Hybrid Rice Adoption in Bangladesh: A Socio-economic Assessment of Farmers' Experiences

A. M. Muazzam Husain
Mahabub Hossain
Aldas Janaiah

December 2000

Research & Evaluation Division
BRAC

Social Sciences Division
International Rice Research Institute

ABSTRACT

The study aimed at finding the farm-level adoption pattern, differential performances, relative profitability and constraints to adoption of two hybrid rice varieties viz., *Alok 6201* and *Sonar Bangla* (CNSGC 6). These varieties were introduced during 1999 *Boro* season in Bangladesh. Findings show that farm size had a negative but education had a positive effect on adoption rate. Grain yield of hybrids were 15% higher than that of HYVs though *Sonar Bangla* did much better than *Alok 6201*. Input costs of hybrids were 23% higher. Profitability of *Sonar Bangla* was higher but that of *Alok 6201* was lower than that of HYVs. Constraints to hybrid rice adoption included external dependence and higher seed cost, higher need for management skill, input intensity, higher incidence of pests and diseases, inadequate yield gain and lower head-rice recovery. Special constraints of *Alok 6201* include high rate of unfilled grain, grain shedding, crop lodging and poor keeping quality of cooked rice. Stickiness of cooked rice and relatively inferior quality in terms of taste may also be considered as other constraints for both varieties. Some of these problems would have been avoided if, instead of introducing rice hybrids without a clear deployment srategy, they were introduced to Bangladesh after scientific on-farm testing for 2-3 seasons/years across agro-ecological regions.

Results tentatively imply that *Alok 6201* may not be sustained for adoption. Though *Sonar Bangla* was highly profitable, its inferior quality may also inhibit growth in its adoption in the long run. High quality local hybrids may be developed and domestic production of hybrid seeds may be expedited. Hybrids for rain-fed environment and resistant to biotic stresses may also be developed. Research infrastructure, scientific on-farm testing of new hybrids before releasing them, integration of credit with extension services, better management practices and co-ordination between public sector and NGOs/private sector should be strengthened.

TABLE OF CONTENTS

I. INTRODUCTION

A brief profile of Bangladesh rice sector

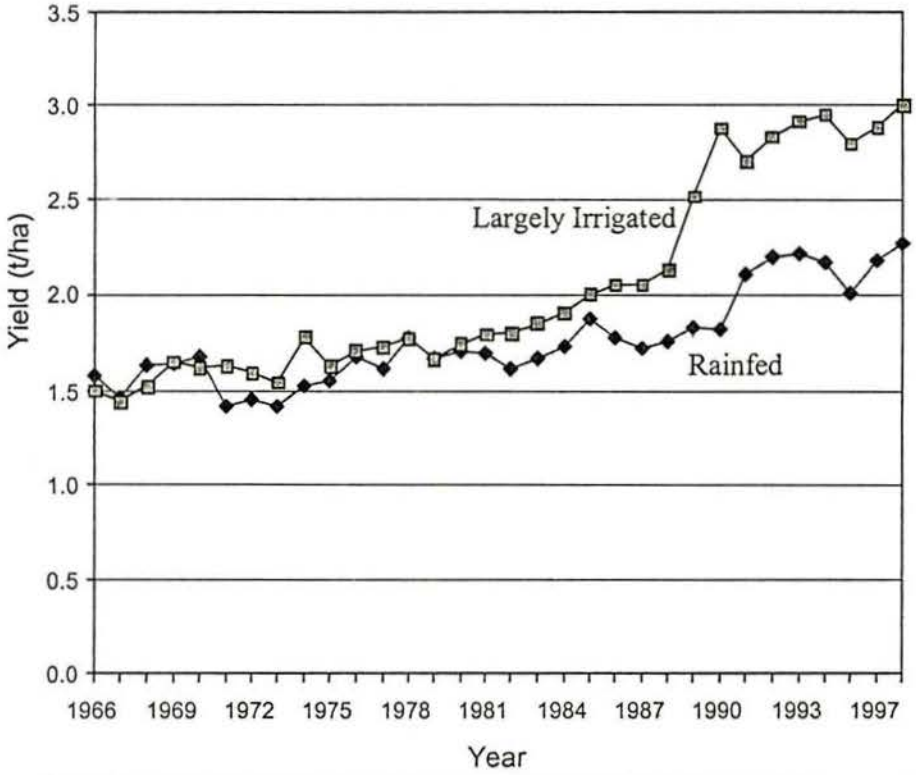
Bangladesh is one of the most densely populated countries in the world with 130 million people living in a land area of 144 sq km. Agriculture employs nearly 60% of its labour force and contributes one third of its gross national product. However, its agriculture suffers from various problems such as small, unviable and fragmented landholdings, frequent natural disasters, and limited technological progress and low productivity of resources. The principal crop and the staple food is rice, which occupies nearly 75% of its total cropped area in the country.

Rice production in Bangladesh remained nearly stagnant in 1950s at around 11 to 12 million MT (rough rice, or paddy). But the population growth rate accelerated from less than one percent per year to nearly three percent during the decade causing a concern for Bangladesh's ability to feed its growing population. The 1960s, however experienced a rapid growth of production due to increase in cropping intensity of rice, changes from direct seeding to transplanting method of cultivation, and introduction of modern agricultural inputs such chemical fertilizers and irrigation by power pumps, promoted by the government's "grow more food production programme"(Ahmed, 1979). Rice production grew from 12.1 m MT in 1959-60 to 16.9 million MT in 1969-70; an increase of 40% over a decade, almost 50% of which came from expansion of cropped area. The potential of further growth of rice production through increase in cultivated land and rice cropping intensity however was almost fully exploited by the end of 1960s.

Although modern high-yielding varieties (HYVs) of rice were adopted beginning in 1968, the rate of adoption remained low till 1975-76. The major sources of growth of foodgrain production in the 1970s were the expansion of area and the yield of wheat. The rapid diffusion of rice HYVs took place after mid-1980s with the liberalization of policies regarding the procurement and distribution of agricultural inputs, and reduction of import duties on agricultural equipments (Hossain, 1996). Rice area covered by modern varieties has now reached nearly 65% supported by an expansion of minor irrigation by tubewells and pumps which now cover nearly 48% of the cropped area.

Traditional varieties are grown only in the unfavourable ecosystems, the rainfed uplands (*Aus*), the deepwater areas (broadcast *Aman*) and the saline affected coastal areas. Rice production increased from 21.4 million MT in 1987-88 to nearly 34 million MT by 1999-2000, and the rice yield increased from 2.0 t/ha to 3.2 t/ha during this period. It can be seen from Figure 1 that the acceleration in the growth of rice yield since the late 1980s occurred both for the irrigated and the rainfed ecosystems.

Fig. 1. Trends in rice yield for largely irrigated and rainfed districts, Bangladesh, 1967-97.



	Average yield (t/ha)			Growth rate(%/yr)	
Ecosystem	1966	1986	1997	1966-86	1986-97
Largely Irrigated	1.50	2.05	3.00	1.4	3.5
Rainfed	1.58	1.78	2.27	0.8	2.5

Source: Bangladesh Bureau of Statistics.

Trend growth rates of area, production and yield of rice in Bangladesh from 1950-51 to 1998-99 are presented in Table 1. It may be noted that the expansion of cropped area (through increase in rice cropping intensity and replacement of land from non-rice crops), which was an important source of production growth till mid 1980s, has dried

up. In fact the area under rice started declining since the mid-1980s. The increase in domestic production is now entirely dependent on the growth in rice yield. Indeed Bangladesh must target a higher rate of growth in yield than the required increase in rice supplies to meet the demand, to release land for other crops whose demand has been growing faster than that of rice.

Table 1: Trend Growth Rates in Area, Production and Yield of Rice in Bangladesh, 1950-51 to 1998-99.

(% per annum)

Year	Area	Yield	Production
1950-51- 1969-70 (Pre-green rev. period)	1.08***	1.41***	2.50***
1973-74- 1985-86 (Early green rev. Period)	0.85***	1.33***	2.17***
1985-86- 1998-99 (Late green rev. Period)	-0.51	2.59***	2.08***

*Note: Trend growth rates have been computed by fitting semi-log functions (lnY = a+bt) to the data. *** denote the statistical significance at 1% probability level. The period 1970-71 to 1972-73 has been excluded from the analysis due abnormal production situations caused by the civil war and the rehabilitation of the displaced population.*

Data source*: BBS published and unpublished reports.*

The adoption of HYV rice technology which enabled Bangladesh to double the yield rate during 1969-70 to 1999-2000 was not however an unmixed blessing (GOB: 1998). The increasing adoption of HYV technology led to displacement of land for non-rice crops like pulses, oilseeds and spices that resulted in the stagnation of their production. The adoption of a few profitable HYVs may have displaced many traditional varieties and contributed to an erosion of biodiversity. Again, increased cropping intensity including intensive rice mono-culture in the irrigated land, and use of improper and unbalanced doses of chemical fertilizers are reportedly depleting soil fertility causing a virtual threat to the long-run sustainability of crop-based agricultural production system in Bangladesh.

On the other hand, Bangladesh needs to increase rice yield further to meet the growing demand emanating from population growth. The United Nations (UNO, 1998) project that even by 2020 the Bangladesh population will grow at 1.2% per year and will reach 173 million, 31% higher than the present number. Nearly 46% of the population will live in urban areas in 2020 compared to 27% now. Farmers will have to generate larger

marketable surplus to feed the growing urban population. Although the recent Household Expenditure Surveys of the Bangladesh Bureau of Statistics (BBS) show that the per capita consumption of rice has started stabilizing in rural areas, and has been declining in urban areas, the demand will continue to increase due the growth of population. The National Commission of Agriculture projected that to remain self-sufficient Bangladesh will need to produce 47 million tons of paddy (31.6 million tons of rice) by year 2020, implying a required rate of growth of production at 1.7% per year. An earlier Agricultural Research Strategy document prepared by the Bangladesh Agricultural Research Council projected the required paddy production by 2020 at 52 million tons (34.7 million tons of rice), which would require a production growth of 2.2% per year. As mentioned earlier, Bangladesh will have to target the yield growth at a higher rate to release some land from rice cultivation for supporting crop diversification and meeting the growing demand for land for housing, industrialization and infrastructure development.

Rice breeders have, therefore, been trying to evolve input-efficient and pest-resistant higher yielding varieties to increase the rice yield while sustaining the natural resource base. One innovation has been the development of hybrid rice varieties for the tropics, which is expected to shift the yield potential of the rice plant by 15-20% or more with same amount of agricultural input. The technology has attracted the attention of researchers and policy makers in many Asian countries who see it as an opportunity to overcome the yield ceilings reached by many enterprising farmers in the irrigated ecosystem.

Hybrid rice research: historical perspective

Rice is a self-pollinated crop with tiny florets in which each plant pollinates and fertilizes, producing itself in the same form of seeds of same variety. The hybridization technique, however, involves two separate parental lines. When the resulting offspring has one or more traits that are superior to those of their parents, we have a phenomenon called *heterosis* or *hybrid vigour*[1]. It was previously thought that it is impossible to produce rice hybrids using procedures used in cross-pollinated crops such as maize, pearl millet and cotton. But, as early as in 1954, Indian rice scientists Sampath and Mohanty at the Central Rice Research Institute, Cuttack, reported on the existence of cytoplasmic male sterility, indicating the possibility of developing hybrids in rice (Sampath and Mohanty, 1954). The same view was also expressed during the early 1970s at the International Rice Research Institute (IRRI), Philippines (Athwal and Virmani, 1972), and in the United States (Carnahan *et al*, 1972). Nevertheless, except for China, no other rice-growing country made serious efforts to explore the possibility of developing rice hybrids until the late 1980s.

Some research on rice hybridization was carried out from 1970 to 1972 at IRRI, Philippines, but it was discontinued because research managers were not convinced about the commercial feasibility of the hybrid rice programme. Almost at the same time, research on hybrid rice was initiated in the USA and Japan, which resulted in the development of some rice hybrids with 10-15% yield advantage. But these hybrids did not provide any additional profits because the higher price of existing high-quality inbreds[2] compared to the hybrids which were also more susceptible to pests. As a result, these hybrids were discontinued in the USA and Japan (Barwale, 1993).

The myth about hybrids in rice was made a reality in China with the large-scale diffusion of hybrid rice varieties since 1976. The success of hybrid rice in China triggered an interest to initiate research at IRRI in the late 1970s as well as in other Asian countries since the late 1980s. By early 1990s IRRI developed several CMS lines which are being

---

[1] The term heterosis means higher yielding capability of newly developed hybrid over its parental lines. This term is widely used in hybrid crops to denote higher yield of hybrids over their parental lines.

[2] The term inbred in rice denotes all high yielding varieties (HYVs) developed over past 30-35 years. All currently known modern varieties or HYVs in rice are inbred varieties.

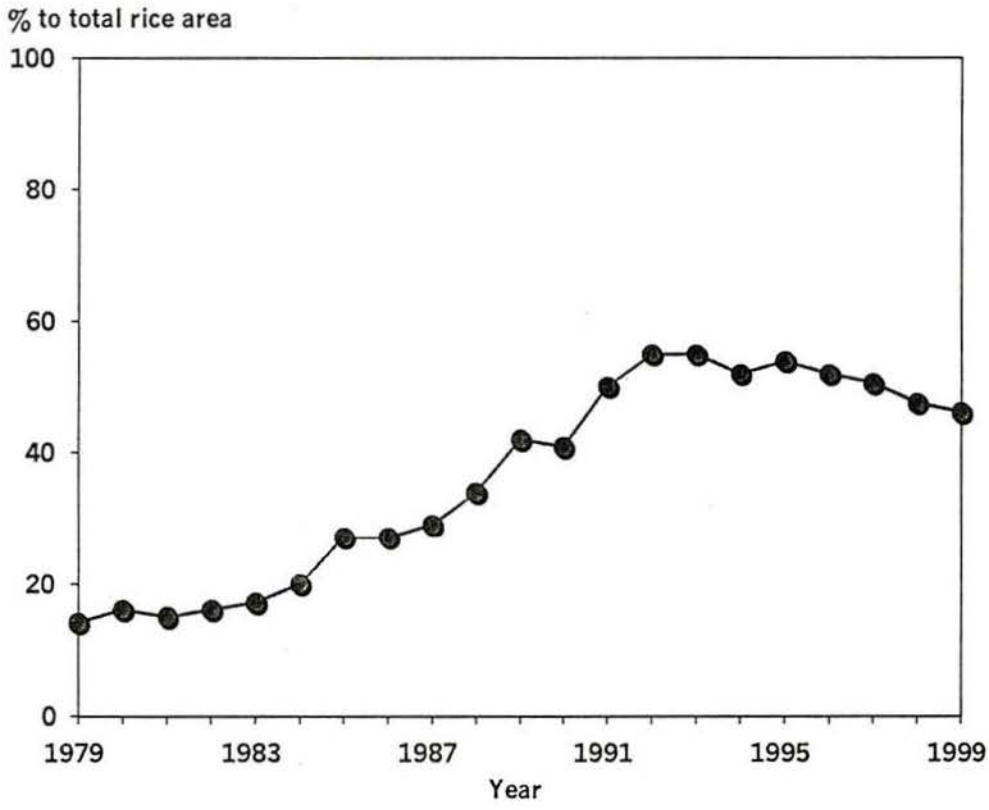
used as parents for developing hybrid rice varieties suitable for local agro-ecological conditions in several countries.

Evaluation of Chinese experiences

The Chinese hybrid rice programme was initiated in Hunan Province in 1964. The first rice hybrid with a marked yield potential was developed in 1974 and released to farmers in 1976 after on-farm testing across the regions (Lin, 1991). Since then, hybrid rice cultivation expanded rapidly, covering 48% of total rice area by 1990 (Lin, 1994). It was reported that hybrid rice in China had a 15% yield gain over the inbred high yielding varieties, but was facing lower price in the market because of its poor grain quality as compared to prevailing inbred varieties (He *et al,* 1987). Hybrid rice was shown to be less profitable than the inbred varieties, although the former had about 15% yield advantages. It was hypothesized that the centralized command economy of China in the 1970s and 1980s was the primary factor behind the large-scale adoption of hybrid rice in that country (Barker and Herdt, 1985). Often farmers were instructed to plant varieties that the government considered good for the country, and the local government agencies ensured that the farmers implemented the decision. It was not unusual in China, when it was a centrally planned economy to promote certain technologies without considering relative profitability and other economic reasons (Lin, 1991; 1992). Government agencies produced and supplied free hybrid rice seeds to farmers along with subsidies on fertilizers and plant protection chemicals (Lin, 1991). The Chinese objective of promoting hybrid rice with direct policy intervention was to increase the domestic rice production to feed the huge rural and urban masses. As supply of hybrid seed and the procurement of the final produce were in the hands of the state, grain quality and hybrid seed cost were not constraints to large-scale adoption of this technology. Therefore, it was the nature of the political and the economic system which was behind the rapid diffusion of hybrid rice in China, not the inherent economic superiority of hybrid rice over the existing HYVs. The Chinese experience may not be replicated in other Asian countries under a democratic social system with free operation of the market forces. It may be mentioned here that in the 1990s, after the introduction of liberalized food production and distribution system, the expansion of the area under hybrid rice has halted, and in some of the prosperous Southeastern provinces the area

has been declining (Fig. 2). With the onset of economic liberalization, farmers and rice consumers in China have started expressing their own preferences. Quality enhancement has now become the primary breeding objective for hybrid rice research in China.

Fig. 2: Trend in the adoption of hybrid rice in China



India's initiatives: some lessons

The Indian Council of Agricultural Research initiated a goal-oriented programme on "promotion of research and development efforts in hybrid rice" in 1989. These efforts were further strengthened with support from the UNDP-FAO-IRRI by the initiation of a nation-wide research network on the *Development and Use of Hybrid Rice Technology* in 1991. Under the network, 12 research centres all over the country conducted research under co-ordination of the Directorate of Rice Research, Hyderabad to develop suitable rice hybrids for the irrigated system and to improve seed production

technologies. A few big private seed companies have also initiated hybrid rice research complemented by free supply of parental lines from public sector hybrid rice network project. Rigorous research efforts over the last decade under the ICAR-UNDP-IRRI-FAO - supported research programme on hybrid rice led to the release of 12 rice hybrids by the public sector and another 8 hybrids by the private sector in India (DRR, 1996-99; Janaiah and Hossain, 2000). As many as 15 private seed companies besides public sector seed agencies have participated in a big way in hybrid rice seed production and marketing at initial stage.

Expectations arose and ambitious targets were fixed at the macro-level for the expansion of hybrid rice cultivation. It was projected that hybrid rice would cover nearly two million ha in 2000, and 25 million ha by 2020 (Barwale, 1993). Based on these projections, an *ex-ante* evaluation study estimated that hybrid rice would contribute nearly 35-40% to meet the additional rice demand by year 2020 (Janaiah and Ilyas, 1996; Janaiah, 1997). Further, it was expected that this technology would generate huge employment opportunities for female workers through hybrid seed production in rural India as hybrid rice seed production is a highly labour-intensive activity. However, the expansion of area under hybrid rice has halted after reaching about 150,000 ha in 1998.

A recent study (Janaiah and Hossain, 2000) indicated that although farmers got about 16% yield advantage in the cultivation of hybrids compared to the popularly grown inbred varieties, the yield gains were not stable. Also there was very little profit margin as six to eight percent of the yield gains were eaten up by additional seed cost and another 10% by lower price due to inferior quality of the hybrid rice grains. So for commercial farmers, there was no economic incentive for adopting hybrid rice. Farmers' perception during on-farm testing (1992-93 and 1993-94) also indicated that the poor grain quality of the tested rice hybrids would constrain large-scale adoption of this technology in India (Janaiah *et al*, 1993; Janaiah, 1995; Janaiah, 1999)). Many of the currently released rice hybrids are those tested during on-farm trials in 1992-93 and 1993-94. Recently India has stepped up research efforts to develop hybrid varieties with acceptable grain quality.

Hybrid rice research in Bangladesh: evolution and progress

Hybrid rice research was initiated at Bangladesh Rice Research Institute (BRRI) during 1983 but only for academic purposes. In 1993, a few female parental lines (CMS-lines) and experimental rice hybrids from IRRI were evaluated at BRRI research farms but in an unorganized way. Systematic efforts were initiated only in 1996 with financial support from BARC. However, hybrid rice programme does not appear to be a high priority at BRRI till now as evident from the allocation of meagre human and financial resources. So far five rice hybrids have been identified, of which two are found to be promising and are in the process of being released. These two hybrid combinations are (i) IR 68025 A x BR 827 (140-145 days duration like BR 28, a check inbred variety) and (ii) IR 68025A x IR 21 567 R (duration: 150-155 days like BR 29 - a check). These hybrids were tested in five locations during 1998-99 *Boro* (dry season irrigated rice) season. The hybrids out-yielded the check varieties (BR-varieties) in three of the five locations.

In the meantime, the new seed policy of the Bangladesh Government encouraged the private sector to participate in the rice seed market. Since the public research system in Bangladesh had not yet developed appropriate hybrids for the country, the government encouraged private sector companies to import hybrid rice seeds from abroad and try them with farmers. Some private seed companies imported rice hybrids and evaluated them through on-farm trials in nine locations, one in each region during 1997-98 *Boro* season. One special evaluation committee was formed under Seed Certification Agency of National Seed Board (NSB) to evaluate the results of these on-farm trials. This special committee recommended the release/introduction/import of seed of rice hybrids, although based on the results of limited trials only for one season. The Government of Bangladesh permitted four private seed companies and one NGO to import 2200 metric tons of hybrid rice seed for the 1998-99 *Boro* season, in response to the recommendation of the NSB and also to cover up the shortage of rice seeds after the devastating flood in the 1998 *Aman* (monsoon season rice) season. A total of about 600 metric tons seed of four varieties from India and one variety from China were imported. Among various hybrids, 75% of total imported seed was of Alok 6201 from India followed by Sonar Bangla of Chinese hybrid. It is estimated from the seed sales

data that about 23,700 ha of area was planted with the hybrid rice in the 1998-99 *Boro* season.

The undertaking of the present study was prompted by the need for an early assessment of the performance of hybrid rice cultivation and to determine the potentials for its adoption in Bangladesh. The present study primarily focuses on the evaluation of socio-economic aspects of hybrid rice cultivation, based on the farmers' experiences of its adoption in Bangladesh. The study has been undertaken jointly by BRAC, Bangladesh and the International Rice Research Institute (IRRI), Philippines.

Objectives of the study

The specific objectives of the study are

- To assess the comparative farm level performance of hybrid and inbred rice vis-a-vis their performance on research/ on -farm trials,
- To study the factors affecting the yield gain of hybrids over the inbred varieties,
- To examine the relative profitability in hybrid rice production as compared to inbred varieties, and to identify factors contributing to profitability differentials,
- To analyze the socio-economic, marketing and technological constraints to hybrid rice adoption.

II. METHODOLOGY

Data sources

Primary data on two selected hybrid rice varieties viz., Alok 6201 (imported from India) and Sonar Bangla CNSGC-6 (imported from China) at farmer level were collected through household survey. Data on marketing aspects were collected from farmers, selected millers and marketing intermediaries. Secondary data related to yield performance at research stations and on-farm trials were collected from Bangladesh Rice Research Institute (BRRI), Bangladesh Agricultural Development Corporation (BADC), Department of Agricultural Extension (DAE) and and a non-governmental organization known as the Agricultural Advisory Service (AAS). Various related publications have also been used to obtain relevant secondary data.

Sampling and data collection

Considering various agro-ecological zones and also main sources of hybrid rice seeds, six districts/regions were selected for the farm household survey. Three clusters of neighbouring villages were selected from each region to draw samples of households. Out of ten samples from each cluster, three large, four medium and three small farmers were selected. The total targeted sample size was 6 x 3 x 10=180 farm households. However, in Jessore region, due to non-availability of adequate number of hybrid rice adopters, 26 instead of 30 samples were selected. To facilitate comparative analysis, three samples were dropped since these farmers did not produce any inbred varieties along with a hybrid variety. Thus, the total samples came down to 173. Also, the number of samples according to farm size could not be maintained for several locations because of sparse adoption of hybrid rice. The distribution of the sampling area and number of samples according to farm size is shown in Table 2.

Out of 173 samples, 108 were Alok 6201 producers and 65 were the producers of Sonar Bangla variety. As mentioned earlier, all the 173 sample farmers produced hybrid rice along with inbred rice varieties so a paired test of the performance of hybrids relative to inbred varieties could be conducted.

Table 2: Distribution of the sampling area and number of sample farmers according to farm size

District/Region	No. of villages included in clusters	No. of farm households			
		Large	Medium	Small	All
Bogra	6	9	12	9	30
Mymensingh	11	9	11	9	29
Jamalpur*	9	9	12	8	29
Comilla	10	4	14	12	30
Habiganj	13	14	10	6	30
Jessore	16	9	9	7	25
Total	65	54	68	51	173

* Some villages from adjoining Sherpur district were also included in the sample in this region.

For the collection of data, samples were divided into three groups based on farm size: large, medium and small. Considering regional diversity in farm sizes, small farmers were termed as those who owned less than 0.6 ha of land, medium farmers were those who owned land between 0.6 to 1.2 ha, and large farmers were those who owned more than 1.2 ha. Accordingly, the number of small, medium and large farmers were 54 (31%), 68 (39%) and 51 (30%) respectively. However, to facilitate comparison, the above farm size distribution was revised when analyzing the data. Sample farmers were classified into four farm size groups, viz., functionally landless (< 0.2 ha.), small (0.2-1 ha.), medium (1-2 ha.) and large (> 2 ha.) landholders. Distribution of sample farmers according to the revised farm size groups is shown in Table 3.

Table 3: Distribution of sample farmers by farm size and farmer status

Farm size	No. of farmers	Average farm size (Ha)
Functionally Landless (<0.2 ha.)	24 (13.87)	0.09
Small farmers (0.2-1 ha.)	71 (41.04)	0.64
Medium farmers (1-2 ha.)	40 (23.12)	1.32
Large farmers (>2 ha.)	38 (21.97)	4.26
All sizes	173 (100.0)	1.52

Note: Bracketed figures are percentages to total sample

The farm household survey was conducted with the help of a structured questionnaire, which was pre-tested before finalizing it. There were both closed and open-ended questions. The latter were usually used for collecting data on perception of farmers on certain qualitative aspects of hybrid rice adoption. A second questionnaire was used to obtain data on marketing and related aspects. Nineteen traders and the same number of millers were interviewed for collecting marketing data. Six field investigators with

prior field experience were selected and trained before they were sent for the household surveys. Farm-level data for the *Boro* season of 1999 were collected through the surveys.

Analytical tools

Data processing and analysis were carried out by using the SPSS package. Farm-level data generated through household surveys was processed using integrated analytical framework. We compared the performance of hybrids and HYVs grown by the same sample farmer. Thus, paired-t test was used to test the significance in the differences between hybrids and HYVs since same farmer grew both hybrids and inbreds in the same season. The pairing of the observations helped dissociate the effect of the variation due to the agro-ecological difference of the farm and the socio-economic characteristics of the farmer. A tabular analysis is followed to present most of the results. To analyze qualitative answers of farmers' perception, we followed frequency distribution to present the results.

A standard Tobit model was attempted to estimate adoption function for hybrid rice. Usually, the estimation of adoption function is more desirable for any technology only if the farmers were well experienced and well aware of this technology. Therefore, farmers would express their preferences thereby affecting the adoption level of an innovation (Adisena and zinah, 1993). However, hybrid rice is still very new to Bangladesh and the present study was undertaken during the first year of hybrid rice introduction. Nevertheless, a preliminary information on factors influencing the probability of hybrid rice adoption was generated through Tobit model in this study.

Problems faced during study period

Since it was virtually the first year/season of adoption of hybrid rice at farmer level in Bangladesh, rate of adoption in each selected area was low and sporadic. As a result, it was difficult to get 10 sample producers from any single village, as initially planned. So a number of villages in the adjacent area were considered as cluster in drawing sample farmers.

Land distribution in Habiganj district is highly skewed with dearth of small producers and a relatively high incidence of large producers. On the other hand, concentration of

small farmers is high in Comilla. Accordingly in selecting farmers of different farm size groups, the proportion of 3:4:3 for small, medium and large farmers could not be maintained in all districts/regions.

Limitations of the study

Since the period of study covered the first year of hybrid rice adoption and the sample size is small although it covered all agro-ecological regions, the findings of the study may not be taken as general conclusions. Field observations indicated that even the perceptions of the respondents were sometimes a little biased because the seed suppliers and promoters of hybrid seed had provided motivation and given high hopes about the potential performance of hybrid rice. Many producers, without being frustrated due to lower than expected yield and returns, believed that they could achieve better results during the next season by improving their management practice; and therefore, many of them expressed optimistic views on hybrid rice. A follow-up study may be conducted two to three years later to further substantiate the results of the present study.

Basic characteristics of sample farmers

The mean age of all sample farmers was 42 years. The mean age of farmers according to farm size shows an increase in age with an increase in farm size.

A large majority (74%) of all sample farmers was literate. On an average, each farmer had six schooling years of education (Table 4) which is much higher than the average for rural Bangladesh. Thus, it appears that it is the better educated who are the initial adopters of hybrid rice. The average gross sown area, covering both *Aus/Aman* and *Boro* seasons, was 2.1 hectares, indicating a cropping intensity of 150% which may be considered as relatively low as compared to the average for Bangladesh which is 176% (BBS:1999). Nearly 69% of the land area was irrigated which was also high compared to the Bangladesh average. The percentage of gross cropped area devoted to production of *Boro* is 55%. Nearly 75% of the *Boro* area was under HYVs and about 25% under recently introduced hybrid rice on sample farms. Distribution of land type of sample

farmers showed a mixed picture. Most of them owned areas of different elevation of high, medium and low land with the majority having medium and low land.

Cropping pattern showed that cereal crops occupied the largest share (91%) of gross cropped area, covering both *Aus/Aman* and *Boro* seasons. Rice occupied 87% of the gross cropped area. Among other crops, oilseeds and pulses covered 3.8%, vegetables including potato 3.6%, jute 0.9%, chilies and onion account for 0.4% and fruits covered 0.3% of the gross sown area of the sample farmers.

III. COMPARATIVE PERFORMANCE OF HYBRID Vs INBRED RICES

This chapter presents the comparative performance of two rice hybrids, viz., Alok 6201 and Sonar Bangla and corresponding HYV rice varieties at the farmer level. Yield performance at the farmer level is also compared with that of research plots and on-farm trials.

Extent of coverage under hybrid and inbred rices

The two hybrid varieties cultivated by the sample farmers were *Alok* 6201 and *Sonar Bangla* (CNSGC-6). One hundred and eight farmers cultivated *Alok* while *Sonar Bangla* was grown by 65 sample farmers.

The allocation of rice area for hybrid according to farm size of sample farmers shows that proportionate allocation of land was relatively higher for smaller farms than larger farms for hybrid rice (Table 4). It may also be observed from Table 4 that the sample farmers have allocated higher proportion of their land for inbred varieties (74.7%) than for hybrids (24.5%). This was expected since the period of study comprised the first year of hybrid rice introduction in Bangladesh.

Table 4: Extent of area allocated for hybrid and HYV of rice in sample farms by farm size (1998-99 *Boro*)

Farm size group	Average farm size (ha.)	Gross cropped area* (ha.)	Area under *boro* rice (ha.)	% area under *boro* rice	
				Hybrid	HYV
Functionally landless (<0.2 ha.)	0.09	0.66	0.29	35.70	63.70
Small farmers (0.2-1 ha.)	0.64	1.28	0.49	25.24	75.62
Medium farmers (1-2 ha.)	1.32	1.80	0.78	21.94	77.58
Large farmers (>2 ha.)	4.26	4.76	2.70	18.55	76.88
All farmers	1.52	2.08	1.01	24.46	74.70

*Includes rented/leased in land

Estimates of adoption function

As stated earlier, the present study is pertained to the first year of hybrid rice introduction in Bangladesh. Farmers were not aware of the hybrid rice performance. Thus, the sample farmers have a little preference to express on hybrid rice in terms of area allocation, because they were not known to hybrid rice. Therefore, the application

of Tobit model to study adoption behaviour of farmers has a limited relevance. Nevertheless, we made an attempt to estimate Tobit model using several combination of farms and farmer specific variables. Finally, we included the following variables:

(a) AGE (years) (b) EDUCATION, number of years of schooling; (c) LAND OWN (land ownership dummy, "1" if it is owned, "0" otherwise; (d) SEED SOURCE, "1" if source of seed for sample farmer is BRAC, "0" otherwise; (e) FARM SIZE, gross cropped area (ha); and (f) LAND TYPE - type of land ("1" if it is upland; "0" otherwise). Percent of rice area under hybrid rice and HYVs during *Boro* 1998-99 season were taken as dependent variables in respective functions for hybrid and HYVs. Results are summarized in Table 5.

Results show that education level of farmers has significant positive relationship with the probability of extending more area under hybrid rice as well as for HYVs in Bangladesh. Interestingly, negative relationship between land ownership and HYV adoption indicates that tenants are interested in adopting HYVs. This may be due to the intention of tenants to increase rice production to feed his family. Further, farm size (gross cropped area) has shown significant negative association with the adoption probability of hybrid rice while it is positive for HYV adoption. Thus, it implies that small farmers are the potential adopters of hybrid rice in future in Bangladesh. The possible reason for this is that the primary objective of small farmers is to enhance household rice production from a small piece of land to feed the family members. Therefore, they would go for hybrid rice technology since its yield is 15-20% higher than that of HYVs. Similarly, positive relationship between gross cropped area and HYVs adoption indicates that the large farmers would go for HYVs of rice because of not yield factor alone but many other traits of variety which improve farm-level profitability. Further it was found that hybrid rice is potentially more suitable for irrigated lowland areas as shown by negative relationship between land type and hybrid rice adoption (Table 5).

Sources of seed

Table 6 shows that BRAC was the principal supplier of *Alok 6201* seed, supplying 64% of the total while a private company was the main supplier of *Sonar Bangla* seed (63%). Another seed company supplied 23% of *Alok 6201* seed. Other sources of seed were fellow-farmers, government extension department, and the BADC. For HYV seeds, over 83% of the farmers used their own seeds while the sources of purchased seeds included BADC, fellow farmers, private seed dealers and the government extension department.

Table 5: Regression results of Tobit-model estimates for hybrid and inbred HYVs of rice.

Variable	Hybrids		HYVs	
	Coefficient	Standard error	Coefficient	Standard error
Constant	83.91***	3.529	74.862	6.650
AGE	0.273E-01	0.534E-01	-0.718E-01	0.132
BDUCATION	0.233*	0.121	0.558**	0.304
LAND OWN	1.323	1.409	-6.094**	3.165
SEED SOURCE	1.131	1.029	5.753*	3.268
FARM SIZE	-1.806***	0.316	0.971*	0.580
LAND TYPE	-1.814**	1.044	-0.649	3.084
R^2	*0.83*		*0.26*	

*, ** and *** indicate significant at 10%, 5% and 1% probality levels respectively.

Table 6: Sources of hybrid and HYV rice seeds for sample farmers (1998-99 *Boro season*).

Sources	*Alok 6201*		*Sonar Bangla*	HYVs
Private seed company/dealer	25	(23.1)	41 (63.1)	12 (6.9)
BRAC (NGO)	69	(63.9)	17 (26.2)	-
Govt. Extension Department	5	(4.6)	1 (1.5)	9 (5.2)
BADC (Public sector agency)	2	(1.9)	1(1.5)	20 (11.6)
Fellow farmers	9	(8.3)	5 (7.7)	16 (9.2)
Owned seed	-		-	144 (83.2)
Total	**108**		**65**	**173**

Note: Figures in parentheses indicate percentages to the total number of sample farmers with respective concerned hybrid. Multiple choice responses considered.

Inputs used

The inputs considered are seed, organic manures, chemical fertilizers, irrigation water, pesticides, labour, costs of machinery used and other miscellaneous costs. Land rent and interest on working capital are not included. Table 7 shows the average amount of input used according to crop variety. For better comparative analysis, input-use pattern is furnished separately for *Alok 6201* and *Sonar Bangla* hybrids along with their HYVs.

Volume of input-use shows that the seed rate for HYV was substantially higher than the recommended amount of around 30 kg per hectare. Since most of the farmers used their own seed from previous harvest and usually the germination rate is lower than scientifically processed and preserved seeds, they are inclined to use a much higher seed rate than recommended level. On the other hand, seed rate for both the hybrid varieties was slightly lower than the recommended dose. High price of hybrid seed might have induced farmers to cut the seed rate. Organic manure used for hybrids was nearly 71% higher than that for HYVs while chemical fertilizer used for hybrids was only 12% higher than that for HYVs. Organic manure and chemical fertilizer use was much higher for *Sonar Bangla* than *Alok 6201*. Even in case of HYVs, those HYV producers who grew *Sonar Bangla*, used much more manure and fertilizer than those who cultivated *Alok-6201* along with HYVs. The highest amount of organic manure was used for *Sonar Bangla* and the lowest for HYV rice.

Use of chemical fertilizer was also higher for *Sonar Bangla* than for both *Alok 6201* and HYVs. Farmers who grew *Sonar Bangla* used 57% higher chemical fertilizer for HYVs than those who cultivated *Alok 6201*. *Sonar Bangla* also had highest frequency of irrigation. The number of pesticides sprays was much higher for hybrid varieties than HYVs. But labour use and irrigation input were almost the same for the hybrid *Alok 6201* and the inbred varieties.

Table 7: Inputs use pattern for production of Alok, Sonar Bangla and HYV rice by sample farmers (1998-99 *Boro season*).

Input	Alok (n=108)	HYV (n=108)	S.Bangla (n=65)	HYV (n=65)	All hybrids (n=173)	All HYVs (n=173)
Seed (kg/ha)	11.5	44.9	11.4	54.4	11.5	48.5
Organic manure (t/ha)	3.0	1.9	5.7	3.1	4.0	2.3
Chemical fertilizer[a] (kg/ha)	392.7	363.1	662.0	570.6	494.0	439.7
Irrigation (no of application)	13.4	12.9	24.8	24.6	17.7	17.3
Pesticides (no of sprays)	2.1	1.2	2.2	1.6	2.1	1.3
Labour (days/ha)	126.0	118.6	126.0	126.0	126.0	121.0

[a]Includes urea, DAP; MOP and other fertilizer applied.

Table 8: Cost of inputs for hybrid and HYVs of rice by sample farmers (1998-99 *Boro season*).

(Tk/ha)

Input	Alok (n=108)	HYV (n=108)	S.Bangla (n=65)	HYV (n=65)	All hybrids (n=173)	All HYVs (n=173)
Seed	2323	545	2445	635	2369	579
	(10.7)	(3.2)	(9.3)	(2.9)	(10.1)	(3.0)
A. Organic manure	1043	614	1377	748	1169	664
B. Chemical fertilizer	3149	2442	5465	4543	4019	3232
Sub Total (A+B)	4192	3056	6842	5291	5188	3896
	(19.2)	(17.8)	(26.1)	(23.7)	(22.1)	(20.4)
Irrigation	3975	3518	6173	6151	4801	4507
	(18.2)	(20.4)	(23.6)	(27.6)	(20.5)	(23.6)
Pesticides	1582	883	1393	941	1510	905
	(7.3)	(5.1)	(5.3)	(4.2)	(6.4)	(4.7)
Labour	7946	7503	7121	7090	7636	7348
	(36.4)	(43.6)	(27.2)	(31.8)	(32.6)	(38.4)
Machinery use for	1629	1609	2171	2164	1833	1818
cultivation	(7.5)	(9.3)	(8.3)	(9.7)	(7.8)	(9.5)
Miscellaneous	157	96	40	22	114	68
	(0.7)	(0.6)	(0.2)	(0.10)	(0.5)	(0.4)
Total cost	21804	17210	26187	22294	23451	19121

Note: Figures in parentheses indicate percentages to total cost.

The survey data indicate that the total cost of inputs was the highest for *Sonar Bangla* followed by *Alok 6201* as compared to the HYVs (Table 8). The total cost of inputs per hectare for *Sonar Bangla* and *Alok 6201* were Tk. 26,187 and Tk. 21,804 respectively. Input costs for HYVs of farmers producing *Sonar Bangla* were 30% higher than that of farmers producing *Alok 6201*. Considering input costs of both hybrids and all HYVs the costs for hybrids were 23% higher than the costs for HYVs. Hybrid rice cultivation in India was also found 19% costlier than inbred varieties (Janaiah and Hossain, 2000).

For all varieties the highest cost was on account of labour which comprised 27% of total cost in case of *Sonar Bangla,* 36% for *Alok 6201* and 38% for all HYVs. Taking both hybrids together, the labour cost was 33% of the total cost. The second highest cost item was fertilizer for hybrids, which was 19% for *Alok 6201* and 26% for *Sonar Bangla*. Fertilizer costs were the third highest cost component for HYVs for which, the second highest cost component was irrigation that constituted 24% of total input costs. Irrigation cost formed the third most important item for both the hybrids, which varied from 18% for *Alok 6201* to 24% for *Sonar Bangla*.

The largest difference in cost items between the hybrids and the inbreds was on account of seeds. The seed accounted for only 3% of total cost for HYVs while for *Alok 6201* it was 10.7%, and for *Sonar Bangla* it was 9.3% of total cost. The total seed cost for hybrid varieties were nearly four times to the cost of seeds for HYVs. This was due to the large difference in the price of hybrid and inbred rice seeds, although the seed rate for the hybrids were substantially lower. The average prices of *Alok 6201, Sonar Bangla* hybrid seeds were Tk. 200, and Tk. 210 per kg respectively, while it was only Tk. 10 per kg for various inbred HYVs. Differences in the relative costs of inputs for the two hybrids and the HYVs has been shown in Fig. 3.

Fig 3: Total input costs for Hybrids and HYVs

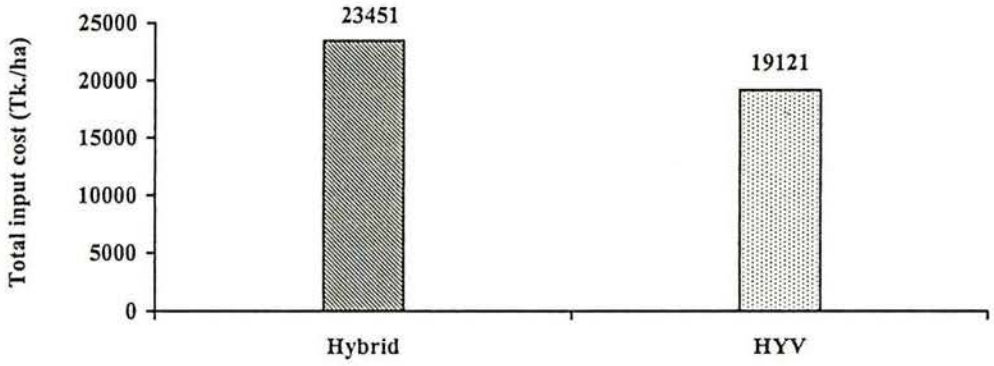


Table 9 presents the costs of various inputs by farm size group. The landless farmers incurred the lowest input costs for both hybrids and HYVs, but costs did not consistently increase with the increase in farm size. For hybrids, the highest input costs were incurred by small farmers while for HYVs, the highest cost was borne by large farmers.

Table 9: Cost of inputs for hybrid and HYV of rice by farm size (tk/ha) on sample farms (1998-99 *Boro* season).

Inputs	Farm size									
	Landless		Small		Medium		Large		Average	
	Hybrid	HYV	Hybrid	HYV	Hybrid	HYV	Hybrid	HYV	Hybrid	HYV
Seed	2420	616	2342	532	2356	608	2400	611	2369	579
Organic manure	970	406	1385	834	917	528	1156	654	1169	664
Chemical fert	3153	2308	3808	2731	4362	4161	4601	3772	4019	3232
Irrigation	4099	3817	5593	5009	4189	4247	4407	4280	4801	4507
Pesticides	1423	849	1761	1160	1238	626	1384	757	1510	905
Labour cost	7515	7281	7517	7279	7092	6942	8508	7947	7636	7348
Machinery cost	1824	1768	1964	1974	1766	1810	1665	1565	1833	1818
Miscellaneous	20	9	68	67	250	93	114	81	113	68
Total cost	21424	17054	24439	19586	22169	19016	24235	19667	23451	19121

Yield performance

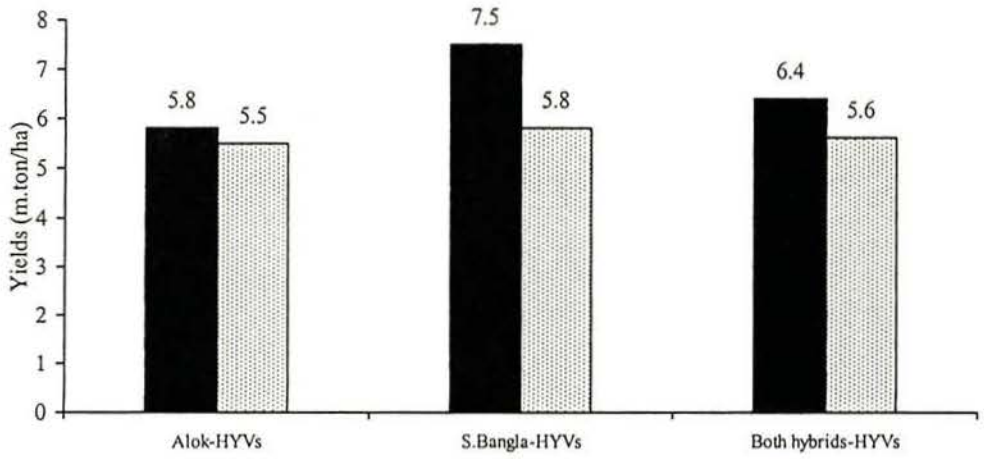
The relative yield performances of the different rice varieties (hybrids and HYVs) are presented in Table 10. Overall yield performance shows that *Sonar Bangla* performed better with an average yield of 7.50 t/ha. The yield of *Alok 6201* was 5.84 t/ha whereas for HYV, it was 5.63 t/ha. For farmers who cultivated both *Alok 6201* and HYVs, the average yield gain of *Alok 6201* over HYVs was only 5% while for farmers who grew both *Sonar Bangla* and HYVs, the average yield gain of *Sonar Bangla* over HYVs was as high as 31%. Taking the two hybrids together, the yield gain of hybrids over HYVs was 15% which is closer to yield gains reported from India (Janaiah and Hossain, 2000). Differences in yield performances of the hybrids and the HYVs may also be seen from Fig.4.

Table 10: Comparative yield levels of hybrids and HYVs of rice on sample farms (1998-99 *Boro* season).

Rice variety	Grain yield (t/ha)	% difference
Alok 6201 (n=108)	5.84	4.66
HYV (n=108)	5.58	(1.62)
Sonar Bangla (n=65)	7.50	31.35***
HYV (n=65)	5.71	(6.05)
Both hybrids (n=173)	6.46	14.74***
All inbreds- HYVs (n=173)	5.63	(5.24)

Note: Figures in parenthesis are estimated 'paired-t' values

Fig 4: Grain yields of hybrids and HYVs on sample farm



District/region-wise yield levels for hybrid and inbred varieties indicate that the performance of *Sonar Bangla* was the highest in Jamalpur and the lowest in Comilla (Table 11). The yield levels of *Alok 6201* varied from 5.05 t/ha in Mymensingh to 6.86 t/ha in Comilla. Average yield per hectare of HYVs was the highest in Comilla and the lowest in Habiganj for all varieties. Overall yield performance appears to be relatively better in Comilla than in other districts (Table 11).

Table 11: District-wise yield performances of different rice varieties of sample farmers (1998-99 *Boro* season).

District/Region	Rice varieties		
	Alok-6201	Sonar Bangla	HYVs
Bogra	5.58	-	6.17
Mymensingh	5.05	-	4.88
Jamalpur	-*	8.79	5.83
Comilla	6.86	6.11	6.39
Habiganj	6.06	-	4.83
Jessore	-	6.67	5.66
Average-All	5.81	7.48	5.63

• One *Alok* 6201 producer from Jamalpur was included in this sample whose yield rate was 7.90 mt/ha.

Yield performance of all hybrids together and HYVs of rice by farm size is shown in Table 12. In case of hybrids, the large farmers obtained the highest yield while the functionally landless had the lowest yield. The yield performance of the landless was also the lowest for HYVs while that of small farmers was the highest.

Table 12: Yield levels of hybrid and HYV of rice by farm size on sample farms (1998-99 *Boro* season).

Farm size	Yield (t/ha)			
	Hybrids	HYVs	% difference	
Functionally landless	5.91	4.96	19.15***	(3.86)
Small	6.39	5.85	9.23**	(2.32)
Medium	6.35	5.74	10.63*	(1.94)
Large	6.45	5.53	16.64**	(2.41)
All sizes	6.46	5.63	14.74***	(5.24)

Note: Figures in parentheses are estimated 'paired-t' values

A comparative picture of yield performances of hybrids and HYVs of rice at farmer level, research plots and on-farm trials is also presented in Table 13. The table shows the yields obtained on the sample farmers, BRRI farms, BADC seed farms, and on-farm trials of the DAE. The results of the recent study by Agricultural Advisory Services (AAS) may be considered as results of on-farm trials since they included only those farmers, numbering 33 from 10 districts, who strictly adhered to the recommended management practice for the hybrid and HYV cultivars.

Table 13: Yield of hybrids and HYVs of rice on sample farms, research farms and on farm trials (1998-99 *Boro* season).

Variety	Sample farms	Research farms	On arm rials		
		BRRI[a]	BADC[b]	DAE[c]	AAS[d]
Alok-6201	5.81	5.27	5.22	7.29[1]	6.06
	(3.2)	(3.1)	(18.6)		(-3.2)
Sonar Bangla	7.48	6.72	5.47	-	7.55
	(32.9)	(25.7)	(24.3)		(20.6)
HYV	5.63	5.11[2]	4.39[3]	-	6.26[4]

Note: Figures in parentheses are % yield gains of hybrid over the HYVs.
Source: a, b, c, d reports of respective organizations
[1] For control plots the average yield recorded was 5.34 t/ha
[2] For BR-28 only, [3] For BR-28, BR-29, BR-26, BR-16 and BR-14, [4] For BR-29 only

Table 13 shows that the yield performance of *Sonar Bangla* was impressive on both sample farms, research farms and on farm trials. The performance of *Alok 6201* did not out yield significantly HYVs of rice on farms. The yield rate of *Alok 6201* ranged from 5.22 t/ha. in BADC seed farms to 6.06 t/ha in AAS farm sites. However, the yield of *Alok 6201* is quite impressive in DAE on-farm trials. The data on DAE farms appear to

be somewhat unreliable in view of *Alok 6201* performance in other farms. In some areas yield of *Alok 6201* are unusually high, e.g., in Dhaka 11.40, Comilla 10.5 and in Jhikargacha 12.8 t/ha which have raised the average figures. DAE figures for control plot yield was 5.34 t/ha. The yield rates of HYVs varied from 4.39 t/ha on BADC farm to 6.26 t/ha under AAS on-farm trials.

It is interesting to note that the yields recorded in BRRI research plots and BADC seed farms were, in general, lower than the yield obtained on farmers' fields. The performance of AAS on-farm trials was even better than BRRI and BADC yield figures. Data on only *Alok 6201* could be procured from DAE which were for the *Boro* season 1997-98. The BRRI and BADC data also pertain to the same season. However, data on AAS on-farm trials relate to 1998-99 *Boro* season. Data on farmer level yields for the present study also relate to the 1998-99 *Boro* season. Data on yield in research farms for 1998-99 were not available since BRRI and BADC have excluded hybrids of *Alok 6201* and *Sonar Bangla* (CNSGC-6) from their trials.

Yield gains

On the basis of the yield performances of sample farmers who grew both hybrid and HYVs, the yield gains of hybrids over HYVs were estimated. For *Alok 6201* it was a marginal 4.7% while for *Sonar Bangla* it was an impressive 31.4%. The yield data of the BRRI research plots and BADC on-farm trials also show that both *Alok 6201* and *Sonar Bangla* performed better than HYVs, but the yield gain was much higher for *Sonar Bangla* than for *Alok 6201*. However, AAS on-farm trials showed a somewhat different picture. *Sonar Bangla* out-yielded both *Alok 6201* and HYVs, but *Alok 6201* had a negative yield gain over popular HYV. It may be noted here that in case of the AAS on-farm trials, only one HYV, BR-29 was considered as a check variety for comparison. BRRI trials also considered a single HYV (BR-28). However, in BADC trials and in case of the present farmer level performance study, a number of HYVs were included. In the present study the yield rate of BR-29 was found to be 6.3 t/ha while yield rates for BR-28 and BR-6 were 6.4 and 6.7 t/ha respectively. Thus, a number of selected inbred varieties showed higher yield levels than *Alok 6201* hybrid in farmers' fields (see Table 26).

Profitability

The details of the costs and returns for the different rice varieties (hybrids and HYVs) are shown in Table 14. Among *Alok 6201, Sonar Bangla* and HYVs, the highest grain value (market price) was obtained for *Sonar Bangla*. Value of grain was relatively higher for *Alok 6201* than for HYVs by about 4%. Note that in the most cases the value (market price) for hybrid grain was provided by the sample farmers based on their own perception but not actual price received for the produce in the market.

Total returns were also highest for *Sonar Bangla* and lowest for HYVs. Total value added was the highest for *Sonar Bangla* and the lowest for *Alok 6201*.

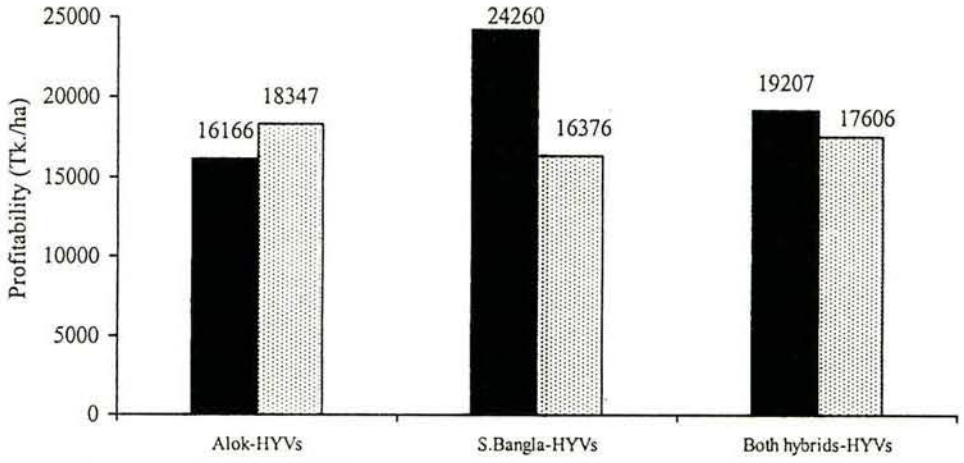
Combining the costs and returns of both the hybrid varieties together, analysis shows that production of hybrid has been relatively more profitable, but the difference is not statistically significant (Table 14). Relative profitabilities of hybrids and HYVs are also shown in Fig. 5.

Table 14: Returns to hybrid and HYV rice production for sample farmers (1998-99 *Boro* season).

Item	Alok (n=108)	HYV (n=108)	% diff.	S. Bangla (n=65)	HYV (n=65)	% diff.	Both hybrid (n=173)	Both HYV (n=173)	% diff.
Yield (tk/ha)	5.81	5.53	5.1* (1.62)	7.48	5.71	31.3 (6.05)	6.44	5.63	14.4*** (5.24)
Market price	6198	5965	3.9*** (3.63)	6458	6358	1.6* (1.70)	6296	6113	3.0*** (3.08)
*Gross return (tk/ha)	37971	3558	6.8** (1.92)	50447	38670	30.5*** (6.43)	42659	36727	16.2*** (5.51)
Total cost (tk/ha)	21805	17211	26.7*** (10.49)	26187	22294	17.5*** (7.56)	23451	19121	22.6*** (12.99)
Net return (tk/ha)	16166	18347	-11.9* (1.72)	24260	16376	48.1*** (4.13)	19207	17606	9.1 (1.44)

* Includes straw value

Fig 5: Profitability of hybrids and HYVs of sample farmers



The economic returns to the production of hybrid and HYV rices by farm size can be reviewed from Table 15. For hybrids, farm operating surplus was positively related with farm size with highest operating surplus received by large farms. However, in case of HYVs, the highest operating surplus was received by medium farms while it was the lowest for the landless. It imply that hybrids were more profitable for large farms because of their capacity to make higher investment in hybrid rice production. Further, it also implies that the hybrid rice production is capital intensive and more responsive to higher inputs as compared to HYVs.

Table 15: Comparative costs and returns for hybrids and HYVs of rice of sample farmers by farm size.

(tk/ha)

	Farm size									
Cost/return	Landless		Small		Medium		Large		Average	
	Hybrid	HYV	Hybrid	HYV	Hybrid	HYV	Hybrid	HYV	Hybrid	HYV
Gross return	38267	31235	42067	37405	42197	38133	47024	37448	42659	36727
Total cost	21424	17054	24439	19586	22169	19016	24235	19667	23451	19121
Farm-operating surplus	16843	14181	17628	17820	20028	19117	22788	17781	19207	17606

Table 16: Relative performance of hybrid and HYV of rice by land type (1998-99 *Boro* season).00

Land type/Variety	Grain yield (t/ha)	Market price (tk/t)	Gross return (tk/ha)	Total input cost (tk/ha)	Net return (tk/ha)
UPLAND					
Alok (n=50)	5.8	6185	37692	22653	15039
HYV (n=50)	5.6	6172	36836	17891	18945
% Difference	3.6	0.2	2.3	26.6	-20.6
Sonar Bangla (n=37)	7.2	6392	48219	27061	21158
HYV (n=37)	5.8	6382	38958	23161	15797
% Difference	24.1	0.2	23.8	16.8	33.9
Both Hybrids (n= 87)	6.4	6273	42169	24528	17641
All HYVs (n=87)	5.7	6261	35704	20133	17606
% Difference	12.3	0.2	18.1	21.8	0.2
LOWLAND					
Alok (n=58)	5.8	6209	38212	21073	17139
HYV (n=58)	5.5	5787	34455	16624	17832
% Difference	5.5	7.3	10.9	26.8	-3.9
Sonar Bangla (n=28)	7.9	6546	53391	25032	28359
HYV (n=28)	5.8	6326	38289	21148	17141
% Difference	36.2	3.5	39.4	18.4	65.4
Both Hybrids (n=86)	6.5	6319	43154	22362	20792
All HYVs (n=86)	5.6	5962	35704	18097	17607
% Difference	16.1	6.0	20.9	23.6	18.1

Relative performance of hybrids and HYVs by land type is shown in Table 16. Results show that the overall performance of hybrids was better in lowland areas than for upland areas. For *Sonar Bangla*, both yields and farm-operating surplus were higher in lowland areas. HYV yields were marginally lower in lowland areas but it was not the case for operating surplus. In lowland areas, the performance of hybrids was relatively better than HYVs.

Yield response functions

We estimated the yield response functions for hybrids and inbred HYVs using the standard Cobb-Douglas production function. The variables included are FARM-SIZE (farm size ha), SEED (seed rate - kg/ha), MANURE (organic manures - kg/ha); FERT (quantity of chemical fertilizers applied (kg/ha); IRRIN (irrigation number); SPRAY number of pesticide applications); LABOUR (labour days/ha); and MACHINE (rental value of machine cost - Tk/ha). Yield response functions were fitted separately for

hybrids and HYVs of rice. Paddy yield (kg/ha) was considered as dependent variables. The R^2 of the estimated functions appear to be low because of per hectare functions where variations in inputs/yields was very small since all are in per hectare. Therefore, R^2 of per unit area function is always less than that of per farm functions.

Among all independent variables, only organic manures and machine-use were found to be significantly influencing factors for the yield of HYVs. However in case of hybrid rice, chemical fertilizers and irrigation were also showing significant effect on yield (Table 17). Interestingly, the value of intercept is nearly same for both hybrid and HYVs, implying that the yield gain of hybrid rice over the HYV was primarily due to increased use of inputs especially chemical fertilizer and frequency of irrigation. Therefore, introduction of hybrid rice basically enables farmers to increase the use and productivity of modern inputs like fertilizer thereby enhancing paddy yields.

Table 17: Estimates of yield response functions for hybrids and HYVs of rice of sample farmers (1998-99 *Boro* season).

Variable	Hybrid (n=173)		HYVs (n=173)	
	Coefficient	Standard error	Coefficient	Standard error
INTERCEP	2.271***	0.581	2.271***	0.458
FARM SIZE	0.046	0.042	-0.006	0.034
SEED	-0.162	0.099	0.064	0.057
MANURE	0.033	0.023	0.057	0.021
FERT	0.103**	0.036	0.020	0.026
IRRIGATION	0.075***	0.028	0.018	0.025
SPRAYS	-0.058	0.050	0.012	0.037
LABOUR	0.229	0.211	0.054	0.0459
MACHINE	-0.075	0.692	0.140***	0.0521
R^2	0.13		0.10	

*, ** and *** indicate significant at 10%, 5% and 1% probality levels respectively.

Timeliness of operations

Time tuning of key farm operations such as seeding, transplantation, weeding, fertilizer applications, irrigation, harvesting and threshing is very important for exploitation of available yield potential of hybrids. Our study indicates that almost all farmers performed these operations in time (Table 18). However, 8% of the farmers who grew *Alok 6201* delayed transplantation by one to three weeks while another 10% *Alok 6201*

growers did not follow irrigation schedule and delayed by one to three weeks. Therefore, the delay of transplantation and irrigation might be a key factor behind the low level of yield gains of *Alok 6201* growers as compared to *Sonar Bangla* whose farmers followed all key farm operations in time.

In case of *Sonar Bangla* 8% of the sample producers faced delay in seeding which also delayed the harvesting of the crop. In spite of these delays the yield of *Sonar Bangla* was the maximum compared to all rice varieties. For HYVs, transplanting and harvesting was delayed only for 5% of the producers. It should be noted here that pesticides were used by 94% of the *Alok 6201* and 88% of the *Sonar Bangla* producers compared to 76% of the producers of inbred HYVs. It suggests that either the hybrids are less resistant to pests or the hybrid producers are more prone to use pesticides to save the crop because of higher investments made in seeds and fertilizers.

The study investigated reasons for the delay in some farm operations and found that late rainfall and problems with machinery use including irrigation equipment were the main factors. Among other reasons mentioned were shortage of capital, dearth of electricity and non-availability of seed in time.

The farmers were also asked questions about problems they faced in connection with labour and water shortage. Responses showed that 21% *Sonar Bangla* producers, 16% HYV producers, and 9% *Alok 6201* producers faced the problem of labour shortage. Labour shortage was reported particularly for the harvesting and transplantation operations. Thirty percent of *Alok 6201* producers, 16% HYV producers and 11% *Sonar Bangla* producers reported facing problems regarding the supply of irrigation water. For *Alok 6201* the problem was faced mostly during grain formation stage, for *Sonar Bangla* the problem was mainly faced during flowering stage while for HYV producers the problem was faced during both grain formation and flowering stage. The problem was least faced during tillering stage.

Table 18: Timeliness of different farm operations followed by sample farmers for rice hybrids and HYVs (1998-99 *Boro* season).

Farm operations	Timely performed (% sample farmers)			Operations delayed by 1-3 weeks (% sample farmers)		
	Alok	S.B	HYV	Alok	S.B	HYV
Seeding	97.2	92.3	97.1	2.7	7.7	2.9
Transplantation	91.7	95.4	95.4	8.3	4.6	4.6
Weeding	96.3	100.0	97.7	3.7	-	2.4
Fertilizer application	98.2	98.5	97.7	1.9	1.5	2.4
Plant Protection*	91.7	87.7	74.6	1.9	1.5	1.8
Irrigation	89.8	95.4	94.2	10.2	4.6	5.9
Harvesting	98.1	93.8	95.4	1.9	6.2	4.6
Threshing	98.1	100.0	97.7	1.9	-	2.3
N	108	65	173	108	65	173

* All farmers did not use pesticides. Thus the percentages shown here do not add up to 100
S.B.-Sonar Bangla; *Alok-Alok* 6201.

Biotic constraints

Regarding damage of crops by different biotic stresses (pests and diseases), the farmers mentioned stem borer, rice hispa, rice bug, brown plant hopper, green leaf hopper, galmidge, rice caterpillar and mites which are affecting hybrids and HYVs of rice. The relatively most common among these biotic stresses was the stem borer (Table 19). It was reported that pest problem was more serious on hybrids than on HYVs in terms of extent of crop losses. Diseases were not reported as significant problems.

Table 19: Incidence of pests and diseases and extent of crop damage on hybrids and HYVs of rice on sample farms (1998-99 *Boro* season).

Pests/disease	No. of sample farmers reported					
	Hybrid (N=173)			HYVs (N=173)		
	extent of damage (%)			*extent of damage (%)*		
	>30	**20-30**	**10-20**	**>30**	**20-30**	**10-20**
Stem borer	12	10	55	7	4	58
Rice Hispa	4	2	12	1	1	6
Rice bug	-	1	8	-	1	3
Brown Plant-hopper	-	2	3	-	-	5
Rice Caterpillar	-	-	-	-	1	-
Green Leaf hopper	-	-	1	-	-	1
Galmidge	-	-	1	-	-	1
Mites	-	-	-	-	-	1
Sub total	*16*	*15*	*80*	*8*	*7*	*75*
Tungro Virus	1	-	-	-	1	-
Blast	-	-	2	-	-	-
Others	-	-	4	-	-	2
Total Cases	17 (9.8)	15 (8.7)	86 (49.7)	8 (4.6)	8 (4.6)	77 (44.5)

Figures in parentheses were percentages to "N"

Among hybrids and HYVs, *Alok 6201* faced highest pest infestation. Seventy-three percent of the farmers reported either pest attack or incidence of disease. In terms of severity of losses caused by pest attack, crop losses of more than 30% was reported for *Alok 6201*. Crop losses, reported by majority, were less than 20% for all varieties.

IV. FARMERS' PERCEPTION OF HYBRID RICE

Consumption of hybrid rice grain

Eighty-five percent of the sample farmers stated to have consumed hybrid rice. Of those who used hybrid rice for consumption, 75% considered hybrid rice as palatable for their taste (Table 20). Of the remaining 25% (mostly for *Alok 6201*) who reported the quality of hybrid not up to mark, nine out of 10 complained about the stickiness of hybrid rice. Relatively more consumers of *Alok* 6201 reported about stickiness of cooked rice than consumers of *Sonar Bangla.* Many respondents mentioned that cooked hybrid rice could not be kept for long i.e., the quality deteriorated soon after cooking (poor keeping quality). So the rice was not suitable for breakfast with the left over rice cooked the previous evening. Among other reasons, 26% mentioned about the inferior quality of the grain, 23% mentioned about inconvenience of cooking, 9% mentioned bad smell, and 6% mentioned other reasons.

Table 20: Reasons stated by respondents for non-suitability of hybrid rice grain consumption (1998-99 *Boro* season.0.....

Reasons	Frequency of Response (n=35)			
	Alok-6201 (n=27)	%	Sonar Bangla (n=8)	%
Stickiness of cooked rice	26	96.3	6	75.0
Taste not so good	13	48.1	5	62.5
Quality deteriorates after cooking	16	59.3	2	25.0
Inferior quality	8	29.6	1	12.5
Inconvenience in cooking	5	18.5	3	37.5
Unfavourable odour	2	7.4	1	12.5
Others	2	7.4	-	-

Note: Multiple choice responses considered.

Consumers' criteria for choice of a variety

The perception of the sample farmers was obtained on their preference for different rice varieties for household consumption. Their responses showed a wide variety of choices included as many as 71 rice varieties. However, considering the frequency of their first preference, *Pajam* (BR-14) was the most popular rice variety followed by BR-3, BR-11, BR-6, and *Swarna* (Table 21).

Table 21: Popular rice varieties preferred by sample farmers' for domestic consumption.

Rice variety	1st Preference	2nd Preference	3rd Preference
Pajam (BR-14)	34 (19.6)	15 (8.7)	-
BR-3	14 (8.1)	12 (6.9)	-
BR-11	13 (7.5)	17 (9.8)	25 (14.5)
BR-6	11 (6.4)	-	-
Swarna	10 (5.8)	-	-

Note: Figures in parentheses indicate percentages of total sample (n=173)

However, these five varieties were preferred by 47% of the total sample farmers. Several other varieties were indicated by the other respondents as the preferred variety, but these were of relatively less importance in terms of frequency of choice and, therefore, are not mentioned here.

There must be a mix of criteria in consumers' mind while choosing a variety among a lot for consumption. An attempt has been made to ascertain the criteria for choice of a variety for household consumption by the sample farmers. These are summarized in Table 22. According to frequency of responses the five major criteria mentioned are good taste, good keeping quality, less stickiness after cooking, ease of cooking and better grain quality (general impression of overall quality). It is observed from the responses that good taste and better grain quality are by far the most important factors that determine the choice of a rice variety for consumption, other things remaining the same. The analysis of consumer preferences would obviously have useful implications on hybrid rice research and development strategy. Future research on hybrid rice development should therefore focus on improvement of grain quality beside yield and pest resistance in the next generation hybrids.

Table 22: Criteria for choosing a rice variety for domestic consumption.

Criteria	Frequency of response	%
Good taste	163	94.2
Better grain quality	152	87.9
Good keeping quality	80	46.2
Less sticky after cooking	71	41.0
Ease of cooking	56	32.4
Others*	19	11.0

*Others include liked by all household members, takes longer time to digest, and fluffiness of cooked rice.
Note: Due to multiple choice answers the frequencies of response exceed the number of samples.

Farmers' perception on continuation of hybrid rice cultivation

Eighty two percent of *Sonar Bangla* producers and only 40% of *Alok-6201* producers expressed their intention to continue cultivating the hybrid variety (Table 23). The stated reasons for continuation of hybrid rice production by *Alok-6201* and *Sonar Bangla* producers are reported in Table. 23.

Ninety one percent of those who wanted to continue the cultivation of hybrids expressed that they would expect better yield in the next year, 56% expected more profit and 44% considered *Alok-6201* as suitable for own consumption. Among *Sonar Bangla* cultivators who are willing to continue, 93% expected better yield and 62% expected higher profit in the next year. Thirty six percent also mentioned about its suitability for consumption while 30% mentioned its suitability for making puffed and flattened rice.

Table 23: Reasons for continuation of hybrid rice cultivation, expressed by sample farmers.

Reason	Alok-6201(n=43)		Sonar Bangla (n=53)	
	Frequency of response	%	Frequency of response	%
Expect better yield next year	39	90.7	49	92.5
Expect more profit	24	55.8	33	62.3
Suitable for own consumption	19	44.2	19	35.8
Suitable for puffed rice and flattened rice	12	27.9	16	30.2
Cooking quality favourable	11	25.6	9	17.0
Suitable for production under different environment	6	14.0	4	7.5
Expect better hybrid variety seeds	5	11.6	3	5.7
Relatively less susceptible to pests/disease	3	7.0	4	7.5
Good flavour	1	2.3	-	-
Others	8	18.6	4	7.5

Note: *Due to multiple choice response, percentages do not add up to 100 n= number of farmers willing to continue hybrid rice cultivation*

Reasons for discontinuation of hybrid rice cultivation

Sixty percent of *Alok 6201* and 18% *Sonar Bangla* growers did not want to continue cultivation of hybrid rice. The reasons for discontinuation of hybrid rice, as stated by the responding farmers, are presented in Table 24 (a) and Table 24 (b).

The tables show that the responses from *Alok 6201* and *Sonar Bangla* producers were not the same, though there were some common reasons expressed. Common reasons were high costs of seed, requirement of more care and management time, lower than expected yield, high pests and disease attack, low profits, unsuitability for home consumption, etc. *Alok 6201* producers mentioned some additional reasons, the most important of which was unfilled grains. Ninety one percent of growers mentioned this as an important factor behind the low yield of *Alok 6201*. Among other reasons mentioned were high grain shedding, lodging of the plant, low headrice recovery after milling and low grain quality. Thus, compared to *Sonar Bangla* farmers, relatively more *Alok 6201* farmers were not in favour of continuing hybrid rice production.

Table 24(a): Farmers' perception on reasons to discontinue hybrid rice by *Alok-6201* growers.

Reasons	No. of respondent (n=65)	
	Frequency of response	Percentage
Chaffy grain/unfilled grain	59	90.8
High cost of seed	50	76.9
More care and management time needed	41	63.1
Yield lower than expected	37	56.9
High grain shedding	35	53.8
Higher attack by pests/disease	31	47.7
Lodging due to weak stem	30	46.2
Low profit	28	43.1
Less market demand	21	32.3
Low grain price	20	30.8
Difficult to obtain quality seed	15	23.1
Low milling recovery	14	21.5
Not suitable for consumption	13	20.0
Low grain quality	10	15.4
Others	10	15.4

Note: Multiple choice response involved.
n= number of farmers not willing to continue hybrid rice cultivation

Table 24(b): Farmers' perception of reasons stated to discontinue hybrid rice cultivation by *Sonar Bangla* growers.

Reasons	No. of respondents (n=12)	
	Frequency of response	Percentage
High cost of seed	5	41.7
Needs more care and management time	4	33.3
Yield lower than expected	4	33.3
High cost of production	3	25.0
Low price	3	25.0
Low profit	3	25.0
Higher attack of pests/disease	2	16.7
Not suitable for home consumption	2	16.7

Note: Multiple choice response involved
n= number of farmers not willing to continue hybrid rice cultivation

Farmers' perception of relative performance of hybrid rice

Majority of respondents comprising both *Alok 6201* and *Sonar Bangla* cultivators reported that hybrid was better in term of higher yield and also better grain quality in terms of appearance of *Alok 6201* (Table 26). Eighty-nine percent of *Sonar Bangla* producers and 52% *Alok 6201* producers mentioned about higher yield of hybrid while 57% of *Sonar Bangla* and 53% of *Alok 6201* producers expressed favourable opinion about grain quality of hybrids. *Sonar Bangla* producers also reported that it was more profitable than HYVs. On suitability of hybrid rice for consumption, 42% of *Alok 6201* and 35% of *Sonar Bangla* producers said that hybrid rice was of better eating quality than the inbred HYVs. So, according to majority of hybrid producers, hybrid rice was either equally or less suitable for consumption than the inbred HYVs. Ninety-four percent of the *Alok 6201* producers expressed unfavourable opinion on hybrid because of high lodging and grain shedding characters of *Alok 6201* and 97% indicated for prevalence of unfilled grain (sterile grain). Majority of *Alok 6201* producers (69%) but only one-third (32%) of *Sonar Bangla* producers mentioned incidence of pests/diseases was higher on hybrids than on HYVs of rice.

Farmers' criteria for adoption of a rice variety

The extent of adoption of a variety by the farmers in a particular location is dependent on the variety traits that are suitable to the farmers' preferences and local environments. Assessing such farmers' criteria would enable prioritizing varietal

improvement programme by integrating farmers' needs into research priorities. We made an attempt in this study to look at the farmers' criteria for allocation of land area under different rice varieties.

The most popular high yielding varieties cultivated by the sample farmers and their area coverage and market price were presented in Table 26. Accordingly the five top varieties in order of area coverage were BR-3, BR-29, BR-6, BR-14 and BR-11 followed by BR-28 and BR-1 (Table 26). The yield rates of these varieties are also presented in the Table which indicate that the yield rates of BR-1, BR-28 , BR-29 and BR-1 are higher than the yield rate of *Alok 6201* which is one of the two hybrid varieties under study.

Table 25: Farmers' perception of relative performance of hybrid and HYV of rice.

Indicators	Alok-6201 (N=108)			Sonar Bangla (N=65)		
	Better than HYV	Worse than HYV	Same as HYV	Better than HYV	Worse than HYV	Same as HYV
Yield of rice	56 (51.9)	40 (37.0)	12 (11.1)	58 (89.2)	4 (6.2)	3 (4.6)
Grain quality	57 (52.8)	28 (25.9)	23 (21.3)	37 (56.9)	15 (23.1)	9 (13.8)
Suitability for consumption	45 (41.7)	20 (18.5)	43 (39.8)	23 (35.4)	16 (24.6)	21 (32.3)
Market price	51 (47.2)	28 (25.9)	29 (26.9)	19 (29.2)	13 (20.0)	32 49.2)
Profitability	37 (34.3)	45 (41.7)	26 (24.1)	43 (66.2)	7 (10.8)	11 16.9)
Incidence of pests/diseases	74 (68.5)	10 (9.3)	24 (22.2)	21(32.3)	14 (21.5)	26 (40.0)
Market demand	21 (19.4)	44 (40.7)	43 (39.8)	14 (21.5)	25 (38.5)	26 (40.0)
Seed cost	105 (97.2)	2 (1.9)	1 (0.9)	63 (96.9)	2 (3.1)	-
Availability of quality seed	40 (37.0)	53 (49.1)	15 (13.9)	22 (33.8)	17 (26.2)	20 30.8)
Yield of straw	36 (33.3)	21 (19.4)	51 (47.2)	32 (49.2)	5 (7.7)	25 (38.5)
Milling recovery rate of rice	14 (13.8)	47 (43.5)	47 (43.5)	14 (21.5)	7 (10.8)	38 (58.5)
Lodging of plant and grain shedding	102 (94.4)	2 (1.9)	4 (3.7)	3 (4.6)	31 (47.7)	25 (38.5)
Unfilled rice	105 (97.2)	2 (1.9)	1 (0.9)	1 (1.5)	43 (66.2)	21 (32.3)
Higher need for production management efficiency	95 (88.0)	2 (1.9)	11 (10.2)	46 (70.8)	-	19 (29.2)

Note: Multiple choice responses considered

Table 26: Major HYVs of rice cultivated by sample farmers (1998-99 *Boro* season).

Rice variety grown	Area coverage (%)	Yield rate (t/ha)	Market price (tk/ha)
BR-3	21.13	5.73	5900
BR-29	13.60	6.32	6450
BR-6	11.91	6.72	6075
BR-14 (Pajam)	10.70	5.53	6375
BR-11	8.09	5.14	6225
BR-28	6.35	6.42	6650
BR-1	5.53	5.83	6500

The sample farmers indicated various criteria which guided them to select a HYV of rice for cultivation. Farmers' criteria by variety is shown in Table 27.

Table 27: Farmers' criteria for selection of various HYVs of rice for cultivation in Bangladesh (1998-99 *Boro* season).

Factors	% respondents reported for HYVs				
	BR-3	BR-29	BR-6	BR-14	BR-11
Higher yield	84%	83	95	78	88
High market price	82	46	53	44	71
Grain quality	61	54	42	37	67
Easy availability of seed	50	67	47	70	46
Shorter maturity period	48	-	-	-	-
Suitability for delayed planting	41	-	-	-	-
Easy to sell/market	34	38	47	37	33

Note: Multiple choice responses considered.

The most important criteria that were considered by sample farmers in selecting an HYV of rice were high yield, high market price, better grain quality, ease of availability of seed and better market demand. Two additional factors mentioned by BR-3 producers included shorter maturity period and suitability for delayed planting of the crop. Therefore, we need to keep these criteria in view while advocating any inbred HYV and hybrid rice variety for Bangladesh. The hybrid rice varieties introduced/imported in 1999 have fulfilled only one criterion i.e., higher yield but did not meet all other criteria. Hybrid varieties that possess multiple traits would have higher probability of success for large-scale adoption within a short period of time.

V. MARKETING ISSUES

Marketing at farmer level

On various aspects of hybrid rice marketing, adequate data were not available for the obvious reason that the period under study was the first year of hybrid rice introduction at farmer level in Bangladesh. The area covered under hybrid rice was less than 25,000 ha (0.25% of rice cropped area), and only a few farmers had actually adoted hybrid rice. This resulted in availability of a relatively small supply of hybrid rice produce for marketing during 1999 season.

Based on the data of the sample farmers, the average area covered under hybrid rice during 1998-99 *Boro* season was only 0.17 hectare per sample farm. Again, 57% of the sample households growing *Alok 6201* and 37% of the sample growing *Sonar Bangla* did not market their hybrid rice produce. They retained the output for home consumption.

Forty-two percent of *Sonar Bangla* producers and 13% *Alok 6201* producers sold hybrid rice grain at the farm-gate to *farias/beparis* while 15% *Alok 6201* and 14% *Sonar Bangla* producers sold at the local primary market. Sixteen percent of *Alok 6201* and 12% of *Sonar Bangla* producers sold their produce at the secondary market. Almost an insignificant number of producers (1% *Alok 6201* and 3% *Sonar Bangla*) sold produce directly to the rice mill. On the other hand thirty seven percent of HYV producers sold their produce at the farm-gate to *farias/beparis.* Thirty-two percent, 27% and 1% producers sold at local primary market, secondary market and rice mills respectively.

It appears from the responses of the sample farmers that most of the hybrid producers sold their produce by disclosing its name. Only 22% of *Alok-6201* producers and 12% of *Sonar Bangla* producers who sold their rice faced problem in selling their hybrid rice. Of them, 15% of *Alok 6201* and 10% of *Sonar Bangla* producers mentioned that traders initially hesitated to buy hybrid rice while 11% of *Alok 6201* sellers mentioned about relatively poorer quality of their rice which resulted in lower price offered for their hybrid rice. Relatively more *Alok 6201* producers faced some problems in selling hybrid rice

than *Sonar Bangla* producers. This is also substantiated by the relatively higher price of *Sonar Bangla* than *Alok 6201* received by sample producers as mentioned in Table 28. The Table shows that the price of *Alok 6201* was significantly lower than the price received by *Sonar Bangla* producers ($p<.01$). The price of *Sonar Bangla* was also higher than that of HYVs but the difference was not statistically significant.

Table 28: Yield and price of hybrid and inbred rice varieties on sample farms.

Variety	Yield (t./ha.)	Price (Tk./t.)
Alok (n=108)	5.81	6197
HYV (n=108)	5.53	5965
Sonar bangla (n=65)	7.48	6458
HYV (n=65)	5.79	6357
All hybrid (n=173)	6.44	6296
All HYV (n=173)	5.63	6113
Percent difference ('t' values)		
Alok vs. HYV	5.1	3.9**
	(1.33)	(2.24)
Alok vs. Sonar Bangla	-22.3***	-4.1**
	(-5.93)	-2.73
Sonar Bangla vs. HYV	29.2	1.6
	(6.07)	(0.98)
All hybrid vs. All HYV	14.3***	3.0**
	(4.56)	(2.38)

Note: ••• indicates level of significance at $p<.001$, •• indicates level of significance at $p<.01$& • indicates level of significance at $p<.05$.

Marketing at intermediary level

Adequate data on different aspects of marketing could not be obtained from traders and millers because hybrid rice produce was not available in the market in considerable quantity. Nevertheless, the scanty information that could be gathered is presented below.

Traders' perception: Nineteen traders were interviewed to gather certain information on selected marketing aspects of hybrid rice. Five of them were from the local primary markets and 14 were from regional/secondary markets. Fifty-eight percent of the selected traders were engaged in rice trade for more than five years while the rest were involved from one to five years.

Only nine (47%) traders were involved in the trading of hybrid rice produce while eight traded produce of *Alok 6201* hybrid and only three traded *Sonar Bangla* produce during

1999 *Boro* season. However, in terms of volume of hybrid rice traded, a higher amount of *Sonar Bangla* was transacted (17.5 tons) than the amount of *Alok 6201* (2.8 tons). The *Sonar Bangla* hybrid fetched higher market price than *Alok 6201*. According to data provided by traders, the market price of *Sonar Bangla* was Tk. 7,000 per ton. All the ten traders who did not deal with hybrid rice said that due to non-availability of hybrid rice produce in the market they could not buy and sell hybrid rice during 1999 season. The traders reported that the head-rice recovery after milling (percentage) of hybrid rice was lower than that of many popular HYVs of rice. Three of them stated that it was 10% lower while the others quoted different figures, which varied from 2% to 7.5%.

The traders also stated various reasons for selecting a variety for purchase of its produce and sale in the market. According to the frequency of answers provided, high market demand, both local and non-local, and quality of rice were the two most important factors influencing their decision in purchasing paddy produce of a rice variety. Among other reasons, higher head-rice recovery, higher profitability, better storage quality and suitability for parboiling were influencing factors in rice trading.

Millers' perception: Nineteen millers were selected for interview from different study regions. Five of them were engaged in rice milling for more than five years while 14 were engaged from one to five years. Only three millers had experience with the milling of hybrid rice, *Alok* 6201. Unfortunately no miller was available who had bought *Sonar Bangla*. Three millers experienced with *Alok 6201* had bought only six metric tons at an estimated average price of Tk 6,458 per metric ton.

Those millers who did not buy hybrid rice did so mainly due to the non-availability of hybrid rice produce in the market. Some minor reasons stated include lack of fund, low head-rice recovery, low consumer demand and inadequate space in their warehouses.

The millers were asked to indicate their perception on the milling recovery rate of different varieties of rice. According to them, HYVs had higher head-rice recovery rate than hybrids and the highest recovery rate was for BR-9 while the lowest was for *Alok 6201* (Table 30).

Table 29: Head-rice recovery rate of different rice varieties after milling as stated by selected millers.

Rice variety	Head-ricerecovery rate (%)	No. of respondents
Hybrids		
Alok-6201	62.7	9
Sonar Bangla	65.00	3
HYVs		
BR-9	70.00	1
BR-6	68.75	2
BR-16	67.50	4
BR-14	66.57	8
BR-1	66.25	2

VI. SUMMING UP

A critical assessment of farmers' experiences with hybrid rice cultivation in this study broadly indicate that hybrid rice has higher yield potential under farmers' fields but facing a mix of problems which are hindering large-scale adoption of this technology. Our findings support the view that hybrids were introduced indiscriminately during 1998-99 *Boro* season without a clear deployment strategy. Some of these problems would have been avoided, if rice hybrids were introduced to Bangladesh after scientific on-farm testing for 2-3 seasons/years across agro-ecological regions.

Our analysis in this study identified various constraints limiting the adoption of hybrid rice by farmers in Bangladesh. These are briefly discussed below. These constraints have been brought out by analyzing the production and marketing data and by considering the farmers' perceptions on various aspects related to hybrid rice adoption.

External dependence and high cost of hybrid rice seeds

During the period of the study, all hybrid seeds were imported. *Alok 6201* seeds were imported from India while *Sonar Bangla* seeds were imported from China. The selling price of these imported seeds appeared to be exorbitant in comparison with their production cost and selling prices in China, Vietnam and India (Table 30).

Table 30: Production cost and market price of hybrid rice seed (1998-99) in various countries (U$$/kg).

Variety/country	Production cost	Market price (retail)
Alok-6201		
India	0.6	2.0
Bangladesh	-	4.0
Sonar Bangla (CNSGC-6)		
China	0.5	1.1
Vietnam	-	1.4
Bangladesh	-	4.0

The Table shows that the production cost of *Alok 6201* seeds was US $ 0.6 per kg while the retail market prices were US $ 2 and US $ 4 in India and Bangladesh respectively. In case of *Sonar Bangla,* production cost was US $ 0.5 in China while the market prices

were US $ 1.1, 1.4 and 4 in China, Vietnam and Bangladesh respectively. The comparative prices of both *Alok 6201* and *Sonar Bangla* seeds appear to be unusually high in Bangladesh.

The high seed price also raised the relative cost of production for hybrids. While seed cost constituted only 3% of the total input costs for HYVs of rice, seed costs accounted for about 10% for hybrid rice varieties. The cost of seeds for *Alok 6201* and *Sonar Bangla* constituted 11% and 9% of their total input costs respectively. By producing seeds in the country instead of importing them, the availability of hybrid seeds could also be improved, in addition to reducing seed prices. Domestic seed production would also contribute to generation of additional employment and income opportunities, especially for the rural women. This would have favourable gender implications too.

Technology dependence and management skill

Besides high seed price, the adoption of hybrid rice is also likely to be constrained due to its high dependence on technological and management knowledge and skill. For example, availability of irrigation facility is an essential requirement for hybrid rice. The present cropped area under irrigation is only about 48% in Bangladesh, which will automatically restrict expansion of hybrid rice production beyond the irrigated area. This constraint also calls for evolving hybrid seeds in the country suitable for rain fed conditions and those resistant to biotic stresses. Again, the hybrids also require more care and management time in addition to higher knowledge about the production technology of hybrids.

Incidence of pests and diseases

The findings of the present study showed that the cost of pesticides use was 67% higher for hybrids than for HYVs. Higher incidence of pests and diseases was another constraint to hybrid rice adoption in Bangladesh. To reduce incidence of pests and diseases, and to reduce costs, it may be necessary to develop hybrid varieties more resistant to pests and diseases.

Inadequate yield gains (heterosis)

The yield of *Sonar Bangla* has been found to be significantly higher than that of different HYVs. The yield gain of hybrid *Sonar Bangla* was 34% over HYVs. The yield gain of *Alok 6201*, however, could not be considered as satisfactory. Though its yield rate was 4-5% higher than the average HYV yield rate, it was lower than the yield rates of some HYVs like BR 6, BR 28, BR 29 and BR 1. With 23-24% higher costs of production for *Alok 6201*, the yield performance attained by *Alok 6201* has been found to be highly inadequate. Thus, the relatively poor performance of *Alok 6201* may be considered as a constraint to its adoption in Bangladesh.

Profitability

The study showed that production of *Sonar Bangla* was more profitable than production of both *Alok 6201* and the HYVs. The profitability of *Alok 6201* was lowest, even lower than that of HYVs by 8-12%, which may be considered as another major constraint to the adoption of *Alok* 6201 by farmers in Bangladesh.

Variety-specific constraints

Alok 6201 had some special features which may be considered as constraints to its adoption. Farmers' perception revealed several unfavourable characteristics of *Alok 6201* which include high rate of lodging of the plant, grain shedding, chaffiness (unfilled grain), stickiness and poor keeping quality of cooked rice. Further, this hybrid is highly sensitive to crop management especially time tuning of some key farm operations and more susceptible to pests and diseases.

The *Sonar Bangla* producers mentioned stickiness of cooked rice and inferior taste besides mentioning high cost of seed, greater need for care and management, higher production cost, and higher attack of pests and diseases. Overall grain quality needs to be improved for both the hybrids. Special efforts need to be taken to reduce or correct the specific unfavourable characteristics of *Alok 6201* hybrid.

Implications

The study findings have valuable implications for setting research priority. High quality local hybrid rice varieties suitable for Bangladesh should be developed. At the same time domestic seed production should be expedited. In evolving hybrids, priority should be given to those hybrids which are suitable for rain-fed environment and are resistant to biotic stresses. Research is also needed to develop appropriate crop management strategy for hybrid rice production.

Policy implications of the study include the following:

(a) Research infrastructure should be strengthened for evolving suitable hybrid rice varieties in the country.

(b) New hybrid varieties should be tested in farmers' fields across the regions at least for 2-3 years before releasing/introducing them, unlike the way that followed in 1998-99 *Boro* season while granting import permission to introduce rice hybrids.

(c) The price of hybrid seeds need to be rationalized and regulated and at the same time, domestic seed industry should be promoted which would have favourable impact on reduction of seed cost and on reduced insecurity of seed supply. This would also provide employment opportunities for the rural poor, especially for rural women. To facilitate development of domestic seed industry, necessary provision should be made for training and input support to seed growers and to promote integrated credit and extension services to growers.

(d) Co-ordination between the public sector and the NGO/private sector in research and extension should also be strengthened at all levels.

Based on the early experiences of the adoption of hybrid rice in Bangladesh, it may, therefore, be tentatively concluded that hybrid rice is higher yielding by 15% which may help improve household food security of resource-poor small and marginal farmers in Bangladesh. At the same time, current hybrids ought to be further refined for long-run sustainability of hybrid rice adoption. However, since the study is based on the first year of hybrid rice adoption and the sample size is relatively small and, therefore, not considered as strictly representative for the country as a whole, a follow-up study should be conducted on a larger scale for two to three years continuously, to further substantiate the results of the present study.

REFERENCES

Adesina, A.A and M. M. Zinah (1993), Technology Characteristics, Farmers' Perceptions and Adoption Decisions: A Tobit Model Application in Sierra Leone', *Agricultural Economics*, Vol. 9: 1993, pp.297-311

AAS-Agricultural Advisory society (1999), Performance of Rice HYbrids Under Bangladesh Conditions: 1998-99 Boro Season, AAS, Dhaka.

Athwal, D.S and S.S. Virmani (1972), Cytoplasmic Male Sterility and Hybrid Breeding in Rice, In *Rice Breeding (Ed)*, IRRI, Los Banos, Manila (Philippines), p. 615-620.

BADC-Bangladesh Agricultural Development Corporation (1998), Report on Performance of Hybrid Rice Seeds Supplied by Different Seed Companies (Boro 1997-98), (Bangla), Mimeo. BADC, Dhaka.

Barker, R and R.W. Herdt (1985), *The Rice Economy of Asia*, Resources for the Future, Washington, D.C.

Barwale, B.R (1993), *Hybrid Rice Food Security in India (Ed)*, Macmillan India Limited, Madras, India.

BBS (1999), 1998 Statistical Yearbook of Bangladesh (19th Ed.), Ministry of Planning, GOB, Dhaka.

DAE-Department of Agricultural Extension (1998), Report of Yield Trial of Hybrid Variety (Alok-6201) Conducted at Different Locations During Boro 1997-98 Season by DAE (mimeo), DAE, Dhaka.

DRR-Directorate of Rice Research (1997), *Development and Use of Hybrid Rice Technology in India- Project Report*, DRR, Hyderabad.

DRR-Directorate of Rice Researches (1996-99), *Progress Reports of Hybrid Rice Projects and AICRIP (Various issues)*, DRR, and Hyderabad.

He Guiting, X. Zhu and J.C. Flinn (1987), A Comparative Study of Economic Efficiency of Hybrid and Conventional Rice Production in Jiangsu Province, *Oryza*, Vol.24; p.285-296.

Hossain M. 1988, Nature of Impact of Green Revolution in Bangladesh, IFPRI Research Report No. 67, IFPRI, Washington, D.C.

Hossain M. and M. Akash (1994), Public Rural Works for Relief and Development, IFPRI Working Paper on Food Subsidy, No. 7, IFPRI, Washington, D.C.

Janaiah, A, M.I. Ahmed and B.C. Viraktmath (1993), Hybrid Rice: An Opportunity for Food Security in India, *Yojana*, Vol.37; No.20; p.7-9.

Janaiah, A. (1995), Economic Assessment of Hybrid Rice Potential in India: An Ex-ante Study, *Ph.D. thesis (unpublished)*, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India.

Janaiah, A and M.I. Ahmed (1996), Impact of Hybrid Rice on India's Food Economy: Some Possible Implications and Policy Issues. Paper presented at *3rd International Symposium on Hybrid Rice*, organized by the ICAR-IRRI, at Hyderabad, India, 14-16 Nov., 1996.

Janaiah, A. (1997), *Socio-economic Impact of Hybrid Rice in India*, a report submitted to UNDP Evaluation Team, Directorate of Rice Research, Hyderabad.

Janaiah, A. (1999), Rice Hybrids: Can Indian Farmers and Consumers Accept Them? *Farmer and Parliament,* Vol. 36; No. 6; p.15-17.

Janaiah, A and M. Hossain (2000), Adoption of Hybrid Rice Technology in India: An Economic Evatualation of Early Farm-Level Experiences, *a paper presented at 24th International Rice Research Conference*, held at IRRI, Los Banos, Philippines during 31 March-4 April 2000.

Janaiah, A and M. Hossain (2000), Issues for Policy Intervention to Promote Hybrid Rice Technology in India: A Few Lessons from Recent Experiences, *INDIA GRAINS*, Vol. 2 (9), pp. 11-15

Lin, J.Y. (1991), The Household Responsibility System Reform and Adoption of Hybrid Rice in China, *Journal of Development Economics*, Vol. 36; p.353-372.

Lin, J.Y. (1992), Hybrid Rice Innovation in China: A Study on Market Demand Induced Technological Innovation, *Review of Economics and Statistics,* Vol. 24; No.1; p.14-20

Lin, J.Y. (1994), Impact of Hybrid Rice on Input Demand and Productivity, *Agricultural Economics*, Vol. 10; p.153-164.

Sampath, S. and H.K.Mohanty (1954), Cytology of Semi Sterile Rice Hybrid, *Current Science*, Vol.23, p.182-183.

Virmani, S.S, E,A, Siddiq and K.Muralidaran (1998), *Advances in Hybrid Rice Technology (Ed)*, IRRI, Los Banos, Manila (Philippines).