic Research in Agriculture

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KEYNOTE PAPER

Socio-Economic Research in Agriculture in Bangladesh

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About two-thirds of the people of the world are poor. Most of them earn their living from agriculture. But their agricultural pursuits are seriously limited in many cases by the quality and quantity of cultivable land, credit, water, and capital goods available to them. Thus, the poor are very likely to become poorer with the passage of time unless this scarcity of resources is counteracted. During the last few decades, academic economists have enlarged our understanding of the economics of human capital, particularly the economics of research, the responses of farmers to new and profitable production techniques, the connection between production and welfare, and the economics of the family. Through the application of knowledge and by means of research, we have discovered substitutes for croplands which Ricardo could not have anticipated. It has been experienced that with their rise in incomes, parents have shown a preference for fewer children. This is a substitution of quality for quantity of children resulting in automatic population control, a fact which Malthus could not have foreseen.

Schultz says, "What matters most in the case of farmland are the incentives and associated opportunities farm people have, to augment the effective supply of land by investments that include the contributions of agricultural research and the improvement of human skills. An integral part of the modernization of the economies of high and low income countries is the decline in the economic importance of farmland and rise in that of human capital, skills and knowledge " This substitution process is well illustrated by changes in maize in the United States. The area planted to maize in 1979 was 33 million acres less than in 1932, but the production was 7.76 billion bushels more which is about a three-fold increase. The physical quanity of land is not the limiting factor in being poor, but rather it is the human agent, i.e., investment in improving population quality can significantly enhance the economic prospects and welfare of poor people.

Marshall, the father of modern economics, said several hundred years ago, "that part of capital which is spent on human elements is the best". Even now investment in education is regarded as the best form of capital for economic development. He also said that human knowledge is the most powerful engine of production, which enables us in different ways in subduing forms of nature to satisfy our wants. The forces of nature can be subdued and tamed by human knowledge, skill and ability for human benefit for increasing man's welfare and comfort through increased production.

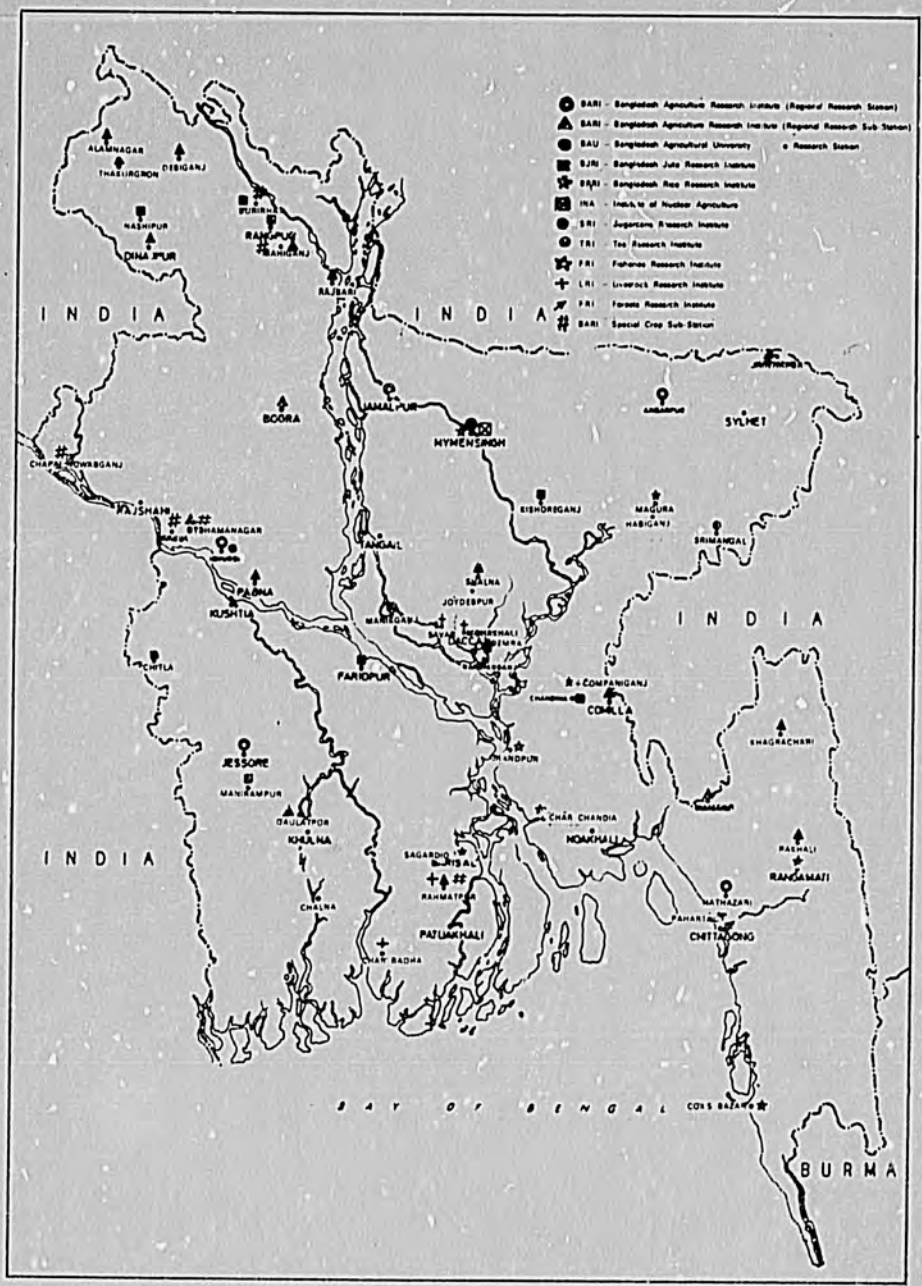

Figure 1. The organization of the national agricultural research system of Bangladesh in 1983.

The return on investment in education and research is well established. Even in developing countries this return is spectacular. Education is sustained and strengthened through continuous teaching and research, the two inseparable "Siamese twins". Indian expenditures on agricultural research increased from 52 million rupees in 1950 to 177 million rupees in 1968 (at 1968 prices). This resulted in an increase of the value of agricultural production from 0.07% to 0.17%. The rate of return on the investment was estimated to be 60%, which is spectacular indeed.

Natural resources—like cropland, physical capital, and raw labour—are not adequate for transforming a developing country into a highly productive modern economy. A wide array of human skills are essential for fueling the dynamics of development. Without these, the economic prospects of a country are bleak.

Table 1 provides a review of the investment in agricultural research by 22 low-income countries, reflected specifically in the expenditures, scientist man years, and average number of publications. The figures cover the 1959 – 1974 period, so information was not available for Bangladesh. However, the amounts for Pakistan include what is now Bangladesh and the situation is far from satisfactory.

Table 1. Agricultural research expenditures, manpower and publications of selected low income countries, 1959–1974

Country	Expenditures (1971 US dollars) (thousands) 1959	1974	Scientist Manyears 1959	1974	Average Annual Publications 1964–73
Argentina	12,000	24,000	320	880	85
Brazil	4,800	48,800	200	2,000	130
Chile	720	4,390	32	192	26
Colombia	6,000	13,340	200	870	36
Mexico	2,160	9,760	190	1,000	39
United Arab Republic	4,800	8,950	400	800	165
Ghana	1,440	2,440	60	140	25
Ivory Coast	2,400	5,130	40	110	12
Nigeria	6,010	16,270	110	300	63
Senegal	1,560	3,250	45	160	4
Kenya	600	3,660	25	280	30
Iran	1,800	14,640	170	500	34
Turkey	2,040	9,760	55	580	23
Sri Lanka	1,320	2,440	50	130	18
India	10,570	26,030	1,150	2,150	1,278
Pakistan	960	2,030	120	280	90
Indonesia	240	3,420	15	380	13
Malaysia	1,440	4,880	40	240	27
Philippines	1,800	5,210	200	620	70
Thailand	660	4,880	150	725	18
South Korea	1,080	2,440	300	650	37
Taiwan	840	2,360	250	400	60

Adopted from James K. Boyce and Robert E. Evenson, Agricultural Research & Extension Programs. New York: Agricultural Development Council. 1975.

A comparison of the rates of return from investments in agricultural research on selected commodities is given in Table 2. The investment in hybrid maize research in the USA gave an annual internal return of 40% over a period of 15 years. Investment in wheat research in Mexico gave a 90% return over 10 years. Sugarcane research in India gave a 60% return over 13

Table 2. Estimates of the return to farmers from investments in agricultural research.

Country	Commodity	Period	Annual rate of return (%)
United States	Hybrid maize	1940–55	35–40
United States	Hybrid sorghum	1940–57	20
United States	Poultry	1955–60	21–25
South Africa	Sugarcane	1945–62	40
Mexico	Wheat	1943–63	90
Mexico	Maize	1943–63	35
Brazil	Cotton	1924–67	77
Colombia	Rice	1957–64	79–96
Peru	Maize	1954–67	35–55
Japan	Rice	1915–50	25–27
Japan	Rice	1930–61	73–75
Colombia	Rice	1957–72	60–82
Colombia	Soybeans	1960–71	79–96
Colombia	Wheat	1953–73	11–12

Source: Evenson, et al. *In* National Agricultural Research Plan. BARC, Dacca. 1979. p. 73.

years. These benefit returns are conservative. Other indirect effects, such as the spillover benefits beyond the country or region, were not considered.

Benefits and returns in advanced and developing countries are significant and enormous. Bangladesh is lagging behind and deprived of these advantages because of a very low rate of investment in research (Table 3).

The contribution made by agricultural production is about 63.1% to the economy in Bangladesh, the highest figure, yet only about 0.023% of this value is spent on research for agriculture in relation to the other countries listed. Bangladesh is the lowest in this regard and in terms of per capita expenditures made on investment on agricultural research among the countries listed. This signifies very little attention to agricultural research in this country.

Studies conducted all over the world confirm the high rates of return to investment in agricultural research. Agricultural production in the developed countries has registered a more than two-fold increase as a result of higher rates of research investments. During 1934 – 38, crop yields were almost identical in the developing and developed counries. But while grain yields increased to 3.0 t/ha in developed countries by 1973 – 75, it remained around 1.5 t/ha in the less developed countries (LDCs). Many studies provide ample

proof that returns on agricultural research have been higher than those of other investment opportunities.

Evenson recently wrote, "The pay-off on research investment in the LDC regions of the world is extraordinarily high. At least twice, perhaps, three times as much growth is with research dollars than with extension and other programme dollars. And there is no good substitute for high quality research systems." A recent preliminary investigation in Bangladesh shows a 55% annual return from research in the 1960s in spite of the very low amount of investment. Another recent study shows that per capita research expentitures in this country are only US$0.03, the second lowest among the neighbouring countries. Research expenditures in the Philippines are 10 times those of Bangladesh, and those of Japan are 50 times higher (Table 3). India increased the research allocation in its Fifth Five Year Plan from 210 million rupees in 1967 - 68 to 1530 million rupees in 1972 - 73. This is about 0.9% of the gross domestic product compared with 0.07% in Bangladesh. Then this allocation was more than doubled to 3250 million rupees in the Sixth Five Year Plan from 1978 to 1983 (Table 4)

Agricultural research is highly remunerative and is the foundation of agricultural development. Neverthless, it has received inadequate attention in our country. For many years the responsibility for agricultural research in Bangladesh was divided among at least nine ministries and agencies. This lack of co-ordination, co-operation and understanding resulted in a weak and ineffective research system.

Experience in Bangladesh shows that the development plans and programmes either lacked appropriate strategies for agricultural development or were incoherent, sporadic and uncoordinated efforts that were not concerted enough to bring about significant economic and social change for sustained growth. Our agricultural research efforts were highly fragmented. The inevitable result was a tendency of researchers to work in isolation, a proliferation of efforts, and a lack of efficient use of scarce trained manpower. The absence of an integrated problem-oriented research programme stood in the way of the evolution of a sound and efficient system for agricultural development. The division and separation of research activities ran counter to a well-defined, integrated, efficient and productive research effort. The stablization of food production through efficient organization was an altogether remote venture.

Advances in knowledge enhance the quality of physical and human capital. Organized research has become a source of addition to the stock of human knowledge. Most basic research in the USA is done by the universities. The results of that research are regarded as public goods, so it has to be supported by public funds and private gifts. About 70% of all basic science research in the USA is paid by the federal government; about 60% of this research is done by universities and their affiliates.

The government of a country nurses, directs, guides, encourages or discourages, or even distorts research through its many-sided policies, most of which are guided by political considerations. In our country, the Government

Table 3. Agricultural research expenditures in selected countries.

Country	Percentage of agricultural production in the economy	Agri-research expenditures as percentage of value of agricultural production	Per capita expenditure on agricultural research (US dollars)
Bangladesh	63.1	0.023	0.03
India	45.7	0.097	0.05
Japan	5.9	7.340	2.66
Pakistan	34.5	0.044	0.02
Philippines	27.7	0.275	0.02
Thailand	30.6	0.207	0.15
United Kingdom	2.7	1.480	1.16
United States	3.1	1.730	3.00

Source: Swensen (IADS/BARI). *In* National Agricultural Research Plan. BARC, Dacca. 1979. p. 74.

Table 4. Percentage of gross domestic product allocated to research in selected countries, 1971.

Country	Percentage of GDP for scientific research and development	National income (Millions US dollars)
United States	3.4	620,968
United Kingdom	2.4	83,064
Netherlands	2.0	16,961
France	1.5	76,153
Japan	1.5	78,153
Germany	1.5	90,610
Sweden	1.5	12,335
Canada	1.0	39,691
Belgium	1.0	14,310
Norway	1.0	5,834
Italy	0.6	49,410
India	0.45	39,401
Pakistan	0.13	11,800

Source: Abdus Salam. Towards a Scientific Research and Development Policy for Pakistan, National Science Council (1970). *In* National Agricultural Research Plan. BARC, Dacca. 1979. p. 75.

is apathetic towards the academicians and scientists. It undermines their values, importance and status, and fails to recognize their critically important role in nation-building. The economic value of scientific advances is grossly neglected and misconstrued by political considerations.

Among the basic issues in research is that of who will do it and who will pay for it. In 1978, 69.3% of the research in the USA was paid for by the federal government, 14.8% by industries, 9.9% by universities, and 6.0% by other non-profit institutions. Universities and their affiliates did 59.1% of the research, federal agencies did 16.1%, industries 16.1%, and other non-profit institutions did 8.7%.

The USA universities do three-fifths of the basic research, yet they receive only one-fourth of the federal research funds. Table 5 indicates who does research in Bangladesh and the Government allocation to socio-economic reseach. Applying the corollary, most research should be done by our universities, but they have not been able to discharge this responsibility due to the non-availability of Government funds. The universities in Bangladesh could discharge this obligation without any infringement on their autonomy. Industries and private donors do not provide any research funds to our universities, though this is a source of significant contributions in advanced countries. This is a mark of ignorance and lack of initiative of our industrialists.

Agriculture is a business which is concerned with the art and science of raising plants and animals. The economic aspects of agriculture are as important as any other discipline. It is a good sign that non-economists have started realizing that fact. In our country there is only one specialized institution devoted solely to economic research. Until recently, our universities have had very few trained personnel able to undertake socio-economic research relating to our problems. Many persons have been trained abroad, but often they have been poorly utilized for research when they returned home.

Table 5. Financial allocation for social science research and training improvement of statistical system, 1978–79.

Sub-sector	Thousands of taka			
	1978–79	1979–80	Total	Percentage
Training	22,425	20,399	42,824	38.51
Research in social sciences and human resources development machinery	19,899	21,200	41,099	36.96
Improvement of the statistical system of planning and development machinery	9,024	18,253	27,277	24.53
Totals	51,348	59,852	111,200	100.00

Source: Two-Year Plan, 1978–80, V.II, P.X.-13.

Our universities do not do the type of policy research needed to meet social and national requirements. The universities seem not to be prepared to part with their autonomy in order to seek research co-ordination with other universities, research institutes and agencies. This results in low utilization of the few trained personnel in the country. Academicians and scientists in advanced countries often get special treatment from their governments for their services in the interest of the nation; no such scope exists in Bangladesh. In the USA, 60% of the total budget of the federal government for basic research in social science went to the universities in 1973. I have no knowledge as to what percentage of our Government funds go to social science research in our universities, but it can be assumed that it is small, and perhaps, very small.

Economic research in agriculture is less than optimum in most universities. There are few doctoral research studies, and master's research is limited except in the Bangladesh Agricultural University at Mymensingh. None of the research is well organized. Only a few graduate students make proper evaluations in their work. The faculty members supervising the students do not feel a responsibility to make the research appropriate and meaningful. It is imperative for all teachers to perform research to earn promotions because this is a major function of a university, but little or no direct financial support is provided for economic research. The financial support problems seem to be more serious in economic research than those in other disciplines.

Research in social science and human research development was emphasized during Two Year Plan (TYP) of 1979–80. In-depth research into social and economic problems of the country is a must to develop a public welfare-oriented administrative system, and to formulate strategies for social and other development plans that are realistic, effective and scientific. The Social Science Research Council was established in June 1976 for the promotion, fostering and development of research activities in the social sciences through closer cooperation among research organizations and individual scholars, but it has not been able to organize itself properly to discharge its responsibility.

The Bangladesh Institute of Development Studies was established as an autonomous organization to conduct policy-oriented development research and impart specialized training in development economics, demography, and other social sciences. One of the responsibilities of BIDS is to increase the research capabilities of the country through trained and specialized manpower in the field of research.

Table 5 indicates the financial allocations to three sub-sectors for social science research and training in the TYP of Bangladesh. These allocations are meagre in view of the available trained personnel and the level of research capabilities in the country. The strategy of human resource development is complementary to those of employment generation, and strengthening and development of a research capability. The essential parts of the human resources development strategy were skill formation and raising the technical capability of the population through education, training, research, extension

and institution building, with appropriate linkages between all these elements.

The Second Five Year Plan (SFYP) envisaged an expenditure for research of Tk. 190 million, roughly 0.7% of the total plan allocation, which is very insignificant according to our research needs.

Investment in research has been responsible for dramatic gains in agricultural productivity in both developed and developing countries. The impact of agricultural research has been felt on several socio-economic variables including output, growth, income distribution, equipment, and nutrition. Return from investment in agricultural research has been quantified in several studies and has always been very beneficial. But expenditures in research in developing countries, including Bangladesh, have remained unbelievably low. During the First Five Year Plan (FFYP) and the TYP, headway was made in the construction of physical infrastructure and development of manpower in the face of serious finanical limitations.

During the SFYP it was realized that agricultural research efforts had suffered from the lack of a national plan, the identification of priority areas of research, and lack of co-ordination and linkages among widely dispersed authorities. The plan envisaged consolidating all agricultural research under the Ministry of Agriculture and Forestry. The need for keeping agricultural research workers in close touch with the farmers' fields and extension workers can hardly be overemphasized. The strategy was to encourage inter-disciplinary and multi-disciplinary research. Measures were to be taken for the establishment of intra- and inter-national linkages with important research institutes and organizations as well. The Bangladesh Agricultural Research Council was expected to play an important role in the co-ordination and consolidation of research institutions and organizations to ensure balanced growth of all related areas. Transfer of technology was to be ensured through on-farm research and feedback mechanisms developed in extension,research, teaching and training.

The SFYP required consideration in these four topics to stimulate and strengthen agricultural research and to attain a balanced growth of the country's economy:

1. Varietal improvement of various cereal and non-cereal crops taking into consideration regional variations in soils and climate and the need of developing varieties that incorporate labour-intensive cultural practices.

2. Improvement of cropping systems with special emphasis on cereal crops, pulses, oilseeds, fruits and vegetables.

3. Soil and water management, pre- and post-harvest technology, and integrated pest managment.

4. Evolution and evaluation of most intensive cropping patterns, using early maturing crop varieties, and the study of them to monitor their long-term effects on the fertility, ecology, economics, and overall benefits to the areas under consideration.

Initially about 60% of the agriculture research allocation was spent on capital items, mainly for building and experimental facilities, so only a small

amount was left for experimentation. Most of the institutes have now built their minimum physical infrastructures, so more funds are expected to be available for research and extension work. The SFYP further envisaged strengthening the research capabilities of the individual institutes and centres through increased investment, improvement in technical support services, training of scientific and technical personnel, and more operational autonomy.

The objectives of agricultural economics research were set, areas were identified, and measures taken to realize these objectives through activities undertaken by universities, institutes, agencies and other organizations.

A number of private foreign agencies work in Bangladesh and undertake multifarious functions and development activities in their own ways; none of them specialize solely in economic research. These donors use their funds in their own ways, so co-ordinated, policy-oriented research to meet Bangladesh's demands is beyond question. The donors are more interested in development activities and relief works rather than in organized research.

There are quite a few internationally reputed donor agencies who support agricultural research in Bangladesh. Among them are the World Bank and the International Development Association, US Agency for International Development, Canadian International Development Agency, the Ford Foundation, and many others of whom I have little knowledge. Foreign aid on many occasions is not free but conditional. The donors impose restrictions and conditions to suit their desires and convenience rather than those of the host countries. Other donor agencies tie in costly experts from the mother country and restrict purchase of materials to the donor country even when the same items are available elsewhere at much lower costs. Schultz has pointed out that the average cost per expert made available by US aid-giving agencies is about US$100,000 per year. In many cases their qualifications and experience do not suit the peculiar local conditions and needs of the aid-receiving countries.

The Bangladesh Agricultural University was established in August 1961 to impart education and training in agricultural sciences and regular disciplines, and to promote research. There were three faculties: veterinary science, animal husbandry, and agriculture. Less importance was attached to socio-economic subjects than those of other disciplines, though an independent Faculty of Agricultural Economics and Rural Sociology was in the plan. Opening this faculty was far easier than those of the biological sciences as it did not require costly laboratory facilities to start teaching and research.

The Department of Agricultural Economics at BAU was opened in September 1962 when the author joined the staff as its first teacher. This post was first of its kind in Bangladesh. The author was also the founding Head of the Department. Initially this was a nucleus for the establishment of an independent Faculty of Agricultural Economics and Rural Sociology which later consisted of four more departments of facilitating university-level teaching and research in socio-economic fields relating to agriculture.

BAU has been producing 25 to 50 students per year with B.Sc. (Hons.) and

M.Sc. degrees from the Departments of Agricultural Economics, Cooperation and Marketing, and Agricultural Finance. The M.Sc. is a research degree. Master's degree students in agricultural economics subjects prepare a thesis or term papers based on empirical studies and field investigations or secondary data as partial fulfillment of the conditions for this degree. This is aimed at basic training in research in the socio-economic aspects of agriculture. However, most of the research topics undertaken by the M.Sc. students at BAU do not conform to the priority principles of national goals and interests. They are selected purely on academic considerations, very subjectively, keeping in mind time and money constraints and personal conveniences. Their findings therefore, have made little impact on the economics of agriculture at the farm level as there are no provisions for a feedback mechanism.

Teachers of the Faculty of Agricultural Economics undertake only limited research because of financial constraints and multifarious non-academic activities they have to perform. They have been unable to give leadership in the field of socio-economic research in agriculture. Table 8 indicates the volume of research done by teachers of the five departments of the Faculty of Agricultural Economics at BAU. This work has been limited by lack of incentive, patronization, encouragement for research, and physical facilities, and the paucity of books and journals. Recently the trend has been reversed as some young teachers have earned good reputations for their research in and outside the country, but much has yet to be done.

The need for a specialized national institute for the promotion, guidance, planning, co-ordination, sponsoring and development of research in agricultural sciences in a young country like ours requires no emphasis. With the end of the War of Liberation, the Pakistan Agricultural Research Council—located in the then West Pakistan—ceased to exist in Bangladesh. However, the critical necessity and importance of such an institution did not dwindle. The Bangladesh Agricultural Research Council was established on 5 April 1973 with a limited technical staff. Its main objectives were to aid, promote, co-ordinate and undertake agricultural research in the country. BARC had five divisions: crops and forestry, livestock and fisheries, soils and irrigation, agricultural engineering, and agricultural economics and social science. A Technical Support Division was added in 1980.

BARC took up six new research schemes during 1974–75 in addition to assisting a few on-going projects. None of them were in agricultural economics.The Agricultural Economics and Social Science Division received a major stimulus for the promotion of research when Dr. Ekramul Ahsan was made its first Member-Director. The Division is firmly established through his hard labour for its onward march to more efficient management and organization, with a keen professional acumen, and profound enthusiasm for this discipline.

Before BARC, agricultural research was highly fragmented among many research institutes (Figure 2) with little national planning. The human and financial resources of Bangladesh were not co-ordinated properly to identify

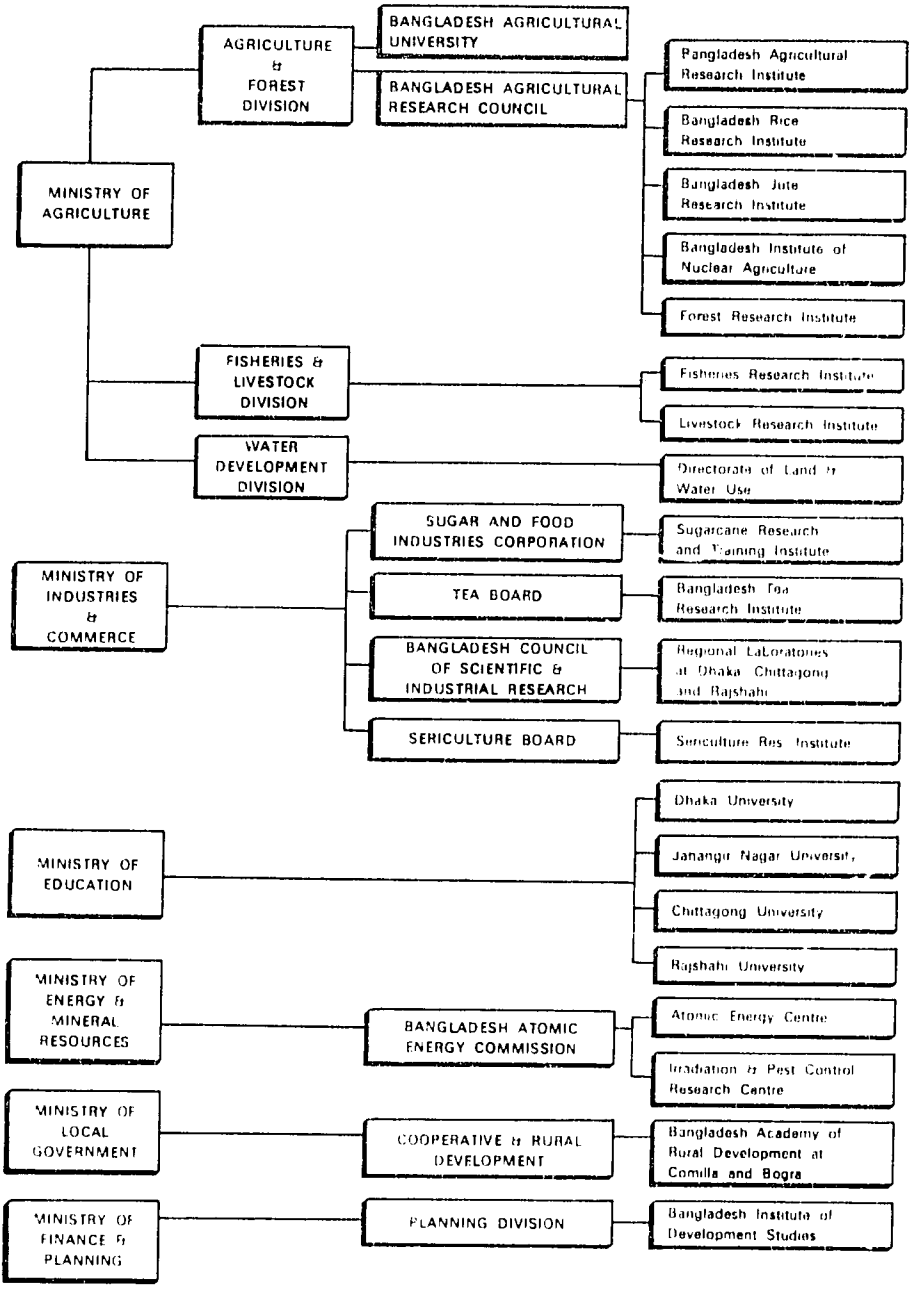

Figure 2. The location of institutes and research facilities of the national agricultural research system in 1983.

priority problems. The most important mission of BARC, therefore, is (1) to co-ordinate all agricultural research to focus on commodity and defined areas of programmes supported by strong problem-oriented research and training throughout the country, (2) co-operation with research institutes and the universities from within and outside the country, and (3) tapping the assistance from private industry and expatriate donors.

Among its main objectives, some of the most prominent are to (1) identify problems in various sectors of agriculture, (2) determine priorities and draw up long- and short-term research programmes, (3) scrutinize and approve research programmes and finance them for implementation, (4) evaluate and co-ordinate research programmes of different institutes, (5) prepare a master plan for the manpower requirements in agricultural research and select the required number of scientists and workers for training abroad, (6) guide and supervise the activities of research projects funded by BARC, (7) recommend research for the utilization of the results of research completed, (8) publish or otherwise disseminate technical and general information on the results of completed research, and (9) serve as the national organization and co-ordination agency for research in all aspects of agriculture and agriculture-related disciplines. With these ambitious objectives, BARC has been advancing slowly but steadily in the face of many difficulties and constraints.

BARC has emerged as the leading institution for co-ordination, support and promotion of agricultural research. Within its authority it has initiated key programmes to consolidate and strengthen the agricultural research system. It has prepared two *National Agricultural Research Plans*, identified farm problems, guided technical manpower and planning, developed and co-ordinated national and international donors, and assisted and established linkages among national and international research and allied organizations.

Even then, perhaps, BARC has not been able to fully exert its authority. A glance at Table 6 compares the authority BARC has with that of similar organizations in some of our neighbouring countries. Relations between BARC and the research centres and outreach stations are shown in Figure 3, indicating that a very small portion of the research in the country is co-ordinated by it. BARC has not been able to exert its full authority to bring all research under its co-ordination and management.

Many international agencies and organizations were working in Bangladesh in 1974-75. There was seemingly no co-ordination nor co-operation among them. Each one was following different practices in the preparation of schemes, funding and objectives. Many of them were indiscriminately introducing plant materials and other articles thereatening to the plants and crop production of the country. To overcome this, BARC quite rightly initiated measures requiring all foreign agencies to follow some determined guidelines. They were to process their activities through a BARC committee before submitting them to the Ministry of Agriculture. The committee also was responsible for co-ordination among the agencies to help execute their schemes. The outcome is yet to be known.

The *National Agricultural Research Plan of 1979* was the first of its kind

Table 6. Comparative authority of national agricultural research councils in Asia.

Country Organization	Position/Control	Authority
India		
Indian Council of Agricultural Research (ICAR)	1. Establish, coordinate and administer research activities in agriculture and animal husbandry.	All research institutes and projects are under the administration and financial control of ICAR.
	2. Receive funds from Government and appropriate them for the research institutes.	Institutes are constituent units of ICAR functioning as executing agencies in integrated national research system.
Indonesia		
Agency for Agricultural Research and Development (AARD)	Fund directly as well as approve all research programmes. Responsible also to plan, organize, monitor and evaluate all research programmes.	Five central research institutes with 92 experiment stations and 5 research centres are under its direct administrative control.
Philippines		
Philippines Council for Agricultural Resources Research and Development (PCARRD)	Planning, coordination, monitoring and budgeting of national research programmes.	It has funding and approval authority of all research institutes and projects.
Bangladesh		
Bangladesh Agricultural Research Council (BARC)	Planning, coordination, monitoring and evaluation but without authority.	No authority in the management of agricultural research system. The functions are not operative for want of authority.

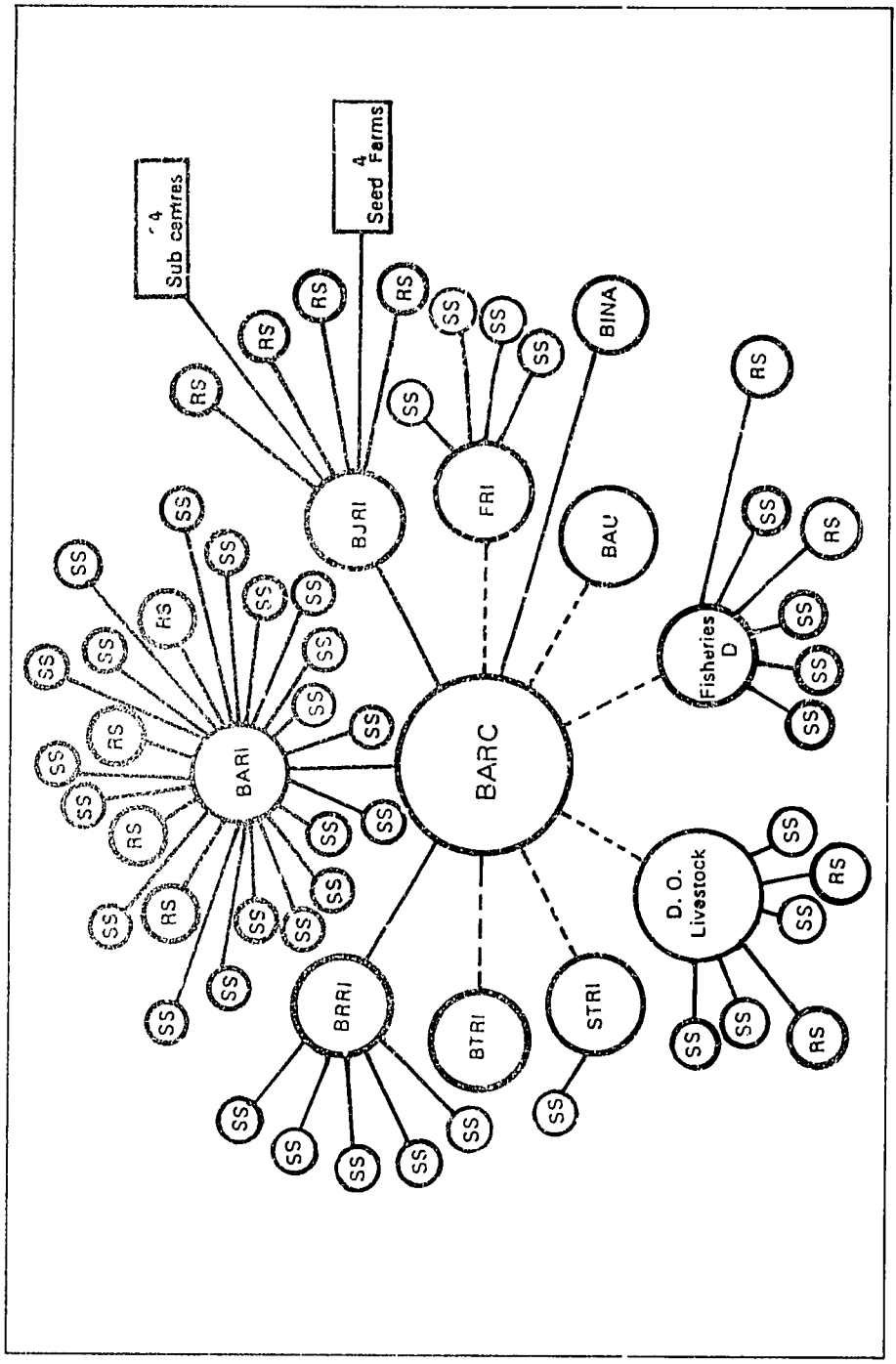

Figure 3. The relationship of the Bangladesh Agricultural Research Council with the research centres and the outreach stations (RS=regional research stations and SS= sub-stations).

prepared in Bangladesh. It provided a comprehensive assessment of needs and priorities of research for agricultural development in particular and economic growth in general. The plan identified the research areas for the next 10 to 15 years. A consolidated list of recommendations was prepared to help the Planning Commission identify priority areas for the SFYP. The proposed research strategy laid continued emphasis on strengthening the intensive HYV programmes. Preparing the NARP of 1979 was a great achievement of BARC, for it had tactfully used the expertise of the available scientists of the country.

Sizeable returns to investment in research were no longer a disputed matter. Emphasis was given to raising the budgetary allocation in research from the unexpectedly low figure of 0.1% of GPD to 0.7% in the SFYP, and then to at least 1.0% by the end of the plan. As the GDP of Bangladesh is one of the lowest in the world, even the raising of the figure to 1.0% is a meagre sum in absolute terms.

Another of the deficiencies of the national agricultural research system is the narrow outlook and one-sided approach to research in general and agricultural economics research in particular. A few years back I visited the Bangladesh Tea Research Institute at Srimangal and was told that there was no agricultural economist at that renowned institution nor any provision to have one. In the Bangladesh Jute Research Institute there was no agricultural economist until very recently: I do not know whether the situation has improved now in all these research centres of national importance. In other research stations either there are no provisions for economists and economic research or it is sadly neglected and no importance is given to this field.

The importance of agricultural economics and social science research was either neglected or pitiably undermined initially by BARC. Between 1974–75 and 1977–78 there were 37 research schemes but none was in the field of agricultural economics and social science (Table 7). Of the 179 schemes handled by BARC from 1974–75 through 1980–81, only 19 were in this discipline, which is only 10.6% of the total. One has to admit that the

Table 7. BARC sponsored and financed research projects, 1974–1981.

	Number of Research Schemes Handled by BARC	
Years	All schemes	Agricultural economics schemes
1974–75	16	0
1975–76	6	0
1976–77	15	0
1977–78	28	3
1978–79	39	4
1979–80	24	5
1980–81	51	7
Totals	179	19

Source: BARC annual reports.

Table 8. Research projects in agricultural economics and social sciences in Bangladesh, 1973–1983.

Organizations	Years										
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982–83	Total
Universities:											
University of Dhaka (BER)	NA	3	1	1	NA	2	NA	NA	NA	NA	7
Rajshahi University	5	1	4	11	4	5	4	11	8	6	59
University of Chittagong	0	7	14	20	8	6	6	13	9	17	100
Jahangir Nagar University	NA	NA	2	5	6	7	7	4	4	6	41
Bangladesh Agricultural University (SERB)	23	12	15	10	4	11	3	5	17	10	110
Sub-total	28	23	36	47	22	31	20	33	38	39	317
Institutes:											
Bangladesh Rice Research Institute	0	3	3	5	4	4	7	7	11	6	50
Bangladesh Institute of Development Studies	9	6	0	2	2	4	0	0	0	0	23
Bangladesh Academy of Rural Development	5	7	5	6	6	7	5	4	6	1	52
Others	0	0	0	0	0	0	1	13	4	23	41
Sub-total	14	16	8	13	12	15	13	24	21	30	166
Total	42	39	44	60	34	46	33	57	59	69	483

Sources: Bureau of Economic Research, University of Dhaka (Bureau publications only); Department of Economics, Rajshahi University; Department of Economics, University of Chittagong; annual reports of Jahangir Nagar University; Bureau of Socio-Economic Research and departments concerned, Bangladesh Agricultural University; all others from lists supplied to author.

socio-economic aspects of agricultural research have always received step-motherly treatment from different quarters in this country.

The author collected information from universities, research bureaus, and institutes engaged in research about the number of research schemes relating to agricultural economics they handled during the last ten years, completed or published. Table 8 gives a picture of the trend of research in these organizations. An estimated 483 research schemes in agricultural economics and social sciences were handled in all organizations. Of these, 317 or 65.6% were handled by the universities. Annual figures indicate there has not been any significant rise in the numbers of research schemes during the decade. Research in agricultural economics and social science in Bangladesh has been advancing slowly but very steadily with great promise and prospects for better days ahead.

Agricultural economics research in all the countries has different target audiences, such as academicians, students, politicians, statesmen, planners, the general public, and farmers themselves. Most research reports in our country are written in English. Very often they are highly mathematical with intricate and difficult theoretical biases and touches which only a few highly qualified academicians can comprehend. They often are not of practical use or importance so far as our farmers are concerned. Many research reports are not published, so do not reach their real target-farmers-in forms and shapes that are desired. Farmers are the most important target group, but in the majority of cases are tactfully kept completely apart from the scene. Academicians and researchers often undertake research schemes to satisfy their personal needs, neglecting the priority criteria defined in the *National Agricultural Research Plan.*

Research is a technical enterprise to be undertaken by highly trained and experienced personnel. Socio-economic research involves extensive and continuing field work in very far-flung areas. Transport and communication facilities in Bangladesh in most cases are absent or pitiably inadequate. The smooth and healthy development of an organized research system in the country is hampered by a lack of facilities, of laboratories and libraries, and by poor printing and publication facilities and computer services.

This is the computer age. If we lag in this trend we may be lost from the mainstream of development. Socio-economic data can now be very efficiently compiled, effectively prosessed, and meaningfully and accurately analyzed within a short time by a suitable computer. But, unfortunately, social scientists and researchers in this country have little access to computer services. BARC does not possess a computer to facilitate data processing. It does not own a press to print publications, an additional restriction to the development of research in the country. BARC should possess all the computer facilities and services, and make provision for suitable training of technical staff.

Development of a suitable research system depends on trained personnel. There are very few personnel trained in research techniques in agricultural economics and social science. One of the objectives of BARC is to train

personnel, but so far results in this field have been limited. There should be strengthened researchers' salaries, along with improved status, service conditions, and other benefits. These should be made more attractive commensurate with the scientists' qualifications and responsibilities. This will improve the research capability of the country through attracting the best talents to this profession. Low-level field workers in research schemes suffer from uncertainty of employment, periods of unemployment, lack of continuity of service, and absence of other benefits available to most regular employees. This seriously inhibits the smooth conduct of research work. BARC should give serious thought to this aspect of human and personnel problems.

The lack of attention and lesser importance given to agricultural economics and social science research has meant this discipline has not developed very much. On the other hand, the lack of co-ordination among researchers, universities and institutes has resulted in too much distortion of this research.

The past research activities in the socio-economic field were fragmented and disorganized; co-ordination about priority areas was unknown and the national interest was obscure. After the establishment of BARC, the tendency for distortion in agricultural economics research was arrested as the *National Agricultural Research Plan* was formulated. Research work supported by BARC was directed toward the national objectives and priority areas. Even then many priority areas of research could not be covered.

A national workshop to prepare the *National Agricultural Research Plan of 1984 – 1989* was held in Dhaka on 25 – 26 November 1983. The participants made intensive studies of the past and present status of agricultural economics research and made recommendations for the future objectives on a priority basis. The following priorities were recommended:

1. Evaluation of improved agrotechnology, developed indigenously or transferred from outside, and its assessment to determine its adaptability to the local conditions, with optimum utilization of irrigation capacities.
2. Assessment of direction of scientific research (i.e., development of HYV input package) in respect of field level conditions (i.e., resource constraints, availability of inputs, and so forth).
3. Impact of modern technology and linkage effects on income generation, local industry, rural industry, and rural infrastructure.

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ABSTRACTS

Crop Production Economics: The Case of Rabi Crops in Bangladesh

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The profitability of twelve winter season crops—wheat, maize, cheena, kaun, potato, sweet potato, mustard, groundnut, soybean, lentil, gram and mungbean—has been worked out in this paper by interviewing the farmers at different locations in Bangladesh. Among the four cereal crops, maize turned out to be the most profitable when the product is sold as green cob. But, its expansion is restricted by its limited market. Unless the consumers' demand for maize is increased and its alternative uses established, it is unlikely this crop will take any appreciable place in the farmers' cropping systems. Wheat was the next most profitable cereal crop with its gross margin at Tk. 2000/ha. Potato was found to be the most profitable crop with over Tk. 9000/ha as the gross margin. However, its high cost of production reduced its cost–benefit ratio to less than that of the sweet potato. Among the three oilseed crops, mustard was the most profitable crop with a higher gross margin and benefit–cost ratio. Lentil turned out to be the most profitable from among the three pulse crops with a high benefit–cost ratio and gross margin per hectare.

Dr. Elias is Chief Scientific Officer, Division of Agricultural Economics, BARI.

Government Policies on Agricultural Marketing and Pricing

KAZI MAZIRUDDIN

Ministry of Agriculture

The paper briefly describes the government policies on agricultural marketing and the pricing of agricultural crops.

The agricultural marketing policy of the government aims at the promotion of the private sector by providing all reasonable facilities, such as (1) withdrawal of price controls, (2) avoiding monopoly/barrier to entry, (3) removal of restrictions on trade, storage and movement of farm products, (4) improvement and expansion of market, storage and transportation facilities, and (5) provision of bank credits. The government also operates a public sector marketing system to protect the interests of farmers and consumers. These activities include the (1) procurement of farm commodities by government agencies at the announced support prices, (2) promotion of co-operative and group marketing, (3) provision of storage and credit facilities, (4) regulation of market charges and practices, and (5) provision of

market information by government agencies. All of these help in providing alternative marketing channels to the farmers and improving the efficiency of the marketing system.

The prices of all crops are determined by market forces. There is, however, some kind of price/buying support for (1) paddy and rice, (2) wheat, (3) jute, (4) sugarcane supplied to mills, (5) cigarette tobacco, and (6) upland cotton. The government announces the support prices of paddy/rice and wheat before or at sowing times. The Food Department makes purchases from any party at the support prices. Sugarcane also is purchased at an announced price by the sugar mills in the public sector. No support or statutory minimum price for jute is announced by the government. However, the government price support agencies and the jute mills in the public sector buy jute at a fair market price. This provides buying support for the jute crop. Minimum procurement prices of cigarette tobacco and upland cotton are announced by the government in consultation with the cigarette manufacturers and the textile mills. However, these prices cannot be enforced as there is no law/mechanism for the purpose.

Mr. Maziruddin is Director of Agricultural Marketing, Ministry of Agriculture.

Agricultural Credit System and Related Research Programmes in Bangladesh

M. LUTFOR RAHMAN

Bangladesh Agricultural University

The agricultural credit system of Bangladesh is characterized by the dominance of non-institutional credit sources. However, in recent years institutional sources have greatly increased their disbursements of agricultural credit. Various national and foreign non-governmental agencies also are extending credit to the rural poor. With government patronage, special rural credit projects and programmes have been undertaken for the landless, rural poor, and women. Nevertheless, the institutionalized sources cover only around 20% of all the credit needs of the farmers. The other 80% either is being met by non-institutionalized sources or left unsatisfied.

The growth of institutional research on finance in Bangladesh has mostly taken place under government patronage. The Bangladesh Agricultural Research Council has the responsibility for determining research priorities in the agricultural sector, guiding research efforts, and establishing co-ordination between research institutions. The Bangladesh Agricultural Research Institute, Bangladesh Rice Research Institute, Bangladesh Institute of Development Studies, Bangladesh Bank, Bangladesh Agricultural University, and various other universities are conducting research in the social sciences and agricultural economics. Only BAU has extensive research activity in agricultural finance. The Department of Agricultural Finance at

BAU has been exclusively involved in finance research for twenty years. Poor linkage among institutions, lack of funds, and shortage of trained manpower have affected finance research in the country.

Past research programmes dealt mostly with the institutional aspects of farm credit. However, information on non-institutional credit also was collected in many studies and showed the dominance of these sources. Most of the studies revealed inadequacies of the available institutional credit. Some micro-level studies examined the profitability of modern inputs and their effect on farmers' income and capital formation. Research studies also examined the efficacy of the special credit programmes for small farmers and the rural poor. Research programmes need to be initiated in financial risk management, liquidity management, and administrative operations of the lending institutions. Along with this, the operations of the non-institutional sources need to be studied more thoroughly to make policy suggestions for a better agricultural credit system in the country.

Dr. Rahman is Associate Professor and Head, Department of Agricultural Finance, BAU.

Part XIII
Communication of Agricultural Research

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KEYNOTE PAPER

Communication of Agricultural Research

S. G. MAHBOOB

Professor and Head
Department of Agricultural Extension and Teachers' Training
Bangladesh Agricultural University

INTRODUCTION

The oft-repeated statement that "Banglades an agricultural country" does not indicate the full importance of agricul ure to our people. In spite of the dominance of agriculture, Bangladesh has been facing chronic food shortages since the early 1950s due to the rapid growth of population and the low level of agricultural production. In Bangladesh, the rate of agricultural production is one of the lowest in the world. To improve this situ 'on, the farmers need to use suitable technology. Many new technologies have been obtained from other countries. Some of them have been adopted by the farmers "as is" while others are adapted to our needs. But for many of our farmers' problems, new methods and technologies must be found. Well-planned and painstaking research is therefore necessary.

MEANING OF COMMUNICATION OF AGRICULTURAL RESEARCH

Communication is often used to mean the transfer of ideas from one individual to another, but it is much more than this. Communication is the process by which two or more people exchange ideas, facts, feelings and impressions in ways that each gains a common understanding of the meaning, intent and use of the messages. It means the movement of knowledge to people in ways that they act on such knowledge to achieve some useful result. Action is implicit in communication. When the receiver does not respond to the message, no practical communication has taken place.

Successful communication requires a credible and skillful communicator sending a message through proper channels, effectively treated, to an appropriate audience that responds as desired. This summarizes the six basic elements of the communication process: communicator (or sender), message, channel, treatment, audience (or receiver), and audience response.

Bangladesh is a developing country. Several organizations are engaged in agricultural research to find suitable technologies and methods for agricultural development. These technologies will yield no benefit unless they are understood, accepted and used by the farmers. In fact, a considerable number of useful technologies are now available in the different fields of agriculture. Notable improvements can take place in Bangladesh agriculture when the available technologies are accepted and applied by the farmers. Proper communication of useful information emanating from agricultural research deserves priority consideration and action.

PRESENT ARRANGEMENT FOR COMUNICATION OF AGRICULTURAL RESEARCH

Research organizations disseminate their results in many ways. The Bangladesh Rice Research Institute provides training for extension workers, subject matter specialists, district training officers, and others. It arranges for the training of farmers through its sub-stations. The Bangladesh Agricultural Research Institute has introduced the Extension and Research Project (E&RP) in which researchers and extension personnel work together in communicating research results to farmers. The Sugarcane Research and Training Institute has an elaborate arrangement for training of farmers.

The major role for the dissemination of results of agricultural research is played by the extension organizations, namely the Department of Agricultural Extension, Directorate of Livestock Services, Directorate of Fisheries, and the Department of Forestry. The DAE has an elaborate staff of personnel at the national, division, district, thana and village levels. The directorates of livestock services and fisheries have staffs only up to the thana level, thus have difficulty in adequately reaching the rural people.

CONSTRAINTS FOR COMMUNICATION OF AGRICULTURAL RESEARCH

Farmers are not using all of the available, useful technologies. This is the result, in large part, of twelve major constraints which hinder the communication of agricultural research.

1. Too many channels for extension work with the farmers. A farmer in Bangladesh cultivates many field crops, maintains cows and other domestic animals and birds, may have a pond for rearing fish, and probably grows forest plants for fuel and timber. Therefore, he needs information and technologies on field crops, livestock, fishery, and forestry. It is most convenient for him to receive this from a single source. But the farmer faces considerable difficulties due to the many specialized organizations, each responsible for a different kind of information. According to the basic tenent of extension, there should be only one channel of extension to the farmers, otherwise they will be confused rather than informed.

2. Need for research studies to find solutions to the problems of disseminating the new technologies. Subject matter technologies are of little use without proper communication to the clientele. This depends on many factors, including the source of information; its usefulness; the communication methods; the needs; the interests and characteristics of the farmers; the norms and values in the social system; the rural leadership; local institutions for the planning, execution and evaluation of programmes; and the manner of extension work and its supervision and administration. There are many gaps in our knowledge of how these factors influence the communication of agricultural technology. There is need for research to fill these gaps, but there is little arrangement . such studies in our country.

Some research on agricultural extension is conducted in the Department of Agricultural Extension and Teachers' Training at the Bangladesh Agricultural University. BARI has subject matter divisions such as agronomy,

horticulture, and soil science, but has no arrangement for studying the problems of disseminating their findings. The same situation prevails in other agricultural research institutions in the country. However, there is precedent for such a research unit, such as the Division of Agricultural Extension Research that is established in the Indian Agricultural Research Institute.

3. **Lack of effective linkages between agricultural research and extension.** Extension field staff should be familiar with the latest recommended practices, hence the extension service needs close and continuing relations with the research system. This relationship also helps scientists to conduct problem-oriented research. The present linkage between agricultural extension and research is far from what it should be.

4. **Lack of appropriate techonology.** Researchers develop various kinds of technologies, but these fail to solve many of the pressing problems of the farmers and other rural people. This happens because scientists often times lack a proper awareness of the needs, interests and problems of the rural people.

5. **Lack of involvement of rural people in extension programmes.** Extension programmes are formulated at the national level, then handed down through the extension hierarchy to the rural people who have practically no involvement in the planning process. The result is that there is inadequate participation in the execution of the programmes.

6. **Lack of knowledge and skills of the extension workers.** The extension field workers and other personnel need adequate knowledge and skills in the different aspects of agriculture to successfully communicate research findings. Extension personnel have difficulty acquiring the latest research findings due to inadequate pre-service education, induction training, and in-service training. Improper supervision and guidance also limit their effectiveness.

7. **Lack of adequate support by subject matter specialists.** Extension workers need to furnish answers to the problems of the rural people. Support from subject matter specialists is essential in this process. But, subject matter specialists are only available to extension workers in the training and visits (T&V) areas, and many of these specialists have inadequate background and research experience to render effective assistance.

8. **Difficulty of communicating with large numbers of rural people.** The clientele of agricultural extension includes all the rural people. In an average union, there are 4,000 families–farmers, landless labourers, and others. It is difficult for one extension worker to serve so many people. As a result, more than one extension worker has been assigned to each union in the T&V areas. There is need for a careful study to find the optimum number of rural families to be served by a village extension worker.

9. **Financial handicap for the farmers.** Effective communication of agricultural research is supposed to result in the farmers' adoption of the relevant technologies. This often requires investments for implements and machinery, seeds, fertilizers, irrigation, chemicals, and other inputs. It is difficult for rural people to make these investments for they tend to lack personal funds and a good system of agricultural credit is also not available.

10. Lack of an adequate marketing and distribution system. The communication of agricultural research recommendations to farmers is to help them increase production. On many occasions, farmers do not get adequate prices for their produce in relation to the costs of production This is due to poor arrangements for marketing and distribution. The result is that farmers lack the incentive to use the new technologies.

11. Inadequate supply of inputs. The adoption of improved practices by the farmers is dependent on their use of different commodities and services. Often these are available in inadequate quantities or not at all. Sometimes farmers have to pay high prices and to travel long distances to procure them.

12. Lack of extension work with rural women and youth. Women constitute one-half of the population. In addition to housekeeping, rural women actively participate in transplanting, weeding, harvesting, threshing, kitchen gardening, storage of agricultural products, feeding of animals, poultry rearing, and other agricultural activities. Boys and girls also help their parents in many of those activities. The efficiency of the rural women and youth can be greatly increased, but there is no arrangement for extension work to communicate the improved methods and practices to them.

SUGGESTIONS FOR IMPROVEMENT OF COMMUNICATION OF AGRICULTURAL RESEARCH

The following are suggestions to minimize the constraints that limit the effective communication of agricultural research:

1. Agricultural extension work with the rural people should be conducted through a single, co-ordinated channel which disseminates the new technologies in crop production, livestock, fishery, forestry, and other related areas.

2. Research should be conducted on communication and other aspects of agricultural extension:

a. An agricultural extension division should be formed at BARI to learn the most effective ways to communicate research findings through agricultural extension, such as: motivation of the farmers; proper use of extension methods; adoption of innovations; local leadership; rural institutions for planning, execution and evaluation of extension programmes; development of rural youth; and procedures for supervision and administration of extension work.

b. BARI and other agricultural research institutions should conduct studies on the different aspects of agricultural extension.

c. An extension research cell should be established in the Department of Agricultural Extension and Teachers' Training at BAU.

d. BARC should have an agricultural extension section to encourage and co-ordinate the dissemination of research information.

3. Effective linkage should be established between agricultural research and extension:

a. A joint research and extension committee should be created to devise ways for more effective liaison between researchers and extension workers.

b. Research stations should conduct regular, periodic visits of extension staffs to their facilities.

c. Research stations should distribute information news sheets to extension personnel which give current happenings, results and recommendations. Even more effective would be news sheets produced jointly by research and extension organizations, with information provided by both.

4. Research projects should be conducted to solve the priority needs, interests and problems of the farmers.

5. Local institutions should be strengthened for planning, execution and evaluation of extension programmes. This will encourage the involvement of the rural people in agricultural development and thus ensure proper communication of useful technologies.

6. Pre-service education should equip extension personnel with the knowledge and skills needed to fulfill their tremendous responsibilities. They should receive adequate induction training and in-service training. Intelligent and careful supervision is necessary to help the extension workers to do their jobs well.

7. All extension field workers should have the support of capable subject matter specialists who have adequate research experience.

8. There should be research to determine the optimum number of rural families to be served by one field extension worker.

9. There should be a sound agricultural credit system to ensure adequate and timely financial support to the rural people so that they can adopt the useful agricultural technologies.

10. There should be a good system of marketing and distribution of agricultural products to ensure reasonable prices for the farmers' products, and thus provide them an incentive to use the new technologies.

11. The supply of production inputs needed to adopt the new technologies should be readily available from convenient sources at fair prices.

12. There should be regular extension work with the rural women and youth to facilitate communication with them of the new technologies.

ABSTRACTS

A Historical Review of Approaches for the Communication of Innovations in Agricultural and Rural Development in Bangladesh

ABDUL HALIM

Bangladesh Agricultural University

This paper is a descriptive review of the different institutional approaches and programmes undertaken for agricultural and rural development in Bangladesh by governments since the British period.

The first section describes the institutions that were used as vehicles for the diffusion of agricultural information for rural development starting in 1885 with the Local Self Government Act. The paper traces the implementation of various nation-building departments created to disseminate information for the development of agricultural education, health, co-operatives and related activities. Some individuals, including Christian missionaries, have initiated developmental programmes since the 1920s. The government made several determined efforts in the 1930s including the establishment in Bengal in 1938 of a Rural Reconstruction Department. This was abolished in 1944 and its activities integrated into the civil administration.

After partition, each governmental agency approached the problems of the villages separately. The Village–Agricultural and Industrial Programme (V–AID) was launched in 1952 to increase agricultural production and for total village development. It failed because it could not obtain adequate co-operation from supporting departments and specialists. The Comilla Approach evolved in the early 1960s and was multiplied in the following decade through the Integrated Rural Development Programme (now the Bangladesh Rural Development Board). Several other governmental and non-governmental programmes were started in agricultural and rural development following independence.

The trend in the 1980s is the decentralization of powers and the renaming of the thanas as upazilas. The administrative hierarchies for development programmes have been minimized and provisions ensured for local-level participation.

The first section describes the institutions that were used as vehicles for increasing agricultural production which began with the recommendations of the Famine Commission of 1864–68. Livestock research started as early as 1818. Two agricultural schools were established in 1922 and the East Bengal Agricultural Institute was established in 1939. A proliferation of agricultural programmes started in the 1960s under several ministries. One of the most important in increasing crop production and transferring technologies to the farmers is the Department of Agricultural Extension. The findings of crop research institutes are mostly disseminated through this department. Until

recently, traditional or indigenous approaches were followed, but in 1978 the Training and Visits System (T&V) was started in many districts. The Bangladesh Agricultural Research Institute has introduced an experimental project, Extension and Research Project (E&RP), for transferring technology from the research stations to the farmers.

The research conducted in the field of agricultural extension shows that several personal, socio-cultural, institutional and psychological factors affect the diffusion of innovations to farmers. The general tendency is for the better educated, younger, owner–cultivators and rich farmers to adopt innovations earlier than others. Farmers with the characteristics of cosmopoliteness, leadership ability and high organizational participation usually adopt innovations earlier. The adoption process is accelerated by exposure of farmers to different communication media—radio and written materials—and their participation in training programmes, tours, meetings, and demonstrations. Micro- and macro-level studies on different aspects of technology generation, adaptation and implementation need to be undertaken by BAU, BARI, and other research organizations. BARI also should try to develop appropriate regional-level extension approaches for diffusion of agricultural innovations that are appropriate for specific socio-cultural and agroclimatic conditions. To perform this research on extension methodologies may require the creation of an agricultural division in BARI.

Dr. Halim is Director, Graduate Training Institute, BAU.

Information Management in Agricultural Research in Bangladesh

MOHAMMAD ZAHIRUL ISLAM

Bangladesh Agricultural Research Council

The development of agricultural research in Bangladesh has not been accompanied by the setting up of a national agricultural information infrastructure and services. This paper attempts to review management issues related to the development of agricultural library, information and documentation services in the research environment. It identifies the main obstacles to the flow of agricultural information and outlines guiding principles for action at the national level. It also gives a brief resume of the activities of the National Agricultural Library and Documentation Centre of the Bangladesh Agricultural Research Council to establish a national agricultural information system.

Mr. Islam is Principal Scientific Officer (In-Charge), National Agricultural Library and Documentation Centre, BARC.

Communication Techniques in Nutrition Education to Rural Women

JINNAT ARA BEGUM

Bangladesh Agricultural University

The significance of communication techniques in nutrition education was demonstrated in the training of rural women at the Bangladesh Agricultural University. Thirty illiterate rural women from ten villages of Bhabokhali Union, Mymensingh, were trained for two weeks to disseminate knowledge in nutrition among rural people. Oral, visual and field demonstrations were effective in training the rural women. Teaching aids included selected posters, charts, bulletins and clay models. Emphasis was given on the nutritional problems of the villages, and deficiency diseases, their causes, effects, prevention and curative steps. Visual demonstrations were conducted of food groups and their functions in human nutrition and balanced diets, along with practical demonstrations on food production, cooking demonstrations of nutritious foods, and the preparation of local weaning foods and supplementary foods. The evaluation of the training showed the performance of the women to be 40% excellent, 30% good, 27% average and only 3% poor. It was observed that the training design, experience of the trainers, readiness of the trainees, and the selection and use of suitable communication techniques contributed to the successful implementation of the training programme. However, further research is needed to develop more effective and practical teaching and communication techniques in nutrition education to rural people.

Miss Jinnat Ara Begum is Head, Department of Food Technology and Rural Industries, BAU.

Factors Determining Communication Behaviour of Low Income Farmers

BIRENDRA LAL ROY AND A. M. ANWARUL KARIM

Bangladesh Agricultural University

This investigation was conducted in 1980 in three villages of the Agrivarsity Extension Project in Mymensingh District to study the farmers' communication behaviour in gaining information about the recommendations of balanced doses of fertilizer for cultivating transplanted aman rice. The respondents were farmers with small incomes who owned two acres or less of land, excluding homestead areas.

The responding farmers generally used more than one communication medium to secure the desired information, with the selections varying due to

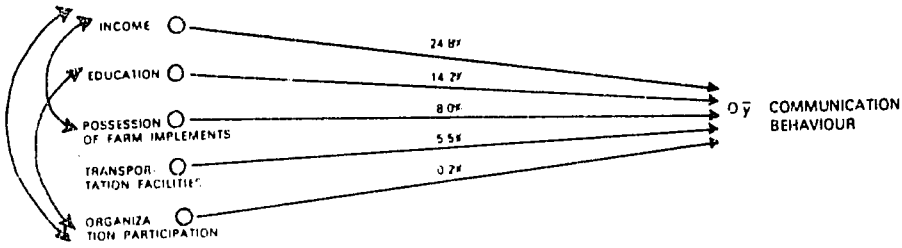

Figure 1. Model of the contributions of five independent variables to the communication behaviour of low income farmers.

socio-economic factors. Discussions with friends and neighbours and listening to the radio farm programmes were widely used. They gained a moderate amount of information by attending agricultural exhibitions and lectures in the field. They also received some required information from the farmers' training centres, method demonstrations, and farm visits by extension agents. Result demonstrations, group meetings, newspapers and bulletins were used by only a few of the farmers. The farm magazine, *Krishikatha*, and leaflets had no significant role in communicating the fertilizer recommendations to these low income farmers.

Five of seven selected variables influenced these low income farmers in their use of different communication media: income, education, possession of farm implements, access to transportation facilities, and organizational participation. The five independent variables accounted for nearly 53% of the total explained variance. (See Figure 1.) The farmers' ages and land ownership did not influence their communication media selections.

It may be concluded that farmers with low incomes who are better educated, economically solvent, and possess a required number of farm implements have a higher tendency to participate in social organizations. Such farmers are in an advantageous position to use a maximum number of communication media for their socio-economic improvement. On the basis of these findings it can be predicted that the communication behaviour of farmers with low incomes in the Agrivarsity Extension Project area can be improved by increasing the levels of income, education, social participation, and possession of farm implements, and by better access to transportation facilities.

Mr. Lal Roy was an M.Sc. scholar and Dr. Karim is Associate Professor, Department of Agricultural Extension, BAU.

Appendices

Message

I am happy to learn that the Bangladesh Agricultural Research Council, the apex agricultural research organisation, is celebrating its tenth anniversary with the main objective of reviewing its achievements. Despite the complexity and magnitude of the task of producing food for millions of people from our limited land area, the contributions of agricultural scientists towards increasing the productivity of land have been very encouraging.

Organised agricultural research has been a profitable investment. The present tempo of rapid production has to be kept up so that food and population equation remains in a positive balance. Agricultural scientists must at the same time bear in mind that the technology generated by them should be compatible with the resource base of their clientele thousands of small farmers. They must, therefore, begin to search for ways to raise production on a large number of small holdings. Their efforts will be judged by these end-users for whom farm production and employment generation are synonymous. The very nature of our agriculture calls for an integrated approach in which many commodity and noncommodity areas interact and overlap. Therefore, to make the best use of our limited resources available with several research institutions, the key role of BARC becomes critically important. It should continue to provide leadership, mobilise resources and ensure high returns on the investment.

I take this opportunity to congratulate the agricultural scientists of our country for what they have already achieved and wish them continued success in their endeavours to make our country self-reliant in food and other agricultural produce. On this auspicious occasion, I wish BARC and its constituent institutions every success.

Lt. Gen. H.M. Ershad
President
&
Chief Martial Law Administrator
People's Republic of Bangladesh

APPENDIX I

Congratulatory Messages

The national agricultural research system of Bangladesh is a part of the world-wide network of agricultural scientists at international and national agricultural research centres and supporting organizations. Dozens of agricultural research leaders sent greetings to BARC on the occasion of its ten year anniversary and the National Symposium on Agricultural Research. These messages commended the scientists of Bangladesh for their many achievements which benefit the people of this country.

THE INTERNATIONAL RICE RESEARCH INSTITUTE

A dynamic agricultural system is the first prerequisite for stimulating and sustaining a dynamic production system. The Bangladesh Agricultural Research Center and the various institutes associated with it have provided the research support that is necessary to improve the productivity and profitability of different farming systems in the country.

Poverty persists under conditions where production potential remains untapped, and the human resource is underutilised. A famine of jobs leading to a famine of purchasing power, more than scarcity of food in the market, is a major cause of undernutrition in many developing countries. Unfortunately, inadequate financial resources and lack of infrastructure including trained personnel hampers progress at the desired pace. Also, when land use shifts from just meeting the needs of the farming family to one catering to both home and external markets, assured and remunerative marketing holds the key to sustaining farmers' interest in producing more.

Agriculture has to provide not only the food requirements of the people but also has to be a major source of generating income and employment. The scientists of the Bangladesh Agricultural Research Council can look back with pride and satisfaction on their contributions during the last 10 years. I have little doubt in the years to come the BARC will enable the country to meet new challenges and help to usher an era of self-reliance in the farm sector.

We at the International Rice Research Institute are fortunate to have the opportunity to work closely with the scientists of the Bangladesh Rice Research Institute and the BARC in the common task of elevating and stabilizing rice production. We shall look forward to a further strengthening of these bonds in the years to come. On behalf of my colleagues and myself, I send our congratulations and greetings to Dr.Kazi M. Badruddoza and all the scientists and staff members of BARC.

M S Swaminathan

12.1.83

TELEX

PLEASE ACCEPT CIMMYT'S HEARTIEST CONGRATULATIONS FOR COMPLETING 10 MOST SUCCESSFUL YEARS AND OUR BEST WISHES FOR EVEN GREATER ACHIEVEMENTS DURING THE COMING DECADE. SINCERELY.

DECEMBER 5, 1983

R.D. HAVENER, DIRECTOR GENERAL
CIMMYT
(International Maize and Wheat Improvement Center)

CABLE

WISH YOU HAPPY 10TH ANNIVERSARY CONTINUED SUCCESS FOR PROGRESS FOR FARMERS AND WORLD AGRICULTURE IN GENERAL. REGARDS.

12 DECEMBER 1983

OJIGBO, DEPUTY DIRECTOR GENERAL
IITA
(International Institute of Tropical Agriculture)

TELEX

THANKS YOUR INVITATION FOR BARC TENTH ANNIVERSARY. REGRET DUE PRIOR COMMITMENTS UNABLE JOIN YOU ON THIS HAPPY OCCASION. PLEASE ACCEPT OUR CONGRATULATIONS AND BEST WISHES FOR THE FUTURE. REGARDS.

21 DECEMBER 1983

SWINDALE, DIRECTOR GENERAL
ICRISAT
(International Crops Research Institute for the Semi-Arid Tropics)

CABLE

DEEPLY REGRET MY TRAVEL SCHEDULE DOES NOT ALLOW ME TO ATTEND TENTH ANNIVERSARY CELEBRATION AT BARC. HOWEVER ON THIS IMPORTANT OCCASION PLEASE ACCEPT MY PERSONAL CONGRATULATIONS ALONG WITH THOSE OF ALL IDRC STAFF WHO HAVE HAD THE PLEASURE OF WORKING WITH YOUR COLLEAGUES. BARC IS THE KEY TO THE IMPLEMENTATION OF A SYSTEMATIC APPROACH TO THE PLANNING, COORDINATION, DIRECTION AND CONDUCT OF AGRICULTURAL RESEARCH IN BANGLADESH. BARCS ULTIMATE OBJECTIVE OF A STRONG AGRICULTURAL SYSTEM IN BANGLADESH IS MUCH CLOSER TODAY THAN A MERE 10 YEARS AGO. WITH WARMEST WISHES.

12 DECEMBER 1983

JINGAI HANCHANLASH
INTERNATIONAL DEVELOPMENT
RESEARCH CENTRE, SINGAPORE

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

1776 Massachusetts Avenue N.W.
Washington D.C. 20036 U.S.A.
(202) 862-5600
Telex 440054
Cable IFPRI

January 6, 1984

Dr. Kazi M. Badruddoza
Executive Vice-Chairman
Bangladesh Agricultural Research Council
Farm Gate, New Airport Road
Dacca 15, Bangladesh

Dear Dr. Badruddoza:

I do want to send my very warmest congratulations to the Bangladesh Agricultural Research Council on the occasion of the 10th Anniversary of the establishment of the Council. Bangladesh has been a trailblazer in the development of integrated agricultural research systems, certainly among developing countries, and, I would say, in the much larger world as well.

Agriculture is of course essential to economic development, and we now fully recognize that the key to agricultural growth is efficiency increasing technological change. The tasks of developing appropriate agricultural research institutions in developing countries, utilizing foreign assistance contributions effectively for that purpose, and allocating a totality of resources efficiently and effectively are all difficult. The Bangladesh Agricultural Research Council has made extraordinary progress in the very short period of 10 years. Not only can Bangladesh as a nation be proud of this achievement, but many countries can learn important lessons from the processes at work in Bangladesh and thereby speed up their processes.

Having observed the development of agricultural research in Bangladesh over a considerable period of time, I want to say again how important that work is and to congratulate you in your particular role in this whole set of processes.

With very best personal regards.

Sincerely yours,

John W. Mellor

IFDC INTERNATIONAL FERTILIZER DEVELOPMENT CENTER . . . MUSCLE SHOALS, ALABAMA 35660
P.O. BOX 2040 . . . 205-381-6600
TWX-810-731-3970 IFDEC MCHL

November 22, 1983

Dr. Kazi M. Badruddoza
Executive Vice-Chairman
Bangladesh Agricultural
Research Council
Farm Gate, New Airport Road
Dhaka-15
BANGLADESH

Dear Dr. Badruddoza:

On behalf of IFDC, it is my pleasure to extend to the Bangladesh Agricultural Research Council warmest greetings on the celebration of the tenth anniversary of its establishment. On this notable occasion, it is fitting to offer well deserved congratulations to the directors, officers, and staff of BARC and its member institutions for their diligent efforts and valued contributions to the futherance of agriculture's advancement in Bangladesh. BARC appears to have indeed met the challenges of the agricultural research leadership role envisaged for it by its founding sponsors 10 years ago.

IFDC has been privileged to work closely with BARC for several years most notably in the studies related to agricultural production, fertilizer use and equity considerations, and the efficiency of fertilizer use in Bangladesh. The dedication of purpose, cooperation, and achievement of the staffs of BARC and its member organizations in these joint endeavors is sincerely appreciated and highly commended.

Again, congratulations on a decade of accomplishment in providing exemplary coordination and leadership to the national agricultural research system. Please accept our best wishes for continued success in the years ahead.

Sincerely yours,

Donald L. McCune
Managing Director

THE INTERNATIONAL POTATO CENTER (CIP)
P.O Box 5969 Lima Peru Cables CIPAPA Lima
Telex 25672 PE Telephones 354920 - 354364

L-760-CIP-83

Lima, November 24th, 1983

Dr. Kazi M. Badruddoza
Executive Vice-Chairman
Bangladesh Agricultural
Research Council
Farm Gate, New Airport Road
Dacca-15, Bangladesh.-

Dear Dr. Badruddoza,

Thank you for your letter of October 31st, 1983, concerning the first National Symposium on Agricultural Research to mark the tenth anniversary of the establishment of BARC. We are extremely pleased that you are celebrating this occasion in such a suitable manner and look forward to receiving a copy of the commemorative book when it appears. In the five years that CIP has been collaborating with BARC, we have witnessed a considerable impact of your organization in the agricultural research in Bangladesh. In our own crop, potatoes, this has been particularly noticeable. I wish on behalf of all our staff to offer our congratulations to BARC and yourself as its Executive Vice-Chairman for a program of work well conceived and efficiently executed.

Concerning the invitation to attend the Symposium, you are probably aware that until December 15th we will be fully occupied with our own Annual Meeting and Internal Review. Immediately after, there commence certain formal annual functions in connection with the coming Xmas. holiday season for all the Lima based staff, at which, our Director level staff should be present. It is also a time of the year devoted to family reunions. Thus, I am sure you will understand if our staff are unable to travel to this important symposium which you are holding. Please accept my regiets.

Yours sincerely,

Richard L. Sawyer
Director General

The International Potato Center (CIP) is a scientific institution, autonomous and non-profit making, established by means of an agreement with the Government of Peru with the purpose of developing and disseminating knowledge for grater utilization of the potato as a basic food. International funding sources for technical assistance in agriculture are financing the Center

CABLE

I AM DELIGHTED TO RECEIVE YOUR LETTER AND TELEX CONCERNING THE FIRST NATIONAL SYMPOSIUM ON AGRICULTURAL RESEARCH IN BANGLADESH. UNFORTUNATELY, IT IS NOT POSSIBLE FOR ME TO ATTEND PERSONALLY, BUT I DO WISH TO SEND CONGRATULATIONS ON THE 10TH ANNIVERSARY OF THE ESTABLISHMENT OF THE BANGLADESH AGRICULTURAL RESEARCH COUNCIL AND BEST WISHES FOR CONTINUED SUCCESS IN THE FUTURE.

A STRONG NATIONAL AGRICULTURAL RESEARCH SYSTEM IS THE KEY TO THE AGRICULTURAL SUCCESS OF A DEVELOPING COUNTRY. IT IS GRATIFYING TO TAKE SPECIAL NOTE OF THE COMMITMENT BANGLADESH IS MAKING TO ITS AGRICULTURAL RESEARCH ESTABLISHMENT.

WE COMMEND YOU IN THIS EFFORT AND WISH YOU EVERY SUCCESS.

DECEMBER 5, 1983

JOAN WALLANCE, ADMINISTRATOR
OFFICE OF INTERNATIONAL
COOPERATION AND DEVELOPMENT
U.S. DEPARTMENT OF AGRICULTURE

CABLE

UNABLE TO ATTEND TENTH ANNIVERSARY OF BANGLADESH AGRICULTURAL RESEARCH COUNCIL. CONGRATULATIONS FOR TEN VERY SUCCESSFUL YEARS AND BEST WISHES FOR THE YEARS AHEAD.

DECEMBER 18, 1983

DR. ANSON R. BERTRAND
DIRECTOR, OFFICE OF AGRICULTURE
BUREAU FOR SCIENCE AND TECHNOLOGY
U.S. AGENCY FOR INTERNATIONAL
DEVELOPMENT

CABLE

SINCERELY REGRET THAT I AM UNABLE TO ATTEND OBSERVANCE OF BANGLADESH AGRICULTURAL RESEARCH COUNCIL ON DECEMBER 22. MAY I OFFER YOU BEST WISHES ON THIS AUSPICIOUS OCCASION

IT IS QUITE OBVIOUS THAT BARC HAS SHOWN EXCEPTIONAL LEADERSHIP OVER THE PAST TEN YEARS IN COORDINATING THE NATIONAL AGRICULTURAL RESEARCH SYSTEM IN BANGLADESH. MY HEARTFELT CONGRATULATIONS ON SUCCESSFULLY ACHIEVING THIS MOMENTUS LANDMARK.

T.B. KINNEY, ADMINISTRATOR
AGRICULTURAL RESEARCH SERVICE
U.S. DEPARTMENT OF AGRICULTURE

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DEC 2 1983

SENIOR ASSISTANT ADMINISTRATOR

Dr. Kazi M. Badruddoza
Executive Vice-Chairman
Bangladesh Agricultural Research Council
Farm Gate, New Airport Road
Dacca-15, Bangladesh

Dear Dr. Badruddoza:

Thank you for your kind invitation to attend the tenth anniversary celebration of BARC. Unfortunately, I will be unable to attend, but I am sure our U.S. A.I.D. Mission in Dacca will represent the Agency for International Development.

I congratulate BARC for their successful years of effective coordination and leadership of the national research system in Bangladesh. You can take much pride in the tremendous progress in agricultural production in Bangladesh during the years since the Council was established.

The Government of Bangladesh is to be congratulated for recognizing that research is the foundation upon which progress is built and for establishing the Agricultural Research Council to provide leadership for this vital activity.

I am honored that you are reserving for me a copy of BARC's new book, Agricultural Research in Bangladesh. I will look forward to reading it and having it in our library.

Best wishes for a successful tenth anniversary celebration and may BARC provide many more years of successful leadership to agricultural research in Bangladesh.

Sincerely,

M. C. Brady
Senior Assistant Administrator
for Science and Technology

We send our warm congratulations on this important milestone in the BARC history and wish you a successful celebration and symposium.

23 November 1983 John L. Nickel
Director General
CIAT: International Center for Tropical Agriculture

ايكاردا
ICARDA
المركز الدولي للبحوث الزراعية في المناطق الجافة
International Center for Agricultural Research in the Dry Areas

Mr. Chairman
Distinguished Participants

I am sorry to be unable to attend the first National Symposium on Agricultural Research which marks the 10th anniversary of the establishment of the Bangladesh Agricultural Research Council. This important occasion, which will be shared by so many distinguished scientists from Bangladesh and from many other parts of the world, is clearly a milestone of great significance in the development of Agricultural Research in your great country.

ICARDA is a young organization, only little over half the age of BARC. We focus primarily on the problems of rainfed agriculture in regions of the world where total moisture supply limits production and where precipitation occurs mainly in the winter months. We target our main research on the crop and livestock systems prevalent in North Africa and West Asia. Built around this central research theme, the Consultative Group on International Agricultural Research (CGIAR) has also charged ICARDA with broader international responsibilities for certain commodities, in particular barley, faba beans and lentils. It is mainly in connection with these crops that contacts between ICARDA and BARC have been based in the past. For example in 1983 we have sent twelve different cereal and food legume nurseries to collaborating scientists in Bangladesh.

ICARDA places great importance on the study of cropping and livestock systems in its scientific activities and we are actively engaged in developing research methodologies which enable a holistic research approch to be taken to the problems facing poor farmers. It is hoped that such methodologies will be of value to researchers not only within the eco-graphic zone on which ICARDA concentrates but beyond as well.

A second important area of contact between ICARDA and Bangladesh in the past has been in through visits, training and communications. Although only a few scientists from Bangladesh have so far received training at ICARDA, this number is expected to increase over the years as the training opportunities offered by ICARDA are developed and expanded.

Our publications and reports are routinely distributed to many Bangladeshi institutions and scientists, and we sincerely hope that these provide relevant and useful information and data.

.../2

Tlx: 331206 331208 331263 P.O. Box 5466, Aleppo, Syria

ICARDA does not work in isolation but seeks to support and collaborate with national agricultural research organizations having similar objectives to our own. We firmly believe that agricultural development requires a solid foundation of scientific research at the national and local level. Wherever possible ICARDA aims to help strengthen such research.

The areas which the focus of ICARDA's activities overlap with those of BARC are relatively few. Nevertheless we feel that closer ties between our organizations will be to the ultimate benefit of both and it is my earnest hope that we, ICARDA, can be of service to you in your noble endeavour to increase food production in Bangladesh and contribute towards relieving rural poverty.

On the occasion of the tenth anniversary of BARC I send you my greetings, and on behalf of ICARDA wish you every success in your deliberations and in your future endeavours. We, in our own small way, as part of the international fellowship of science, pledge you our support.

Please accept, distinguished colleagues, this expression of my highest regard and good wishes.

Sincerely yours

Mohamed A. Nour
Director General

CABLE

MY CONGRATULATIONS AND WARMEST BEST WISHES FOR YOUR ANNIVERSARY AND SYMPOSIUM. AT ILCA WE HAVE WATCHED THE GROWTH OF BARC OVER RECENT YEARS WITH GREAT APPRECIATION AND ADMIRATION FOR THE EFFORTS APPLIED AND THE IMPORTANT RESULTS ACHIEVED. I HOPE THAT OUR TWO INSTITUTIONS MAY DRAW MORE CLOSELY TOGETHER IN THE YEARS TO COME. WITH VERY BEST WISHES FOR A MOST PRODUCTIVE FUTURE FOR BARC AND ALL ITS STAFF.

PETER BRUMBY
DIRECTOR GENERAL
INTERNATIONAL LIVESTOCK CENTER FOR AFRICA

INSTITUT PENYELIDIKAN DAN KEMAJUAN PERTANIAN MALAYSIA
MALAYSIAN AGRICULTURAL RESEARCH AND DEVELOPMENT INSTITUTE
P.O. Box 12301, G.P.O., Kuala Lumpur 01-02, Malaysia. Telex: MA 37115

November 17, 1983

On behalf of the Malaysian Agricultural Research and Development Institute I wish to take this opportunity to extend our warmest regards and congratulations to you on the occasion of the tenth anniversary of the establishment of Bangladesh Agricultural Research Council. Although ten years is a relatively short period of time for a research establishment like BARC to be fully operational and effective, from what I have been able to observe in my last visit to your institute and from reading your annual reports I must say that I am very impressed indeed with the progress of your organisation that has been achieved up to date. I wish you continued success in the future in your endeavour to promote agricultural development as well as to uplift the living standards of the farmers in your country. I am sure that BARC's contribution towards the development of your country and nation will be well recognised and appreciated both nationally and internationally.

Congratulations once again.

Yours sincerely,

(DR. MOHD YUSOF BIN HASHIM)
Director General
MARDI

BERKHIDMAT UNTUK NEGARA

SERDANG, SELANGOR TELEPHONE 03 [illegible] 12 TELEGRAM "MARDI"

بسم الله الرحمن الرحيم

Telephone : 25966
Telegrams : AGRESCOUNCIL
Telex No. 5604 PARC PK
D. O. No. PS/Chairman/83/9491.

PAKISTAN AGRICULTURAL RESEARCH COUNCIL
1-13, Almarkaz, F-7 Post Box 1031, ISLAMABAD

Dr. Amir Muhammed
Chairman

DATED 27th Nov. 1983.

MESSAGE

I am glad to know that Bangladesh Agricultural Research Council is celebrating 10th Anniversary of its establishment. The coming into existence of BARC in 1973 coincided with the growing recognition by the national as well as international community of leaders of the importance of organized agricultural research for development, particularly in the third world. We have watched the progress of BARC with keen interest and it is my great pleasure to say that this organization has done an admirable job not only in developing and implementing a National Agricultural Research Plan in Bangladesh but also in coordinating efforts of other institutes and scientists to achieve greater agricultural production in the land of golden fibre. BARC has, under the dynamic and competent leadership of Dr. Kazi M.Badruddoza, successfully overcome the initial organizational and coordinational difficulties and is now set for a major thrust for greater achievements in research. The national agricultural research needs have been scientifically identified and the strengthening of the system by way of effective manpower planning and training, regional and international cooperation and meaningful external assistance has been achieved. There is a mark impact of the policies pursued by BARC on the agricultural development in Bangladesh.

I take this opportunity to congratulate BARC on its past achievements and wish it continued success in carrying out its mandate in future. BARC, as a member of the community of International Agricultural Research System, will continue to attract support and collaboration from its Pakistani counterpart in multilateral as well as bilateral areas of interest.

Amir Muhammed

(Amir Muhammed)

iads

ROSSLYN PLAZA, 1611 N. KENT ST., ARLINGTON, VIRGINIA 22209 USA

INTERNATIONAL AGRICULTURAL DEVELOPMENT SERVICE
SERVICE INTERNATIONAL POUR LE DÉVELOPPEMENT AGRICOLE
SERVICIO INTERNACIONAL PARA EL DESARROLLO AGROPECUARIO

December 19, 1983

Dr. Kazi M. Badruddoza
Executive Chairman
BARC Complex
Farm Gate
Dhaka 15
BANGLADESH

Dear Dr. Badruddoza:

It is a pleasure to send my personal greetings along with those of the International Agricultural Development Service on the occasion of the tenth anniversary of the establishment of the Bangladesh Agricultural Research Council.

The Bangladesh Agricultural Research System has made many significant achievements. Modern facilities have been constructed and equipped. Scientists and many professionals trained at home and abroad are demonstrating their capabilities to develop improved crops, livestock, fisheries, forests, and new agricultural technologies. The benefits to farmers and consumers of Bangladesh already far surpass the investment costs.

IADS is proud to be associated with BARC and its constituent institutions during this period of dynamic growth. Yet these accomplishments are but the beginning of major breakthroughs that will bring food self-sufficiency to Bangladesh and expanded trade in agricultural commodities.

The IADS staff joins me in sending best wishes to the agricultural scientists and farmers of your country. We are confident that the national agricultural research efforts, with the leadership and support of BARC, will continue to produce substantial benefits for Bangladesh.

Sincerely yours,

A. Colin McClung
President

/bsp

TELEPHONE (703) 525-9430 TELEX 248589 via RCA CABLE IADSERVIS ARLINGTONVIRGINIA

डा० हरि कृष्ण जैन
निदेशक
DR. H. K. JAIN
DIRECTOR

दूरभाष :EPHONE: 581493
तार ..LEGRAM : KRISHIPUSA
भारतीय कृषि अनुसंधान संस्थान
नई दिल्ली-११००१२
INDIAN AGRICULTURAL RESEARCH INSTITUTE
NEW DELHI-110012

दिनांक 26th November, 1983.
DATE

I am happy to learn that the Bangladesh Agricultural Research Council is celebrating its tenth anniversary. On behalf of all of us in the Indian Agricultural Research Institute, I send our best wishes for the continued success of the Council in the years to come. Bangladesh in a very short period of time has made impressive progress in increasing its food production; this has been possible because of the important contributions made by your scientists in taking the first step in the transformation of a traditional agriculture into a more modern system of farm production. For countries of south Asia nothing is going to be more important than their ability to achieve higher rate of agricultural growth in the face of rapidly increasing populations which will reach explosive proportions towards the end of the century. Fortuntely, the potential for increased production continues to be very high and research in agriculture in the developing countries offers probably the largest returns from investment in science anywhere. It is in this context that the Bangladesh Agricultural Research Council is destined to play a crucial role for the economic and social advancement of your country. I have no doubt that with the excellent start which it has already made the Council will meet this challenge.

H.K. Jain
(H.K. Jain)
Director

OFFICE OF THE EXECUTIVE DIRECTOR

6 December 1983

In behalf of the entire scientific and research community of the Republic of the Philippines, it is my distinct honor to salute the Bangladesh Agricultural Research Council on its tenth founding anniversary.

We at the Philippine Council for Agriculture and Resources Research and Development (PCARRD), your counterpart in this part of the world, acknowledges this event in a more commemorative spirit knowing that, despite being a year older than BARC, we have trodded similar paths and we share the same triumphs and tribulations attendant to our mandates.

Despite the odds, PCARRD and BARC were born amidst the realization that, though technology generation is a slow and tedious process, it has become apparent that research holds the answer to our drive towards self-sufficiency in food and other essential requirements and that this is the approach to be relied upon even if it means making haste slowly.

For Bangladesh, this recognition came with the passing of President's Order No. 32 (amended later by Ordinance No. 11), placing BARC in charge of streamlining agricultural research activities in a country whose resources should be marshalled towards a united coordinative bid for progress. Your task is as far-reaching as ours: to manage and coordinate all aspects of agricultural research among the various institutes, universities, and academies.

Like us at PCARRD, I am sure that if the last ten years have taught

PHILIPPINE COUNCIL FOR AGRICULTURE & RESOURCES RESEARCH & DEVELOPMENT
LOS BAÑOS, LAGUNA, PHILIPPINES TEL. NO. 50015—50019
MANILA OFFICE 827-2332 • 83-72232 • 8322773 • 8322733
Cable Address: AGRESPHIL Manila

as anything, it is the indomitable belief that no country should accept life sentence in hunger and poverty for majority of its citizens and that this anniversary is more than a checkpoint for chronological age. It is a useful devise for measuring progress, for setting up realistic goals, and for mapping out new strategies to attain those goals.

We mark this anniversary at a time when, despite some improvements in food security, unmet human needs are spiralling. But with the firm resolve of a dynamic national research enterprise, we nurture the confidence that we shall prevail.

Our sincerest felicitations and may we look forward to strengthening the collaborative efforts BARC has forged with us before and to a more meaningful working relationship in the future.

Mabuhay!

RAMON V. VALMAYOR
Executive Director

TELEX

ON OCCASION OF THE TENTH ANNIVERSARY OF THE BANGLADESH AGRICULTURAL RESEARCH COUNCIL, THE IADS STAFF JOINS ME IN EXTENDING BEST WISHES TO YOU AND THE AGRICULTURAL SCIENTISTS AND FARMERS OF BANGLADESH. THE SIGNIFICANT ACHIEVEMENTS OF BARC OVER THE PAST 10 YEARS GIVE US CONFIDENCE THAT WITH CONTINUED LEADERSHIP AND SUPPORT OF BARC THE NATIONAL AGRICULTURAL RESEARCH SYSTEM WILL PRODUCE SUBSTANTIAL BENEFITS LONG INTO THE FUTURE. IADS IS PROUD TO BE ASSOCIATED WITH BARC AND ITS CONSTITUENT INSTITUTES. REGARDS.

BE ASSOCIATED WITH BARC AND ITS CONSTITUENT INSTITUTES. REGARDS.

DECEMBER 20, 1983

D.S. ATHWAL, VICE PRESIDENT
INTERNATIONAL AGRICULTURAL DEVELOPMENT SERVICE

TELEX

WARMEST CONGRATULATIONS AND BLST WISHLS ON OCCASION OF BARC TENTH ANNIVERSARY. HOWEVER I DO REGRET AM UNABLE TO JOIN DECEMBER 22 FESTIVITIES. MORE POWER TO YOU AND BARC. WARMLST PERSONAL REGARDS TO YOU AND BARC COLLEAGULS.

DECEMBER 9, 1983

J. MADAMBA, FORMER DIRECTOR
SOUTHEAST ASIA REGIONAL CENTER FOR GRADUATE STUDY AND RLSEARCH IN AGRICULTURE

ANNIVERSARY OF BARC: THE FIRST DECADE.

****

To commemorate and celebrate a distinguished event such as the Anniversary of BARC provides opportunity to preserve in memory, recognized qualities which characterise the eminent position BARC has assumed in Bangladesh Agriculture. Since its inception BARC has been fortunate in having three outstanding scientists statesmen as Executive Vice Chairmen. Together they have played no mean part in giving direction, form and impetus to a strengthened Bangladesh Agricultural Research System.

Special citation must be given to the present Executive Vice Chairman Dr.Kazi Badruddoza who during two critical periods in the life of BARC has provided outstanding leadership. He has exercised patience, persistence, perseverence and prudence in guiding the evolution of BARC into a respected organization. To plan, coordinate, allocate and develop resources, monitor and evaluate Agricultural Research in Bangladesh are now established activities carried out by BARC

Committed Leadership in the various technical fields of Agricultural Research has been provided by a select group of capable member directors. Tact and social wisdom together with technical competence have been necessary in accomplishing the coordinating role of member directors. Long term research needs regardless of short term political expediency have been demanded of them.

That BARC has acquired success in mobilizing many groups of people to understand the broader concept of an Agricultural Research System, in most credible. Farmers, agricultural support services, economic incentives, land improvement schemes, have benefited by training and other various Council activities. Indeed, BARC has on occasions been attentive to the research needs, findings and policy issues and articulated them to politicians.

High priority has recently been given by the Council in creating awareness among politicians of the role, importance and pay off from Agricultural research.

The generation of improved technology and tailoring programs to accelerate agricultural growth and maximize resource use remains an important mission of BARC. The on farm testing of available new technology has been a feature of many BARC supported projects. Inventories of National manpower and facility research resources has been undertaken while training at all levels within country and abroad continues under BARC support. One of the most important exercises conducted by BARC has been in strengthening institutes within the National Net Work, to plan and impliment prioritized research. Assistance has often been provided institutes in developing their respective Five Year Master Program Plans.

Developing and coordinating external linkages with various bilateral, multilateral agencies and foundations has been another major role successfully carried out by BARC.

May this BARC Anniversary be not only a commemorative event that recognizes significant achievements but also provides occasion to assess where the future Council thrust should reside. Perhaps it is timely that BARC redefine its own Five Year Master Plan mindful of five major Council Functions to:

i. Identify national, regional and local opportunities for advances in agricultural productivity and profitability, estimating their potential impact and making the results available to authorities in understandable language.

ii. Help establish national, regional and local goals against which progress can be measured and elaborating strategies and tactics for reaching those goals quickly at reasonable cost.

iii. Develop and test components for improved production practices; better systems of harvesting, storage, transport, and marketing of produce and more effective conservation of resources.

iv. Manage components into profitable high yielding farming systems for each locality.

v. Identify and make known improvements in supply of services-extension, input supply, credit, marketing, price policy, and other activities - that will substantially advance agriculture and the well-being of rural people.

vi. Train staff for research, extension or educational institutions.

M. D. DAWSON

Dr. Dawson is Advisor to the Pakistan Agricultural Research Council. He formerly was Project Supervisor, IADS/BARC.

APPENDIX II

Organizing Committee National Symposium on Agricultural Research

22—23 December 1983

Kazi M. Badruddoza, Ph.D. *Chairman*
Executive Vice-Chairman
Bangladesh Agricultural Research Council

A. K. M. Aminul Haque, Ph.D.
Vice Chancellor
Bangladesh Agricultural University

M. Kasem Ali, Ph.D.
Executive Director
Bangladesh Jute Research Institute

S. M. H. Zaman, Ph.D.
Director
Bangladesh Rice Research Institute

M. M. Rahman, Ph.D.
Director
Bangladesh Agricultural Research Institute

M. Omar Ali, Ph.D.
Director
Forest Research Institute

M. Shahjahan, Ph.D.
Director
Sugarcane Research and Training Institute

A. J. Miah, Ph.D.
Acting Director
Institute of Nuclear Agriculture

Mirza A. Jalil, Ph.D.
Director
Directorate of Livestock Services

A. Q. Chowdhury, M.Sc.
Director
Directorate of Fisheries

Ekramul Ahsan, Ph.D.
Member-Director (Agricultural Economics and Social Science)
Bangladesh Agricultural Research Council

M. A. Mannan, Ph.D.
Member-Director (Soils and Irrigation)
Bangladesh Agricultural Research Council

Kamal Uddin Ahmad, M.S.
Member-Director (Crops and Forests)
Bangladesh Agricultural Research Council

M. S. U. Chowdhury, Ph.D.
Secretary
Bangladesh Agricultural Research Council

Abdur Rahim, Ph.D.
Director (Nutrition)
Bangladesh Agricultural Research Council

M. Altaf Hossain, Ph.D.
Director (Livestock and Fisheries)
Bangladesh Agricultural Research Council

Ahmed Hussain, M.Sc.
Director (Training)
Bangladesh Agricultural Research Council

A. Mannan Chowdhury, M.A.
Director (International Project Service Unit)
Bangladesh Agricultural Research Council

David M. Daugherty, Ph.D.
Project Supervisor/Adviser
International Agricultural Development Service

Theodore Hutchcroft, Ph.D.
Agricultural Communication Specialist
International Agricultural Development Service

APPENDIX III

Participants

The list of participants in the National Symposium on Agricultural Research was prepared from information given by each individual to the Registration Committee, Dr. Ekramul Ahsan, chairman. Unfortunately, not all persons attending the Symposium submitted registration forms, so the list is incomplete. The list is presented in alphabetical order by last name, and includes position and institution.

The acronyms of the research institutions are published in Appendix V. Scientific and research positions are indicated by the standard acronyms, PSO = Principal Scientific Officer, SSO = Senior Scientific Officer, SO = Scientific Officer, SRO = Senior Research Officer, and CRO = Chief Research Officer. All persons listed are working in Bangladesh unless otherwise indicated by their address.

Dr. Md. Zainul Abedin
Head, E&R Project
BARI

Mr. Kamal Uddin Ahmad
Member-Director (Crops and Forestry)
BARC

Dr. M. S. Ahmad
Associate Director
BRRI

Dr. A. Ahmed
Retired Director

Mr. A. K. Naziruddin Ahmed
Research Officer
Livestock Research Institute

Dr. Hamizuddin Ahmed
Head, Plant Pathology Division
BARI

Mr. Md. Jalal Uddin Ahmed
SO, Regional Agricultural Research Station/Jamalpur
BARI

Mr. Minhaj Uddin Ahmed
SO
BARC

Mr. M. Mostaque Ahmed
SO
BARI

Mr. Moslehuddin Ahmed
Ex-Member-Director (LSS)
BARC

Mr. Mostaque Ahmed
SO
BARC

Dr. M. U. Ahmed
Assistant Professor
BAU

Dr. Musletas Ahmed
PSO
BARI/Ministry of Agriculture

Mrs. Nilufar Ahmed
PSO, Plant Pathology Division
BJRI

Dr. Q. A. Ahmed
Ex-Executive Director
BJRI

Mr. Sofiuddin Ahmed
SSO
BARC

Dr. Sufi Mohiuddin Ahmed
Project Director (Wheat)
BARI

Dr. Ziauddin Ahmed
Professor and Chairman
University of Dhaka

Dr. Ekramul Ahsan
Member-Director (Agricultural
Economics and Social Science)
BARC

Mr. Md. Nurul Alam Akhand
PSO
BARC

Mr. Md. Alam
Manager (Seeds)
BADC

Mr. Md. Khurshed Alam
Budget Officer
BARC

Dr. Md. Nurul Alam
PSO (Entomology)
BARC

Mr. Nurul Alam
Chief Information Officer
Agricultural Information Service

Dr. Shamsul Alam
Head, Division of Entomology
BRRI

Mr. Md. Al-Amin
SO, Fruit Sub-station/Rajshahi
BARI

Dr. Erfan Ali
Member
BCSIR

Dr. Md. Ashraf Ali
Professor and Dean
Faculty of Agricultural
Economics and Rural Sociology
BAU

Dr. Md. Idris Ali
PSO
INA

Mr. Md. Liaquat Ali
Senior Accounts Officer
BARC

Mr. Md. Liaquat Ali
Project Director
Directorate of Fisheries

Mr. Md. Sadeque Ali
SSO, Potato Research Centre
BARI

Mr. Mir Mozhar Ali
Director, Project Development Unit
Bangladesh Tea Board

Dr. M. Kasem Ali
Executive Director
BJRI

Dr. M. Myser Ali
Director, Jute Seed Division
BJRI

Dr. Mohsin Ali
Project Director
Marine Fisheries Research,
Management and Development Project

Dr. M. Omar Ali
Director
Forest Research Institute

Dr. M. Youssouf Ali
Secretary
Fisheries and Livestock Division

Dr. S. M. Ali
Retired Animal Husbandry Commissioner

Dr. S. M. Arshad Ali
Head, Irrigation and
Water Management Department
BAU

Dr. Md. Monsurul Amin
Associate Professor
BAU

Dr. S. M. R. Amin
PSO
BARC

Mr. A. M. Anisuzzaman
Secretary
Agriculture and Forests Division

Col. (Rtd.) Syed Ali Ansar
Chairman
BADC

Mrs. Sadeka Arangzeb
PSO
BJRI

Mr. S. N. H. Arangzeb
Executive Director
Cotton Development Board

Mr. A. A. Asadullah
Chief Extension Officer
BWDB and Directorate of Land

Mr. M. Atiqullah
Chief Conservator of Forests
FRI

Mr. Md. Abul Kalam Azad
SSO
BJRI

Dr. Idris Ibn-Al Azim
PSO
BARI

Dr. Kazi M. Badruddoza
Executive Vice-Chairman
BARC

Mr. Md. Wahed Baksha
Senior Research Officer (Entomology)
FRI

Mr. S. Deedar Baktu
ENA

Mr. B. C. Basak
SO
INA

Mr. Md. Abul Bashar
SSO, CVSRC
BARI

Mr. M. K. Bashar
SO
BRRI

Dr. Douglas Beck
NifTAL Project
Bangkok, Thailand.

Miss Jinnat Ara Begum
Head, Department of Food
Technology and Rural Industries
BAU

Ms. Shamsad Begum
SO
BARC (INA)

Mr. S. B. Bhattacharjee
Deputy Director
Fisheries Technological Research
Station/Chandpur
Directorate of Fisheries

Prof. N. I. M. Salam Bhuiya
Rajshahi University

Dr. Abdul Latif Bhuiyan
Professor
Institute of Marine Services
University of Chittagong

Dr. A. M. Bhuiyan
Director (Technological Research)
BJRI

Dr. Nurul Islam Bhuiyan
PSO and Head (Incharge)
Soil Chemistry Division
BRRI

Mr. S. J. Bhuiyan
Additional Director of Agriculture (Rtd.)

Dr. M. A. Biswas
Director
BCSIR

Mr. Anthony Bottrall
Program Officer
Agriculture and Water Management
Ford Foundation

Dr. S. M. Bulbul
Associate Professor and Head
Department of Poultry Science
BAU

Dr. K. J. Chandra
BAU

Dr. S. D. Chaudhuri
Ex-Executive Vice-Chairman
BARC

Mr. Enamul Huq Chaudhury
PSO
BARI

Dr. S. H. Chaudhury
Director
BTRI

Mr. A. T. M. Salehuddin Choudhury
PSO
BARC

Dr. Nurul Hoque Choudhury
PSO
BRRI

Mr. Ramendra Choudhury
PSO
BJRI

Mr. Abdul Mannan Chowdhury
Director (IPSU)
BARC

Mr. A. Q. Chowdhury
Director
Directerate of Fisheries

Brig. Gyas Uddin Chowdhury
Chairman
Bangladesh Fisheries Development Corporation

Dr. M. S. U. Chowdhury
Secretary
BARC

Prof. M. U. Ahmed Chowdhury
Retired Scientist

Dr. M. Y. Chowdhury
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APPENDIX IV

Recommendations

A proposed set of recommendations based on the papers and discussions of the participants was introduced at the concluding session. The Chairman, Dr. Kazi M. Badruddoza, directed that the document be presented to the Member-Directors and Directors of BARC for their review. The recommendations were drafted by Mr. Kamal Uddin Ahmad, Member-Director of BARC.

Recognizing the facts that Bangladesh:

- Is the most densely populated country in the world;
- Has a very high rate of population growth;
- Has the highest ratio of people to land in the world;
- Is a country in which the size of land holdings is small;
- Has the top-most rice-eating population in the world;
- Has a water supply in which too much is available during the rainy season and then there is too little for nearly five months of the year;
- Has many crops, and that almost every farmer is involved in the production of cereal food, roots and tubers, vegetables, fruits, livestock, poultry, and sometimes fish; and
- Has research and development activities which have to take into account all of these matters in their entirety.

Therefore, the following recommendations are made in the concluding session of the National Symposium on Agricultural Research:

1. Research has contributed considerably to the general production of rice, particularly through evolving of many high yielding varieties and of cultivation technologies. Recently the trends have been (a) to a stabilized yield/acre of HYV and (b) to boro rice taking a lion's share of the water during times of scarcity. Therefore, we should plant more wheat and other rabi season crops thus multiplying the coverage of land by using the same amount of available water.

2. However, efforts should continue to develop varieties and methods to attain higher production of rice through vertical expansion. The reasons for the recent stagnation of wheat in terms of its total and per acre production should be investigated and then the hurdles should be removed as expeditiously and effectively as possible.

3. The efficacy of other cereals—particularly maize, in the context of our cropping systems, and the nutritional needs of both people and animals—should be examined very carefully. Research and development activities should be initiated as appropriate.

4. It is well recognized that both wheat and Irish potatoes have attained considerable advancement because of recent special thrusts. This tempo should be continued through appropriate promotional activities for attaining

higher consumption and utilization, and better storage and marketing of these food crops.

5. The sweet potato is a low input, low cost staple food crop which should receive more attention in order to supplement other staple foods through nutritionally richer, high yielding varieties, and better production techniques.

6. As Bangladesh at one time was one of the biggest pulse-consuming populations in the world and we still depend on pulses for considerable amounts of our protein supply, these should receive emphasis at the policy-making level. Both research and extension organizations should try to fit pulses as much as possible into the cropping systems.

7. While major dependence on mustard will continue, other oilseeds, particularly groundnut, should find a good place in our research development efforts.

8. The coconut is often disowned by both oilseed researchers and the horticulturists even though our agro-ecological conditions are favourable for its production. We import a lot of coconut oil which is costly in terms of foreign exchange. The Coconut Research Station should be strengthened and the production of an adequate amount of quality seed should be assured.

9. We should evolve high yielding, high sugar, disease resistant varieties of sugarcane, and also increase the crushing capacities of the mills.

10. For the survival of jute—our number one foreign exchange earner—there has to be intensified research for reduced cost of production, increased per acre yield, and to find various additional uses for the crop. This should not only be at the laboratory stage but also at the industrial level both for internal use and export uses.

11. The good work should continue that has made it possible to produce a sizeable portion of the cotton required to operate our mills. At the same time, research should be strengthened for developing a miniature size and capability, and also to arrange for the exploitation of industrial by-products such as oil cake.

12. Researchers on tobacco should seek to attain quality production leading to high grade cigarettes that can capture international markets.

13. Researchers should continue to backstop the tea industry. There should be a thorough replacement of the low yielding clones and seedstocks by newer, high yielding clones, and the rehabilitation of the old soils.

14. There is a consensus that production and consumption of fruits and vegetables in Bangladesh is among the lowest levels in the world; almost every other country has made advancement in these crops in recent times. Appropriate measures should be taken in this country to break this stalemate and to gear up activities for fruit and vegetable research and development.

15. Special thrusts are necessary for crops such as bananas, mango, pineapple, papaya and citrus fruits. Different research and development teams should be entrusted with the tasks of their development.

16. Country vegetables in general and leafy vegetables in particular should receive priority, leaving most other vegetables to be taken care of later

on. We can only depend on the outside world for seed supply of a few of these country vegetables.

17. The results of the tests by various organizations of farming/cropping systems should be put together to determine their pragmatic application; we also need to see how much more must be done experimentally and how much can now be extended to the end-users.

18. Post-harvest matters--such as storage, processing, marketing, food habit changes and other allied areas--must receive higher priority as they are so closely related to pre-harvest activities.

19. An integrated pest management system, with proper pest surveillance and forecasting, may be initiated to reduce or at least put a brake on the increases of pesticide applications. Adequate facilities and manpower should be developed to take care of the research and development needs of crop protection.

20. While fertilizer use efficiency should be improved, (a) biological nitrogen fixation should be exploited, (b) compost-making should be revived and intensified, and (c) the use of micronutrients should be thoroughly studied. Soil constraints for effective fertilizer use and integrated plant nutrition systems should be worked out.

21. There should be effective use made of the irrigation pumps that have been installed and those that will be installed in the future. The additional number of pumps should be decided judiciously with the use of mathematical models relating to extraction rates, river levels, and rainfall and aquifer characteristics. On-farm water distribution systems should be tested under farmers' field conditions to determine their acceptability.

22. To improve livestock production, the research infrastructure should be strengthened through the establishment of a national livestock research institute and by a manpower development programme.

23. It is essential there be an evaluation of the fisheries resources, their jurisdiction, and the proportion and potential yield of fish and shellfish currently being exploited. The areas suitable for aquaculture should be determined as should the culture systems that have the best chances to be successful.

24. Studies should be done on the bearing of the young fish, and on the food and environmental conditions throughout their life cycles. The proven methods of fish culture should be brought to the doors of fish culturists.

25. High yielding, quality tree species with short rotation lengths should be found. Fast-growing coppicing tree species should be established in plantations and the local development programmes, especially in homestead areas, to provide fuel wood and feed for animals.

26. Farm forestry technologies should be developed to contribute to the national food production goal. Studies should be undertaken to develop multiple-use tree species in rural homesteads. The productivity of the tidal forests should be augmented. New products and processes should be developed for better utilization of forest products.

27. Appropriate programmes of applied nutrition should be im-

plemented that are suitable for being utilized by farmers themselves.

28. For the effective communication of research, an agricultural extension division should be opened at BARI, an extension research cell at BAU, and an extension section at BARC.

29. Research studies need to be conducted on biomass utilization so that Bangladesh farmers can make effective use of the plentiful supplies of agricultural by-products available to them.

30. Agricultural economists should develop research studies on marketing and price policies, for these often serve as incentives or disincentives when farmers are making decisions on the adoption of new technology.

31. Bangladesh farmers annually are confronted with floods, droughts and other extremes of nature. There needs to be attention given to disaster research, seeking to develop explanations of these happenings, and plans for preparedness to reduce disaster proneness.

APPENDIX V

Acronyms

AVRDC	Asian Vegetable Research and Development Center
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARD	Bangladesh Academy for Rural Development
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCSIR	Bangladesh Council of Scientific and Industrial Research
BGA	Blue green algae
BHDB	Bangladesh Horticultural Development Board
bhp	Brake horsepower
BIDS	Bangladesh Institute of Development Studies
BIRTAN	Bangladesh Institute of Research and Training on Applied Nutrition
BJRI	Bangladesh Jute Research Institute
BLRI	Bangladesh Livestock Research Institute
BNF	Biological nitrogen fixation
BOAA	A neurotoxin produced in khesari which causes paralysis of the lower limbs in human males.
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
B.Sc.	Bachelor of Science
BTRI	Bangladesh Tea Research Institute
BUET	Bangladesh University of Engineering and Technology
BV	Biological value
BVRDC	Bangladesh Vegetable Research and Development Centre
BWDB	Bangladesh Water Development Board
cfs	Cubic feet per second
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CRWRC	Christian Reformed World Relief Committee
cusec	One cubic foot per second
CVSRC	Citrus and Vegetable Seed Research Centre
DAE	Directorate of Agricultural Extension
DANIDA	Danish International Development Agency
DLS	Directorate of Livestock Services
DTW	Deep tubewell

E&RP	Extension and Research Project
ELISA	Enzyme-linked immunosorbent assay
FAO	Food and Agriculture Organization of the United Nations
FFYP	First Five Year Plan
GDP	Gross domestic product
GTZ	German Agency for Technical Cooperation
HYV	High yielding variety
IADS	International Agricultural Development Service
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
IDA	International Development Association
IMP	Irrigation Management Programme
INA	Institute of Nuclear Agriculture (now Bangladesh Institute of Nuclear Agriculture)
INFS	Institute of Nutrition and Food Science
INSFFER	International Network on Soil Fertility and Fertilizer Evaluation
IPM	Integrated pest management
IPN	Integrated plant nutrition
IRRI	International Rice Research Institute
LDC	Less developed countries
LEM	Leukocytic endogenous mediator
LLP	Lowlift pump
LRI	Livestock Research Institute
MCC	Mennonite Central Committee
M.Sc.	Master of Science
MYMV	Mungbean Yellow Mosaic Virus
NALDOC	National Agricultural Library and Documentation Centre
NARP	National Agricultural Research Plan
NDV	Newcastle Disease Virus
NPKS	Nitrogen-phosphorus-potassium-sulphur
NPU	Net protein utilization
PER	Protein efficiency ratio
Ph.D.	Doctor of Philosophy
ppm	Parts per million
ppt	Parts per thousand
PRC	Potato Research Centre
PU	Prilled urea
RBC	Red blood corpuscle

RD	Ranikhet (Newcastle) disease
S	Salinity
SCU	Sulphur coated urea
SFYP	Second Five Year Plan
SRTI	Sugarcane Research and Training Institute
STW	Shallow tubewell
T&V	Training & Visit System
TPS	True potato seed
TYP	Two Year Plan
UDS	Underground distribution system
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UP	Utilizable protein
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USG	Urea supergranule
V-AID	Village-Agricultural and Industrial Programme
VPS	Vertebrate Pest Section
WHO	World Health Organization