A study on hybrid rice in Bangladesh:

History, impact and current status of hybrid rice research, development and delivery in Bangladesh

Prepared by:

Harun-Ar-Rashid
A.W. Julfiquar
Shahjahan Ali

Submitted to:

International Food Policy Research Institute (IFPRI)
2033 K. Street, NW
Washington, DC 20006-1002, USA
Tel: +1.202.862.5600, www.ifpri.org

Submitted by:

Agricultural Advisory Society (AAS)
House # 8/7 (Ground Floor), Block-B, Lalmatia, Dhaka-1207
Phone: 880-2-8113645
E-mail: harunaas@gmail.com

14 January 2011

Table of Content

Acronyms/Abbreviations/Exchange Rate

AAS	Agricultural Advisory Society
ACI	Advanced Chemical Industries
ADB	Asian Development Bank
ADP	Annual Development Program
Aftab	Aftab Bahumukhi Farm Ltd.
AIT	Advance Income Tax
APSA	Asia Pacific Seed Association
ARMP	Agricultural Research Management Project
ATV	Advanced Trade VAT
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCIC	Bangladesh Chemical Industries Corporation
BDT	Bangladeshi taka (the currency of Bangladesh)
BIFF	Bangladesh Infrastructure Finance Fund
BINA	Bangladesh Institute of Nuclear Agriculture
BLB	Bacterial Leaf Blight
BLS	Bacterial Leaf Streak
BMDA	Barendra Multipurpose Development Authority
Boro	Winter Rice, Transplanting: December-February
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BRRI	Bangladesh Rice Research Institute
BS	Breeder Seed
BSc	Bachelor of Science
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
CAAS	Chinese Academy of Agricultural Sciences
CBD	Convention of Biodiversity
CBOs	Community Based Organizations
CCB	Cash cost basis
CD	Customs Duty
CFS	Contract farming System
CM	Centimeter
CMS	Cytoplasimc Male Sterile
CPD	Centre for Policy Dialogue
CS	Certified Seed
CV	Covariance
DAE	Department of Agricultural Extension
DAM	Department of Agricultural Marketing
DAP	Diammonium Phosphate

DFID	Department for International Development
DTW	Deep tube well
EAL	Energypac Agro Ltd
EEF	Equity & Entrepreneurship Fund
FAO	Food and Agriculture Organization
FCB	Full cost basis
FS	Foundation Seed
GA_3	Gibberellic acid
GDC	Ganges Development Corporation
GDP	Gross Domestic Product
GMOs	Genetically Modified Organisms
GOB	Government of Bangladesh
ha	hectare
HYVs	High-yielding varieties
ICB	Investment Corporation of Bangladesh
IFPRI	International Food Policy Research Institute
IP	Import Permit
IRHON	International Rice Hybrid Observational Nursery
IRRI	International Rice Research Institute
Kg	kilogram
Kg/ha	kilogram/hectare
KSS	Krishok Samobay Samity
L/C	Letter of Credit
LLP	Low lift pump
LMOs	Living Modified Organisms
Ltd.	Limited
M. S	Master of Science
MOA	Ministry of Agriculture
MoF	Ministry of Food
MoP	Muriate of Potash
MOU	Memorandum of Understanding
MRP	Maximum Retail Price
MSC	Mollika Seed Co.
MT	Metric Ton
NAFCO	NAFCO Private Limited
NARES	National Agricultural Research and Extension Systems
NARS	National Agricultural Research System
NCPGR	National Committee on Plant Genetic Resources
NGO	Non Government Organization
NICOL	Northern Agricultural and Industrial Ltd.
Nr.	Number
NSB	National Seed Board
NTBs	Non-Tariff Trade Barriers
OF	On Farm

OMS	Own management system
OS	On Station
PETRRA	Poverty Elimination Through Rice Research Assistance
Ph. D	Doctor of Philosophy
PPP	Public-Private Partnership
PVPA	Plant Variety Protection Act
R & D	Research and Development
RCBD	Randomized Complete Block Design
RDC	Research Development Center
SCA	Seed Certification Agency
SD	Supplementary Duty
SE	Standard Error
SPS	Sanitary and Phytosanitary
SPSS	Statistical Package For Social Science
SSCL	Supreme Seed Co. Ltd
STW	Shallow Tube well
T. Aus	Early Summer rice, Transplanting: March-April
T. Aman	Late Summer Rice, Transplanting: July-August/September
t/ha	ton/hectare
TBT	Technical Barriers to Trade
TC	Technical Committee
TCDC	Technical Cooperation between Developing Countries
TCP	Technical Cooperation Programme
Tk.	Taka
Tk/kg	Taka/Kilogram
TLS	Truthfully Labelled Seed
TRIPS	Trade Related Aspects of Intellectual Property Rights
TSP	Triple Super Phosphate
TTI	Total Tax Incidence
UK	United Kingdom
USA	United States of America
WTO	World Trade Organization

Exchange Rate: 1 US$ = BDT (Taka) (1998-2010)

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
46.9	49.1	52.1	55.8	57.9	58.2	59.5	64.3	68.9	68.9	68.6	69.0	69.7

Source: Asian Development Bank (ADB)
Web: http://www.adb.org/Documents/Books/Key_Indicators/2009/pdf/ban.pdf

Bangladesh Bank:
Web: http://www.bangladesh-bank.org/econdata/exchangeratenew.php

I. Executive Summary

The study on the hybrid rice in Bangladesh for an in depth review of the history, impact and current status of hybrid rice research, development and delivery in Bangladesh for an industry and farm-level analysis was conducted by Agricultural Advisory Society (AAS) on behalf of International Food Policy Research Institute (IFPRI). Necessary information were collected from the relevant organizations (such as DAE, Seed Wing & SCA of MOA, BADC, DAM, MoF, research institutes, private seed companies, seed dealers, lead farmers, international organization, individual scientists/experts etc) in the form of project documents, reports, academic literature, published scientific papers, published and un-published reports, book, thesis, various relevant data as hard copy and soft copy as those were readily available. The relevant valuable information collected from library, office, web sites and other relevant sources for the study. The little information is available relevant to history, impact and current status of hybrid rice research, development and delivery in Bangladesh for an industry-and farm-level analysis

Bangladesh is one of the most densely populated countries of the world, with a population of more than 150 million, and an area of 14.47 million hectares. Agriculture plays a significant role in the economy contributing 18.64% GDP-12.64% from crops and forest, 2.32% from livestock, and 3.68% from fisheries at current prices in 2008-9 (BBS); Agriculture is the main occupation of the rural people, and accounts for 55% of national employment. Currently the gross cultivated area for rice (counting multiple crops in a year) is 12.25 million ha, in the country, which is about 88% of the total gross cropped area of the country. Rice accounts for about 77% of the gross cropped area, 95% of total food grain production, and two-thirds of value added in crop production. Over the last several decades, Bangladesh has achieved dramatic growth in the agricultural sector, and rice plays the most significant role in this process. Rice total (gross) cropped area increased 38% from 1960 to 2009 (8.8 to 12.25 million ha) with average annual compound growth rate of 0.66% in Bangladesh. National rice production increased 253% from 1960 to 2009 (14.52 to 51.33 million ton) with average annual growth rate of 2.61% in Bangladesh. Average paddy yield increased about 156% from 1960 to 2009 (1.64 to 4.19 t/ha) with 1.93% average annual compound growth.

From 1998-99 to 2009-10, total of 85 rice hybrids has been released and notified by the NSB in Bangladesh. Out of 85 released rice hybrids, only 2 rice hybrids released for transplant Aman season. Out of which 80 come from private sector/NGO and 5 from public sector (4 from BRRI and one from BADC). Eight rice hybrids are developed in Bangladesh, of which 4 developed by BRRI, 2 developed by BARC and 2 developed by a private seed company. Most of these hybrids are sticky rice with amylose content less than 25% and most are also bold grain hybrids.

In 9 years from 1998-99 to 2007-8, hybrid rice area increased about 4263% (0.024-1.011 million ha) and subsequently, hybrid rice area decreased it peak in 2007-8 by 7% in 2008-9 and by 34% in 2009-10. Clean rice production from hybrid rice increased about 4368% from 0.11 million MT in 1998-99 to 4.8 million MT in 2007-8, before falling to an estimated 4.31 million MT in 2008-09 and 3.15 million MT in the 2009-10. Such change in area and production of hybrid rice it estimated at very higher percentage due to very low base. High rice yield is estimated with more or less similar trends from 1998-99 to 2009-10 between 4.59-4.75 t/ha

Research and development of hybrid rice technology began in 1993 at BRRI in collaboration with International Rice Research Institute (IRRI). From 1996 onward, BRRI's hybrid rice research gained momentum with the formation of a working group, technical support from IRRI, and financial support from the Bangladesh Agricultural Research Council (BARC). Recently BRRI has developed quite a good number of hybrid parental lines which are being utilizing in developing heterotic rice hybrid(s). Other countries including China are not willing to share their best materials. In this situation for promoting hybrid rice cultivation in the country Bangladesh should be developed its own parental lines. Keeping this target in mind BRRI has developed several A, B & R lines by utilizing CMS source from other countries. Recently BRRI has developed quite a good number of hybrid parental lines which are being utilizing in developing heterotic rice hybrid(s). An IRRI developed hybrid (IR69690H) was identified as promising in the four regions of the country and released as BRRI hybrid dhan-1 by the National Seed Board (NSB) in 2002 for commercial cultivation by the farmers in those regions. A 5-year project on hybrid rice entitled "Research and Development of Hybrid Rice in Bangladesh" for US$ 1 million was approved by Bangladesh government to provide financial support for hybrid rice research in the country. This project initiated in July 2005 and was supposed to be end in June 2010. Since 2001 BRRI's developed 4 rice hybrids have released by the NSB for commercial cultivation, of which 3 are intended for the Boro season and one for the T. Aman season. BRRI has been supplying parent lines (A & R lines) seeds among the involved agencies (e.g. BADC, NGOs, Private seed companies, farmers etc) after releasing of BRRI hybrid dhan 1 from 2002. Similarly, BRRI has been supplying parental lines (A & R lines) of BRRI hybrid dhan 2, 3 and 4 among the trained involved agencies. Besides, parental lines, BRRI has also been supplying F_1 rice hybrids seed through involved agencies and farmers in view for popularizing it rice hybrids among the farmers all over the country.

In addition to BRRI, BRAC (a large NGO) and one private seed company (Supreme Seed Company Ltd) have their own R & D for hybrid rice. BRAC initiated their hybrid rice R & D in collaboration with IRRI and sharing their germplasm. Through R & D program, BRAC developed two rice hybrid varieties, which have released by the National seed Board (NSB) for commercial cultivation in the country. A leading private company, Supreme Seed Company limited has its own research program for hybrid rice and developed two rice hybrids, which have released by NSB for commercial cultivation and seed production in the country. Currently 40 private seed companies are engaged in selling hybrid rice seed, only Supreme Seed Company has developed an R & D program. No significant investment was made by the private seed companies in R & D of hybrid rice except one private company (Supreme Seed Company limited) and one NGO (BRAC) have their own R & D for hybrid rice under their own funding support. At present some private seed companies has initiated their own R & D program on hybrid rice and utilizing parental materials from BRRI, India and China and few of them have technical manpower. Most of the seed companies are importing hybrid seed from outside (mostly from China and few from India) and marketing through their existing seed dealers' network in the country. Several potential seed companies are producing hybrid rice seed in collaboration with the overseas seed companies (China and India).

Researchers from BRRI assessed the agronomic performance of rice hybrids through on station and on farmer trials to evaluate the exotic, elite, promising and released rice hybrids during 2006-2009 T.Aman and Boro seasons. During this period researchers from BRRI submitted their developed and evaluated rice hybrids to SCA for regional testing for the purpose of releasing and notification by NSB. For this purpose, BRRI researchers conducted rigorous assessment on agronomic performance of their developed rice hybrids

over the most popular inbreds through on station and on farm trials at various regions. BRRI's developed 3 rice hybrids were released and notified by the NSB due to better agronomic performance than the existing best and most popular inbreds. In this regards, researchers assessed the agronomic performance of the promising rice hybrids against high yielding popular inbreds on the basis of their several agronomic characters such as grain yield, growth duration, plant hight, tillering habit, filled and unfilled grain formation and proportion, grain weight etc. Most of the promising rice hybrids' grain yield recorded consistently higher than the selected popular inbreds. Other relevant agronomic characters of BRRI developed promising rice hybrids recorded consistently better than the selected popular inbreds with few exceptions. Variability on agronomic performance is existed among the released and promising rice hybrids developed by BRRI. Finally, NSB has released and notified 3 rice hybrids (BRRI hybrid dhan 2, 3 &4) for commercial cultivation and seed production in the country.

Regarding agronomic performance of the selected released rice hybrids under farmers' field trials was found consistently better than selected most popular rice inbreds during early stage of hybrid rice introduction and adoption in Bangladesh. Under such trials, agronomic performance of the selected rice hybrids was assessed on the basis of the most common agronomic characters and most of the assessed rice hybrids' agronomic characters performed better than the selected most popular rice inbreds in the country. Similarly, IRRI/BRAC conducted a study on a socioeconomic assessment of farmers' experiences and AAS conducted a study on the prospect and potentials of rice hybrids and their findings revealed more or less same to the previous farmers' field trials with few exceptions. But DAE and SCA trials' findings of the studies revealed conflated performance on grain yield of rice hybrids over popular rice inbreds among the regions and assessed rice hybrids.

Currently, hybrid rice accounts for about 22% of total Boro rice or 9% of the total rice area of Bangladesh in 2007-8. Hybrid rice produced about 26% of the total clean rice harvested in the Boro season, and about 15% of the total clean rice produced in 2007-8. During 1998-2010, a total of 16.57 million MT of clean rice was produced through cultivating hybrid rice on a cumulative total of 3.54 million ha. Hybrid rice accounted for a net increase in production of clean rice of about 3.88 million MT during 1998-2010, sufficient to feed approximately 23 million people for a year. The additional rice production of 3.88 million MT contributed US$ 1,406 million (BDT. 97,000 million) to GDP during 1999-2010. In addition, a total of about 13,503 MT of hybrid rice seed was produced in the country on 5,478 ha during 1999-2010. Domestic production of hybrid seed saved about US$ 34 million (BDT 2,436 million) of foreign exchange. Moreover, production of hybrid rice and hybrid rice seed generated a lot of rural employment in the country,

The relative profitability of hybrid rice vs. inbred varies over time throughout the period of 1998-2010. Hybrid rice cultivation appears to have been more profitable than inbred cultivation during 1998-99 to 2007-8 Boro seasons. But hybrid rice cultivation during 2008-9 to 2009-10 Boro seasons appears to be less profitable than inbred cultivation on a full cost and cash cost basis. Lower net returns for hybrid rice than for inbred rice during 2008-10 Boro seasons are due to hybrids' low paddy price along with relatively higher cost of production. Total cost for hybrid rice production is higher than for inbred rice during 10 years period of analysis under full cost and cash cost basis. Compared to the 1998-99 boro season, hybrid and inbred paddy prices were about 158% and 178%, respectively, higher in the 2007-8 Boro season. From 2007-8 to 2008-9 boro seasons, paddy prices decreased 34% and 31% for hybrid and inbred, respectively.

There are several determinants, which influence on the economic performance of hybrid rice since its introduction in Bangladesh. The common determinants which are influenced on the economic performance of hybrid rice in the country, such as productivity of hybrid rice, price of hybrid rice, grain quality, consumer acceptance, adaptability of rice hybrids, quality seed supply, crop production inputs availability and price, land rent, labor availability and cost, cost of production and return, abiotic/biotic hazards (e.g. Diseases and pest, storm, flood etc.) etc. Among these determinates, the market price of hybrid rice is the utmost determinate, which plays major role on the economic performance of hybrid rice in the country. Fundamental to price determination of rice is the operation of supply and demand in the Bangladesh environment. Higher hybrid rice productivity per unit area over existing high yielding conventional rice varieties is an important determinate, which plays important role on the economic performance of the hybrid rice for the country. Besides productivity, rice grain quality dictates for higher price and ultimately higher level of profit. Better profitability earning from hybrid rice depends on the production cost, which highly influenced by higher costs from labor, land rent and production inputs. Overall favorable cost and return can increase hybrid rice acreage and production. Ultimately better hybrid rice's economic performance can enhance national economic growth at reasonable rate.

Besides the public sector, private sector seed marketing agencies have undertaken significant promotional activities for hybrid rice since 1998-99. Accordingly, farmers' acceptability of hybrid rice technology in the country is found very much encouraging with few exceptions up to 2007-8. However, hybrid rice acreage increased from 23700 ha to 1011000 ha from 1998-99 to 2007-8. Nevertheless, farmers' acceptability on hybrid rice technology in the country is found very much encouraging with few exceptions during this period. Such tremendous acreage increased with hybrid rice mostly in Boro season is possible on the basis of farmers' satisfaction in the country. Subsequently, hybrid rice area decreased it peak in 2007-8 by 7% in 2008-9 and by 34% in 2009-10 mainly due to low price of paddy.

.

However, it could be concluded that higher grain yield advantage of hybrid rice over inbred rice is highly acceptable among the rice farmers in Bangladesh. When hybrid rice was first introduced, the grain price gap between hybrid and inbred rice was not visible in the market, at least not for Chinese hybrids. Relatively low grain price for hybrid vs. inbred rice has been reported from 2004-5, apparently due to stickiness of cooked rice from hybrids available in Bangladesh. Impact of low paddy price has been recorded on hybrid rice from 2009. At the same time, various corners disseminated rumors against hybrid rice, especially its grain quality, through electronic and mass media, fostering dissatisfaction among farmers. But farmers in Bangladesh are found quite willing to continue hybrid rice cultivation with expected primarily higher yield and profit than inbred rice, mainly during the Boro season. Overall farmers in Bangladesh are reasonably satisfied with higher productivity and profitability for hybrid vs inbred rice. But farmers are in general dissatisfied on the grain quality, especially low Amylose content. Rice breeders in Bangladesh and in other countries (China, India, etc) should develop rice hybrids with acceptable grain quality with at lest 20% higher productivity (heterosis). Bangladeshi farmers will be grateful to the breeders after receiving acceptable rice hybrids for commercial cultivation during boro and T. Aman seasons. In recent years, there has been “no qualitative study” on the satisfaction and dissatisfaction of farmers, millers, traders and consumers with hybrid rice technology in the country.

Compatible extension service providers, effective extension approaches and appropriate uptake pathways are integral components of any extension service system for dissemination

of potential technology. In Bangladesh hybrid rice has been disseminating among the farmers through public, private organizations and NGOs, those who are engaged in hybrid rice seed business from 1ate 1990s.. Internationally recognized, both formal and informal seed systems are prevailed in Bangladesh. But hybrid rice technology has been disseminating and selling seed through formal seed system with private sector, public sector (BRRI, BADC) and NGOs in the country. Beside DAE, among the involved service providers, private sector seed companies and NGOs are "*playing major roles in dissemination of hybrid rice"* than public sector (BADC, BRRI) using various effective extension approaches/methods.and materials. Several private seed companies have already invested reasonable amount of fund for various promotion activities for introduction of rice hybrids, as they called it as "sale promotion for the product" which is the integral components for the products markets. Accordingly, hybrid rice acreage has increased from 23,700 ha to 1000000 ha during 1998 to 2010 in the country. Lowest acreage of hybrid rice was reported in Munsiganj and Barguna districts during 2007-8 and 2008-9 Boro season respectively. On the other hand, the highest acreage of hybrid rice was reported in Rangpur and Bogra district during 2007-8 and 2008-9 Boro season respectively.

Private seed companies and NGO (BRAC) are the major agencies in hybrid rice seed marketing and BADC is the only agency from public sector for marketing hybrid rice seed in the country. Hybrid rice seed marketing agencies have been using various seed marketing approaches and strategies in collaboration with their appointed dealers and retailers from late 1990s. Currently more than 1000 marketing staffs are engaged directly and indirectly for selling with target at least about 10000 MT hybrid rice seed per year. Currently the highest market share is estimated for Supreme Seed (31.45%) followed by BRAC (18.02%), Lalteer (13.68%), Aftab (7.38%), Mollika seed (6.88%), others sellers (5.82%), EAL (5.61%), ACI (3.61%), United (2.97%), Ispahani (2.59%) and Metal (1.98%).

Large-scale adoption of hybrid rice has been hampered since 1998-99 by several constraints, including unattractive physicochemical characteristics of the available hybrids, negative positions by some public sector extensionists, researchers and to some extent policy markers, problems with seed quality, high seed cost, inconsistent yield performance, inconsistent relative profitability, low grain quality, low grain price, less attention for adoption of hybrid rice during T.Aman and T.Aus seasons and sometimes negative propaganda about hybrid rice and insufficient support from government. Even so, the adoption of hybrid rice along with the establishment of hybrid rice seed production in the country within a decade is very much encouraging. It was possible to achieve due to involvement of both the private sector (including NGO) and public sector, with active participation of motivated farmers.

From 1998-99 to 2009-10 a total of 85 rice hybrids have been released and notified for commercial cultivation and seed production in Bangladesh. Out of 77 imported rice hybrids, 66, 10, 8 and 1 from China, India and Philippines respectively. Out of total 85 released rice hybrids, of which 80 come from the private sector / NGO, and 5 from the public sector for seed production and marketing in the country. Thus, a total of 85 rice hybrids are available for commercial seed sale and seed production in Bangladesh. From 1998 to 2010 a total of 44 organizations have been involved with hybrid rice technology development and transfer, seed selling and seed production in the country, of which private seed companies are recorded as highest (40) followed by NGOs (2), BRRI and BADC.

Three categories of organizations such as public, private and NGO are involved in rice hybrids seed production and marketing. In this regards, private seed companies and NGOs

have been playing crucial role in rice hybrids seed import, local F_1 seed production and supply of hybrid rice seed among the farmers through their established seed dealers' network in the country. Incase of inbred rice seed supply, public sector (BADC) supplied maximum seed (from 90%-97%) of the total inbred seed supply and private sector supplied maximum hybrid rice seed (from 88% to 100%) of the total hybrid rice seed supply during 2001-2 to 2009-10. Overall average price as maximum retail price (MRP) of F_1 hybrid rice seed is estimated about Tk. 237/Kg during 2010-11 Boro season. Average Tk. 230/Kg (range Tk. 140-260/Kg) and Tk. 244/Kg (range Tk. 175-275/Kg) is estimated for bold grain and slender grain of hybrid rice seed respectively during 2010-11 Boro season.

The successful commercialization of the hybrid rice production in Bangladesh needs to link with quality rice seed supply chain including hybrid rice seed production system development in the country. Both importing and in-country production of hybrid rice seed are equally important in the current seed supply chain. There are two sources of hybrid rice seed supply, they are imported seed (China & India) and in country production with various organizations (Public, Private and NGO). Maximum F_1 rice seed is supplied by the private sector seed companies/NGO and minimum from public sector (BADC). Major seed supply chain (pathway) for delivering seed among the farmers is through appointed dealers and their retailers of the seed marketing agencies in the country. However, major hybrid rice seed selling is found through large number of experienced seed dealers, which are the major players of the chain of hybrid rice seed supply all over the country. Contribution of rice hybrid seed in national annual rice seed replacement is estimated very thin in comparing with contribution of inbred rice seed replacement during 2001- to 2009 in the country.

Production of hybrid rice seed in Bangladesh increased from 47.56 MT in 1999-2000 to 3,600 MT in 2009-10 Boro seasons. Hybrid rice seed production area increased from 52.63 ha in 1999-2000 to about 1,200 ha in the 2009-10 Boro season. Average hybrid rice seed yield increased about 233%, from 0.99 t/ha to 3.00 t/ha from 1999-2000 to 2009-10 Boro seasons. As of 2010, the highest recorded hybrid rice seed yield in Bangladesh is more than 4.0 t/ha, which can be compared to a maximum yield of less than 1.3 t/ha achieved in 1999-2000

Beginning in 1999-2000, Bangladesh has been producing F_1 hybrid rice seed in the Boro season using China's three-line system with cytoplasmic male sterility. Currently, some private seed companies, BRAC, and BADC produce commercial F_1 hybrid rice seed with imported A line and R line mostly from China, and also some from India and the Philippines. BRRI has been providing A and R lines to produce F_1 hybrid rice seed of its 4 released rice hybrids among BADC, Private Seed Companies, NGOs, model farmers etc. Organizations producing hybrid rice seed in Bangladesh find that the quality of A and R lines imported from China is sometimes questionable. This is also applicable for BRRI parental A and R lines in general and specifically for BRRI hybrid Dhan-2 beginning from the 2008-9 Boro season.

For successful F_1 hybrid rice seed production, several exotic chemicals are crucial, including gibberellic acid (GA_3), Tiaohuafei, Bacteriocides and specialized weedcides (for seedbeds). Bangladesh, average seed yield of hybrid rice increased 233% (0.9-3.0 t/ha) from 1999-2000 to 2009-10, with average annual compound growth of 13% due to rapid progress in seed technology among the organizations producing hybrid rice seed. Besides development of rice hybrids, BRRI has developed an F_1 hybrid rice seed production package and provided various types of training in hybrid rice seed production for staff of BADC, private companies, NGOs, and progressive farmers. Presently, involved seed companies and BRAC have developed their own F_1 hybrid rice seed production guidelines on the basis of their practical knowledge earned during seed production with the guidance of Chinese

experts. Nearly all steps of hybrid rice seed production and parental lines multiplication can affect seed quality and purity. Quality control is vital to the widespread adoption of hybrid rice. Quality control needs to be done through the entire process of seed production. In Bangladesh such seed quality standards have not yet been developed for hybrid F_1 rice seed and parent lines.

Hybrid rice seed production started in greater Mymensingh district and later rice hybrid seed production extended into several districts in different agro-ecological zones. Organizations producing hybrid rice seed are producing either through contract farmers or by leasing land for own management or by using both systems. Presently, about 300 technical staffs are working for hybrid rice seed production, of which more than 80% are field staff. On a full-cost basis, the average cost to produce hybrid rice seed is estimated at Tk.78.41/kg and on a cash cost basis, average cost to produce hybrid rice seed is estimated at Tk. 54.71/Kg. Among seed producing organizations, the current seed procurement price is about Tk. 80/Kg, which is not profitable and attractive for the contract growers. The highest cost component is labor (averaging Tk.63,497/ha) followed by seed of parental lines (averaging Tk.36732/ha), other costs include land rent (Tk.34,651/ha), fertilizer (Tk. 26,844/ha), and special chemicals use (Tk.15,296/ha), with other costs less than Tk.15,000/ha.

There are two seed systems are existed in Bangladesh such as (i) Formal seed system and (ii) Informal seed system for seed production, seed used, seed supply, seed sell and seed exchange of various crops. Since 1977 there has been several regulatory frameworks, policy, Act and rules in Bangladesh mainly for agricultural crop variety improvement, research & development, variety release and notification, seed production, seed quality standardization, seed quality control, import and marketing. The Seeds Ordinace,1977 (Ordinace No. XXX III of 19977) was notified on the 13th July, 1977. The National Seed Policy, 1993 notified on 8 March 1993 followed by the seeds (Amendent) Act, 1997 notified on 13 March 1997. The Seed Rules, 1998 notified on 8 March 1998 followed by the seed (Amendent) Act, 2005 notified on 22 September 2005. Both the Intellectual Property Rights and Plant Variety Protection Act (2009) and The Plant Quarantine Act (2010) are under process for notification. The National Seed Board (NSB) of the Ministry of Agriculture, Government of Peoples Republic of Bangladesh is the Central Regulatory Body on seed related matters of the Government. Regarding variety development through breeding locally, and introduced from abroad as well as through local selection are evaluated and recommended by the Technical Committee (TC) and finally approval for registration, release and notification are done by the NSB.

The specific policy and guidelines on hybrid rice evaluation and registration were first formulated in the 40th Meeting of the NSB held on 9 September1998. In that initial guidelines the F_1 hybrid rice seeds were allowed to import for commercial cultivation for three years effective from 1998-99 Boro rice crop season. The initial guidelines of 1998 were subsequently revised and modified, and accordingly the updated policy/guidelines were approved by the NSB in the 52nd Meeting held on July 20, 2003. The modified hybrid rice guidelines were approved in the name of *"Hybrid Rice Variety Evaluation and Registration Procedures, 2003,"* circulated by the Seed Wing, Ministry of Agriculture, and published in the *Bangladesh Gazettee, Wednesday, December 24, 2003.*In this modified procedure of 2003, the F_1 hybrid rice seeds were allowed to import for commercial cultivation for five years instead of initially allowed for three years in 1998. Hybrid Rice Variety Evaluation and Registration Procedures, 2003 Bangladesh Gazettee, notified on 24 December 2003 and 6 April 2007. It may be noted here that the condition for allowing F_1 hybrid rice seed import for five years as approved in 2003 has been amended into 8 years in the 60th meeting of the

NSB held on August 3, 2006, circulated on March 18, 2007, and it was published in the Bangladesh Gazettee on April 16, 2007.

Since 1998, in Bangladesh, the policy makers are in favor of hybrid rice development and promotion. The latest policy on hybrid R&D, F_1 hybrid seed import and selling, import of parental lines for local F_1 hybrid rice seed production and supplying F_1 hybrid seed to the farmers are favorable for public, private and NGOs. The existing policy may be improved and updated. At present there is no subsidy for hybrid rice seed import, local production and supplying to the farmers for the private seed companies and NGOs in the country. The support and commitment of policymakers would greatly be enhanced by the formulation of strategies and guidelines for an effective and sustainable adoption of hybrid rice. Therefore, the formulation of strategies and guidelines for an effective and sustainable increased the adoption of hybrid rice will need to be the expertised and encouraged for participation of all stakeholders.

The policy makers in crop agricultural are mainly from Ministry of Agriculture (MoA) and has delegated to the National Seed Board (NSB) and Technical Committee (TC). The NSB constituted with the Secretary, MoA and members from the National Agricultural Research System (NARS) and other related persons and organizations/agencies. The TC constituted with the Executive Chairman, Bangladesh Agricultural Research Council (BARC) and members from NASRS and other related persons and organizations/agencies. The Agricultural crops and seed related policy and legal affairs Regulatory Body in Bangladesh is the NSB of the Ministry of Agriculture. The Seed related all policies and rules are regulated by the NSB and all technical matters are evaluated, verified, and monitored by the *TC* under the guidance of NSB of the Ministry of Agriculture, Government of the Peoples Republic of Bangladesh.
The reasonable response from relevant policy makers has been commemorated for hybrid rice technology introduction, release and notification, adoption, R&D, seed production and marketing of seed since late1990s.

The key policy recommendations are proposed for hybrid rice technology development, introduction, large scale dissemination, the quality seed supply and marketing in the country. Among the policy recommendations, development of demand-led rice hybrid is prioritized as the highest followed by rice hybrid release guidelines, hybrid rice seed production, grain quality test, level playing field, seed quality monitoring, GOB paddy procurement and rice hybrid data based. The existing seed related legal frameworks (Policy, Act, Rules and guidelines) of Bangladesh might need to be improved, modified, up-graded and amended in general for seed sector and in particular for demand-led hybrid rice technology development and its large scale dissemination in the country.

An in-depth field study could be undertaken to assess the performance of rice hybrids in the country on the basis of response from hybrid rice growers (farmers), seed producing farmers, seed dealers, seed entrepreneurs, consumers, traders and millers on routine basis in the country. The findings of the study will be useful for the policy makers, involved agencies (private/NGO and public) and all other relevant stakeholders for their better understanding and preparation of future work/business plan on hybrid rice in the country.

II. Introduction

Scenario of rice economy of Bangladesh

Bangladesh is one of the most densely populated countries of the world, with a population of more than 150 million, and an area of 14.47 million hectares. Agriculture plays a significant role in the economy contributing 18.64% GDP-12.64% from crops and forestry, 2.32% from livestock, and 3.68% from fisheries at current prices in 2008-9 (BBS, 2006 & 2008); Agriculture is the main occupation of the rural people, and accounts for 55% of national employment. Although agriculture remains the dominant sector of the national economy, its contribution to GDP has declined by about 50% from 1970 to 2010.

Within the crop sector, rice dominates with a 71% share of the gross value of all crops. Currently the gross cultivated area for rice (counting multiple crops in a year) is 12.25 million ha, in the country (DAE, 2010). Rice accounts for about 77% of the gross cropped area, 95% of total food grain production, and two-thirds of value added in crop production. Rice also provides about 70% of calorie intake making it the most important food crop for the Bangladesh. Food security remaining a critical issue for at least 60% of households and is largely determined by rice production at house and national levels (Abedin, et al, 2010). In Bangladesh rice consumption is also very high, exceeding 170 Kg per capita annually. Rice is not only the foremost staple food but it also provides nearly 48% of rural employment, two-third of total calories, and half of the protein intake for an average person. Over the last several decades, Bangladesh has achieved dramatic growth in the agricultural sector, and rice plays the most significant role in this process. To improving food security, Boro rice has helped stabilize prices of staple food and has been the major factor behind the country's recent downward trend in inflation, as well as in the reduction of poverty by almost 1 percent per year (Hossain, M. 2009). As a result, Bangladesh has moved out from chronic hunger to self-sufficiency in food. Currently, Bangladesh has achieved near self-sufficiency in food production, leaving an annual food grain deficit of more than 1 million ton (Figure.II.1 & Annex.II.1)

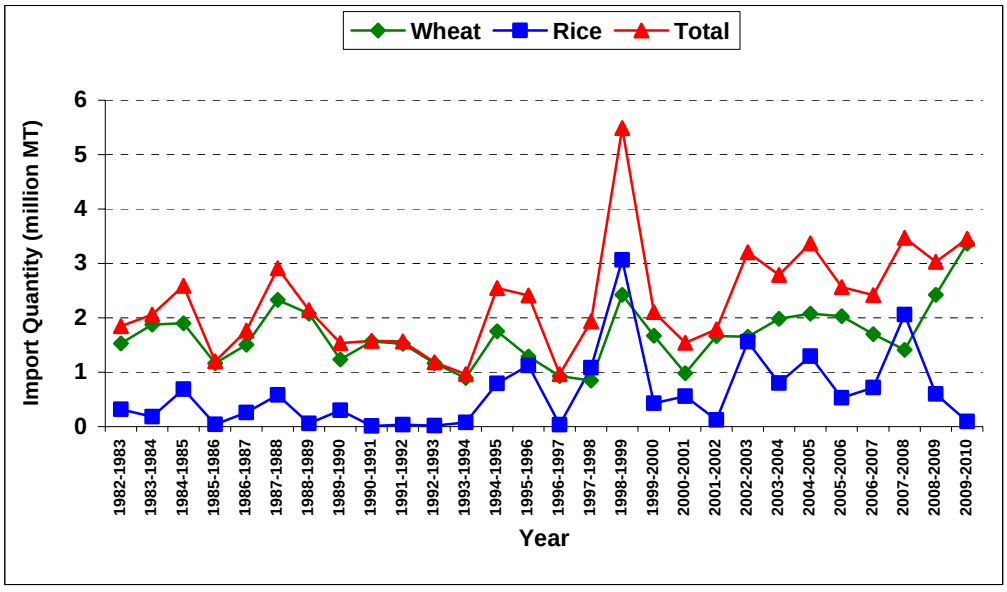


Figure.II.1: Import quantity of wheat, rice and total during 1982-2010

Profile of Bangladesh rice sector

Rice total (gross) cropped area increased 38% from 1960 to 2009 (8.8 to 12.25 million ha) with average annual compound growth rate of 0.66% in Bangladesh (USDA, 2009 and FAO, 2008). The average annual growth rates of rice total cropped areas are 1.13%, 0.40%, 0.42%, 0.13% and 1.32% during 1960-1970, 1970-1980, 1980-1990, 1990-2000 and 2000-2009 respectively (Table.II.1 and Annex.II.2 & 3).

Table.II.1: Compound annual growth rates (%) in area, production and yield of rough rice in Bangladesh during 1960-2009

Period	Area	Production	Yield
1960-1970	1.13	1.43	0.30
1970-1980	0.40	2.22	1.05
1980-1990	0.42	2.54	2.44
1990-2000	0.13	3.46	3.02
2000-2009	1.32	3.50	2.15
1960-2009	**0.66**	**2.61**	**1.93**

National rice production increased 253% from 1960 to 2009 (14.52 to 51.33 million ton) with average annual growth rate of 2.61% in Bangladesh (Table.II.1). The highest average annual growth rate is estimated during 2000-2009 (3.50%) followed1990-2000 (3.46%), 1980-1990 (2.54%), 1970-1980 (2.22%) and 1960-1970 (1.43%). Average paddy yield increased about 156% from 1960 to 2009 (1.64 to 4.19 t/ha) with 1.93% average annual compound growth. The highest average annual growth rate of paddy yield is estimated during 1990-2000 (3.02% t/ha) followed 1980-1990 (2.44%), 2000-2009 (2.15%), 1970-1980 (1.05%) and 1960-1970 (0.30%). Rice total cropped area (m ha), rough rice production (m ton) and yield (t/ha) during 1960 to 2009 are provided in Figure.II.2.

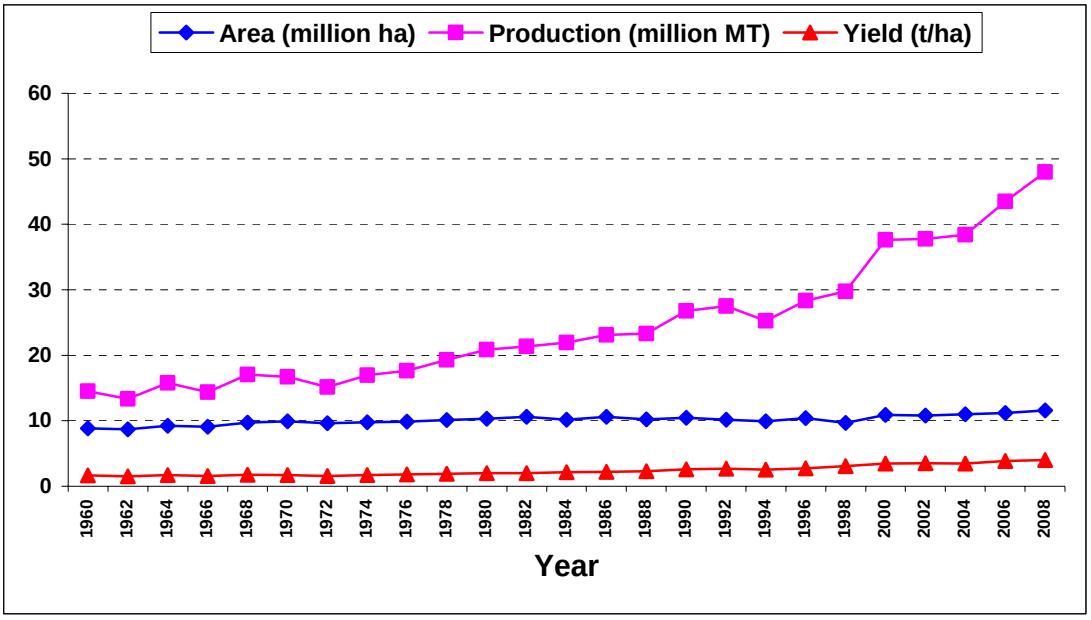


Figure.II.2: Total rice cropped area, total rough rice production and yield (1960-2009)

The average annual growth rates of national paddy production were 1.67%, 3.86%, 2.22%, 1.42%, 2.47% and 5.07% for Pre-green revolution intervention period (1960-65), Very early green revolution period (1966-70), Early green revolution period (1970-80), Late green revolution period (1980-88), very late green revolution period (1988-98) and current green revolution period (1998-2009) respectively. Incase of paddy yield, the highest average annual growth rate is estimated 2.87% during 1998-2009 (Current green revolution period) followed 2.35% during 1988-1998 (Very late green revolution period), 1.80% during 1970-1980 (Early green revolution period), 1.70% during 1966-1970 (Very early green revolution period), 1.53 during 1980-88 (Late green revolution period) and 0.48% during 1960-1996 (Pre-green revolution intervention). Average annual growth rates of national rice production area were 1.10%, 2.24%, 0.40%, -0.11%, -0.53% and 2.15 for Pre-green revolution intervention period (1960-65), Very early green revolution period (1966-70), Early green revolution period (1970-80), Late green revolution period (1980-88), Very late green revolution period (1988-98) and Current green revolution period (1998-2009) respectively (Table.II.2).

Rice production in Bangladesh remained nearly stagnant in 1950s at around 11 to 12 million MT of rough rice, or paddy. The 1960s however experienced a rapid growth of rice production due to increase in area with higher cropping intensity along with introduction of IR-8 (HYVs), expansion of the transplanting method of cultivation, chemical fertilizers and power pumps for irrigation under the then government's grow more food production programme " (Hossain, 1988). Paddy production increased from 14.52 to 15.77 million MT (9%) during 1960 to 1965 with 1.67% average annual growth rate for pre-green revolution intervention period in Bangladesh. During this period, annual growth rates were 0.48% and 1.10% for paddy yield and production area respectively (Table.II.2). In this period, green revolution intervention was at rudimentary stage in the country.

Higher growth rates are estimated for national paddy production (3.86%), production area (2.24%) and yield (1.70 t/ha) during very early green revolution period (1966-70) than pre-green revolution intervention period (1960-1965). Further, annual growth rates of national paddy production decreased following three decades during 1970-80 (2.22%), 1980-88 (1.42%) and 1988-1998 (2.47%). Such average annual growth rate is estimated 5.07% for national paddy production as highest for the current green revolution period (1998-2009) during last five decades since 1960. Average annual growth rates of paddy yield progressively increased from pre-green revolution period (0.48%) to current green revolution period (2.8%). On the other hand, annual growth rates of national paddy production area are found inconsistent and undulating trends during last five decades since 1960 (Table.II.2). However, the achievement of high average annual growth rates of paddy production during the current green revolution period due to adoption of modern production technologies such as HYVs and rice hybrids, higher irrigated rice cropping area, higher rates of fertilizer use, and plant protection chemicals. This growth followed the liberalization of policies regarding import and distribution of agricultural inputs, and reduction of import duties on agricultural equipment (Hossain, M. et al. 1994). Increase in rice production is now dependent on growth in rice yield: Vertical expansions of rice production possible, but not horizontal expansion. Thus, Bangladesh must aim for rice yields to grow faster than demand and to release land for other crops. Notably, demand for other high value cash crops has been growing faster than demand for rice.

Table.II.2: Compound annual growth rates in area, production and yield of rough rice in Bangladesh during pre and post green revolution (1960-2009)

Period	Area	Production	Yield
1960-1965 (Pre-green revolution intervention)	1.10	1.67	0.48
1966-1970 (Very early green revolution)	2.24	3.86	1.70
1970-1980 (Early green revolution)	0.40	2.22	1.80
1980-1988 (Late green revolution)	-0.11	1.42	1.53
1988-1998 (Very late green revolution)	-0.53	2.47	2.35
1998-2009 (Current green revolution)	2.15	5.07	2.87

China's success with hybrid rice and its scale-up

Hybrid rice has made great contributions to china's food security since 1976. China's rice breeders began hybrid rice development in 1964 using a three-line system. By 1976 China started large-scale commercial production of hybrid rice using the three-line hybrid rice system. In 1995, China successfully commercialized the two-line hybrid rice technology. In 2000, the "super hybrid rice breeding" phase I objective of 10.5 t/ha was attained, and the phase II objective of 12 t/ha was accomplished in 2004 (Li, et al 2009). The phase-III super hybrid rice reached a yield of 13.5 t/ha in 2006 (Yuan, 2010). China's hybrid rice national average seed production yield rose from 450 Kg/ha in the late 1970 to 3750 kg/ha in 2008 with highest recorded about 7.4 t/ha. (Li, et al 2009)

Presently, China grows rice on 29 million hectares with an average yield about 6.3 t/ha. Out of this 29 million hectares, hybrid rice accounts for about 64% of the area (18.6 million hectares). China's hybrid rice has an average yield of 7.2 t/ha compared with 5.9 t/ha for conventional rice in 2008 (Li, et al 2009). The average incremental yield of hybrid rice vs. convention rice is more than 20%, feeding 70 million more people. Currently China needs an annual grain output of 500 million tons to feed the nation's 1.3 billion people (Yuan, 2010). Hybrid rice technology has helped China save 5 million ha of rice land from 1978 to 2008, while increasing total rice production. Hybrid rice technology has created more than 100,000 direct jobs and 10 million indirect jobs in China. To date, China has developed and released more than 1,000 rice hybrids for commercial production within and outside China (Pandey and Bhandari, 2009, ppp). A total of 459 rice hybrids commercially were grown in china during 2006, of which 26 were two-line hybrids (Mao, 2010)

China's rice hybrid technology has been tested in many rice growing countries, including Bangladesh, India, Vietnam, Philippines, Indonesia, Srilanka, Myanmar, Korea, Egypt, Mexico, Brazil, Colombia, etc. China's rice hybrids can out-yield inbred HYVs by a margin of 1-1.7 t/ha under farmers' field conditions in irrigated rice ecosystem. Outside, China, the pace of adoption of this technology has been rather slow since its introduction due to its higher input costs and the lower market price for its inferior grain quality. But, the adoption of hybrid rice technology in several Asian countries is found encouraging, including Vietnam,

Bangladesh, Philippines, Indonesia, India, etc. Adoption of hybrid rice in Bangladesh depends primarily on hybrid rice technology from China, with high seed cost and sticky rice. However, consumers in Bangladesh and some other Asian countries prefer non-sticky rice.

Hybrid Rice scenario in Bangladesh

Hybrid rice R & D status in Bangladesh: Bangladesh Rice Research Institute (BRRI) is the only public sector research institute in Bangladesh mandated to conduct research on rice. Realizing the importance of hybrid technology in food security and rural employment, the Government of Bangladesh changed its outlook to favor this technology after 1990.

Research and development of hybrid rice technology began in 1993 at BRRI in collaboration with International Rice Research Institute (IRRI). Initially research was limited to the evaluation of F_1 hybrids and testing CMS and restorer lines from IRRI. From 1996 onward, BRRI's hybrid rice research gained momentum with the formation of a working group, technical support from IRRI, and financial support from the Bangladesh Agricultural Research Council (BRAC). At that time, BRRI's hybrid rice research program was supported by a contract research sub-project of the Agricultural Research Management Project (ARMP) funded by World Bank and coordinated by BARC. BRRI's R & D program on hybrid rice was further strengthened when two scientists from China worked closely with BRRI scientists for several months during 1997-98, assisting seed production and hybrid rice breeding under the TCP project funded by FAO. Concurrently three more Chinese hybrid rice experts also started to work with BRRI under the Technical Cooperation between Developing Countries (TCDC) programs under the funding support from FAO. Subsequently, BRRI's hybrid rice program was further strengthened through an IRRI-ADB project initiated in 1998. Under that project, a few Indian consultants visited Bangladesh to formulate a hybrid rice program and a long-term master plan. During that period some BRRI scientists and staff of Bangladesh Agricultural Development Corporation (BADC) trained at home and abroad on hybrid rice breeding and seed production technology. A chronology of rice hybrids development by BRRI is provided in Box 1.

Box 1: History of hybrid rice R & D for Bangladesh Rice Research Institute (BRRI)

1993: -Collaboration on hybrid rice research started between Bangladesh Rice Research Institute (BRRI) and International Rice Research Institute (IRRI)
1995:- First promising restorer line BR 827-35-2-1-1-1R found in Bangladesh
- International Hybrid Rice Observational Nursery (IRHON) started in Bangladesh
1997: Started FAO funded hybrid rice project with Chinese experts
1998: -Project on "Research and Development of Hybrid rice in Bangladesh" initiated through Agricultural Research Management Project funded by Bangladesh Agricultural Research Council (BARC) and implemented by BRRI.
- Initiated IRRI-ADB Project on hybrid rice
2000: -First CMS line BRRI1A developed by BRRI
2001: -First public bred hybrid rice variety BRRI hybrid dhan1 released from BRRI for Boro season by NSB.
2002: -Hybrid rice seed yield more than 1.5 ton/ha achieved
- Started poverty elimination through rice research assistance (PETRRA) funded Project on "Research and Development of Hybrid rice in Bangladesh"
2003: -Two new CMS lines developed by BRRI
2004: -Some promising restorer lines identified
2006: -New project "Research and Development of Hybrid rice in Bangladesh" started by BRRI with financial support by Government of Bangladesh
2008: -Second public bred hybrid rice BRRI hybrid dhan2 released from BRRI by NSB
2009: -Hybrid rice seed yield more than 2.5 ton/ha achieved by BRRI
-Third public bred hybrid rice variety BRRI hybrid dhan3 released from BRRI by NSB
2010: -First Aman season hybrid rice variety BRRI hybrid dhan4 released from BRRI by NSB

However, BRRI's hybrid rice program did not appear to be a high priority until 2000, as it evident from the allocation of meager human and financial resources. Resources from BRRI's core budget for hybrid rice R & D were too meager to carry out extensive research activities until 2000. Over the subsequent 10 years to 2010, government is convinced about the potential of this technology and gives priority to accelerating hybrid rice R & D. Since 2001 BRRI has released 4 rice hybrids for commercial cultivation, of which 3 are intended for the Boro season and one for the Aman season. BRRI has received fund from BARC, ADB, PETRRA (an IRRI/DFID project), GOB core fund etc for conducting R & D on hybrid rice since 1996.

In addition to BRRI, BRAC (a large NGO) and one private seed company (Supreme Seed Company Ltd) have their own R & D for hybrid rice. BRAC initiated their hybrid rice R & D in collaboration with IRRI and sharing IRRI's germplasm. Although more than 30 private seed companies are engaged in selling hybrid rice seed, only Supreme Seed Company has developed an R & D program. The other companies import hybrid rice seed – mostly from China and some from India. Several private seed companies, BRAC, and BADC have been producing appreciable quantities of hybrid rice seed (F_1) in the country, mostly with imported parent lines (A & R lines) from China, India and the Philippines.

Hybrid rice adoption: More rice production could be obtained by expanding rice area, but the expansion of rice area is not possible in Bangladesh due to limited land availability for rice cultivation. Adoption of hybrid rice in Bangladesh shows that more rice could be produced even on less land with hybrid rice. Accordingly, China's hybrid rice technology is one of the options for vertical expansion, with a capacity to produce at least 20% higher

yields than existing HYVs. From 1998-99 to 2009-10 a total of 85 rice hybrids have been released and notified in Bangladesh (Figure II.3), out of which 80 come from private sector/NGO and 5 from public sector (4 from BRRI and one from BADC). Eight rice hybrids are developed in Bangladesh, of which 4 developed by BRRI, 2 developed by BARC and 2 developed by a private seed company. Out of 85 released rice hybrids, only 2 rice hybrids released for transplant Aman season. Thus, a total of 85 rice hybrids are available for commercial seed sale and seed production in Bangladesh. Most of these hybrids are sticky rice with amylose content less than 25% and most are also bold grain hybrids. From 1998 to 2010 a total of 44 organizations have been involved with hybrid rice technology transfer, seed selling and seed production in the country, of which private seed companies are recorded as highest (40) followed by NGOs (2), BRRI and BADC.

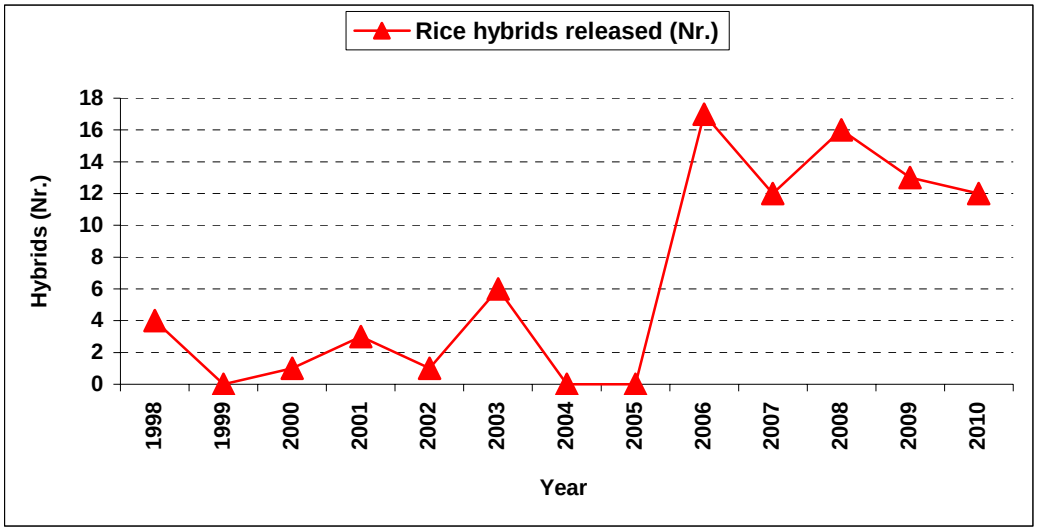


Figure.II.3: Hybrid rice variety released in Bangladesh during 1998-2010

In late 1990s several seed companies took the initiative to introduce hybrid rice in Bangladesh by establishing trial plots for their own experience gain and also to show to the relevant Government policy makers. Since the research system in Bangladesh was not developed for rice hybrids, the GOB encouraged private companies to import hybrid rice seeds and to try them with farmers for its introduction in the country to increase rice production with anticipation for its higher yield potentiality than the existing high yielding inbred. Some private seed companies imported seed of rice hybrids and evaluated them through on-farm trials in nine agricultural regions in the country during the 1997-98 Boro season. A special evaluation committee was formed under the Seed Certification Agency (SCA) of the National Seed Board (NSB) to evaluate the results of these on-farm trials. This special committee recommended the release/introduction/import of seeds of rice hybrids based on the results of limited trials for only for one season. Accordingly, GOB permitted four rice hybrids - Aalok (HR 6021), Sonarbangla-1 (CNSGC-6), Loknath 503 and Amarsree-1 - for seed sale during the 1998-99 Boro season based on the recommendation of the National Seed Board (NSB).

In cooperation with the four involved seed companies, Agricultural Advisory Society (AAS) as a third neutral party assessed the performance of the four permitted rice hybrids during the 1998-99 Boro season in 10 districts. Overall, Sonarbangla-1, a Chinese rice hybrid performed better than the 3 Indian hybrids and BRRI dhan 29, a local inbred HVY. The study's findings were influential among private seed companies and NGOs. Subsequently,

other private seed companies and BRAC, the largest NGO in Bangladesh, decided to import hybrid rice seeds from China. The current area planted to rice hybrid is about 1 million hectares, primarily with 66 Chinese rice hybrids from 40 private seed and agro-chemical companies and BARC. Altogether, private seed companies, NGO and public sector (BADC) sell seed for 85 released hybrids in the country. Farmers most commonly adopt hybrids during the Boro season with Chinese rice hybrids. Thus acceptability of Chinese rice hybrids among the farmers is at maximal level in the country. Business relationship between rice hybrids seed (F_1 & parent lines) supplying agencies in China and seed buying agencies (private seed companies & NGO) in Bangladesh is very much congenial and productive in terms of business deal from late 1990s. Accordingly, Chinese hybrid rice technology adoption is found as enormous within shortage possible time with few reservations in Bangladesh.

In 9 years from 1998-99 to 2007-8, hybrid rice area increased about 4263% (0.024-1.011 million ha) and subsequently, hybrid rice area decreased it peak in 2007-8 by 7% in 2008-9 and by 34% in 2009-10. Clean rice production from hybrid rice increased about 4368% from 0.11 million MT in 1998-99 to 4.8 million MT in 2007-8, before falling to an estimated 4.31 million MT in 2008-09 and 3.15 million MT in the 2009-10. Such change in area and production of hybrid rice is estimated at very higher percentage due to very low base. High rice yield is estimated with more or less similar trends from 1998-99 to 2009-10 between 4.59-4.75 t/ha (Figure.II.4 & Annex.II.4). Hybrid rice acreage and production was peak in 2007-08, this might be due to great push from Ministry of Agriculture (MOA) through DAE in collaboration with Private Seed Companies those were involved for hybrid seed marketing in Bangladesh. Following year in 2008-9 acreage of hybrid was declined due to higher price of chemical fertilizers, propaganda against hybrid rice regarding its disease susceptibility (BLB & BLS) during 2007-8 Boro season, trends of low paddy price at the beginning of sowing time of Boro season, less push from DAE on hybrid rice cultivation and comparative high market demand for popular inbred rice in the country. Further hybrid rice acreage was declined in 2009-10 due to low price of paddy in general and hybrid paddy in particular, very less push from DAE on hybrid rice cultivation and comparative higher market demand for popular inbred rice in the country.

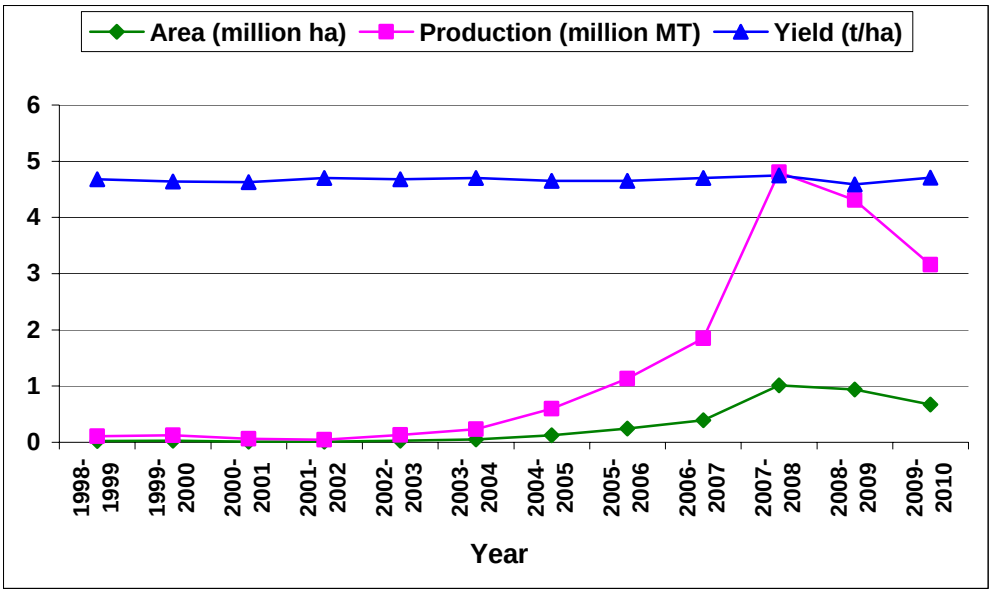


Figure.II.4: Area, production and yield of hybrid rice during 1998-2010

Production of hybrid rice seed in Bangladesh increased from 47.56 MT in 1999-2000 to 3,600 MT in 2009-10 Boro seasons. Hybrid rice seed production area increased from 52.63 ha in 1999-2000 to about 1,200 ha in the 2009-10 Boro season. Average hybrid rice seed yield increased about 233%, from 0.99 t/ha to 3.00 t/ha from 1999-2000 to 2009-10 Boro seasons. As of 2010, the highest recorded hybrid rice seed yield in Bangladesh is more than 4.0 t/ha, which can be compared to a maximum yield of less than 1.3 t/ha achieved in 1999-2000 **(Figure.II.5).**

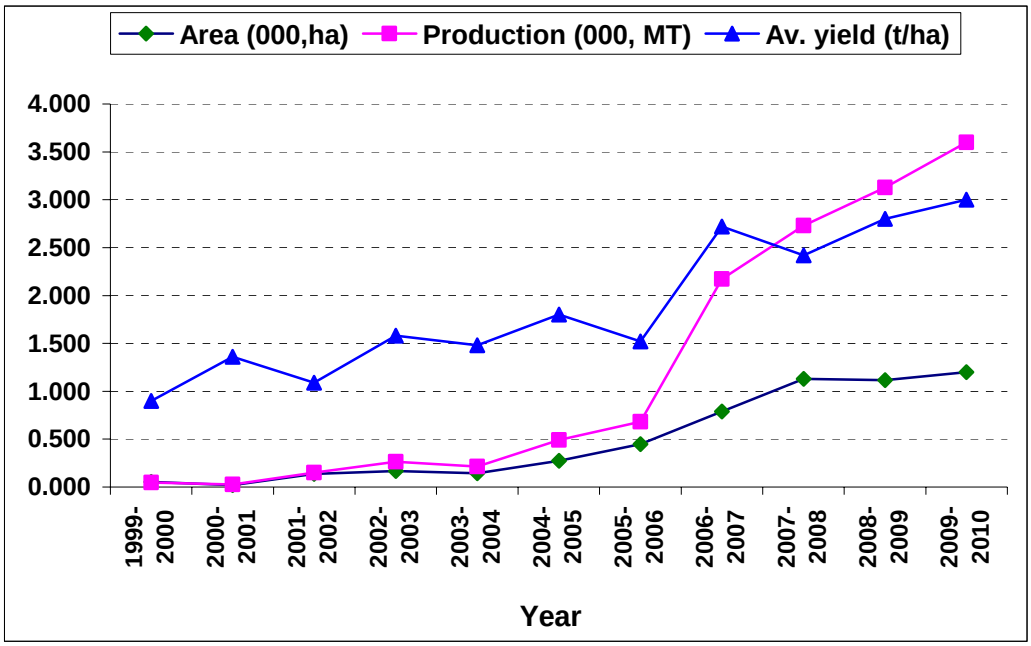


Figure .II. 5: Hybrid rice seed production area, production and yield

According to the Department of Agriculture Extension (DAE), hybrid rice area was about 1.01 million ha (but private seed companies claimed not more than 0.8 million ha), producing 4.81 million MT of clean rice during the 2007-8 Boro season. Hybrid rice accounts for about 22% of total Boro rice area or 9% of the total rice area of Bangladesh during the 2007-8 cropping seasons. Hybrid rice produced about 26% of the total clean rice harvested in the Boro season, and about 15% of the total clean rice produced in 2007-8. During the 2007-08 Boro season, the average yield of clean rice from hybrids was about 23.40% higher than the average yield of clean rice from inbred (4.75 t/ha vs. 3.85 t/ha).

Among three rice cropping seasons, acreage of hybrid rice is reported mainly for Boro season during 12 years from 1998-99 Boro season. But hybrid rice is not well accepted during T.Aus and T.Aman seasons with available rice hybrids in the country. Hybrid rice acreage during 2007-8 Boro season was about 22%, which is quite encouraging compared to rest two rice cropping seasons throughout the year in the country. As a result, currently only about 9% area is estimated with hybrid rice of the total rice acreage in the country. Proportion of hybrid rice acreage and clean rice production is provided in Figure.II.6.

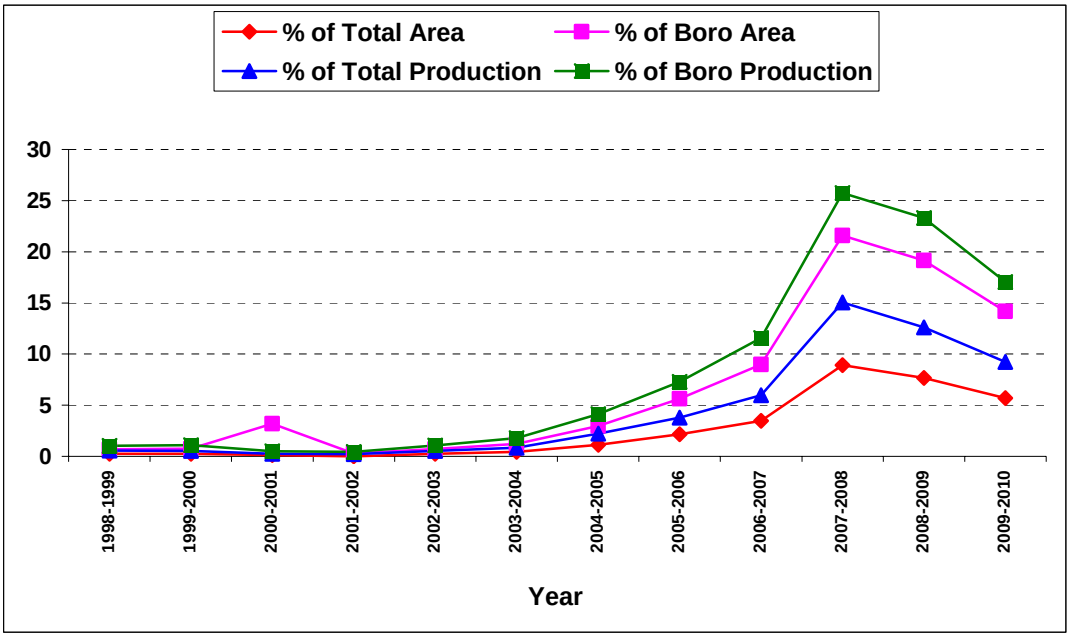


Figure.II.6: Proportion of hybrid rice of total rice area, total rice production, Boro area and Boro production during 1998-2010

Objectives of the study:

(i) To document the status and investment of the hybrid rice research and development in Bangladesh;

(ii) To document the policy issues relevant for hybrid rice technology development and introduction, public and private R&D investment, seed promotion and marketing, variety registration, etc;

(iii) To document the sources of hybrid rice seed with an emphasis on the price, quantities and types of hybrid rice seed provided by public agencies, private companies and non-governmental organizations:

(iv) To find-out the mechanisms for disseminating and marketing the hybrid rice seed in the country;

(v) To find-out the agronomic performance of hybrid rice in trials, research stations, and farmers' field conditions in Bangladesh;

(vi) To evaluate the status of hybrid rice seed production system development in Bangladesh;

(vii) To evaluate the economic performance of hybrid rice in Bangladesh;

(viii) To document the response from policy makers, farmers and consumers to hybrid rice in Bangladesh;

(ix) To formulate recommendations to enhance the research, development and delivery of hybrid rice for the benefit of farmers and consumers, and to reduce any risks associated with hybrid rice.

III. Methodology

Design and method

The study has been conducted through reviewing available project documents, academic literature, published scientific papers, published and un-published reports, relevant available documents from the web, government statistics, private sector data and information and informal meetings with relevant public, private and NGO staff. The study was designed to document the history, impact and current status of hybrid rice research, development and delivery in Bangladesh. The design and method were prepared by Harun-Ar-Rashid along with members of the study team, Dr. A.W. Julfiquar and Md. Shahjahan Ali.

Study Team

The study was conducted by a small group of experts which includes (i) Harun-Ar-Rashid, as Collaborator, an agronomist with long experience in research and extension, particularly in rice in Bangladesh; (ii) Dr. A.W. Julfiquar, as Member, a reputed hybrid rice breeder with outstanding technical background on research and development on hybrid rice technology, and (iii) Md. Shahjahan Ali, as Member, a seed agronomist with strong background on seed policy in general and hybrid rice seed in particular. Necessary data were analyzed by A.H.M. Asadur Rahman in cooperation of Ibrahim Hossain of AAS. The study was scheduled to be conducted from 1 July 2010 to 14 January 2011.

Information Collection

Necessary information were collected from the relevant public, private and NGO organizations, including DAE, Seed Wing and Seed Certification Agency (SCA), MOA, BADC, Department of Agricultural Marketing (DAM), research institutes (BRRI, BINA, etc), private seed companies, seed dealers, lead farmers, IRRI, FAO, individual hybrid rice scientists, relevant agricultural experts, seed experts, and economists. Relevant information was collected from reports, books, published scientific papers, un-published papers, thesis, and various data in soft and hard copies, as available. Information was collected from the libraries of the relevant organizations. Finally, a lot of information was collected from the web sites of international and national organizations.

Data Analysis

Relevant collected data were entered in MS Excel spread sheet and analyzed using MS Excel and SPSS package. Descriptive statistics, mean, CV and standard error (SE) were performed as needed, especially to compare hybrid with inbred rice. Growth rates were calculated as compound annual rates. The cost and return analysis for both hybrid and inbred rice was carried out using MS Excel and SPSS package.

Translation

Most of the government document (policies, rules, meeting proceedings etc) were collected as hard copies in Bengali, and these were translated into English as necessary for this report. .

Limitations of the study

The study is a review of available documents and information from various sources. As such, the study was limited by the information that was available, either in written form, or through interviews. Data and information on hybrid rice from public sector organizations such as DAE, Seed Wing and SCA, BADC etc, are not at a satisfactory level. For example, SCA has regional on-farm and on-station trials data with code number against each submitted rice hybrid, but these data are not easily accessible. IRRI/BRAC conducted only one study on hybrid rice adoption in Bangladesh during the early introduction stage in 2000. Only four reports are available on rice hybrid trials and performance during 1998-2004, all of which were prepared by AAS. Satisfactory information is not available on many aspects of hybrid rice in Bangladesh, such as hybrid rice production, hybrid rice seed production, seed importing (F_1, A, B & R lines), seed marketing, and R & D in private companies as well as in the public sector.

IV. Investment on and process of hybrid rice R & D

Having recognized the heterosis breeding as one of the most feasible approaches for increasing the productivity of rice in the country in order to meet the ever increasing demand, Bangladesh Rice Research institute initiated a goal oriented time bound hybrid rice program in 1996. This program starts with one hybrid rice expert who trained at IRRI along with three B.S/M.S level agricultural graduates. The manpower support was provided from a contract research program from the World Bank funded Agriculture Research Management project (ARMP) of Bangladesh Agricultural Research Council (BARC). Other logistic support and recurrent cost was bear out from the core budget of BRRI. It should be mentioned here that the then the Director General supported the program but there was lot of controversy among the conventional breeder including scientists from other discipline regarding the prospect of hybrid rice and the feasibility of hybrid rice program in Bangladesh.

Later on this program got momentum with FAO support and a TCP project in the name of “Development and use of hybrid rice in Bangladesh” was undertaken in 1997. Through the TCP project one breeder from BRRI and one seed production staff from BADC were trained in China for 3 months. In this program 5 Chinese experts also visited Bangladesh for more than two months in two groups. Some necessary equipment was also procured under this project. During this period some IRRI parental lines and hybrids were evaluated along with Chinese hybrids brought by the Chinese experts. However, those hybrids failed to show higher yield than the existing conventional varieties.

“Development and use of hybrid rice in Bangladesh” project was further strengthened through IRRI-ADB project in 1998. The IRRI-ADB project entitled "Development and Use of Hybrid Rice in Asia" was launched in March 1998 at the International Rice Research Institute (IRRI), with the funding support from Asian Development Bank (ADB) and collaboration established among IRRI, Food and Agriculture Organization (FAO) of the United Nations, Asia Pacific Seed Association (APSA) and six Asian countries viz., Bangladesh, India, Indonesia, Philippines, Sri Lanka and Vietnam. China has joined the project as a regular member from the year 2000. The major goal of the project is to support increased rice production by the development and use of hybrid rice technology.

Milestone of hybrid rice research in Bangladesh was established by this project. This project opened the opportunity to regional and International cooperation. During this project period (1998-2001) some parental lines (A, B & R) was received through International nursery. Bangladesh Rice research Institute started to develop parental lines by utilizing the exotic CMS line. Simultaneously, on-station and on-farm trial of the introduced hybrids were conducted in different region of the country. Under this IRRI-ADB project a pilot production program for selected promising rice hybrids started. An IRRI developed hybrid (IR69690H) was identified as promising in the two regions of the country and accordingly it was released and notified as BRRI hybrid dhan-1 by the National Seed Board (NSB) in 2001 for commercial cultivation by the farmers in those regions of the country.

Although BRRI was the coordinator of this project, other public and private organizations and two Agricultural Universities of the country were also involved as partners of this project. Several training program conducted during this period on hybrid rice development, seed production and cultivation. Personnel from public and private organizations were trained on hybrid rice development and seed production at IRRI. Five hybrid rice breeders trained

during this project period those who were able to develop some parental lines and experimental hybrids. But those trained manpower left at the end of the project period and only one or two people from BRRI core program retained in the project. Until this period no significant support and commitment came from the Government Peoples Republic of Bangladesh.

After the termination of the hybrid rice project, R & D activities on hybrid rice by the public sector (BRRI, BADC, Universities) has started to shrink, probably due to the lack of commitment from institutional and national side. But the private sector was interested to produce as well as to import more private hybrid rice seed because of the increasing demand by the farmer.

Later, hybrid rice was included as a priority areas for project funding by DFID (UK) under a bilateral aid project entitled Poverty Elimination Through Rice Research Assistance (PETRRA) that was implemented by IRRI from 2002. In this project public, private and NGO sectors were involved to identify and solve some major problems regarding research and development of hybrid rice in Bangladesh. The project provided human resources and financial support, infrastructure development, and the operational costs of hybrid rice R & D in the country. A goal oriented time bound program for individual organizations along with required fund were allotted for the partner organizations in this project.

Two seed production agencies- BADC and BRAC in the NGO sector were selected for seed production and began large scale seed production. The hybrid IR69690H released as BRRI hybrid dhan1under the IRRI-ADB project was promoted through PETRRA project.

BRRI in close collaboration with 9 organizations (Public, Private, Universities and NGO's), the sub-project activities were implemented to hybrid rice technology generation, seed production, capacity building and technology transfer. This project continued up to 2005. Again it was not possible to retain the manpower who, was trained through working in this project.

Later government took initiative to strengthen the nation's hybrid rice program. A 5-year project on hybrid rice entitled "Research and Development of Hybrid Rice in Bangladesh" for US$ 1 million was approved by Bangladesh government to provide financial support for hybrid rice research in the country. New manpower (Scientific staff and supporting staff) were procured for this project.

According to DPP, the objectives of this project were:

1. Development of hybrid rice varieties from the varieties/lines adapted to Bangladesh conditions and take necessary measure for its use by the farmers.

2. Development, optimization and/or refinement of hybrid rice seed production and cultivation technologies suitable for Bangladesh condition

3. Impart training to researchers, extentionists and seed producers on hybrid rice seed production and cultivation technologies.

4. Produce nucleus and breeder's seed and meet the demand of hybrid rice seed in the country.

This project initiated in July 2005 and was supposed to be end in June 2010. As of now four hybrid rice varieties have been developed and released from BRRI for the commercial cultivation by the farmer. This project has been extended for one year more and a proposal for including the hybrid rice program in the core program of BRRI is underway. The research investment on hybrid rice by public, NGO and private organizations are provided in Table.IV.1.

Table.IV.1: Research investment on hybrid rice by public, NGO and Private Organizations

Organization	Financial expenditure			Remarks
	Infrastructure	Research	Equipment	
Public Organization:				
Bangladesh Rice Research Institute (BRRI) (ARMP-Project)		US$ 33000		Budget for 1998-2001
Bangladesh Rice Research Institute (BRRI) (IRRI-ADB Project)	-	US$ 26800	-	Budget for 2000
Bangladesh Rice Research Institute (BRRI) (PETRRA Project)	-	US$ 270920	-	Budget for 3 Years
Bangladesh Rice research Institute (BRRI)	US$ 1,17,142	US$ 8,00,000	US$ 1,54,285	Budget for 5 years from ADP,GOB
Bangladesh Agriculture Development Corporation (BADC)		US$ 12,80,000		For seed production only
NGO:				
Bangladesh Rural Advancement Committee (BRAC)	NA	NA	NA	
Private Seed Company:				
Supreme seed co. Ltd.	US$ 3,00,000	US$ 3,30,000	US$ 1,00,000	Budget for 1 year

Private Agencies: The government allowed private sector companies to import hybrid seeds to make up the shortage of seed for 1998-99 Boro production after the disastrous floods in 1998. It was stipulated that companies importing seed would produce seed in Bangladesh within three years. Four private seed companies imported seeds from India and China for cultivation in the 1998-99 Boro season. Indian varieties did not perform well, but a Chinese variety, Sonar Bangla1 performed well with a yield gain of 20% over conventional variety. Since then a number of companies have been importing seeds from China, and some have started seed production in the country with Chinese parental materials and technical support.

No significant investment was made by the private seed companies in R & D of hybrid rice except one private company (Supreme Seed Company limited) and one NGO (BRAC) have

their own R & D for hybrid rice. Although 44 private seed companies are engaged in seed business, probably they have not yet developed R & D program for hybrid rice. They are importing hybrid rice seed from outside (mostly from China and few from India) and marketing through their existing seed dealers' network in the country. Supreme Seed Company limited and BRAC have a moderate investment in the manpower & research in R & D for hybrid rice.

Sources of Germplasm and Hybrid Parent breeding lines

BRRI is the only public sector research institute mandate for conducting research on rice. Informal collaboration in hybrid rice research began between Bangladesh Rice Research Institute (BRRI) and International Rice Research Institute (IRRI) in 1993. Initial work involved for testing of F_1 hybrids, evaluation of CMS lines and restorer lines from IRRI. Later BRRI started hybrid rice breeding works for development of hybrid parental lines utilizing the germplasm from indigenous sources (gene bank of BRRI, conventional breeding program) and International nurseries mostly from IRRI. A number of germplasm (A, B & R) lines were also supplied by the Chinese expert during their consultancy mission under TCP project funded by FAO in 1997-98. Although the parental lines from China were not adapted to Bangladesh and were susceptible to pest and diseases but those were found as good CMS source. Therefore, BRRI used those CMS source and developed some new CMS and B lines. Since CMS lines introduced from China were unstable to Bangladesh condition, the IRRI developed CMS lines IR58025A and IR62829A were used to develop locally adapted CMS lines. Several selected local varieties/lines were identified as maintainer and were backcrossed to their respective CMS sources. A large number of high yielding locally developed elite lines were tested along with some good restorer from IRRI. These restorers were purified and multiplied for use in the production of experimental hybrids. BRRI also received some Indian germplasm through IRRI.

Other countries including China are not willing to share their best materials. In this situation for promoting hybrid rice cultivation in the country like Bangladesh should developed its own parental lines. Keeping this target in mind BRRI has developed several A, B & R lines by utilizing CMS source from other countries (Table.IV.2) (BRRI, 2010). Recently BRRI has developed quite a good number of hybrid parental lines which are being utilizing in developing heterotic rice hybrid(s).

BADC being the only public sector seed producing agency was engaged in producing hybrid seed of the national released hybrid from BRRI. Recently, BADC is producing hybrid rice seed with a hybrid named SL-8H (a three-line hybrid, has been widely grown in the Philippines) getting parent materials from a Chinese seed company SL Agro Tech. based in Philippines.

BRAC initiated their hybrid rice R & D in collaboration with IRRI and sharing their germplasm. Through their R & D program, BRAC developed two hybrid varieties which got approval of the National seed Board (NSB) for commercial cultivation and seed production in the country.

At present some private seed companies has initiated their own R & D program on hybrid rice and utilizing parental materials from BRRI, India and China. But only few of them hired technical manpower and others are producing hybrid rice seed in collaboration with the seed companies from which they import the hybrid rice seed. A leading private company, Supreme Seed Company limited has its own research program and released two hybrids.

Table.IV.2: A, B, R lines used in hybrid rice development in Bangladesh. (2002-2010)

Sl No.	Designation	Cyto source	Country of origin	Restorer line	Source
1	Zhen shan 97A/B	WA	China	Zhong-Yu-3	China
2	V_{20}A/B	WA	China	Zhong-Yu-7	China
3	Jin23A/B	WA	China	Gui99R	China
4	You 1A/B	WA	China	M.H 77R	China
5	D. Shan A/B	Dissi	China	NR-11	India
6	Gan 46 A/B	Dissi	China	Ajay R	India
7	II 32 A/B	Indonesian paddy	Indonesia	PMSRI-17-4-B-13	Philippines
8	Ajay A/B	WA	India	IR52713-2B-8-2B-1-2	IRRI
9	PMS 4 A /B	WA	India	IR65209-3B-6-3-1	IRRI
10	PMS 8 A /B	WA	India	IR65610-38-2-4-2-6-3	IRRI
11	PMS 11 A /B	WA	India	IR44675R	IRRI
12	PSRC-8 A/B	WA	Philippines	IR71137-328-2-3-3-2R	IRRI
13	IR68886A/B	WA	IRRI	IR69713-3-2-1-3-2R	IRRI
14	IR68888 A / B	WA	IRRI	IR69702-91-2-3R	IRRI
15	IR68890 A/B	WA	IRRI	IR73885-10-4-3-2-1-6R	IRRI
16	IR68897A/B	WA	IRRI	IR65482-7-216-1-2R	IRRI
17	IR69627 A / B	WA	IRRI	IR69713-127-2-1-3-2R	IRRI
18	IR70960 A / B	WA	IRRI	BR 827R	BRRI
19	IR73328 A / B	Mutagen	IRRI	BR 168 R	BRRI
20	IR 75595 A/B	Gambiaca	IRRI	BR 736R	BRRI
21	IR75608 A / B	Dissi	IRRI	BR6839-41-5-1R	BRRI
22	IR77801 A / B	Gambiaca	IRRI	BR7013—62-1-1R	BRRI
23	IR 77805 A/B	Gambiaca	IRRI	BR7011-37-1-2R	BRRI
24	IR 77808 A/B	Gambiaca	IRRI	BR 6723-1-1-2R	BRRI
25	IR77809 A / B	Dissi	IRRI	BRRI 10R	BRRI
26	IR77811 A / B	Kalinga	IRRI	BRRI 11R	BRRI
27	IR78354 A/B	Gambiaca	IRRI	BRRI 12R	BRRI
28	IR 78361 A/B	Dissi	IRRI	BRRI 13R	BRRI
29	IR79157 A/B	Mutagen	IRRI	BRRI 14R	BRRI
30	IR58025 A/B	WA	IRRI	BRRI 15R	BRRI
31	IR79128 A/B	WA	IRRI	BRRI 16R	BRRI
32	IR79155 A / B	Mutagen	IRRI	BRRI 17R	BRRI
33	IR 79156 A/B	WA	IRRI	**Local germplasm used in hybrid rice**	
34	IR 80151 A/B	WA	IRRI	Luhagara	Germplasm bank
35	IR 80154 A/B	Gambiaca	IRRI	Malail	Germplasm bank
36	IR 80156 A/B	Kalinga	IRRI	Binnimuri	Germplasm bank
37	BRRI 1A/B	WA	BRRI	Sharisha Mota	Germplasm bank
38	BRRI 2A/B	WA	BRRI	Dongra	Germplasm bank
39	BRRI 3A/B	WA	BRRI	Kajalsail	Germplasm bank
40	BRRI 4A/B	WA	BRRI	Kacha Nonia	Germplasm bank
41	BRRI 5A/B	WA	BRRI	Khato Vajan	Germplasm bank
42	BRRI 6A/B	WA	BRRI	Sonaroti	Germplasm bank
43	BRRI 7A/B	WA	BRRI	Jupri	Germplasm bank
44	BRRI 8A/B	WA	BRRI	Gudi Songna	Germplasm bank
45	BRRI 9A/B	Gambiaca	BRRI		
46	BRRI 10A/B	WA	BRRI		
47	BRRI 11A/B	WA	BRRI		

Source: BRRI Annual Research Review Workshop June2009-July2010, Gazipur.

Research expertise

Organized hybrid rice research started at BRRI in 1996 with only one trained hybrid rice breeder and 2-3 plant breeders. Subsequently some experts from public, NGOs and private sector were developed through local training for hybrid rice breeding and seed production. Later two Chinese scientists worked closely with BRRI scientists (including hybrid rice breeders) for several months during 1997-98 in connection with seed production and hybrid rice breeding under a TCP project funded by FAO. Concurrently three more Chinese hybrid rice experts under Technical Cooperation between Developing Countries (TCDC) programs have also started working to share their experiences with BRRI scientists under funding from FAO. The Chinese experts organized a medium term (3-months) training program and trained 30 scientists from various public, NGO and private organization. During the TC project one scientist from BRRI and one senior officer from BADC were also trained in China on hybrid rice breeding and seed production for four months. After that, hybrid rice program of BRRI was further strengthened through IRRI-ADB project initiated in 1998. Under that project, at least 12 scientists were trained at IRRI. Moreover, a training program was organized at BRRI where some resource speakers hired from IRRI and trained more than 30-scientists. In addition a few Indian consultants visited Bangladesh to formulate effective hybrid rice program and a long-term Master Plan. During that period some BRRI scientists and Bangladesh Agricultural Development Corporation (BADC) personnel were trained at home and abroad on hybrid rice breeding and seed production techniques.

It was a long demand from the researchers to establish a national team for the hybrid rice program and the team members should receive adequate training but that was not provided. However, in 2005 MOA approved a hybrid rice project and provided 25 technical staff to run the hybrid rice program.

The private seed companies who started the hybrid rice seed production program hired hybrid rice experts/technician from China who used to stay for the entire seed production season and worked with the local hybrid rice seed production experts and technical staff.

From the very inception of the hybrid rice program several persons from public and private organizations were trained under funding support either from donor agencies or BRRI but it should be mentioned here that those trained persons could not continue their works in hybrid rice technology due to termination of the project or transfer to other relevant research task. Moreover, hybrid rice research and development is cumbersome and laborious task and the scientists and technical staff do not get any extra incentive for this challenging job.

BRRI is playing a pioneer role for improvement and release of new variety of rice since its inception in 1970. Recently, Bangladesh Institute of Nuclear Agriculture (BINA), few Agricultural Universities, NGO sectors and Private companies came forward in the research and development (R & D) of rice hybrid variety. These organizations are also playing important role especially in the development and dissemination of hybrid rice in the country. Hybrid rice experts engaged in hybrid rice R & D, and seed production in public and private organizations in Bangladesh (Table.IV.3). Organization wise hybrid rice experts engaged in research and seed production is provided in Annex.IV.1.

Table.IV.3: Hybrid rice experts engaged in hybrid rice research and seed production in public and private organizations in Bangladesh (2010).

Activity Type	Experts' Education Level				Total
	Ph.D	M.S	B.Sc.	Diploma	
Research	8	22	24	41	95
Seed Production	4	56	98	159	317
Total	**12**	**78**	**122**	**200**	**412**

Source: Personal Communication

Scale up of rice hybrids of BRRI

BRRI has been supplying parent lines (A & R lines) seeds among the involved agencies (e.g. BADC, NGOs, Private seed companies, farmers etc) after releasing of BRRI hybrid dhan 1 from 2002. Similarly, BRRI has been supplying parental lines (A & R lines) of BRRI hybrid dhan 2, 3 and 4 among the trained involved agencies. Besides, parental lines, BRRI has also been supplying F_1 rice hybrids seed through involved agencies and farmers in view for popularizing it rice hybrids among the farmers all over the country. List of agencies and farmers, those have received parent lines and F_1 seed of the released rice hybrids during 2009-10 Boro season is provided in Annex.IV.2

Other inputs in the R & D process

Besides germplasm (seed), other inputs e.g., fertilizer, pesticides, several exotic chemicals such as GA_3, Tiaohuafei, Bacteriocides, specialized weedcides etc, irrigation and agricultural machinery are also essential for ensuring a good crop. At present, all necessary inputs particularly seed, fertilizer, pesticides, irrigation and mechanical powered agricultural equipments are available through existing marketing networks through importing and in country production on market demand driven basis.

Fertilizer: Fertilizer is one of the important inputs for rice production. Major amount of fertilizer is supplied by the public sector Bangladesh Chemical Industries Corporation (BCIC) and BADC. Private sector also playing significant role by supplying fertilizers through import of TSP, MoP, DAP, Zinc Sulphate, Borax and locally blended mixed fertilizer like NPKS. The government also provide subsidy for non-urea fertilizers such as TSP, DAP and MoP. Accordingly, current fertilizers availability through the established fertilizers supply chain is found at satisfactory level from early 2010.

Pesticides: The rice crop is vulnerable to attack by various harmful pests and diseases. Most of the necessary pesticides for rice production are supplied by the private sector pesticide companies through their well established dealers' network all over the country. About 49000 tones of pesticides as finished products (15000 tones as active ingredient) are used in 2009 in Bangladesh (Krishi diary, 2010). Some special chemicals are necessary for hybrid rice seed production and those are not readily available in the country.

Exotic chemicals: Among the several exotic chemical are necessary for hybrid rice research and development, currently government has authorized several chemical

companies to import and market those chemicals for hybrid rice seed production. Rest of the exotic chemicals are available in the country, but not through authorized import chennels.

Irrigation: Irrigation is a major challenge for farmers growing crops in the dry season in general and boro hybrid rice in specific with higher achievable production per unit area. According to DAE out of total 9.1 million ha of cultivable land of which about 5.0 million ha of cultivable land is under irrigation with three minor irrigation devices (1.554 million nr.) during 2008-9 in the country. Among the 3 irrigation devices, Shallow Tube well (STW) is reported as in the top account about 3.25 million ha (65%) with about 1.38 million number of STW in operation followed by Low lift pump (LLP) about 0.96 million ha (19%) with about 0.15 million number in operation and Deep tube well (DTW) about 0.79 million ha (16%) with 32,174 number in operation during 2008-9. More than 15 million farmers are the users within the command area of 5.0 million ha irrigated land under 3 minor irrigation devices (Table.IV.4).

Table.IV.4: Minor irrigation devices, irrigated area and number of water users during 2008-9 (DAE, 2010)

Irrigation Devices	Total (Nr.)	%	Irrigated area (ha)	%	Total water users (Nr.)	%
DTW	32174	2.07	790115	15.83	2113985	13.78
STW	1374548	88.48	3245143	65.00	10741795	70.00
LLP	146792	9.45	957035	19.17	2488881	16.22
Total	**1553514**	**100**	**4992293**	**100**	**15344661**	**100**

Source: Krishi Diary 2010, AIS, MOA

This surge in productivity can be largely attributed to the proliferation of relatively simple and affordable shallow tubewells along with the development of high-yielding, dry season rice, known locally as *boro* rice. In fact, *boro* rice production has increased from 10 percent of the country's rice total rice production in 1966–67, when the Green Revolution was initiated, to 61 percent in 2008. The additional rice cultivated with the improved *boro* rice variety now feeds nearly 22 million people annually. Modern, small-scale irrigation technologies-devices such as deep tubewells, shallow tubewells, hand tubewells, and low-lift pumps-have played an important role in Bangladesh's agricultural sector since the early-1960s. Their use began in 1962-63 with the supply of low-lift pumps for lifting water from surface sources to adjoining fields. The low-lift pumps spread quickly in the depressed basins of the northeastern and central regions where surface water was easily available in the dry season. By the mid-1970s, nearly 35,000 shallow tubewells were fielded, irrigating nearly 0.57 million hectares of land. By 1982-83, deep tubewells and shallow tubewells together were irrigating 0.61 million hectares of land, 40 percent of the country's total irrigated area.

The total area of land irrigated increased from 2.06 million hectares in 1988 to 3.56 million hectares in 2001 and 5.05 million hectares in 2008, or an average rate of increase of 150,000 hectares per year. Most of the increase can be attributed to groundwater exploitation through tubewells, with shallow tubewells accounting for 85 percent of the total

increase. Today nearly 70 percent of farm households in Bangladesh use shallow tubewells for irrigation-equivalent to two-thirds of the country's total irrigated area, or some 3.2 million hectares of land (*Hossain, M. 2009*).

Agricultural Machinery

Bangladesh is going to change the cultivation method from indigenous method to mechanization. The government and the private sector playing supportive and encouraging role for the farmers in mechanization in agricultural activities especially rice production. Mainly private sectors have been supplying agricultural machinery through their existing marketing networks in the country. Recently Ministry of Agriculture (MOA) has undertaken a project namely "Enhancement of Crop Production through Mechanization". Through this project government provide support to the farmers for popularization of essential farm machineries by providing subsidy, training, demonstration and other facilities. The popular and commonly used agricultural machinery for land preparation is the power tiller which is imported by the private sector and sells through their existing dealers' network in the country. Highly skilled local enterprises are manufacturing most of the agricultural equipment and machineries without any financial support from GOB and donors. Thus agricultural equipment and machinery is mainly supplied by the private sector enterprises mostly through local manufacturing.

Constraints experienced in Hybrid rice R and D

Several constraints experienced in hybrid rice research and development work in Bangladesh of which important constraints are: (i) Inadequate human resources deployed to the hybrid rice national research team to undertake breeding for developing locally adaptable parental lines, demand-led rice hybrid, seed production and agronomic research using our own fund as well as donor fund; (ii) Limited number of rice hybrids are developed in the country and yet those are not popular in the country. (iii) The commercial F_1 rice hybrids currently developed through R and D and grown in the country have very little cytoplasmic diversity, which makes rice production potentially vulnerable to disease or insect outbreak; (iv) Most of the available commercial rice hybrids including locally bred do not possess good grain quality; (v) Leading rice hybrids are becoming susceptible to diseases and insects in certain regions due to changes in physiological races and biotypes; (vi) In hybrid seed production plots the incidence of Bacterial leaf blight disease has been increasing; (vii) Due to the low outcrossing rate (less than 50%) of male-sterile lines, hybrid seed yields are still lower; (viii) Limited availability of stable CMS lines; (ix) Lack of availability of CMS lines with high out crossing potential; (x) GA_3 for facilitating complete panicle exsertion is very expensive; (xi) Maintenance of genetic purity of parental lines and F_1 seeds is difficult; (xii) Lack of proper facilities for parental line multiplication and F_1 seed production of promising/released hybrids; (xii) Heading synchronization of parental lines is difficult in different regions; (xiv) Lack of well organized R and D based hybrid rice seed industry; (xv) Limited exchange of genetic materials among national agricultural research and extension systems (NARES); (xvi) Inadequate and not well-defined policies for supporting national hybrid rice programs; (xvii) Ineffective coordination and linkage of hybrid rice research; (xviii) Inadequate trained manpower in heterosis breeding techniques and F_1 seed production.

Constraints relating to hybrid rice adoption/diffusion

(i) Acceptability of farmers, consumers and millers on physicochemical properties of released rice hybrids is not encouraging in the country; (ii) Non-availability of suitable rice

hybrids during T.Aman and T.Aus season; (iii) Propaganda and rumour about released rice hybrids from various corners; (iv) Inconsistant initiative from DAE (Public extention organization) for large scale dissemination of hybrid rice technology in the country during 1998-2010; (v) Comparative low price of hybrid paddy than inbred paddy due to inferior grain size and low amylose content in hybrid rice grain; (vi) Currently estimated low relative profitability from hybrid rice cultivation than inbred; (vii) Farmers' preference extremely high for the cultivation of the most popular commercial rice inbreds (BRRI dhan 28 & 29) during Boro season; (viii) Compititive land allocation/availability for hybrid rice cultivation from limited land for Boro cultivation; (ix) Reasonable supply of popular inbred rice seed from formal seed system in the country and seed dealers are more inclined to sell inbred rice seed on the basis of higher profit from it; (x) GOB paddy procurement policy not infavour for hybrid rice; and (xi) Sometimes farmers' face problem in selling hybrid paddy

Comparative inputs use

Large numbers of inputs are used for hybrid rice seed production, commercial hybrid rice cultivation, inbred rice cultivation and local rice variety cultivation. Regarding ***seed,*** parent lines (A & R lines) are used for F_1 seed production and F_1 seed used for commercial hybrid rice production. Certified and farmer's saved seed used for rice grain production of inbreds and local varieties of rice. ***Specialized and exotic chemicals*** (eg GA_3, Alcohol and Tiaohuafei) are used for successful rice hybrid F_1 seed production and these are not needed for rest 3 types of rice. ***Organic fertilizer*** application depends on the status of organic matter content of the soil and type of rice. Listed ***chemical fertilizers*** are used for 4 types of rice production with an exception for Boron (Borax) application in rice production. Its requirement for rice grain production is reported at very minimum level. But Chinese Agronomists are recommended for both seed and grain production of hybrid rice. Accordingly, Boron (Borax) is used for hybrid rice seed production in Bangladesh. Chemical fertilizers application rate is comparatively high for hybrid rice seed and grain production than modern and high yielding inbreds. On the other hand chemical fertilizers application rates are much higher for modern inbreds than local varieties of rice. ***Pesticides*** are used for all types of rice cultivation on the basis of incidence of pests and diseases and profitability of their application. ***Weedicide*** is used on the basis of weed infestation in field and seedbed. But weedicide application is very much important for hybrid seed production in general and seedling production on seedbed in particular. ***Irrigation*** is used for all types of rice culture during Boro season (winter and dry season) in Bangladesh (Annex. IV.3).

V. Agronomic performance of hybrid rice

Researchers from BRRI assessed the agronomic performance of rice hybrids through on station and on farmer trials to evaluate the exotic, elite, promising and released rice hybrids during 2006-2009 T.Aman and Boro seasons. During this period researchers from BRRI submitted their developed and evaluated rice hybrids to SCA for regional testing for the purpose of release and notification by NSB. For this purpose, BRRI researchers conducted rigorous assessment on agronomic performance of their developed rice hybrids over the most popular inbreds through on station and on farm trials at various regions. On the basis of the better agronomic performance of the studied rice hybrids than the existing best and most popular inbreds were released and notified by the NSB. In this regards, researchers assessed the agronomic performance of the promising rice hybrids against high yielding popular inbreds on the basis of their several agronomic characters such as grain yield, growth duration, plant hight, tillering habit, filled and unfilled grain formation and proportion, grain weight etc. Most of the promising rice hybrids' grain yield recorded consistently higher than the selected popular inbreds (both short duration and long duration). Other relevant agronomic characters of BRRI developed promising rice hybrids recorded consistently better than the selected popular inbred with few exceptions. Variability on agronomic performance is existed among the released and promising rice hybrids developed by BRRI. Finally, NSB has released and notified 3 rice hybrids (BRRI hybrid dhan 2, 3 &4) for commercial cultivation and seed production in the country.

Regarding agronomic performance of the selected released rice hybrids under farmers' field trials was found consistently better than selected most popular rice inbreds during early stage of rice hybrid introduction and adoption in Bangladesh. Under such trials, agronomic performance of the selected rice hybrids was assessed on the basis of the most common agronomic characters and most of the assessed rice hybrids' agronomic characters performed better than the selected most popular rice inbreds in the country. Similarly, IRRI/BRAC study on A socioeconomic assessment of farmers' experiences and AAS study on the prospect and potentials of rice hybrids and findings revealed more or less same to the previous farmers' field trials with few exceptions. But DAE and SCA trials' findings of the studies revealed mixed performace on grain yield of rice hybrids over popular rice inbred among the regions and assessed rice hybrids.

Variability is existed among the released and promising rice hybrids developed by public sector BRRI, private sector (Seed Company and NGO) and imported rice hybrids from China, India and Philippines. Out of 85 released rice hybrids of which 5 released from public sector (BRRI and BADC) during 1998-2010 (SCA, 2010). However, 4 rice hybrids released from BRRI, of which BRRI hybrid dhan 1 released during 2002 and currently its acreage is minimal due to its poor acceptability among the farmers in the country. On the other hand, BADC has discontinued for seed production and marketing of BRRI hybrid dhan 1 from 2005-6 Boro season. Moreover, BADC has started seed production for marketing a three-line rice hybrid (SL-8H) from a Chinese seed company "SL Agro Tech"., based in Philippines from 2006-7 Boro seson. The yield performance of SL-8H rice hybrid did not show its superiority over the existing popular rice hybrids in Bangladesh (See Table.V.3). Three rice hybrids have been released from BRRI during 2008-10 and their acceptability not yet recorded. Moreover, BADC's role in seed (F_1) production and marketing for the latest 3 released rice hybrids of BRRI is not significant since their release and notification by NSB. Thus, it can be concluded that private sector rice hybrids have been dominating since 1998 in Bangladesh and probably it will continue in future in the country.

According to inspiration from the success of the "Chinese miracle" policy markers, researchers and seed marketing agencies in Bangladesh considered hybrid rice as an innovative technology to sustain the growth in rice production during mid 1990s. Besides researchers and inspiration from policy makers, the seed marketing agencies (Private Seed Company and NGOs) participated significantly from 1998-99/1999-2000 in hybrid rice seed marketing, seed production, promotion and seed importations, in anticipation of a good seed business in the country. Therefore, the current area under hybrid rice is about 1.00 million ha within about a decade. Thus, currently (2007-2010) the higher area is under hybrid rice due to higher grain yield advantage and other relevant agronomic performance over inbred rice in Bangladesh.

Agronomic performance of hybrid rice is presented under research trials and farmer's field trials/conditions in the following sub-sections:

(a) Research trials

Evaluation of rice hybrids are beeing routinely done at BRRI for the assessment of their agronomic performance through research trials mainly at research farms and at farmer's field. The rice hybrids collected from exotic sources, receive from International trial and locally developed are included in the trials. Agronomic performance of hybrids in recent year shows that some hybrids are able to out-yield the conventional check variety by more than 20% which is the set standard for releasing a variety. Accordingly, agonomic performance of rice hybrids on the basis of research trials under Boro and T.Aman seasons is presented below:

Boro & T. Aman seasons research trials

Performance of exotic hybrids during Boro season

Twelve exotic hybrids were evaluated during Boro season (2006-07) at BRRI farm along with BRRI hybrid dhan1, BRRI dhan28 & BRRI dhan29 as checks. Results indicated that yield and yield contributing characters were found significantly different among the tested varieties (BRRI, 2007). However, Heera produced the highest (7.64 t/ha) grain yield followed by 4 hybrids (Sonarbangla-1, LP-50, China-2 and BRRI 1A/BR168R), 2 hybrids (RRI 1A/BR827 R & BRRI hybrid dhan1), 4 hybrids (Tinpata, Taj-2, Jagoron & BRRI dhan 29), 3 hybrids (Aloron, Pan and BG 4074), while lowest was with BRRI dhan 28 (6.3t/ha). Yield and yield contributing characters of twelve exotic rice hybrids and 3 local inbreds are provided in Table.V.1.

Table.V.1: Yield and yield contributing characters of different hybrids were grown at BRRI farm during Boro season-2006-07 (BRRI)

Name of Hybrids	Panicle/m2 (No.)	Grain / Panicle	1000-grain wt.(g)	Grain yield (t/ha)
Heera	290 cd	106.47 fg	26.07 f	7.64 f
Aloron	284 c	98.20 de	25.97 f	6.88 b
Tinpata	294 de	104.61 f	23.80 c	6.92 bc
Sonarbangla	277 b	109.43 g	25.73 f	7.43 ef
Taj-2	290 cd	102.33 ef	25.47 ef	7.19 cde
LP-50	359 j	88.38 ab	24.63 d	7.38 ef
Jagoron	300 ef	94.37 cd	25.90 f	6.94 bcd
Pan	310 g	103.17 f	22.47 b	6.83 b
China-2	231 a	133.17 i	24.97 de	7.39 ef
BG 407 H	330 h	96.88 cd	22.03 ab	6.68 ab
BRRI 1A/BR 168 R	333 h	87.53 a	25.70 f	7.38 ef
BRRI 1A/ BR 827 R	343 i	87.10 a	26.00 f	7.31 e
BRRI hybrid dhan 1	340 i	87.73 a	25.83 f	7.23 de
BRRI dhan 28 (ck)	328 h	92.73 bc	22.37 b	6.43 a
BRRI dhan 29 (ck)	304 fg	114.73 h	21.63 a	7.20 cde
CV (%)	1.3**	2.6 **	1.3 **	2.3 **

Means followed by a common letter are not significantly different at the 5% level by DMRT.
Source: National hybrid rice yield trial *boro* 2006-2007

Performance of the International Rice Hybrid Observational Nursery (IRHON)

Forty five (45) elite rice hybrids of IRRI along with four international and a local check (BRRI dhan 29) were evaluated. Out of 45 elite rice hybrids, 15 rice hybrids were reported in this report. The growth duration of 20 reported hybrids and inbreds was found more than 150 days. However, IR81985H, IR82365H, IR 82375H were found out-yielded by more than 1 t/ha than check (IR75217H) with more or less similar growth duration (BRRI, 2007). The highest yield was reported with IR82397H (9.27 t/ha) with yield advantage (> 3t/ha) than all rice hybrid checks (Table.V.2).

Table.V.2: Yield and ancillary characters of selected materials of IRHON during Boro 2006-07 (BRRI)

Sl. #	Entry #	Designation	PACP Veg	PACP Mat.	PHT (Cm)	DTM	SF%	Yield (t/ha)	Yield advantage (t/ha)
1	004	IR81985H	5	5	85	157	64.76	6.60	1.18 over IR75217H
2	005	IR82352H	3	3	105	167	83.61	7.40	
3	007	IR82365H	5	5	91	154	72.70	6.50	1.08 over IR75217H
4	013	IR82375H	4	4	92	158	82.04	6.98	1.56 over IR75217H
5	018	IR82381H	5	4	106	163	78.61	6.65	
6	022	IR82387H	5	4	102	164	64.64	6.71	
7	027	IR82397H	3	1	107	158	83.50	9.72	>3.0 over all the checks
8	033	IR83197H	3	4	106	162	59.96	6.80	
9	037	IR83204H	3	3	110	163	63.32	7.36	
10	038	IR83205H	5	5	103	169	76.23	6.52	1.13 over IR72
11	039	IR83207H	4	4	105	163	59.63	6.84	
12	040	IR83208H	4	4	106	169	69.86	6.80	1.41 over IR72
13	046	IR68284H(PSB RC72H, HC)	4	4	102	169	73.32	6.47	
14	047	IR75207H(HC)	3	4	87	154	64.26	6.47	
15	048	IR75217H(HC)	4	5	91	156	68.81	5.42	
16	049	IR42 (In. C)	5	5	98	177	76.38	5.74	
17	050	IR50 (In. C)	4	5	77	155	79.47	6.69	
18	051	IR72 (In. C)	5	5	81	165	64.35	5.39	
19	052	PSB RC2(IR32809-26-3-3, In. C)	3	5	88	168	73.21	6.17	
20	053	BRRI dhan29 (LC)	3	3	105	168	81.17	6.71	

HC = Hybrid check, In.C = International check, LC = Local check; PACp-Phenotypic acceptability; DTM-Days to maturity, PHT = Plant height (cm), SF% = Spikelet fertility (%)

Performance of National hybrid rice yield trials

Every year national hybrid rice trials are conducted by seed certification agency (SCA) during boro and T. Aman season in six agro ecological zones across the country. Based on two years consecutive results which variety is expressed 20% yield advantage over standard check variety has subject to get registration for commercial cultivation in the positively performed agro ecological zones. During boro season 2007-08, 96 rice hybrids were tested from private seed companies along with two public organizations such as BRRI and BADC. Out of 96 tested rice hybrids, NSB was approved 16 rice hybrids for commercial

cultivation and seed production in the country. BRRI research team assessed the agronomic performance of the 16 rice hybrids against 2 check varieties during 2007-8 Boro season at BRRI farm, Gazipur (NHRYT, 2008). In the trials, both BRRI hybrid dhan 2 (9.23 t/ha) and AgroG 1 (9.24 t/ha) performed as the best followed by AgroG 2 and TK 6 (9.09 t/ha) and Heera 4 & 6 (8.50 t/ha) and rest of rice hybrids (Except one) showed significant higher yield than the chick BRRI dhan 28 (Table.V.3).

Table.V.3: National hybrid rice on-stations trial during Boro 2007-08 at Gazipur

Hybrids	PHT	D50%F	DTM	Till/hill	PL	FG	SF%	1000 GW	Yield
TK-6	97.11ab	109.0 bcde	134.8 fgh	11.00ab	24.33 bc	141.7 cd	91.72 c	28.56 d	9.085 b
Shera	93.42 cd	108.7bcde	133.2 gh	7.00 f	26.04a	105.9 j	70.39 m	27.61 a	5.807 l
Tej	87.36 f	110.0 bcd	135.3 efg	7.33 f	23.22 e	107.7 ij	71.77 l	29.89 bc	6.100 k
Hera-6	76.44 h	103.3 fg	126.0 j	8.66 d	24.39 bc	135.9 ef	90.97 cd	26.64 g	8.504 c
Jamunna	92.81 cd	111.0abc	137.0 def	8.33 de	24.14 bcd	128.9 g	85.54 g	28.54 d	7.376 g
BRRIhybrid dhan2	87.57 f	110.3abcd	134.7 fgh	10.67 bc	23.14 e	152.6 b	93.21 b	27.24 ef	9.226 a
Chamak-1	84.27 g	111.7abc	135.4 efg	9.00 d	23.68 cde	143.8 c	86.43 fg	30.38 ab	7.615 f
Panna-1	91.23 de	111.7abc	139.0 cd	9.00 d	24.13 bcd	133.4 f	85.98 g	27.75 e	7.465 g
Hera-4	97.27ab	107.7 cdef	128.8 ij	10.00 c	24.43 b	138.4 de	90.70 d	28.76 d	8.396 c
Lili-1	99.66a	107.7 cdef	129.1 ij	7.00 f	25.57a	93.77 k	70.71 m	27.71 e	5.296 m
Raj Kumar	97.61ab	113.3ab	142.4 b	7.66 ef	25.67a	124.5 h	81.10 h	27.80 e	7.111 h
Shampad	92.48 cde	109.0 bcde	140.3 bc	7.33 f	23.52 de	122.9 h	78.13 i	30.50 a	6.939 i
Folon	99.41 a	105.0 efg	128.6 ij	7.00 f	24.28 bc	122.0 h	75.67 j	30.92a	6.726 j
AgroG-1	95.03 bc	111.7abc	138.3 cde	11.67a	24.08 bcd	163.7a	94.41a	29.90 bc	9.240a
AgroG-2	91.44 de	110.3abcd	142.4 b	10.67 bc	24.68 b	162.7a	91.24 cd	29.75 c	9.088 b
BRRI dhan 28	94.46 c	102.3 g	126.3 j	7.33 f	24.61 b	110.7 i	74.00 k	22.85 h	6.184 k
BRRI dhan-29	90.00 e	115.0a	148.6a	9.00 d	25.46a	153.8 b	89.38 e	22.00 i	8.107 d
SL-8H	91.68 de	106.0 defg	131.6 hi	7.66 ef	24.42 b	150.4 b	87.17 f	26.84 fg	7.886 e
Lsd	2.388	4.172	3.019	0.7195	0.6319	4.302	0.9043	0.5194	0.1173
CV(%)	1.56	2.30	1.35	5.00	1.56	1.95	0.65	1.12	0.98

PHT= Plant height (cm), D50%F= Days to 50% flowering, DTM= Days to maturity, Till/hill= No. of tillers per hill, PL= Panicle length (cm), FG= No. of filled grains, SF%= Spikelet fertility, 1000GW= Thousand grain weight

Means followed by common letters are not significantly different from each other at 5% level by DMRT.

During Boro season 2008-09, 99 hybrids were tested under the overall supervision of seed certification agency for registration. Out of 99 tested rice hybrids, NSB apporoved 13 rice hybrids for commercial cultivation and seed production in the country. Research team of BRRI assessed the agronomic performance of 17 rice rice hybrids agaisnt 2 check varieties during 2008-9 Boro season at BRRI Research farm, Gazipur (NHRYT, 2009). Public hybrid BRRI hybrid dhan 3 come out with great promise and showed highest yield potential followed by WRB-8 and QA-63. Most of the hybrids performed better in respect of yield over both BRRI dhan 28 and BRRI dhan 29 check inbrid varieties (Table.V.4).

Table.V.4: National hybrid rice on-stations trial during Boro 2008-09 at Gazipur

Hybrids	PHT	D50%F	DTM	Till/hill	PL	FG	SF%	1000 GW	Yield
Folon-2	112.0a	119.0 b	137.0 bcd	7.4 jk	26.00abc	123.4 i	81.00 h	26.30 ef	7.400 hi
Arize	103.0 bc	115.0 c	140.0 b	7.3 k	27.00a	121.3 i	88.00def	26.23 f	7.420 hi
Golden-1	100.1 cd	112.3 c	136.4 cd	9.2 de	25.24 cde	151.1 e	88.97 cde	31.63a	8.063 f
BRAC-5	92.83 ghi	107.0 d	132.6 e	8.83 ef	24.91cdef	144.7 f	87.78 ef	30.57 b	7.691 g
WBR-8	87.90 jk	108.0 d	134.7 de	10.0 bc	24.52 def	176.9a	96.31a	27.68 d	9.468a
China King-2	97.42 de	105.3 de	128.4 f	9.65 cd	24.80cdef	165.6 c	91.20 bc	28.80 c	8.505 d
Metal Seed-1	90.03 ij	106.3 d	132.2 e	8.50 fg	22.16 h	135.8 g	86.50 fg	30.53 b	7.503 gh
BRAC-6	98.82 de	113.7 c	139.0 bc	9.17 de	23.54 fg	154.0 d	90.00bcd e	27.78 d	8.323 de
RN-001	82.13 l	102.7 ef	126.7 fg	7.90 hij	22.60 gh	127.3 h	85.73 fg	25.74 g	7.287 hi
Sankar-3	95.36 efgh	112.7 c	139.6 b	9.66 cd	24.57 def	173.6 b	95.29a	27.75 d	9.156 b
Mongol	93.28 fghi	112.0 c	139.7 b	9.66 cd	23.62 fg	166.7 c	91.54 b	28.72 c	8.867 c
QA-63	91.68 hij	115.0 c	139.7 b	10.43 b	25.54 bcd	175.6ab	95.33a	26.63 ef	9.417a
Sonali-1	85.54 kl	106.0 d	128.7 f	7.06 kl	22.49gh	85.00 j	67.67 k	23.74 i	5.160 k
BRRI Hybrid dhan-3	97.03 def	101.3 f	137.4 bcd	11.33a	21.42 hi	175.7ab	95.73a	24.78 h	9.503 a
HG-001	91.60hij	106.3 d	128.2 f	9.33 de	20.78 i	154.6 d	90.37 bcd	27.94 d	8.325 de
BRRI dhan 28	96.04 efg	112.0 c	137.4 bcd	8.00 ghi	25.19 cde	126.7 h	84.63 g	27.87 d	4.900 l
BRRI dhan-29	103.0 bc	113.3 c	147.0 a	6.60 l	24.00ef	78.27 k	77.33 i	22.67 j	7.267 i
Lili-10	106.3 b	122.7a	133.3 e	7.467ijk	24.67 cdef	86.43 j	70.33 j	21.80 k	6.420 j
HTM-808	113.3a	120.3ab	137.7 bc	8.36 fgh	26.67ab	127.4 h	88.00 def	26.77 e	8.220 ef
Lsd	3.569	3.040	2.696	0.5237	1.188	2.490	2.225	0.4713	0.2095
CV (%)	2.24	1.65	1.20	3.58	2.96	1.07	1.53	1.05	1.60

PHT= Plant height (cm), D50%F= Days to 50% flowering, DTM= Days to maturity, Till/hill= No. of tillers per hill, PL= Panicle length (cm), FG= No. of filled grains, SF%= Spikelet fertility, 1000GW= Thousand grain weight

Means followed by common letters are not significantly different from each other at 5% level by DMRT.

Performance of rice hybrids in Multi-location trial

Hybrids which found promising in the preliminary trial are evaluated in multi-location research trial in different regional stations of BRRI (on-station) and farmers' field (on-farm)

before proposing to Seed Certification Agency (SCA) for their approval by NSB for commercial cultivation and seed production in the country.

Promising hybrids during Aman season: During T.Aman season 2006, two promising hybrids were evaluated at four BRRI research farms (Gazipur, Barisal, Satkhira and Rangpur) with BRRI dhan31, BRRI dhan32 and BRRI dhan33 as check. The combination BRRI1A/BR 827R showed stable performance and showed more than 1 ton yield advantage in all regional stations. These two hybrids were evaluated in the following 2008 T.Aman season with BRRI dhan 30, BRRI dhan 33 and BRRI dhan 39 as check. BRRI 1A/BR 827R and BRRI1A/BR168R combinations were out yielded by 1.30 t/ha and 1.23 t/ha, respectively compared to local checks BRRI dhan 33 and BRRI dhan 39 with similar growth duration at BRRI, Gazipur (Annex.V.1 & 2). Both the tested promising rice hybrids were not proposed to Seed Certification Agency (SCA) for approval by the NSB for their commercial cultivation and seed production due to unfavourable flowering synchronization between parent lines (A & R lines).

Two new promising combinations were tested in five regional stations and five farmers' fields with 3 inbred checks (BRRI dhan 31, 32 & 39) during 2008 T.Aman season. Both the combinations were found suitable in four regions (Gazipur, Rangpur, Comilla and Satkhira) except Rajshahi region (Annex.V.3). During 2009 T.Aman season, three potential hybrids were evaluated in five regional stations (Gazipur, Comilla, Satkhira, Barisal and Rangpur) with BRRI dhan 31 and 39 as check varieties. Out of five locations, Gazipur and Comilla were found suitable for the tested three rice hybrids and achieved more than 1 ton yield advantage over two inbred check varieties (Annex.V.4).

Promising hybrids during Boro season: Three promising hybrids were evaluated with BRRI dhan 28, BRRIdhan 29 and BRRI hybrid dhan 1 as check during 2006-7 Boro season in 5 regional stations (Gazipur, Barisal, Satkhira, Comilla and Rangpur) of BRRI. BRRI 1A/ BR 827 R and BRRI 1A/ BR 168 R were found out-yielded by 1.98 t/ha and 1.95 t/ha respectively compared to BRRI dhan 28 (check) with more or less same short growth duration in five reginal stations of BRRI (Annex.V.5).

Five promising hybrids were evaluated both in BRRI Headquarter and three regional stations of BRRI (Barisal, Comilla, and Rangpur) and two entries were evaluated in Satkhira with BRRI hybrid dhan 1, BRRI dhan 28 and BRRI dhan 29 as check during 2007-8 Boro season. BRRI 1A/BR 168R and BRRI 10A/ BRRI 10R combinations gave yield advantage by 1.07 to 2.28 t/ha and 2.00 to 2.70 t/ha, respectively over checks with apparently similar short growth duration in 5 regional stations. IR58025A/ BRRI 10R were found 0.94 to 1.57 t/ha yield advantage compared to BRRI dhan29 with apparently similar long growth duration (Annex.V.6).

During Boro season 2008-09, three promising hybrids were evaluated along with BRRI dhan2, BRRI dhan28 and BRRI dhan29 as check variety in five regonal stations of BRRI (Gazipur, Comilla, Satkhira, Barisal and Rangpur). Three tested rice hybrids were performed better than two inbred check varieties (BRRI dhan 28 & 29) in four regional stations (Gazipur, Comilla, Satkhira and Barisal) with more or less similar short growth duration except in Rangpur. Based on F_1 seed production feasibility, the combination of BRRI 11A/BRRI 15 R was proposed as BRRI hybrid dhan 3 to seed certification agency (SCA) on the same season for NSB approval through field trial for commercial cultivation and seed production in the country (Annex.V.7).

Eight hybrids were evaluated during 2009-10 Boro season under multi location trials at five regional stations of BRRI (Gazipur, Barisal, Satkhira, Comilla and Rangpur) with BRRI dhan 28 & 29 check variety. In three locations, Gazipur, Barisal and Comilla all the tested hybrids performed well and out yielded than BRRIdhan 28 by more than 1 tons with more or less similar short growth duration. But in case of Satkhira regional station, reverse situation was observed and all the tested hybrids showed around 0.5-1.0 ton yield advantage over BRRI dhan29 but growth duration of the tested hybrids were at least six days less than BRRI dhan 29. The same sets of hybrids when tested in Rangpur regional station did show yield advantage over BRRI dhan 28 but growth duration of the tested rice hybrids was more than 150 days and when a hybird shows more than 150 days growth duration it is compared with long duration check variety BRRI dhan 29 in national hybrid rice yield trials. But the yield advantage did not show with tested rice hybrids against the long duration check variety (BRRI dhan 29) in Rangpur regional station trial (Annex.V.8).

(b) Farmer's field trial/condition

Agronomic performance of tested and released rice hybrids under farmer's field trials/conditions is explained in the following sub-sections:

Yield and variability in yields of hybrid rice

Early stage introduction of hybrid rice: Milestone of the hybrid rice introduction in Bangladesh was undertaken by Agricultural Advisory Society (AAS) during 1998-1999 Boro season through on farm trial on the performance of rice hybrids under Bangladesh conditions. Four rice hybrids Sonarbangla-1 (CNSGC-6), Amarsree-1, Aalok (HR6201) and Loknath 503 along with BRRI dhan 29 as check-were assessed by AAS during 1998-1999 Boro season with 33 farmers in 10 districts covering 11 agro ecological zones. Rice hybrids and inbred were assessed on the basis of their physical characteristics, pest infestation, physicochemical properties and cost and return.

Compared with check (BRRI dhan 29) in terms of grain yield (Unhusked paddy) production, the Sonarbangla-1 ranks first, Aalok second, Loknath third and Amarsree-1 fourth. Compared to the check variety, their yield performance was, respectively, about 20 percent higher, and 3, 18 and 22 percent lower. In terms of 1000 grain weight BRRI dhan 29, Aalok and Amarsree-1 are similar, that of Loknath is slightly heavier and Sonarbangla-1 is the heaviest. In terms of field duration days Loknath requires about 16 days and Sonarbangla-1, 7 days less time than check (Table.V.5).

In terms of benefit cost ratio, and net return as percentage of gross value of the main product and by-product Sonarbangla-1 stands first followed by the check (BRRI Dhan-29) Aalok, Loknath and Amarsree-1 last. Overall very low level insect infestation and disease infection were observed and varietal differences were not found in respect of pest infestation in all observed demonstration sites (Rashid, et.al.,1999 & Parvez, et. al.,2003).

Table.V.5: Comparison of means of different characters of four hybrid rice check grown in 33 locations in Boro season 1998-99 (AAS, 1999)

Parameters/ Characteristics	Sonar bangla-1 (F_1)	Amar sree-1 (F_1)	Aalok (F_1)	Loknath (F_1)	BRRI Dhan-29 (Check)	CV %
A. Unhusked paddy yield (t/ha)	7.55**	4.86**	6.06^{ns}	5.11*	6.26	18.12
B. Yield contributing Characters						
1. Average grains (nr/m^2)	29561^{ns}	26669^{ns}	26132*	25234*	30619	13.74
4 Average 1000 grain weight (gm)	28.44**	21.48^{ns}	21.08^{ns}	23.18**	21.00	5.76
3. % filled grain/panicle	79.10**	51.67*	58.17^{ns}	76.24**	61.66	12.35
4. % of effective tillers/hill	66.28^{ns}	58.49**	63.02^{ns}	60.92*	67.00	15.82
C. Average field duration (days)	102**	99**	98**	93*	109	5.76
D. Other Ancillary characters						
1. Average plant height (cm)	95.30**	94.20**	93.30**	87.90**	97.00	1.84
2. Panicle production (nr /m^2)	292**	314^{ns}	318^{ns}	336^{ns}	339	13.74
3. Total leaves at maximum tillering stage	86^{ns}	109^{ns}	84^{ns}	104^{ns}	93	14.38
4. Length of Flag leaf (cm)	28.60^{ns}	27.64^{ns}	29.72*	28.58^{ns}	28.32	9.94
5. Breadth of Flag leaf (cm)	1.70^{ns}	1.42^{ns}	1.47^{ns}	1.44^{ns}	1.58	14.71
6. % Seedling recovery	60.50*	54.27^{ns}	68.38**	53.62^{ns}	45.53	19.73

Note: Means of different characteristics were compared with check (BRRI Dhan-29) by LSD at 0.05 and 0.01 level of probability.

* & ** indicate significant difference respectively from the check mean either positively or negatively.

ns: indicates statistically non-significant

Source: Rashid, *et al* 1999

Follow-up study on hybrid rice adoption: IRRI in collaboration with BRAC conducted a study on hybrid rice adoption in Bangladesh: A socioeconomic assessment of farmers' experiences (Husain et al, 2001). In the study two hybrids Sonarbangla-1 and Aalok were compared with popular high yielding inbred. The study team showed that the yield performance of Sonarbangla-1 was impressive on sample farms, research farms and on farm trials. Aalok 6201 did not significantly out-yield HYVs in on sample farms. The yield rate of Aalok 6201 ranged from 5.22 t/ha in BADC seed farms to 6.06 t/ha in AAS farm sites. However, the yield of Aalok 6201 is quite impressive in DAE on-farm trials. The data on DAE

on-farm trials appear to be somewhat unreliable in view of Aalok 6201's performance in sampled farms. It is interesting to note that the yield recorded in BRRI research plots and BADC seed farms were, in general, lower than the yield obtained on farmers' fields (Husain *et al* 2001). The yield of rice hybrids and HYVs on sample farms, research farms, and on-farm trials during 1998-99 is provided in Table.V.6.

Table.V.6: 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 BRRI[a]	On farm trials		
			BADC[b]	DAE[c]	AAS[d]
Aalok 6201	5.81 (3.2)	5.27 (3.1)	5.22 (18.16)	7.29[1]	6.06 (-3.2)
Sonarbangla-1	7.48 (32.9)	6.72 (25.7)	5.47 (24.3)	-	7.55 (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
Source: Husain, et al 2001

On the basis of the yield performances of sample farmers that grew both hybrid and HYVs, the yield gains of hybrids over HYVs were estimated. For *Aalok* 6201 it was a marginal 5% while for *Sonarbangla-1* it was an impressive 29%. The yield data of the BRRI research plots and BADC on farm trials also show that both *Aalok* 6201 and *Sonarbangla-1* performed better than HYVs, but the yield gain was much higher for *Sonarbangla-1* than for *Aalok* 6201. However, AAS on-farm trials showed a somewhat different picture. *Sonarbangla-1* out-yielded both *Aalok* 6201 and HYVs, but *Aalok* 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 *Aalok* 6201 hybrid in farmers' fields (Husain *et al* 2001).

Majority of respondents comprising both *Aalok* 6201 and Sonarbangla-1 cultivators reported that hybrid was better in term of higher yield and also better grain quality in terms of appearance of *Aalok* 6201. Eighty-nine percent of *Sonarbangla-1* producers and 52% *Aalok* 6201 producers mentioned about higher yield of hybrid while 57% of *Sonarbangla-1* and 53% of *AaIok* 6201 producers expressed favourable opinion about grain quality of hybrids. *Sonarbangla-1* producers also reported that it was more profitable than HYVs. On suitability of hybrid rice for consumption, 42% of *Aalok* 6201 and 35% of *Sonarbangla-1* producers said that hybrid rice was of better eating quality than the inbred HYVs. Majorities of hybrid producers rated hybrid rice as either equally or less suitable for consumption than the inbred HYVs. Ninety-four percent of the *Aalok* 6201 producers expressed unfavorable opinion on hybrid because of high lodging and grain shattering, and 97% noted its high percentage of unfilled grain (sterile grain). Majority of *Aalok* 6201 producers (69%) but only one-third (32%) of *Sonarbangla-1* producers said that incidence of pests/diseases was higher on hybrids than on HYVs of rice (Husain *et al* 2001). But study during the 1998-99 boro season

revealed that varietal differences were not found in respect of insect infestation and disease infestation (Rashid *et al* 1999).

The yield of *Sonarbangla-1* has been found to be significantly higher than that of different HYVs. The yield gain of hybrid *Sonarbangla-1* was 29% over HYVs. The yield gain of *Aalok* 6201, however, could not be considered as satisfactory. Though its yield rate was 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 *Aalok* 6201, the yield performance attained by *Aalok* 6201 has been found to be highly inadequate. Thus, the relatively poor performance of *Aalok* 6201 may be considered as a constraint to its adoption in Bangladesh (Husain *et al 2001*).

Pilot testing of BRRI hybrid dhan1: PETRRA a project of IRRI funded by DFID selected Agricultural Advisory Society (AAS) as the collaborator for pilot testing BRRI hybrid dhan 1 under farmers' field conditions in Rajshahi region. BRRI hybrid dhan 1 was assessed against BRRI dhan 29 as check during 2001-2 Boro season at 15 villages in 15 upazilas of 6 districts (Pabna, Natore, Rajshahi, Nogaon, Bogra and Sirajganj) covering six agro-ecological zones in Rajshahi region (Table.V.7).

Table.V.7: Comparison of means of different characters of BRRI dhan 1 with a check (BRRI dhan 29) pilot tested in 2001-2 Boro season in Rajshahi region

Characteristics/ Parameters	BRRI hybrid dhan 1				BRRI dhan29			
	Mean	CV (%)	SE	Plot (Nr)	Mean	CV (%)	SE	Plot (Nr)
Paddy yield (t/ha)	7.22	18.38	1.33	33	7.01	17.29	1.21	32
Field duration (days)	110	4.08	4.00	33	111	4.06	5.00	32
Tillers and Panicles Production:								
(a) Max. tillers/hill (Nr)	24.24	22.61	5.48	29	23.05	19.28	4.44	29
(b) Panicles/hill (Nr)	13.72	14.25	1.96	29	14.66	16.60	2.43	29
(C) % Effective tillers	59.02	22.95	13.55	29	65.02	18.63	12.11	29
Grains Production:								
(a) Filled grains/Panicle	79.46	27.94	22.20	29	90.03	19.98	17.99	29
(b) Unfilled grains/Panicle	48.52	25.52	12.38	29	37.85	22.90	8.67	29
(c) % Unfilled grains Panicle	38.62	27.79	10.73	29	29.89	23.25	6.95	29
1000-grain Wt (gm)	25.30	7.86	2.19	29	21.33	11.68	2.75	29

Source: *Rashid, H. 2002.*

The average grain yield of BRRI hybrid dhan -1 (7.22 t/ha) was about 3 percent higher than BRRI dhan29 (7.01 t/ha). The average field duration was more or less similar with BRRI hybrid dhan-1 (110 days) and BRRI dhan 29 (111 days). The average panicles per hill of BRRI dhan 29 (14.66/hill) was about 7% higher than BRRI hybrid dhan 1 (13.72/hill). Moreover, the proportion of effective tillers was about 10 percent higher with BRRI dhan 29 (65.02%) than BRRI hybrid dhan 1 (59.02%). The average number of filled grains per panicle was about 90 and 80 with BRRI dhan 29 and BRRI hybrid dhan 1, respectively. But the average proportion of unfilled grains was higher with BRRI hybrid dhan 1 (38.62%) than BRRI dhan 29 (29.89%). The 1000-grain weight was higher with BRRI hybrid dhan 1 (25.30

gm) than BRRI dhan 29 (21.3); these statistics are similar to the expected 1000-grain weights for both cultivars.

The average grain yield of BRRI hybrid dhan 1 was 7.22 t/ha, which is more or less similar to BRRI dhan 29. On the other hand, the maximum grain yield of BRRI hybrid dhan 1 was as much as 9.49 t/ha and that of BRRI dhan 29 was 9.30 t/ha. This indicates the higher-level yield potentiality of both cultivars. Farmers initially expected higher yield with BRRI hybrid dhan-1, but were disappointed with the high percentage of unfilled grains. Finally, farmers' acceptability of BRRI hybrid dhan 1 is found poor during the following years of the pilot testing (Rashid, H. 2002).

Private seed companies, BRAC (NGO), and BADC produced about 6 MT of F_1 seed of BRRI hybrid dhan 1 during 2001-2002 boro season and continued to distribute through their marketing channels up to the 2004-5 boro season. BADC discontinued the seed production and distribution of BRRI hybrid dhan 1 from 2005-6 Boro season due to poor acceptability of BRRI hybrid dhan 1 among the farmers in the country (Nuruzzaman, 2009).

Study during adoption process of hybrid rice: A special study conducted by AAS on the prospects and potentials of rice hybrids in Bangladesh under funding support from PETRRA (IRRI/DFID) to assess the performance and overall impacts of hybrid rice cultivated in 9 agro ecological zones in the country during 15 April-15 May 2004 (Kabir and Rashid 2004).

The average yield achieved with hybrids and inbreds was 7945 Kg/ha and 5574 Kg/ha, respectively, showing a difference of 2372 Kg/ha. The average yield differences between hybrids and inbred in 11 sites ranged from 21-69% with an average 43%. Based on the overall yield, it is absolutely clear that hybrid varieties have tremendous potentials over the existing modern inbred varieties in the country during boro season. Comparative yields of hybrid and inbred rice of 12 sites are provided in following Table.V.8:

Table.V.8: Comparative yields of hybrid and inbred rice of 12 sites (AAS, 2004)

Site	Soil type	Cropping system	Average yield (t/ha)		Yield gain	% Gain
			Hybrid	Inbred		
Natore-1	High fertile	Single crop	8665	6521	2144	32.88
Natore-2	High fertile	Single crop	8793	5879	2914	49.57
Natore-3	High fertile	Single crop	8428	5322	3106	58.36
Sirajganj	High fertile	Single crop	7301	5409	1892	34.98
Nagoan	High fertile	Single crop	9218	6301	2917	46.22
Gopalgoanj	High fertile	Single crop	8359	5644	2715	48.1
Jessore	Moderate fertile	Double crop	7588	5928	1660	28
Jhenaidah	Moderate fertile	Double crop	7608	5276	2332	44.2
Gaibandha	Moderate fertile	Double crop	7647	6302	1345	21.34
Jamalpur	Moderate fertile	Double crop	9040	5360	3680	68.66
Moulvibazar	High fertile	Single crop	4742	3359	1383	41.17
Habiganj	Moderate fertile	Double crop		5592		
Mean			**7944.45**	**5574.42**	**2371.64**	**43.04**
CV%			**15.65**	**14.62**	**32.06**	**31.51**
SE			**374.96**	**235.33**	**229.26**	**4.09**

Source: *Kabir and Rashid, 2004*

Field trial on rice hybrids during adoption process: Farmers' participatory field trial was conducted on 6 rice hybrids by AAS to assess the performance during 2003-4 Boro season. Field trial was conducted in 10 districts covering 7 agroecological zones in 3 regions of the country (Rashid, H. 2004).

Among the 6 rice hybrids tested in three regions, Hira was found to be highest in average grain yield, followed in order by Sonarbangla-1, Aftab LP50, Richer-101, Jagoran-1 and BRRI hybrid dhan-1 during the boro season 2003-2004 (Annex.V.9). Out of the three study regions, the yield potentiality was highest in Northwest region followed in order by Southwest and Northeast regions. Comparative average yield of 6 cultivars is provided in Figure.V.1.

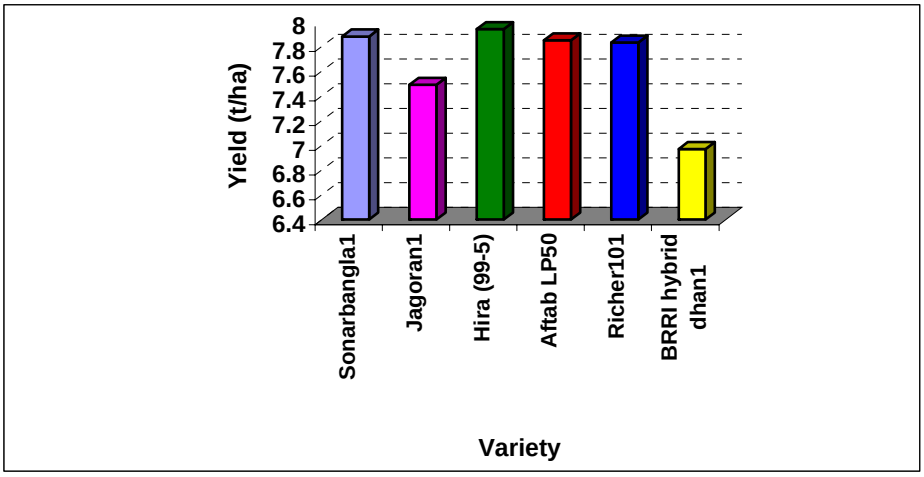


Figure.V.1: Yield Comparison of 6 cultivars

The yield potential of 3 varieties, Sonarbangla-1, Hira, and BRRI hybrid dhan-1 in Northeast region, exceeded 9 ton/ha. On the other hand the yield potential of all 6 varieties in Northwest and Southwest regions exceeded 9 ton/ha. In the Northwest region, the highest observed yield exceeded 10 ton/ha for all 6 cultivars. Highest observed paddy yield of 6 cultivars of 3 regions is provided in the following Table.V.9:

Table.V.9: Yield potentiality of 6 cultivars tested in 3 regions (AAS, 2004)

Variety	Northeast region			Northwest region			Southwest region		
	Plot(s) with yield above 9 t/ha	Highest yield (t/ha)	Average yield above 9 t/ha	Plots with yield above 9 t/ha	Highest yield (t/ha)	Average yield above 9 ton/ha	Plots with yield above 9 t/ha	Highest yield (t/ha)	Average yield above 9 t/ha
Sonarbangla-1	2	9.64	9.38	11	10.50	9.73	10	9.78	9.35
Jagoran 1	-	8.66	-	7	11.29	9.92	3	9.36	9.17
Hira (99-5)	2	9.58	9.58	10	10.18	9.51	4	9.37	9.25
Aftab LP 50	-	8.62	-	13	10.70	9.89	6	9.78	9.33
Richer 101	-	8.87	-	12	11.60	9.81	10	9.63	9.31
BRRI hybrid dhan 1	1	9.58	9.58	6	10.64	9.80	2	9.13	9.11

Source: *Rashid, H. 2004*

The average field duration was highest with about 113 days in BRRI hybrid dhan-1, while for the other 5 varieties, the average field duration was approximately 104 days (Annex.V.10). Growth duration of 6 cultivars is provided in Figure.V.2.

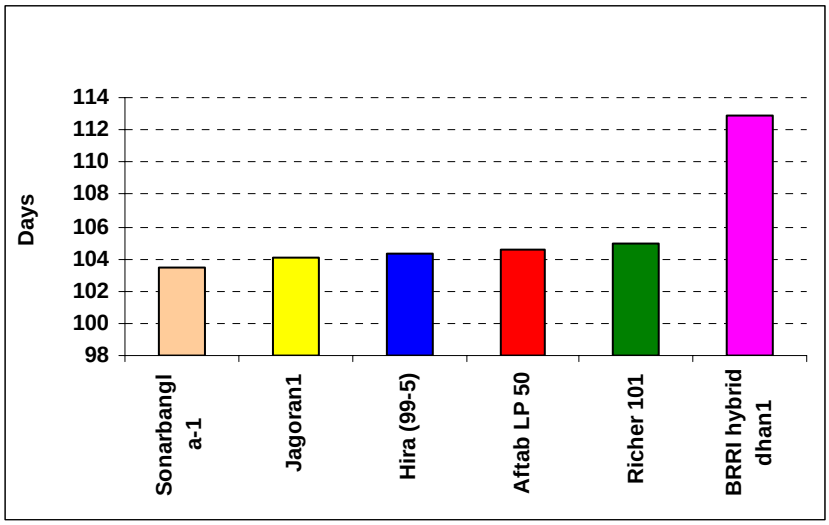


Figure.V.2: Field duration (days) of 6 cultivars

BRRI hybrid dhan-1 had the highest average maximum tillers per hill and average panicles per hill, but the lowest average percentage of effective tillers (Annex.V.11). In Hira, average maximum tillers per hill and average maximum panicles per hill were the least but the average effective tiller production percentage was the highest. Maximum tiller and panicle per hill of 6 cultivars are provided in Figure.V.3.

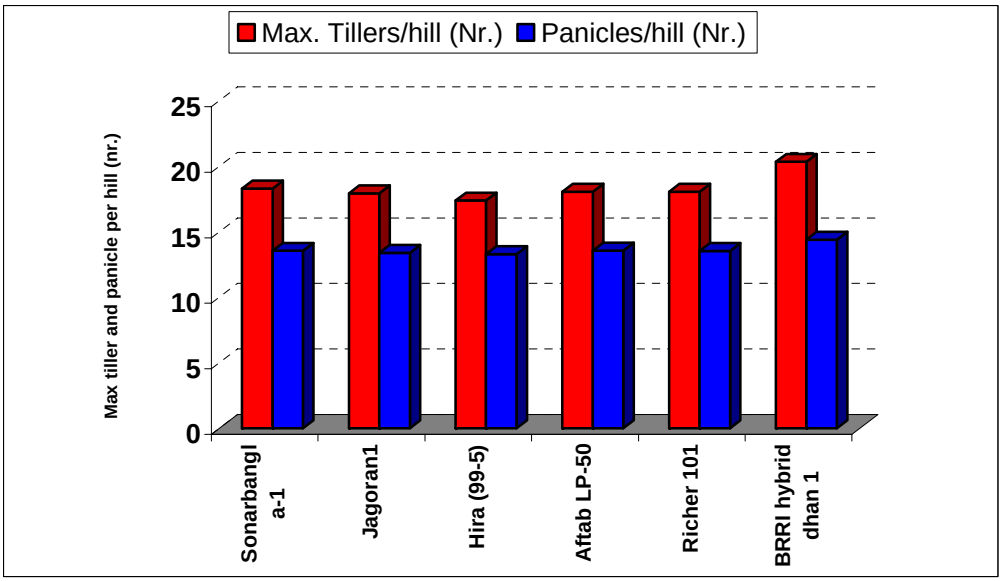


Figure.V.3: *Max tiller and panicle per hill of 6 cultivars*

The average number of filled grains per panicle was highest with about 110 in Hira followed in order by Sonarbangla-1, Richer, Aftab LP50, Jagoran-1 and BRRI hybrid dhan-1. The average number of unfilled grains per panicle was highest with about 41 in BRRI hybrid dhan-1 followed in order by Aftab, Jagoran, Richer, Sonarbangla-1 and Hira. The highest percentage of unfilled grain was 30% in BRRI hybrid dhan-1, followed in order by Jagoran, Aftab, Hira, Richer and Sonarbangla-1 (Table.V.10).

Table.V.10: Grain production per panicle of 6 rice hybrids (AAS, 2004)

Variety	Filled grains/panicle		Unfilled grains/panicle		% Unfilled grains	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Sonarbangla-1	106.58	28.50	23.78	33.81	18.73	34.22
Jagoran1	103.26	26.89	31.44	29.70	23.97	31.71
Hira (99-5)	110.07	21.80	29.98	40.76	21.22	34.07
Aftab LP 50	104.37	28.65	31.58	28.09	23.95	33.57
Richer 101	105.68	29.07	25.55	29.51	20.39	34.97
BRRI hybrid dhan 1	96.82	24.61	41.07	23.11	29.99	25.94

Source: *Rashid, H. 2004*

The average highest oven dry weight of thousand grains (un-husked paddy) was with 27.32 gm in Sonarbangla-1 followed in order by Richer, Aftab LP50, Jagoran1, Hira and BRRI hybrid dhan-1 (Table.V.11).

Table.V.11: 1000 grains weight of 6 cultivars of rice hybrids (AAS, 2004)

Variety	Oven dry 1000 grains weight (gm)	
	Mean	CV (%)
Sonarbangla-1	27.32	2.67
Jagoran1	26.03	1.42
Hira (99-5)	25.34	1.34
Aftab LP50	26.18	5.04
Richer 101	26.54	6.59
BRRI hybrid dhan1	24.68	1.62

Source: *Rashid, H. 2004*

DAE on farm trial on hybrid rice: Department of Agriculture Extension (DAE) conducted farmers' field demonstration on hybrids and HYVs of rice under its "17.5% yield increase project" during 2007-2010 boro seasons (3 seasons) in 10 regions of the country (Table.V.12). Rice hybrids out-yielded inbreds by an average of 20% in these trials. The highest yield increase is estimated for Chittagonj Hill Tracts (46.42%) followed by Sylhet (35.54%), Mymensingh (25.94%), Rangpur (25.64%), Jessore (24.41%), with less than 20% increases in 4 regions (Comilla, Chittagong, Rajshahi and Barisal) and yields decreased in only Dhaka (-12.98%).

Table.V.12: Comparative performance of hybrid rice over popular inbred rice in 10 regions during 2007-10 Boro season (DAE)

Region	Average paddy yield (t/ha)			
	Hybrid	**Inbred**	**Yield Diff**	**% Diff**
Comilla	8.04	6.93	1.11	16.02
Mymensingh	5.39	4.28	1.11	25.94
Dhaka	4.09	4.7	-0.61	-12.98
Chittagong	5.61	4.73	0.97	19.87
Chittagong HTs	7.16	4.89	2.27	46.42
Sylhet	5.53	4.08	1.45	35.54
Rajshahi	6.05	5.18	0.87	16.8
Rangpur	8.38	6.67	1.71	25.64
Jessore	8.97	7.21	1.76	24.41
Barisal	8.25	7.77	0.48	6.18
Average	**6.75**	**5.64**	**1.11**	**19.68**
SE	**0.52**	**0.43**	**0.25**	**5.09**
CV (%)	**24.14**	**23.99**	**71.42**	**78.92**

Source: *DAE, 2010*

Results from DAE's trials showed variability in yield differences between hybrid and inbred rice according to year and region (Table.V.13). The highest yield difference is estimated for Chittagonj Hill Tracts (68.31%) during 2008-9 boro season followed by Chittagonj Hill Tracts (52.88%) during 2007-8 boro season and Mymensingh (31.69%) during 2009-10 boro season.

Table.V.13: Yield difference and % difference of hybrid and inbred rice of 3 Boro seasons in 10 regions of the country (DAE)

Region	2007-8 Boro		2008-9 Boro		2009-10 Boro		Average	
	Yield Diff (t/ha)	%Diff	Yield Diff (t/ha)	%Diff	Yield Diff (t/ha)	%Diff	Yield Diff (t/ha)	%Diff
Comilla	1.62	24.18	0.89	12.5	0.83	11.91	1.11	16.20
Mymensingh	1.07	24.83	0.93	21.83	1.35	31.69	1.12	26.12
Dhaka	-0.29	-6.24	-0.48	-10.26	-1.05	-22.06	-0.61	-12.85
Chittagonj	0.95	20.88	1	21.28	0.87	17.65	0.97	19.94
Chittagonj HTs	2.39	52.88	3.07	68.31	1.33	23.46	2.26	48.22
Sylhet	1.9	46.57	1.18	28.64	1.27	31.36	1.45	35.52
Rajshahi	0.97	18.2	1.1	21.15	0.49	9.68	0.85	16.34
Rangpur	2.9	43.03	1.57	24.8	0.66	9.51	1.71	25.78
Jessore	1.54	20.92	1.72	23.63	2.02	28.94	1.76	24.50
Barisal	-0.25	-3.23	0.85	11.11	0.85	10.76	0.48	6.21
Average	**1.28**	**24.202**	**1.183**	**22.299**	**0.862**	**15.29**	**1.11**	**20.60**
SE	**0.32**	**6.16**	**0.28**	**6.19**	**0.25**	**5.03**	**0.25**	**5.19**
CV (%)	**80.18**	**80.48**	**74.90**	**87.79**	**93.14**	**104.04**	**71.51**	**79.64**

Source: *DAE, 2010*

Year-wise and region-wise yield of hybrid and inbred (BRRI dhan 28 & 29) rice, yield difference and percentage yield difference are provided in Annex.V.12.

SCA trial on hybrid rice: Seed certifying agencies (SCA) conducted on station and on farm trials on rice hybrids with BRRI dhan 28 and 29 as check variety during 3 consecutive Boro seasons (2004-2007) in 6 regions to assess the varietals performance of rice hybrids for releasing as commercials variety for cultivation in the country.

Hybrid rice was out-yielded average about 10.60% over inbred rice during boro season in on-station trials. The highest percentage difference in paddy yield production is estimated in on-station trial in Mymensingh region (21.15%) followed by Dhaka region (20.60%), while in the other 4 regions, the percentage difference was less than 7%. Similarly hybrid rice out-yielded inbred rice by an average of 8.12% during boro season in on farm trials. The highest percentage yield difference was observed in Mymensingh region (21.06%) followed by Rangpur region (14.90%), Comilla region (14.10%), less than 6% difference in two regions, and a negative difference in Jessore region (Table.X.14).

Table.V.14: Comparative yield of hybrid and inbred rice under on station and on farm conditions in 6 regions for 3 years during 2004-7 Boro seasons (SCA)

Region	On Station yield (Kg/ha)				On Farm yield (Kg/ha)			
	Hybrid	Inbred	Yield Diff	% Diff	Hybrid	Inbred	Yield Diff	% Diff
Dhaka	7388	6126	1262	20.60	6428	6060	368	6.07
Mymensingh	7304	6029	1275	21.15	8093	6685	1408	21.06
Comilla	7550	7193	357	4.96	8504	7453	1051	14.10
Jessore	6897	6470	427	6.60	6967	7602	-635	-8.35
Rajshahi	6008	5798	210	3.62	6971	6906	65	0.94
Rangpur	5903	5535	368	6.65	6957	6055	902	14.90
Mean	**6841.67**	**6191.83**	**649.83**	**10.60**	**7320.00**	**6793.50**	**526.50**	**8.12**
CV (%)	**10.53**	**9.41**	**74.56**	**75.89**	**10.88**	**9.76**	**141.63**	**132.21**
SE	**294.00**	**237.84**	**197.81**	**3.28**	**325.23**	**270.58**	**304.43**	**4.38**

Source: *SCA seasonal trial reports, 2004-7 Boro seasons*

SCA's 2004-07 trials observed average higher yields in on-farm trials than in on-station trials for both hybrid rice (479 Kg/ha) and inbred rice (602 Kg/ha) during the boro season (Table.X.15). The average yield difference was greater for inbred (8.86%) than for hybrids (6.54%). Among hybrids, the highest yield difference was seen with Lily (19.58%) and the lowest with Raja (1.74%).

Table.V.15: Average yield of 16 hybrids and 2 inbreds of rice under on station and on farm conditions (SCA)

Variety	Average Yield (Kg/ha)						CV (%)
	OS	OF	Yield Diff	% Diff	Overall	SE	
Bijoy 4	6,930	7,727	-797.17	-10.32	7,329	262.14	7.69
Heera 6 (HS 48)	7,025	7,370	-345.17	-4.68	7,197	227.18	3.39
CNR 5104 (Lily 1)	6,640	8,257	-1616.67	-19.58	7,449	357.49	15.35
DU 527 (Lily 7)	7,150	7,667	-517.00	-6.74	7,407	282.65	4.94
HRM 03 (kANOK 8)	7,274	7,002	271.67	3.88	7,138	294.76	2.69
Agro-G-1 (EAL 9201)	6,760	7,124	-364.33	-5.11	6,942	276.21	3.71
Bijoy 5	6,638	7,639	-1001.17	-13.11	7,138	289.73	9.92
Pena-1	7,148	6,866	281.67	4.10	7,007	257.99	2.84
Barkat	6,940	7,554	-613.83	-8.13	7,247	275.15	5.99
HM-07 (Aromatic)	6,509	6,718	-209.17	-3.11	6,614	201.42	2.24
Raja	7,109	7,234	-125.83	-1.74	7,171	283.13	1.24
Agro-G-2 (EAL 9202)	7,090	6,977	113.00	1.62	7,033	290.45	1.14
HM 08	6,702	7,450	-748.00	-10.04	7,076	282.63	7.47
Bijoy 3	5,871	6,715	-844.33	-12.57	6,290	216.03	9.49
Super Hybrid SL-8H	6,813	7,146	-333.33	-4.66	6,979	237.43	3.38
Hi-Tech 1 (Bumper Dhan 5)	6,864	7,671	-806.33	-10.51	7,268	251.97	7.84
Average Hybrid	**6,841**	**7,320**	**-478.50**	**-6.54**	**7,080**	**221.15**	**4.78**
Standard Error	**84.70**	**105.90**	**-21.20**	**-20.02**	**72.89**	**9.27**	**20.57**
BRRI dhan 28	5,691	6,482	-791.67	-12.21	6,086	212.42	9.20
BRRI dhan 29	6,693	7,105	-412.00	-5.80	6,899	212.49	4.22
Average Inbred	**6,192**	**6,793**	**-601.83**	**-8.86**	**6,493**	**194.21**	**6.55**
Standard Error	**501.08**	**311.25**	**189.83**	**60.99**	**406.50**	**0.03**	**33.02**

Source: *SCA seasonal trial reports, 2004-7 Boro seasons*

Regional mean yields of 16 rice hybrids against 2 check varieties for 3 years on station and on farm trials in 6 regions during 2004-7 Boro season are provided in Annex.V.13.

During 2005-07 boro seasons, SCA conducted on-station and on-farm trials on 81 rice hybrids with 2 check inbred (BRRI dhan 28 and 29) in 6 regions (see details in Annex.V.14). In these trials, hybrid yields averaged 10.74% higher than inbred yields (Table.V.16). This modest average yield difference might be due to the range of hybrids included in the trials, including slender, fine, and aromatic hybrids. Most of the slender, long grain, fine and aromatic hybrids have lower yields than hybrids of bold rice.

Table.V.16: Comparative yield performance of 81 hybrids and 2 popular Inbred rice (SCA)

Item	Av. Yield (Kg/ha)	CV (%)	SE
Hybrid (81)	7172.3	4.77	38.04
Inbred:			
BRRI dhan 28	6077.2	1.46	39.81
BRRI dhan 29	6875.8	1.75	53.86
Average Inbred	6476.5		
Yield difference	695.8		
% Difference	10.74		

Source: *SCA seasonal trial reports, 2005-7 Boro seasons*

During 2005-6 Boro season, SCA conducted on-station and on-farm trials on 48 rice hybrids with a check inbred (BRRI dhan 28) in six regions (See details in Annex.V.15). In these trials hybrid yield averaged 16.36% and 22.48% higher than inbred yield of the on-station and on-farm respectively. Averaged yield advantage of rice hybrids is estimated better for on-farm trials (22.48%) than on-station trials (16.36%) over inbred (BRRI dhan 28) during 2005-6 Boro season (Table.V.17).

Table.V.17: Comparative yield performance of 48 hybrids and 1 inbred (BRRI dhan 28)

Item	Average Yield (t/ha)		CV%		SE	
	OS	OF	OS	OF	OS	OF
Hybrid (48)	6.40	7.41	8.31	7.15	0.08	0.08
Inbred	5.50	6.05	18.33	12.66	0.41	0.31
Yield difference	0.90	1.36	-10.02	-5.51	-0.33	-0.23
% Difference	16.36	22.48	-54.66	-43.52	-80.49	-74.19

OS = On station, **OF =** On farm

Source: SCA seasonal trial reports, 2005-6 Boro season

VI. Economic performance of hybrid rice

Currently, hybrid rice accounts for about 22% of total Boro rice or 9% of the total rice area of Bangladesh. Hybrid rice produced about 26% of the total clean rice harvested in the Boro season, and about 15% of the total clean rice produced in 2007-8. During 1998-2010, a total of 16.57 million MT of clean rice was produced through cultivating hybrid rice on a cumulative total of 3.54 million ha. Hybrid rice accounted for a net increase in production of clean rice of about 3.88 million during 1998-2010, sufficient to feed approximately 23 million people for a year. The additional rice production of 3.88 million MT contributed US$ 1,406 million (BDT. 97,000 million) to GDP during 1999-2010. In addition, a total of about 13,503 MT of hybrid rice seed was produced in the country on 5,478 ha during 1999-2010. Domestic production of hybrid seed saved about US$ 34 million (BDT 2,436 million) of foreign exchange. Moreover, production of hybrid rice and hybrid rice seed generated a lot of rural employment in the country,

The relative profitability of hybrid rice vs. inbred varies over time throughout the period of, 1998-2010. Hybrid rice cultivation appears to have been more profitable than inbred cultivation during 1998-99 to 2007-8 Boro seasons. But hybrid rice cultivation during 2008-9 to 2009-10 Boro seasons appears to be less profitable than inbred cultivation on a full cost and cash cost basis. Lower net returns for hybrid rice than for inbred rice during 2008-10 Boro seasons are due to hybrids' low paddy price along with relatively higher cost of production. Total cost for hybrid rice production is higher than for inbred rice during 10 years period of analysis under full cost and cash cost basis. The highest paddy price was recorded in 2007-8 followed by the 2009-10 Boro season. Compared to the 1998-99 boro season, hybrid and inbred paddy prices were about 158% and 178%, respectively, higher in the 2007-8 Boro season. From 2007-8 to 2008-9 boro seasons, paddy prices decreased 34% and 31% for hybrid and inbred, respectively.

There are several determinants, which influence on the economic performance of hybrid rice since its introduction in Bangladesh. The common determinants which are influenced on the economic performance of hybrid rice in the country, such as productivity of hybrid rice, price of hybrid rice, grain quality, consumer acceptance, adaptability of rice hybrids, quality seed supply, crop production inputs availability and price, land rent, labor availability and cost, cost of production and return, biotic hazards (e.g. Diseases and pest, storm, flood etc.) etc.

Among these determinates, the market price of hybrid rice is the utmost determinate, which plays major role on the economic performance of hybrid rice in the country. Fundamental to price determination of rice is the operation of supply and demand in the Bangladesh environment. However, the domestic rice price in late 2007 jumped due to the world price increases, India's decision not to export rice, and the concerns generated by the Bangladesh Government's actions. These factors caused a panic leading for everyone able to afford it, increased rice holdings. Price began to decline as stocks were released; the new 2008 T.Aman crop fed into the market and confidence returned that there was enough rice. The price reached at floor after harvesting the 2008-9 Boro. As a result farmers were frustrated for producing rice in general and hybrid rice in particular from 2008-9 Boro and follow-up 2009-10 Boro seasons. Consequently, lower rice production achieved from hybrid rice during 2008-9 and 2009-10 Boro seasons on less acreage with hybrid rice. Prices of rice began to increase after 2009 T.Aman harvest and continuing until to-day.

Accordingly, few months before the starting of the seed selling, the expectation of rice hybrid seed selling agencies was at least 30% more hybrid rice seed selling during 2010-11 Boro season than last 2009-10 Boro season. Probably rice hybrid seed has sold less during the

current 2010-11 Boro season than last 2009-10 Boro seasn. This might be due to higher demand for seed of the most popular and commercial inbreds (BRRI dhan 28 & 29) from farmers all over the Bangladesh. However, farmers are very much intended to grow more of BRRI dhan 28 & 29 during Boro season due to its higher profitability than rest of the rice varieties in general and hybrid rice with higher yield than inbred in particular. It is evident that the comparative price and profitability of exiting rice hybrids over inbreds is not attractive among the farmers in the country and consequently acreage under hybrid rice has been decreasing from peak in 2007-8 to till-now (2010-11Boro season). Consequently, rice hybrids with most desirable physicochemical quality and comparative higher productivity than inbred should be considered before introducing any rice hybrid in Bangladesh.

Higher hybrid rice productivity per unit area over existing high yielding conventional rice varieties is an important determinate, which plays important role on the economic performance of the hybrid rice for the country. Besides productivity, rice grain quality dictates for higher price and ultimately higher level of profit. Better profitability earning from hybrid rice depends on the production cost, which highly influenced by higher costs from labor, land rent and production inputs. Overall favorable cost and return can increase hybrid rice acreage and production. Ultimately better hybrid rice's economic performance can enhance national economic growth at reasonable rate.

This section reviews the evidence on economic performance of hybrid rice on the basis of cost and benefit analysis for cultivating hybrid rice in comparison with inbred rice during introduction stage of hybrid rice, early stage of hybrid rice adoption and current stage of hybrid rice adoption in the country is presented in the following sub-sections:

i. Introduction stage of hybrid rice

Early stage introduction of hybrid rice: AAS conducted on farm trials to assess the performance of 4 rice hybrids with a check (BRRI dhan 29) with 33 farmers in 10 districts during 1998-99 Boro season. Under this performance study, cost and return analysis was done to find-out the economic feasibility of hybrid rice in Bangladesh. However, the net return in terms of gross value of the main product and by-product on full cost basis Sonarbangla-1 ranks first, BRRI dhan 29 second, Aalok third and Loknath fourth and Amarsree-1 fifth and cash-cost basis BRRI dhan 29 ranks first, Sonarbangla-1 second, Aalok third, Loknath fourth and Amarsree-1 fifth. Cost of production and net-return of the main product and by-product of 4 hybrids and inbred rice is provided in the following Table. VI.1:

Table VI.1: Cost and return of the cultivars conducted during Boro seasons 1998/99 (AAS, 1999)

Items	Variety				
	Sonarbangla-1 (F_1)	**Amarsree-1 (F_1)**	**Aalok (F_1)**	**Loknath (F_1)**	**BRRI Dhan-29**
Paddy yield (kg/ha)	7545	4860	6055	5107	6257
Price of Paddy (Tk/kg)	6.75	6.70	6.75	6.74	6.73
Straw Yield (kg/ha)	7545	4860	6055	5107	6257
Price of Straw (Tk/kg)	0.40	0.4	0.4	0.40	0.40
Gross return (Tk/ha)	53946.75	34506.00	43293.25	36463.98	44612.41
Total Cost (Tk/ha)					
(i) Full-cost basis: a/	30719.81	30285.86	30261.88	29868.96	26586.78
(ii) Cash-Cost basis b/	15431.97	14969.50	14950.20	14592.88	11670.08
Net return (Tk/ha)					
(i) Full-Cost basis	23226.94	4220.14	13031.37	6595.02	18025.63
(ii) Cash-Cost basis	38514.78	19536.50	28343.05	21871.10	32942.33
Benefit-cost ratio					
(i) Full Cost basis	1.76	1.14	1.43	1.22	1.68
(ii) Cash-cost basis	3.50	2.31	2.90	2.50	3.82
Net return in terms of gross value of the product (%)					
(i) Full cost basis	43.06	13.93	30.10	18.09	40.41
(ii) Cash cost basis	71.40	56.62	65.47	59.98	73.84

a/ Full-cost includes human labour, bullock power, seeds, fertilizers, insecticides, irrigation, interest on working capital fixed cost @ 10% of the total cost.
b/ Cash-cost includes cost of seeds, fertilizers, insecticides, irrigation and interest of the outflow cash.
Note: Grain and straw ratio is considered at 1:1 for this cost and return analysis.
Source: Rashid, et.al, 1999

Pilot testing of BRRI hybrid dhan 1: AAS conducted pilot testing of BRRI hybrid dhan 1 under farmers' field conditions at 15 villages in 15 upazilas of 6 districts in Rajshahi region during 2001-2 Boro season. The purpose of the pilot testing was to evaluate the performance of BRRI hybrid dhan 1 against BRRI dhan 29 as check variety of rice.

Considering both the main product and by-product (straw), the gross return of BRRI hybrid dhan 1 and BRRI dhan 29 is Tk 56,749 and Tk 55,099 per ha, respectively (Table. VI.2). The corresponding net return, considering all costs, is Tk 23,368 and 23,501 per ha, respectively, for BRRI hybrid dhan 1 and BRRI dhan 29; while net returns on a cash basis were Tk 39,916 and Tk 40,120 per ha, respectively. The benefit cost ratio for the cultivars on the full cost basis stand at 1.70 and 1.74, respectively; and on a cash cost basis is 3.37 and 3.68.

The net return on a full cost basis for BRRI hybrid dhan 1 and BRRI dhan 29 is 41.18 and 42.65 percent, respectively, of the value of total output (main product and by-product). Similarly, net return on a cash cost basis is 70.34 and 72.81 percent, respectively. Thus, the net return in terms of the total value of the main product and by-product is slightly higher for BRRI dhan 29 than for BRRI hybrid dhan 1 (Table. VI.2),

Table.VI.2: Comparative cost and return of the two cultivars for 2001-2 Boro season (AAS, 2002)

Items	Variety		Diff	% Diff
	BRRI hybrid dhan 1	BRRI dhan 29		
Paddy Yield (Kg/ha)	7220	7010	210	3.00
Price of Paddy (Tk/Kg)	7.5	7.5	0	0
Straw Yield (Kg/ha)	5776	5608	-	
Price of Straw (Tk /Kg)	0.45	0.45	-	
Gross return (Tk/ha)	56,749	55,099	1650	3.00
Total Cost (Tk ha)				
(i) Full-cost basis [a]	33,381	31,598	1783	5.64
(ii) Cash-cost basis [b]	16,833	14,979	1854	12.38
Net return (Tk/ha)				
(i) Full-cost basis	23,368	23,501	-133	0.57
(ii) Cash-cost basis	39,916	40,120	204	0.51
Benefit-cost ratio				
(i) Full-cost basis	1.70	1.74	-0.04	
(ii) Cash-cost basis	3.37	3.68	0.31	8.42
Net return in terms of gross value of the product (%)				
(i) Full-cost basis	41.18	42.65	-1.47	3.45
(ii) Cash-cost basis	70.34	72.81	-2.47	3.39

[a]Full-cost includes human labours, bullock power, seeds, fertilizers, insecticides, interest on working capital and land rent.

[b]Cash-cost includes seeds, fertilizers, insecticides, irrigation and interest of the outflow cash.

Note: The ratio of grain weight to straw weight is considered to be 1:0.8 for this cost analysis.

Source: Rashid, H. 2002

Follow-up study on hybrid rice adoption: IRRI in collaboration with BRAC conducted a study on hybrid rice adoption in Bangladesh: A socioeconomic assessment of farmers' experiences during very early stage of its adoption (Husain et al, 2001). In the study two hybrids (Sonarbangla-1 and Aalok) were compared with popular high yielding inbreds (Table.VI.3). Among Aalok 6201, Sonarbangla-1 and HYVs, the highest grain value (market price) was obtained for Sonarbangla-1. Value of grain was relatively higher for Aalok 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, not on actual price received for the produce in the market.

Total returns were also highest for Sonarbangla-1 and lowest for HYVs. Total value added was the highest for Sonarbangla-1 and the lowest for Aalok 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.VI.3).

Table VI.3: Returns to hybrid and HYV rice production for sample farmers during 1998-99 Boro season (IRRI/BRAC, 2001).

Item	*Aalok* (n=108)	HYV (n=108)	% diff.	Sonar 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	5.79	29.2 (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)

Note: Figures in parentheses are estimated 'paired-t' values.
* Includes straw value.
Source: Hussain, *et al* 2001

Higher profitability difference (48.14%) is estimated with Sonarbangla-1 vs HYVs. For Aalok vs HYVs, the estimated profitability difference is negative (-11.88%). Combining both hybrids, the profitability difference is 9.09% (Table.VI.4).

Table.VI.4: Relative profitability of hybrids and HYVs (IRRI/BRAC, 2001)

Variety	Profitability (Tk/ha)
I. Aalok	16166
HYVs	18347
Difference	-2181
% Difference	-11.88
II. Sonarbangla-1	24260
HYVs	16376
Difference	7884
% Difference	48.14
II. Bolth hybrids	19207
Both HYVs	17606
Difference	1601
% Difference	9.09

Source: *Hussain, et al 2001*

Returns to production of hybrid and HYV rice show some variation by farm size (Table.VI.5). For hybrids, farm-operating surplus was positively related with farm size, with the highest operating surplus (in TK/ha) received by large farms. However, in case of HYVs, the highest operating surplus (in Tk/ha) 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 high inputs as compared to HYVs.

Table.VI.5: Comparative costs and returns for hybrids and HYVs of rice of sample farmers by farm size (taka/ha) (IRRI/BRAC, 2001).

Cost/ return	Farm size (Taka/ha)									
	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

Source: Husain, *et al* 2001

Relative performance of rice hybrids and HYVs under upland and lowland is estimated (Table.VI.6). The overall performance of hybrids was better in lowland areas than for upland areas. For Sonarbangla-1, 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.

Table.VI.6: Relative performance of rice hybrid and HYV of rice by land type during 1998-99 Boro season (IRRI/BRAC, 2001)

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					
Aalok (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
Sonarbangla-1 (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					
Aalok (n=50)	5.8	6209	38212	21073	17139
HYV (n=50)	5.5	5787	34455	16624	17832
% Difference	5.5	7.3	10.9	26.8	-3.9
Sonarbangla-1 (n=37)	7.9	6546	53391	25032	28359
HYV (N=37)	5.8	6326	38289	21148	17141
% Difference	36.2	3.5	39.4	18.4	65.4
Both Hybrids (n=87)	6.5	6319	43154	22362	20792
All HYVs (n=87)	5.6	5962	35704	18097	17607
% Difference	16.1	6.0	20.9	23.6	18.1

Source: Husain, *et al* 2001

ii. Early stage of hybrid rice adoption

Cost and benefits during adoption process of hybrid rice: With funding from PETRRA (IRRI/DFID), AAS conducted a study during April-May 2004 to assess the performance and overall impacts of hybrid rice cultivated in the country (Kabir and Rashid 2004). The study examined costs and returns for both hybrid and inbred rice in 10 sites (Table.VI.7).

Table.VI.7: Summary cost and returns analysis of hybrid and inbred of rice in 10 sites (AAS/IRRI, 2004)

Site (District)	Total cost (Tk./ha)		Gross return (Tk./ha)		Net-return (Tk/ha)		Net Return	
	Hybrid	Inbred	Hybrid	Inbred	Hybrid	Inbred	Diff	% Diff
Natore-1	36013	32900	48165	40755	12152	7855	4297	54.70
Natore-2	26229	25175	48165	33345	21936	8228	13708	166.60
Sirajganj	24540	20872	47523	34580	22983	13709	9274	67.65
Naogaon	24762	21662	64022	42385	39261	20723	18538	89.46
Gopalganj	22872	17586	60515	42361	37643	24774	12869	51.95
Jessore	26886	25305	53352	43349	26466	18044	8422	46.67
Jhenaidah	26256	24500	59280	44350	33024	19850	13174	66.37
Gaibandha	27654	23060	50684	42385	23030	19325	3705	19.17
Jamalpur	28850	29467	72248	48412	43398	18945	24453	129.07
Moulvibazar	16754	13338	53352	35568	36598	22230	14368	64.63
Mean	**26081.60**	**23386.50**	**55730.60**	**40749.00**	**29649.10**	**17368.30**	**12280.80**	**70.71**
CV	**18.56**	**23.83**	**14.60**	**11.74**	**33.14**	**32.69**	**0.45**	**1.39**
SE	**1530.77**	**1762.64**	**2572.69**	**1513.34**	**3107.38**	**1795.37**	**1312.01**	**73.08**

Source: *Kabir & Rashid, 2004*

BRRI's hybrid project analyzed costs and benefits of hybrid and inbred rice during the 2007-8 Boro (presented at project meeting in 2008 at BRRI). BRRI reported that paddy yield, total cost, gross return and net return for hybrids. Estimated 6.42%, 5.35%, 6.29% and 7.04%, of paddy yield, total cost, gross return and net return respectively is revealed higher for hybrid than inbred rice. BRRI's cost-return analysis used a paddy price of Tk 11.25/kg, for both hybrid and inbred, which is about 60% lower than the actual paddy price during 2007-8 Boro season. Moreover, the irrigation cost used in their analysis is also lower than farmers' irrigation costs across Bangladesh. In cost analysis, the cost for the pesticides, land rent, and interest on working capital is not included. Thus, the paddy production cost (Tk/kg) is underestimated in this analysis (Table.VI.8)

Table.VI.8: Comparative cost and benefit of hybrid and inbred rice during 2007-8 Boro season (BRRI hybrid project 2008)

Item	Cost-return (Tk/ha)		Difference	% Difference
	Hybrid	Inbred		
1. Land Preparation	3000	3000	0	0
2. Labor	20160	20384	-224	-1.10
3. Seed	2800	500	2300	460
4. Fertilizer	5942	5942	0	0
5. Pesticides:	0	0	0	0
6. Irrigation	9000	9000	0	0
7. Land rent in	0	0	0	0
8. Interest on working capital (5%)	0	0	0	0
9. Total Cost	40902	38826	2076	5.35
10. Gross return:	93211	87694	5517	6.29
11. Net return	52309	48868	3441	7.04
12. Cost Benefit Ratio	2.28	2.26	0.02	0.88
13. Paddy production cost (Tk/Kg)	5.48	5.54	-0.06	-1.08
14. Grain yield (Kg/ha)	7458	7008	450	6.42

Notes: The hybrids considered in this study were Hira, Sonarbangla-1, LP 50, BRRI hybrid dhan 1, BR 827 (Promising line). The Inbreds were: BRRI dhan 28 & 29. The analysis assumes a paddy price of Tk 11.25/Kg for both hybrid and inbred. The cost for pesticides, land rent in and interest on working capital is not included in the cost-return analysis.

Source: Hybrid rice project, BRRI

Note: Paddy price is considered within 2 months of the crop harvest

In 2008, AAS and Research Development Center (RDC), analyzed costs and returns for selected food crops, with funding support from DFID (Cookson et al, 2009, Rashid, H. 2008). The cost and return analysis considered crops grown during 2006-2008 in the selected locations. In the case of rice, the cost and return analysis looked at both hybrids and inbreds for Boro, T. Aus and T. Aman seasons during the 2006-2008 cropping seasons.

This study estimated that net returns with hybrid rice were 29.36% greater than with inbreds on a full cost basis during the two boro seasons during 2006-8 (Table.VI.9). Net returns for hybrids were 16.49% greater than for inbreds on a cash cost basis. On the other hand, full costs and cash costs to grow hybrids were only 3.59% and 2.88% greater, respectively, than full and cash costs to grow inbred rice. Gross returns for hybrids were 12.47% greater than for inbreds, and yields were 19.87% (Table.VI.9).

Table.VI.9: Comparative cost and profit of hybrid and inbred rice in Natore and Sirajgonj districts for 2 seasons during 2006-8 Boro seasons (AAS, 2008)

Item	Hybrid	Inbred	Difference	% Diff
Total Cost (Tk/ha)				
a) Full cost basis	80283	77504	2779	3.59
b) Cash cost basis	35958	34951	1007	2.88
Gross return (Tk/ha)	133011	118266	14745	12.47
Net return (Tk/ha)				
a) Full cost basis	52,728	40,762	11,966	29.36
b) Cash cost basis	97053	83315	13738	16.49
Cost Benefit Ratio				
a) Full cost basis	1.66	1.53	0.13	8.50
b) Cash cost basis	3.70	3.38	0.32	4.48
Paddy yield (Kg/ha)	8803	7344	1459	19.87

Source: *Rashid, H. 2008*
Note: *Paddy price is considered within 2 months of the crop harvest*

In Natore district during the 2007 Aus season, net returns for hybrids were 27.84% and 25.27% greater than for inbreds on a full and cash cost basis, respectively. Production cost of hybrid rice was 21.14% and 19.51% greater than for inbreds on a full cost and cash cost basis, respectively. Paddy yield for hybrids was 27.02% higher than for inbreds (Table.VI.10).

Table.VI.10: Comparative cost and profit of hybrid and inbred rice in Natore district during 2007 T. Aus season (AAS)

Item	Hybrid	Inbred	Difference	% Diff
Total Cost (Tk/ha)				
a) Full cost basis	53850	44451	9399	21.14
b) Cash cost basis	25087	20992	4095	19.51
Gross return (Tk/ha)	84928	68761	16167	23.51
Net return (Tk/ha)				
a) Full cost basis	31078	24310	6768	27.84
b) Cash cost basis	59841	47769	12072	25.27
Cost Benefit Ratio				
a) Full cost basis	1.58	1.55	0.03	1.94
b) Cash cost basis	3.39	3.28	0.11	3.35
Paddy yield (Kg/ha)	4875	3838	1037	27.02

Source: *Rashid, H. 2008*
Note: *Paddy price is considered within 2 months of the crop harvest*

During the 2007 aman rice season, a study in Natore and Sirajgonj Districts reported that net returns for hybrids were 75.59% and 16.94% greater than for inbreds on a full cost and cash cost basis, respectively. In the same study, costs were 4.25% less for hybrids than for inbreds. Paddy yield of hybrid rice was 20.21% higher than for inbreds (Table.VI.11).

Table.VI.11: Comparative cost and profit of hybrid and inbred rice in Natore and Sirajgonj districts during 2007 T. Aman season (AAS, 2008)

Item	Hybrid	Inbred	Difference	% Diff
Total Cost (Tk/ha)				
a) Full cost basis	56627	59140	-2513	-4.25
b) Cash cost basis	29905	24560	5345	21.76
Gross return (Tk/ha)	97702	82533	15169	18.38
Net return (Tk/ha)				
a) Full cost basis	41076	23393	17683	75.59
b) Cash cost basis	67797	57974	9823	16.94
Cost Benefit Ratio				
a) Full cost basis	1.73	1.40	0.33	23.57
b) Cash cost basis	3.27	3.36	-0.09	-2.68
Paddy yield (Kg/ha)	5650	4700	950	20.21

Source: *Rashid, H. 2008*
Note: *Paddy price is considered within 2 months of the crop harvest*

According to study in India, average grain yield gain, input costs and market price of grain were taken into account while computing economic returns from hybrid and inbred rice cultivation. The market price of hybrid rice grain was 11% lower than that for inbred rice grain while the input cost was 19% higher mainly on account of the higher cost of hybrid seed and plant protection. The 16% yield gain was insufficient to compensate for the additional costs and lower grain price. As a result, the operating farm surplus was 5% lower, although statistically not significant, compared to inbred rice production. If the market price of hybrid rice grain had been the same as inbred rice grain, then the net return to hybrid rice production would have gone up by 12.3%, despite additional seed cost (Janaiah and Hossain, 2005).

iii. Current stage of hybrid rice adoption

For the 2009-10 boro season, Energypac Agro Ltd (EAL) collected cost and return data of hybrid and inbred rice from Chuadanga district, while AAS staff collected similar data from Natore District. Data show 19.53% higher yields with hybrid than inbred rice. But the average net-return of hybrid rice is estimated about 14.03% less than inbred rice on a full cost basis, and 20.84% less on a cash cost basis. Estimated lower profits with hybrid vs inbred rice are mainly due to hybrids' lower market price and higher cost of production (Table.VI.12).

Table.VI.12: Comparative cost and profit of hybrid and inbred rice in Chuadanga and Natore districts during 2009-10 Boro season (EAL & AAS)

Item	Hybrid			Inbred			Difference	% Diff
	EAL	AAS	Average	EAL	AAS	Average		
Total Cost (Tk/ha)								
a) Full cost basis	103163	111038	107101	97335	105013	101174	5927	5.86
b) Cash cost basis	43706	43706	43706	38469	38273	38371	5335	13.90
Gross return (Tk/ha)	127500	129900	128700	122438	126600	124519	4181	3.36
Net return (Tk/ha)								
a) Full cost basis	22864	17276	20070	25103	21587	23345	-3275	-14.03
b) Cash cost basis	66995	69395	68195	83968	88328	86148	-17953	-20.84
Cost Benefit Ratio								
a) Full cost basis	1.22	1.15	1.19	1.26	1.21	1.24	0	-4.05
b) Cash cost basis	2.11	2.15	2.13	3.18	3.31	3.25	-1	-34.36
Paddy yield (Kg/ha)	**7500**	**7650**	7575	6225	6450	6338	1238	19.53

Note: *Energypac Agro Ltd. collected data from Chuadanga district and AAS collected data from Natore district.*

Note: *Paddy price is considered within 2 months of the crop harvest*

Centre for Policy Dialogue (CPD) conducted a 3 years' cost and return analysis for hybrid and inbred rice during three boro seasons, 2007-10 (Deb *et al* 2008 & 2009). Hybrids averaged 14.08% higher paddy yield than inbred rice. Farmers' estimated net-returns with hybrids averaged 4.21% less than inbreds on a full cost basis, but 3.92% higher than inbreds on a cash cost basis. Estimated average paddy production costs for hybrid rice were 9.99% and 10.66% greater than for inbreds on a full cost and, cash cost basis respectively. Estimated gross-return of hybrid rice was 6.06% greater than for inbred rice (Table.VI.13) and details cost and return analysis are provided in Annex.VI.1.

Table.VI.13: Comparative cost and profit of hybrid and inbred rice for 3 Boro seasons during 2007-10 Boro cropping seasons (CPD)

Item	Hybrid	Inbred	Difference	% Diff
Total Cost (Tk/ha)				
a) Full cost basis	80245	72957	7288	9.99
b) Cash cost basis	35436	32022	3414	10.66
Gross return (Tk/ha)[1]	106979	100866	6113	6.06
Net return (Tk/ha)				
a) Full cost basis	26735	27910	-1175	-4.21
b) Cash cost basis	71544	68844	2700	3.92
Cost Benefit Ratio				
a) Full cost basis	1.33	1.38	-0.05	-3.62
b) Cash cost basis	3.04	3.16	-0.12	-3.80
Paddy yield (Kg/ha)	6669	5846	823	14.08

[1] *Gross return is estimated*

Source: *Deb, et al 2008 & 2009*

Note: *Paddy price is considered within 2 months of the crop harvest*

Hybrid rice profit scenario: The relative profitability of hybrid rice vs. inbred varies over time (Annex.VI.2). Hybrid rice cultivation appears to have been more profitable than inbred cultivation during 1998-99 to 2007-8 Boro seasons. But hybrid rice cultivation during 2008-9 to 2009-10 Boro seasons appears to be less profitable than inbred cultivation on a full cost and cash cost basis. *Lower net returns for hybrid rice than for inbred rice during 2008-10 Boro seasons are due to hybrids' low paddy price along with relatively higher cost of production.* Total cost for hybrid rice production is higher than for inbred rice during 10 years period of analysis under full cost and cash cost basis (with an exception). Total and cash costs vary during the 10 years' period. The highest paddy price was recorded in 2007-8 followed by the 2009-10 Boro season. Compared to the 1998-99 boro season, hybrid and inbred paddy prices were about 158% and 178%, respectively, higher in the 2007-8 Boro season. From 2007-8 to 2008-9 boro seasons, paddy prices decreased 34% and 31% for hybrid and inbred, respectively (Table.VI.14).

Table.VI.14: Percent difference between hybrid and inbred on net return & total cost and paddy rice (Tk/Kg) with data source during 1998-2010.

Season	Net-return (% Diff)		Total cost (% Diff)		Paddy price (Tk./Kg)		Data Source
	FCB	CCB	FCB	CCB	Hybrid	Inbred	
1998-99 Boro[1]	28.86	16.92	15.55	32.24	6.75	6.73	AAS, 1999
2001-02 Boro[2]	0.57	0.51	5.64	12.38	7.50	7.50	AAS/IRRI/BRRI, 2002
1998-99 Boro[3]	-11.89	-	26.69	-	6.20	6.00	IRRI/BRAC, 2001
1998-99 Boro	48.14	-	17.46	-	6.46	6.36	IRRI/BRAC, 2001
2003-4 Boro	70.71	-	11.52	-	6.13	6.13	AAS/IRRI, 2004
2006-8 Boro	29.36	16.49	3.59	2.88	14.26	15.09	AAS/RDC, 2009
2007 T. Aus	27.84	25.27	21.14	19.51	15.88	15.96	AAS/RDC, 2009
2007 T. Aman	75.79	16.94	-4.25	21.76	15.97	15.97	AAS/RDC, 2009
2008 Boro	7.04	-	5.35	-	11.25	11.25	BRRI, 2008
2007-8 Boro	10.60	10.29	9.02	9.73	17.00	18.00	CPD, 2009
2008-9 Boro	-73.57	-5.91	10.20	11.46	11.25	12.50	CPD, 2009
2009-10 Boro	-1.55	3.72	8.97	10.76	16.50	17.50	CPD, 2010
2009-10 Boro	-14.03	-20.84	5.86	13.90	16.00	18.25	EAL/AAS, 2010

FCB = Full cost basis, CCB = Cash cost basis

[1] Analysis includes Sunarbangla 1 (Hybrid) & BRRI dhan 29 (Inbred)

[2] Analysis includes BRRI hybrid dhan 1 & BRRI dhan 29

[3] Analysis includes Aalok (Hybrid) and HYV (Inbred)

Paddy price is used within 2 months of the crop harvest as farm gate price during 10 years of cost and return analysis. Net return, total cost, average paddy price and data source of hybrid and inbred rice during 1998-2010 are provided in Annex.VI.2.

Determinants for hybrid rice's economic performance

There are several determinants, which influence on the economic performance of hybrid rice since its introduction in Bangladesh. The common determinants which are influenced on the economic performance of hybrid rice in the country, such as productivity of hybrid rice, price of hybrid rice, grain quality, consumer acceptance, adaptability of rice hybrids, quality seed supply, crop production inputs availability and price, land rent, labor availability and cost, cost of production and return, biotic hazards (e.g. Diseases and pest, storm, flood etc.) etc.

Among these determinates, the market price of hybrid rice is the utmost determinate, which plays major role on the economic performance of hybrid rice in the country. Fundamental to price determination of rice is the operation of supply and demand in the Bangladesh environment. Rice prices are established by a combination of the Indian parity price (Indian rupee prices ∗ Taka/rupee exchange rate) and the domestic supply conditions (Cookson et al 2009). In this regards, three theories are reviewed and the theories are: (a) Price determined by the Indian rice price; (b) Price determined by domestic supply and demand with imports exogenous to the system; and (c) Simultaneous determination of price and imports. The first and third work when there is a access to the Indian rice market. When there are limited or restricted imports then the second theory must hold (Cookson et al, 2009). However, the domestic rice price in late 2007 jumped due to the world price increases, India's decision not to export rice, and the concerns generated by the Bangladesh Government's actions. These factors caused a panic leading for everyone able to afford it, increased rice holdings. This froze the rice market driving up prices. The high prices increased farm gate prices and induced production of a large crop in response with high land rent and to some extend labor cost. Price began to decline as stocks were released; the new 2008 T.Aman crop fed into the market and confidence returned that there was enough rice. The price reached at floor after harvesting the 2008-9 Boro. As a result farmers were frustrated for producing rice in general and hybrid rice in particular from 2008-9 Boro and follow-up 2009-10 Boro seasons. Consequently, lower rice production achieved from hybrid rice during 2008-9 and 2009-10 Boro seasons on less acreage with hybrid rice. Prices of rice began to increase after 2009 T.Aman harvest and continuing until to-day (December 2010) (Figure.VI.1&2 and Annex.3).

Accordingly, few months before the starting of the seed selling, the expectation of rice hybrid seed selling agencies was at least 30% more hybrid rice seed selling during 2010-11 Boro season than last 2009-10 Boro season. Rice seed selling has ceased during this current 2010-11 Boro season by end of December 2011. As per report from rice hybrid seed selling agencies, probably rice hybrid seed has sold less than last 2009-10 Boro season. This might be due to higher demand for seed of the most popular and commercial inbreds (BRRI dhan 28 & 29) from farmers all over the Bangladesh. However, farmers are very much intended to grow more of BRRI dhan 28 & 29 due to its higher profitability than rest of the rice varieties in general and hybrid rice with higher yield than inbred in particular. Moreover, there was a sufficient supply of quality seed from formal seed system mainly from BADC and also from private sector seed companies. The incremental rice production can be achieved with higher acreage in the country when rice price would be attractive among the farmers on the basis of high profit of the desirable rice varieties. Thus, it is evident that the comparative price and profitability of exiting rice hybrids over inbreds is not attractive among the farmers in the country and consequently acreage under hybrid rice has been decreasing from peak in 2007-8 to till-now (2010-11Boro season). Therefore, rice hybrids with most desirable

physicochemical quality and comparative higher productivity than inbred should be considered before introducing any rice hybrid in Bangladesh.

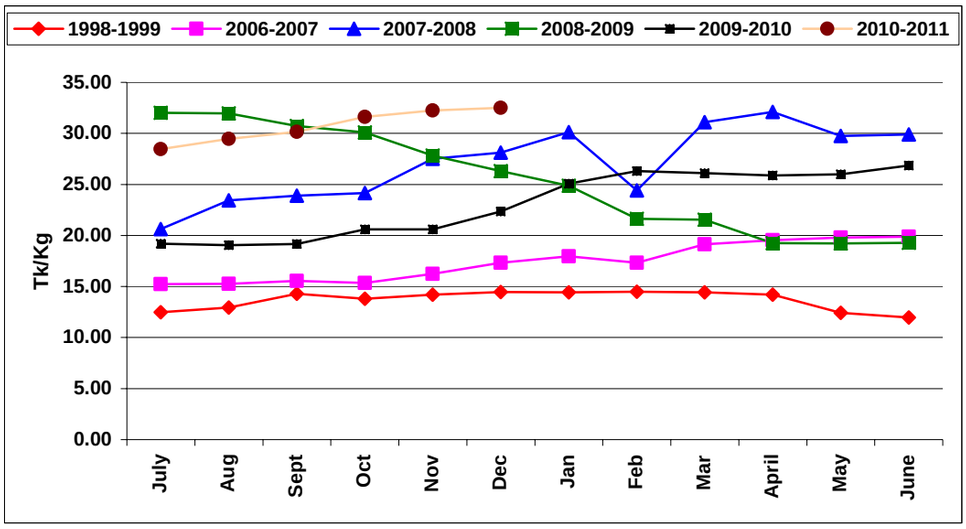


Figure.VI.1: Month-wise rice price (Tk./Kg) for 6 FYs

Higher hybrid rice productivity per unit area over existing high yielding conventional rice varieties is an important determinate, which plays important role on the economic performance of the hybrid rice for the country. Besides productivity, rice grain quality dictates for higher price and ultimately higher level of profit. Better profitability earning from hybrid rice depends on the production cost, which highly influenced by higher costs from labor, land rent and production inputs (fertilizers, pesticides, irrigation etc). Overall favorable cost and return can increase hybrid rice acreage and production. Ultimately better hybrid rice's economic performance can enhance national economic growth at reasonable rate.

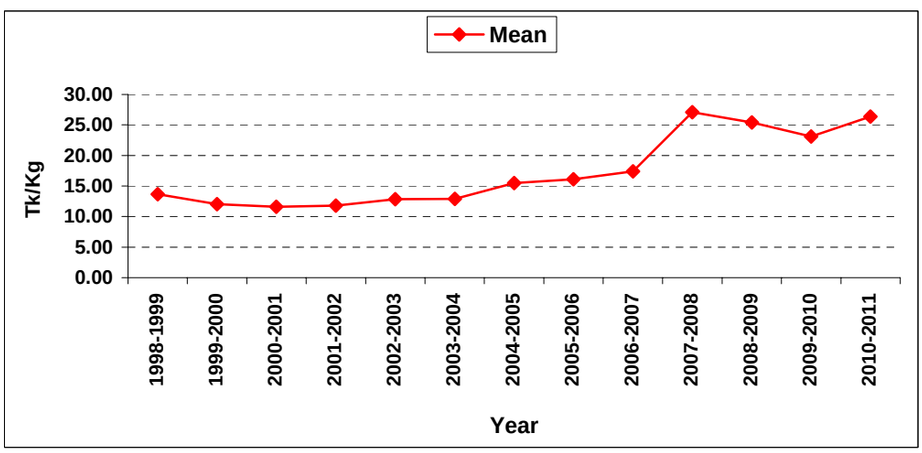


Figure.VI.2 : Yearly average price (Tk./Kg) of coarse rice during 1998-99 to 2010 (December 2010)

VII. Response from farmers and consumers to hybrid rice

This section reviews the response (satisfaction and dissatisfaction) of farmers and consumers along with the traders and millers (key actors of rice supply chain) to hybrid rice technology during its adoption process in the country for about a decade since 1998-99.

Total of 85 varieties of hybrid rice are available for commercial cultivation in the country through authorization by the National Seed Board (NSB) of the Ministry of Agriculture (MOA). Commercial cultivation of hybrid rice began from 1998-99 with four permitted rice hybrids, of which 3 hybrids were from India and 1 from China. Finally, farmers' accepted the rice hybrid (Sonarbangla-1) from China due to its high grain yield potential, and higher profitability compared to the high yielding rice inbred, and with low stickiness of rice grains (amylose content is about 25%). Hybrid rice acreage increased from 23,700 ha to 1,011,000 ha from 1998-99 to 2007-8, at 52% compound annual growth rate. Area under hybrid rice has lately decreased to 939,000 ha in 2008-9 and 670,000 ha in 2009-10 with 7% and 23% compound annual growth rates respectively.

Large-scale adoption of hybrid rice has been hampered since 1998-99 by several constraints, including unattractive characteristics of the available hybrids, negative positions by some public sector extensionists, researchers and to some extent policy markers, problems with seed quality, high seed cost, inconsistent yield performance, inconsistent relative profitability, low grain quality, low grain price, less attention for adoption of hybrid rice during T.Aman and T.Aus seasons and sometimes negative propaganda about hybrid rice and insufficient support from government. Even so, the adoption of hybrid rice along with the establishment of hybrid rice seed production in the country within a decade is very much encouraging. It was possible to achieve due to involvement of both the private sector (including NGO) and public sector, with active participation of motivated farmers.

Besides the public sector, private sector seed marketing agencies have undertaken significant promotional activities for hybrid rice since 1998-99. Accordingly, farmers' acceptability of hybrid rice technology in the country is found very much encouraging with few exceptions. Achieved acreage of hybrid rice is estimated to be about 22% in the boro season (irrigated rice in the dry season), and about 9% of the total rice area during the 2007-8 cropping season.

In recent years, there has been “no qualitative study” on the satisfaction and dissatisfaction of farmers, millers, traders and consumers with hybrid rice technology in the country. But at the early stage of hybrid rice introduction, IRRI/BRAC conducted a study, Hybrid Rice Adoption in Bangladesh: A socioeconomic assessment of farmers' experiences in 2000 (Husain *et al* 2001). The major findings of the study on the farmers' very early and untested perceptions (satisfaction and dissatisfaction) about hybrid rice are briefly presented below:

Consumption of hybrid rice grain: Eight-five percent of the sampled farmers reported having eaten hybrid rice. Of those who had eaten hybrid rice, 75% considered it to be palatable. Of the remaining 25% (mostly commenting on the hybrid Aalok 6201), 9 out of 10 complained about the stickiness of cooked rice. This was not a major issue for farmers who ate Sonarbangla-1. Many respondents mentioned that cooked hybrid rice could not be kept for long, i.e., the quality deteriorated soon after cooking. So the rice was not suitable for breakfast with the left over rice from the previous evening. Among other criticisms, 26% mentioned inferior quality of the grain, 23% mentioned inconvenience of cooking, 9% cited as bad smell and 6% mentioned other problems.

Farmers' perception (satisfaction) on continuation of hybrid rice cultivation: Eighty-two percent of Sonarbangla-1 producers and only 40% of Aalok 6201 producers expressed their intention to continue the cultivating the hybrid variety. The stated 10 reasons for continuation of hybrid rice production by Aalok 6201 and Sonarbangla-1 producers are given in the report. Ninety-one percent of those who wanted to continue to cultivate rice hybrids said they expected better yields in the next year, 56% expected more profit and 44% considered Aalok 6201 as suitable for own consumption. Among Sonarbangla-1 cultivators who wished to continue, 93% expected better yield and 62% expected higher profit in the next year. Thirty six percent noted its suitability for consumption, while 30% mentioned its suitability for making puffed and flattened rice.

Farmers' perception (dissatisfaction) for discontinuation of hybrid rice cultivation: Sixty percent of Aalok 6201 and 18% Sonarbangla-1 growers did not want to continue cultivation of hybrid rice. Fifteen reasons for discontinuation of hybrid rice, as stated by the sampled farmers, are documented in the report. The responses from Aalok 6201 and Sonarbangla-1 producers were not the same, though there were some common reasons. Common reasons were high seed cost, requirement of more care and management, lower than expected yield, high pests and disease attack, low profits, unsuitability for home consumption, etc. Aalok 6201 producers mentioned some additional reasons, the most important of which was unfilled grain. Ninety one percent of growers mentioned this as an important factor behind the low yield of Aalok 6201. Among other reasons mentioned was high grain shattering, crop lodging, low rice recovery after milling and low grain quality. Thus, compared to Sonarbangla-1 farmers, relatively more Aalok 6201 farmers were not in favor of continuing hybrid rice production.

Farmers' perception (satisfaction/dissatisfaction) of relative performance of hybrid rice: Eighty-nine percent of *Sonarbangla-1* producers and 52% of *Aalok* 6201 producers mentioned higher yield from hybrids while 57% of *Sonarbangla-1* and 53% of *Aalok* 6201 producers expressed favorable opinion about grain quality of hybrids. *Sonarbangla-1* producers also reported that it was more profitable than HYVs. On suitability of hybrid rice for consumption, 42% of *Aalok* 6201 and 35% of *Sonarbangla-1* 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 *Aalok* 6201 producers expressed unfavorable opinion on hybrid because of high lodging and grain shattering, and 97% noted problems with unfilled grain (sterile grain). Majority of *Aalok* 6201 producers (69%) but only one-third (32%) of *Sonarbangla-1* producers said that the incidence of pests/diseases was higher on hybrids than on HYVs (Husain *et al* 2001). However, another study during the 1998-99 Boro season found no difference between hybrids and inbred with respect to insect infestation and disease infection (Rashid *et al* 1999).

The same group of reputed economists, mostly from IRRI, conducted another similar study on the adoption of hybrid rice, with attention to the perceptions (satisfaction/dissatisfaction) of farmers, traders, millers and consumers in India during 2002-2005, and they published several scientific papers on that study. The study evaluated farmers' experiences with hybrid rice in India, Bangladesh and Vietnam. The analysis indicates that the particular political system and other socioeconomic factors, and not the inherent economic superiority of this technology, were the driving forces behind the success of Chinese hybrid rice. Thus in other Asian countries, where these factors are not evident (apart from Vietnam), it is unlikely that the success of Chinese hybrid rice will be replicated in toto. Although hybrid rice delivers yield gains of about 15-20% over the existing HYVs outside China, it is not attractive to farmers because of higher input costs and lower market prices due to its inferior grain

quality. Thus currently available rice hybrids are unlikely to succeed in irrigated rice systems in the tropics. For hybrid rice to succeed on farms outside China, grain quality and seed production practices must be improved. These problems could be addressed with proper planning based on a micro-level analysis of the socioeconomic factors likely to affect rice hybrid adoption (Janaiah *et al* 2000).

An ex-ante assessment of the potential of hybrid rice in India based on data from on-farm trials (1992-93 and 1993-94) revealed 12% yield gains over the prevalent inbred varieties. However, rice hybrids tested in the on-farm trials were not readily acceptable to farmers due to their poor grain quality, as indicated by their lower output price in the market, additional cost, and insufficient resistance to major pests and diseases (Janaiah 1995). Farmers' perception during on-farm testing also indicated that poor grain quality would constrain large-scale adoption of this technology in India. A frequently raised concern about the prospects for large scale adoption of hybrid rice in a country such as India is consumer acceptability. Consumer acceptance determines price, which in turn determines revenue earned per unit of land at a given level of yield. Consumer acceptance plays a greater role in irrigated rice systems where farming is highly commercialized, and where farmers are oriented to the market. About 80-85% of the sample farmers who produced and consumed hybrid rice reported inferior grain quality compared to the popular inbred rice in terms of cooking, storage quality, and greater stickiness of cooked rice. Nearly 66% of the sample farmers felt that hybrid rice has an unpleasant order after cooking. The survey found that the price of hybrid rice was 11% lower than the price of inbred varieties (Janaiah and Hossain, 2005).

Farmers' own perceptions (satisfaction and dissatisfaction) or their experiences with hybrid rice cultivation were elicited in the study. Nearly 84% of the sample farmers said that they would not continue cultivation of hybrid rice. About 10% of the sample farmers who were willing to continue cultivation said that they would do so with the expectation of getting new hybrids with better quality in the near future. Another 14% of the sample farmers felt that higher yield was the reason for continuing hybrid rice production. However, none of the farmers felt that hybrid rice grain was highly priced. Of the total sample, 11% (most of them in West Bengal) were in favour of continuing cultivating hybrid rice, whose grain they felt was suitable for parboiling. On the other hand, low output price, low consumer demand, unsuitability for domestic use, higher risks, non-availability of pure hybrid seed, and unstable yield were the major reasons for discontinuing cultivation of hybrid rice, according to about 80% of the total sample. In addition, formation of chaffy or sterile grain in the productive tillers (sometimes up to 40-50%) was also a constraint; it was the least important one. Poor grain quality was the major impediment to adoption of hybrid rice in India (Janaiah and Hossain, 2005).

The perception (satisfaction and dissatisfaction) of traders and millers with at least 10 years of experience further confirmed hybrid rice's inadequate demand in the grain market. About 90% of the respondents revealed that its grain quality was poor. Interestingly, about 93% of the traders and millers reported that head rice recovery (milling percentage) of hybrid rice was lower by 8-10% than that of popular inbred varieties. Traders were therefore reluctant to accept hybrid rice grain due to lack of demand from millers and consumers on account of poor grain quality. Thus it is very clear that most of the marketing constraints are related to problems with quality (Janaiah and Hossain, 2005).

The study discussed in previous paragraphs presented the farmers' dissatisfaction with hybrid rice, mainly on the basis of grain quality. But the study did not provide any scientific analysis of grain quality (physiochemical properties) for the involved rice hybrids in India. Moreover, the study highlighted farmers' negative perceptions about the performance of rice

hybrid. When a promising technology (crop variety) is not attractive to farmers, this reflects on the failure of scientists (plan breeders, agronomist, entomologist, etc) to work with farmers to address their concerns. However, the study did not formulate conclusions and recommendations for the involved scientific institutions to address recognized problems. Hence, one can wonder what the purpose of the study was. The relevant institutions have not addressed identified problems. Researchers should be thinking about what they can do for hybrid rice farmers in Asian countries like India and Bangladesh, where non-sticky rice with high productivity is crucial to the success of rice hybrids. It is also notable that every year a reasonable quantity of hybrid rice seed is smuggled to India from Bangladesh through Northeast to Southwest border districts, from Sylhet to Natore, during the boro season. This indicates that there is a demand for Chinese rice hybrids in India's West Bengal state. Similarly farmers' acceptability on hybrid rice in West Bengal also reported in the study of Janaiah *et al,* 2005. Seed exchange among the farmers of their acceptable crop varieties between the two neighboring countries is the common practice. Thus every year various acceptable crops seed (including rice, vegetables etc) is exchanged in several ways among the farmers in the boarder districts of India and Bangladesh. Accordingly, hybrid rice seed is smuggled to India from Bangladesh.

However, it could be concluded that higher grain yield advantage of hybrid rice over inbred rice is highly acceptable among the rice farmers in Bangladesh. When hybrid rice was first introduced, the grain price gap between hybrid and inbred rice was not visible in the market, at least not for Chinese hybrids. Relatively low grain price for hybrid vs. inbred rice has been reported from 2004-5, apparently due to stickiness of cooked rice from hybrids available in Bangladesh. At the same time, various corners disseminated rumors against hybrid rice, especially its grain quality, through electronic and mass media, encouraging dissatisfaction among farmers. But farmers in Bangladesh are found quite willing to continue hybrid rice cultivation with expected primarily higher yield and profit than inbred rice, mainly during the Boro season.

At the early stage of hybrid rice adoption in Bangladesh, the popular rice hybrids' amylose content was about 25%, a level at which rice chemists recognize the rice as non-glutinous, with intermediate (medium) amylose content (20-25%). In general, when amylose content in rice grain is 25% and above is called non-sticky rice. The amylose content of six rice hybrids (5 from China and 1 from BRRI) is provided in Table VII.1.

Table.VII.1: Comparison of physicochemical properties of six rice hybrids (2003-4 Boro)

Variety	Milling outturn (%)	Amylose (%)	Protein (%)	Cooking time (Min)
BRRI hybrid dhan 1	71.67	24.67	5.87	22.00
Sonarbangla-1	68.33	24.77	5.65	22.67
Jagoran 1	71.33	24.80	6.00	22.50
Hira	72.33	24.67	6.26	21.5
Aftab LP 50	71.00	24.30	6.26	21.00
Richer 101	70.00	24.70	5.42	22.83
Mean	**70.78**	**24.65**	**5.91**	**22.08**
CV (%)	**2.01**	**0.73**	**5.67**	**3.26**
SE	**0.58**	**0.07**	**0.14**	**0.29**

[1] *Analysis conducted at BRRI, Gazipur*
Source: Rashid, H. 2004

The percent milling outturn and head rice recovery of nine rice hybrids are found similar to one of the most popular inbred, BRRI dhan 29 (Tables.VII.1 & VII.2). But many scientists, extensionists, economists, and policy markers spread misleading "propaganda" about the bad physicochemical properties of hybrid rice in Bangladesh. On the other hand farmers have been interested to continue the cultivation of hybrid rice since 1998-99, with few setbacks during last more than 10 years. Motivated and satisfied farmers in Bangladesh grow a large number of rice hybrids (bold, slender, and long slender grains), mostly from China. From beginning of the adoption process, private seed companies and a prominent NGO (BRAC) have been working with farmers to extend hybrid rice.

Table VII.2: Comparison of physicochemical properties of 4 rice hybrids and BRRI dhan 29 (1998-99 Boro season, AAS)

Variety	Milling outturn (%)	Head rice (%)	Amaylose (%)	Protin (%)	Cooking time (Min)
Aalok	68.00	75.00	23.40	6.70	20.00
Amarsiri-1	67.00	74.00	21.90	6.70	19.00
Loknath	70.00	90.00	25.30	7.70	19.50
Sonarbangla-1	68.00	67.00	22.10	6.80	20.00
BRRI dhan 29	65.00	75.00	26.70	6.80	20.50
Mean	**67.60**	**76.20**	**23.88**	**6.94**	**19.80**
CV (%)	**2.69**	**11.03**	**8.71**	**6.16**	**2.88**
SE	**0.81**	**3.76**	**0.93**	**0.19**	**0.25**

1 Analysis conducted at BRRI, Gazipur

For the first time in 2009, BRRI's Rice Technology Division analyzed 99 seed samples of rice hybrids from the Seed Certifying Agency's (SCA) rice hybrid trials, pursuant to a decision of the 59th meeting of the technical committee of MOA's National Seed Board (NSB). From these 99 rice hybrids, 64 were found to have medium (intermediate) amylose content, 29 had low amylose content, and 6 had high amylose content. Thus only 6% of the hybrids undergoing SCA trials were found to have non-stick physicochemical properties, which is one of the important consumers' preferences in Bangladesh (Table VII.3).

The SCA conducts regional on-station and on-farm trials to assessing the performance of the candidate rice hybrids from seed marketing agencies. Based on the results of these trials, the NSB decides whether to allow a hybrid for commercial cultivation in the country. Since rice consumers in Bangladesh prefer non-sticky rice, NSB should arrange for all candidate hybrids to be tested for their physicochemical properties including amylose content before submitting seed for field trials. Such physiochemical tests will guide for selection of hybrids with grain quality acceptable to consumers in Bangladesh. In addition, NSB should also introduce genetic finger printing to identify released and proposed rice hybrids.

Table VII.3: Percent Amylose content of 99 seed samples of rice hybrids under 3 categories (BRRI, 2009)

Category (%Amylose)	Variety		Mean	CV (%)	SE	Remarks
	(Nr.)	%				
I. 15-19.9	29	29.29	17.51	11.27	0.37	Low Amylose
II. 20.24.9	64	64.65	21.6	5.34	0.14	Medium Amylose
III. $\geq$ 25	6	6.06	25.28	1.07	0.11	High Amylose
Total Average	**99**	**100.00**	**21.46**	**5.89**	**0.21**	-

Source: Rice Technology Division, BRRI

From their own experience, farmers and millers have developed ways to reduce stickiness of cooked hybrid rice. They found that storing unhusked paddy and clean rice for at least two months reduces stickiness after cooking. They also claim that parboiling hybrid rice 1-2 times improves its quality and taste. But the scientific community has not recognized and validated farmers' innovations to improve of cooked hybrid rice.

At the early stage of hybrid rice adoption, bold grain hybrid rice was introduced, and later hybrids with slender/long slender grain were introduced. Both bold and long slender/slender hybrids are appreciated. There are some pockets where grain preference is specific either for bold or long slender as per the consumer tastes as well as demand from the millers. Such rice grain size preference consumer tastes are very much location specific all over the country. In general bold grain hybrid rice variety yield is higher than long slender/slender hybrids. In some cases, higher sterility and shattering is reported with long slender hybrids from China. In general, F_1 seed yield is lower with long slender/slender hybrids compared to bold hybrids. Poor synchronization of flowering of A & R lines is found with long slender hybrids, both in Bangladesh as well as in China.

In Bangladesh all categories of farmers grow hybrid rice mainly in Boro season. In general selling of hybrid rice (both unhusked and clean rice) is not difficult. But traders and millers offer a lower price for hybrid paddy than for inbred paddy. Compared to marginal and small farmers, large farmers have better access to public sector procurement by the Department of Food. Thus large farmers are more interested to grow hybrid rice with higher yield gain. Large farmers' decision to produce hybrid entirely depends on higher relative profitability of hybrid over inbred rice. Moreover, large farmers store paddy for a longer time (> 5 months) before selling, which gives them a better price and profit. Paddy traders often go first for bold rice. Farmers with long slender paddy expect higher prices, and are able to wait.

DAE extension staff have reported farmers' complaints about hybrid rice, including: (i) Hybrid F_2 grain can't be used as seed; (ii) High infestation and infection of pests and diseases; (iii) Lack of knowledge on hybrid rice cultural practices; (iv) Production cost with hybrid rice is high; (v) Low grain price of hybrid rice; (vi) High price of hybrid rice seed; (vii) Comparative low grain quality of hybrid rice vs. inbred rice; (viii) Cooking quality of hybrid rice grain is bad; (ix) High un-filled grain; (x) More susceptibility of hybrid rice to climatic stress than inbred rice and (xi) Low tolerance to water-logging. These are the common

general expressions, responses, and reactions from farmers since the introduction of hybrid rice in 1998-99.

In 2007-8 the grain price (paddy and rice) was very high. With high prices, profitability of rice production was found incredibly high for all types of rice, and in specific for hybrid rice. Farmers' satisfaction was high for rice production in general and, in particular, for hybrid rice Thus, the highest acreage of hybrid rice was about 1.0 million ha during 2007-8 Boro season. This area was achieved due to farmers' satisfaction with hybrid rice cultivation along with DAE's and MOA's drive to promote hybrid rice cultivation. However, during boro season 2007-08, there were out-breaks of bacterial diseases (bacterial leaf blight and bacterial leaf streak). The highest infection was found with hybrid followed in order by inbred and local varieties of rice.

The bacterial diseases outbreak during 2007-8 Boro season was due to several reasons, including storm, unbalanced use of fertilizers (eg high nitrogen and low potassium), and favorable weather conditions for infection. But crop scientists and others blamed hybrid rice for these bacterial diseases outbreaks. However, a clear view of the matter points to other causes. For example, there was no bacterial diseases incidence on rice in Natore district, because farmers in Natore district are accustomed to using balanced fertilizers with extra top-dressing of potassium fertilizer (MOP at the later stage of the crop growth); and there was no storm in Natore district during the 2007-8 Boro season. Also, there was very high incidence of bacterial diseases on rice in Jhenaidah district, because farmers used too much urea with no or minimum use of potassium fertilizer (MOP); and there were strong storms. In subsequent seasons, there has been no news report or complaint about bacterial diseases on the rice crop. This is might be due to weather conditions. But "propaganda" has continued against hybrid rice for spreading bacterial diseases. Moreover, the rice price fell from November/December 2008 to a much lower price in after harvesting of 2008-9 Boro crop. As a result, the hybrid acreage decreased.

Overall farmers in Bangladesh are reasonably satisfied with higher productivity and profitability for hybrid vs inbred rice. But farmers are in general dissatisfied on the grain quality, especially low Amylose content. Rice breeders in Bangladesh and in other countries (China, India, etc) should develop rice hybrids with acceptable grain quality with at lest 20% higher productivity (heterosis). Bangladeshi farmers will be grateful to the breeders after receiving acceptable rice hybrids for commercial cultivation during boro and T. Aman seasons.

VIII. Mechanisms for disseminating and marketing of rice hybrids

Compatible extension service providers, effective extension approaches and appropriate uptake pathways are integral components of any extension service system for dissemination of potential technology (Rashid, H.2007). Adopting a new variety or hybrid in a market economy is basically an economic decision by a farmer as empirically proved by the pioneering work of Griliches (1957) on the adoption of hybrid corn in the USA. However, product value and farm operating surplus are the major factors determining the reallocation of rice land from prevalent varieties to new ones (e.g. hybrid rice). Thus, three basic factors-yield gain, additional input cost (if any), and higher and lower market price of the produce-determine the profitability of a new variety/hybrid over an existing one (Janaiah and Hossain, 2005). The relative profitability of a new variety/hybrid is one of the decision making issue for farmers' acceptability for the same. In Bangladesh hybrid rice has been disseminating among the farmers through public, private organizations and NGOs, those who are engaged in seed business. Internationally recognized, both formal and informal seed systems are prevailed in Bangladesh. But hybrid rice technology has been disseminating and selling through formal seed system with private sector, public sector (BRRI, BADC) and NGOs in the country. Beside DAE, among the involved extension service providers, private sector seed companies and NGOs are "*playing major roles in dissemination of hybrid rice"* than public sector (BADC, BRRI) using various effective extension approaches/methods. Several private seed companies have already invested reasonable amount of fund for various promotional activities for introduction of rice hybrids, as they called it as "sale promotion for the product" which is the integral components for the products markets. Accordingly, hybrid rice acreage has increased from 23,700 ha to 1000000 ha during 1998 to 2010 in the country.

Private seed companies and NGO (BRAC) are the major agencies in hybrid rice seed marketing and BADC is the only agency from public sector for marketing hybrid rice seed in the country. Hybrid rice seed marketing agencies have been using various seed marketing approaches and strategies in collaboration with their appointed dealers and retailers from late 1990s. Currently more than 1000 marketing staffs are engaged directly and indirectly for selling target at least about 10000 MT hybrid rice seed per year. Currently the highest market share is estimated for Supreme Seed (31.45%) followed by BRAC (18.02%), Lalteer (13.68%), Aftab (7.38%), Mollika seed (6.88%), others sellers (5.82%), EAL (5.61%), ACI (3.61%), United (2.97%), Ispahani (2.59%) and Metal (1.98%).

Dissemination of hybrid rice technology

Hybrid rice technology has been disseminating in Bangladesh from late 1990s through participation of various relevant agencies and using various sustainable extension approaches and methods.

Disseminating agencies' role and responsibilities: In dissemination of hybrid rice in Bangladesh various actors and players have been playing vital roles in Bangladesh since mid 1990s. Participating actors are private seed companies, NGOs, BRRI, DAE, BADC, seed dealers (including agents and retailers), media, innovative farmers, international organizations (IRRI, FAO, ADB), overseas seed companies (China, India, Philippines) etc. Major actors have been playing vital role in dissemination of hybrid rice technology in Bangladesh from late 1990s through using various approaches, methods and materials. Major approaches, methods and materials are explained below:

Field demonstration on hybrid rice: Both involved public and private agencies are engaged in dissemination of hybrid rice technology through demonstration at field. But public sector agencies (DAE, BRRI, BADC etc) conduct field demonstration on hybrid rice technology through conventional approaches, such as providing all inputs (Seed, fertilizers, pesticides etc) with their existing lead farmers in the community. On the other hand private seed companies conduct field demonstration on hybrid rice through distribution of hybrid rice seed only among the farmers in general and innovative farmers in particular, considering them as community based seed selling agents with incentive in collaboration with their appointed dealers. Such field demonstration of private sector is found very much cost-effective than conventional field demonstration. During early stage of hybrid rice introduction in the country, a case study was conducted on hybrid rice introduction and dissemination through an innovative farmer (Kabir and Rashid, 2004) is provided in the following Box:2.

Gabinda Chandra Hira, a small farmer, holding 2.5 acres of land of Silna village, under Ragunathpur union of Gopalganj Sadar Upazila, first heard about hybrid in 2001/2. He was too curious to see the performance of hybrids and purchased 2 kg seeds from a local seed shop (Bishnu Podo Biswas, M/S Anik Traders) at Gopalganj town. With this amount in 2001he planted 32 decimals of land. After harvest, when he measured the yields of his plot, he could not believe his own eyes. It was 42 mounds, more than double of his usual harvest. Next year in 2002/3, he bought 300 kg seeds of the same variety, and planted 2 acres. The rest of the seeds he sold to other farmers. Being they noticed his yields, it was very easy for him to sell the seeds. He made 10 taka margin from a kilo of seed, plus he was able to harvest 218 mounds of rice from his two acres of land. The new money changed his life style. He built a new house and at the same time became a small seed dealer. This year he sold 1,500 kg seeds and was able to profit around 15,000 taka from the sale. He planted 2 acres hybrid too, and is expecting similar yields as harvested previously.

Dealers Gobinda and his wife with their new house

Training: Training on hybrid rice technology for staff and farmers have been conducting by public and private sectors since inception of hybrid rice technology from late 1990s in the country. In this regards public sector role is more prominent than private sector seed companies and NGO.

Field days and farmers' gathering: Public and private sectors' actors including NGOs have been conducting field days and farmers gathering as farmers' motivational activities for large scale dissemination of hybrid rice technology among the motivated farmers since inception of hybrid technology from late 1990s. In case of private seed companies conduct field days using cost-effective strategy in collaboration with dealers and retailers. Usually involved dealers and retailers are arranged field days in consultation with staff of private seed company. Accordingly, such cost-effective field days are conducted on demand driven basis of the involved dealers and retailers. Thus, such farmers' motivational activities for hybrid rice technology are found more cost-effective than traditional motivational activities conducted by public sector.

Media coverage: Media coverage with electronic media and printing media has been playing significant role through motivation of all section of peoples including farmers for dissemination of hybrid rice technology in the country from beginning of introduction of hybrid rice technology. But electronic media and printing media are expensive for promoting a product. Thus, several private seed companies invested reasonable fund for hybrid rice technology promotion and dissemination in the country.

Hybrid rice technology materials: BRRI has developed materials on hybrid rice technology as leaflet, booklets etc for distribution among the relevant organizations and farmers. Similarly several private seed companies prepared and distributed such hybrid rice technology materials and other relevant materials among the farmers.

Uptake pathways: Extension service providers, extension approaches and uptake pathways are integral components of any extension service system in general and agricultural technology (eg. hybrid rice technology) transfer in particular. Government, NGOs and other service providers have sometimes, in the past, show little concern or curiosity about the particular uptake pathways that are most likely to lead to widespread adoption of the selected technologies. It is essential to assess the farmers' prevailing sentiment about preferred uptake pathways in order to better understanding their inclination to incorporate new and improved approaches and technology into their farming system. Accordingly, an effective extension system, in Bangladesh context, must be demand-led and the uptake pathway must reflect the farmers' sentiments. Thus, hybrid rice technology disseminated at reasonable level in Bangladesh due to use of appropriate extension approaches by the involved service providers from public and private/NGO sectors with fruitful uptake pathways on the basis of farmers' sentiments. Hybrid rice technology dissemination through farmers' accepted uptake pathways with Energypac Agro Ltd. (EAL) is provided in Figure.VIII.1.

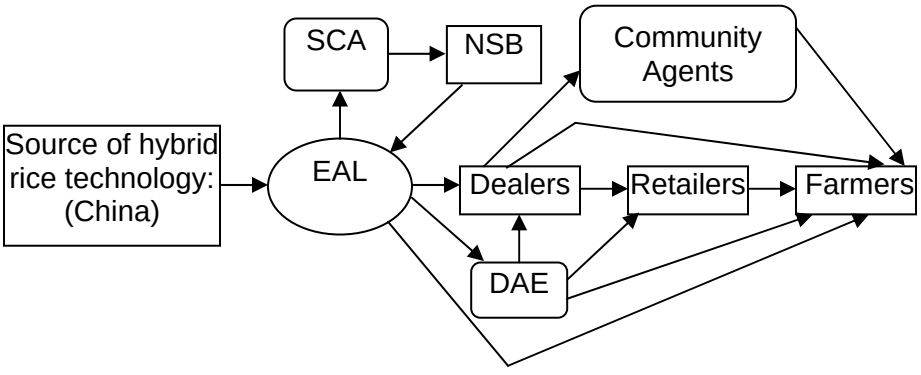


Figure.VIII.1: Hybrid rice technology uptake pathways for EAL

Hybrid rice dissemination scenario

Acreage category-wise hybrid rice dissemination in 64 districts during 2007-8 and 2008-9 Boro seasons in the country is presented in figure.VIII.2, 3 & 4 and Annex. VIII. 4 & 5.

Lowest acreage of hybrid rice was reported in Munsiganj and Barguna districts during 2007-8 and 2008-9 Boro seasons respectively. On the other hand, the highest acreage of hybrid rice was reported in Rangpur and Bogra district during 2007-8 and 2008-9 Boro season respectively. The highest number of districts was reported under 1001-5000 ha acreage category of hybrid rice (18) followed by 10001-20000 ha acreage category of hybrid rice (17), 20001-40000 has acreage category (13), 5001-10000 ha acreage category (9), 101-1000 ha acreage category (4), 50-100 ha acreage category (2) and 40001-60000 ha acreage category (1) during 2007-8 Boro season. Similarly, the highest number of districts was reported under 1001-5000 & 10001-20000 ha acreage of hybrid rice (16) followed by 20001-40000 ha acreage (13), 5001-10000 ha acreage (10), 101-1000 ha acreage (5) and 50-100 & 40000-60000 ha acreage (2) during 2008-9 Boro season. Such hybrid rice scale-up differences is estimated very minimum between 2007-8 and 2008-9 Boro seasons (Figure.VIII.2 and Annex.VIII.4 & 5).

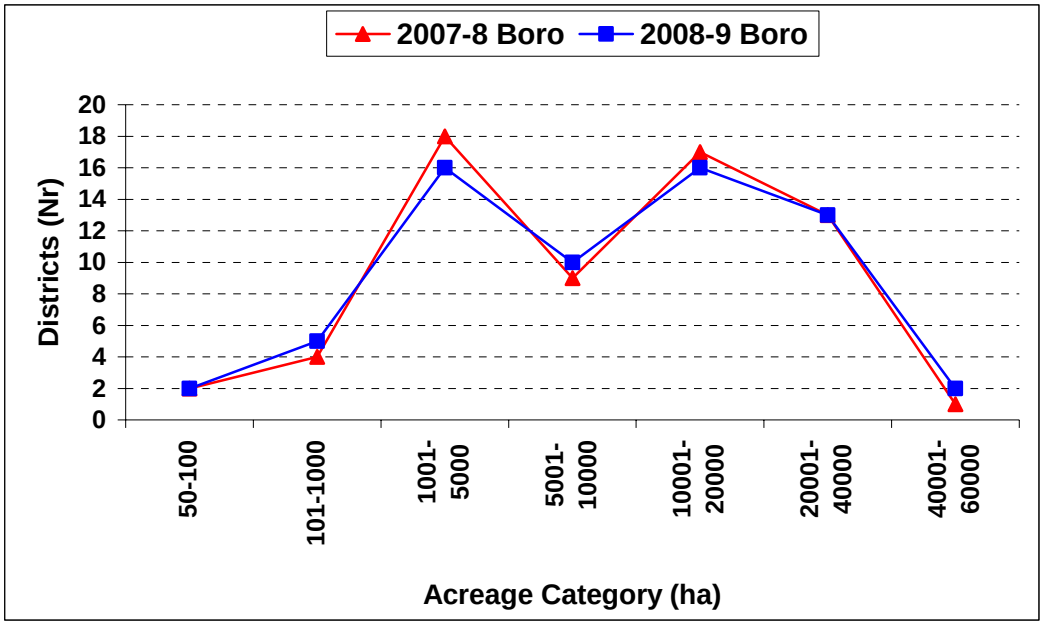


Figure.VIII.2: Acreage category-wise district coverage (Nr) during 2007-8 and 2008-9 Boro seasons (DAE)

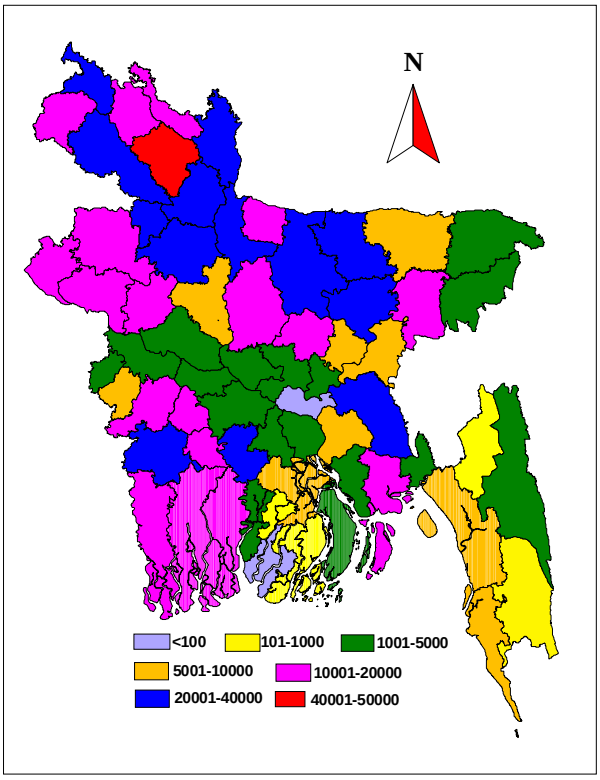


Figure.VIII.3: Acreage category-wise districts, 2007-8 (DAE)

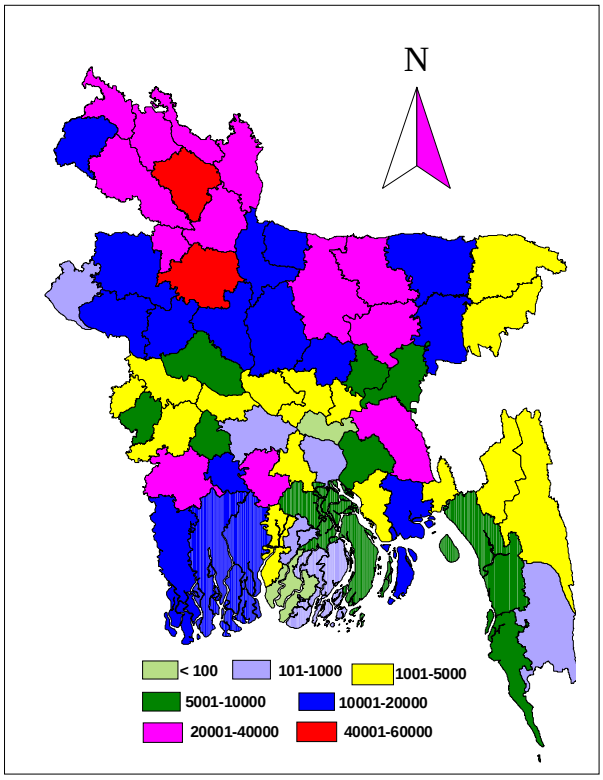


Figure.VIII.4: Acreage category-wise districts, 2008-9 (DAE)

Hybrid rice seed marketing

Private seed companies and NGO (BRAC) are the major agencies in hybrid rice seed marketing and BADC is the only agency from public sector for marketing hybrid rice seed in the country. Hybrid rice seed marketing agencies have been using various seed marketing approaches and strategies from late 1990s. Major approaches and strategies for hybrid rice seed marketing are described below:

Dealers and retailers network: Each seed selling private seed company/NGO has established its own seed dealers/retailers network for marketing the seed throughout the country. BADC has its own appointed seed dealers all over the country since long time. Accordingly, private seed companies, NGOs and BADC have been selling hybrid rice seed form late 1990s through their established dealers' network in the country. Initially BRAC has tried through the members of credit groups for selling seed in general and hybrid rice in particular. After one season BRAC has started selling hybrid rice seed through using the existing its own seed dealers' network in the country.

Dealers and retailers capacity building: Private seed companies have undertaken various initiatives to develop capacity of seed dealers and retailers for selling hybrid rice seed during last more than 10 years and initiatives are: (i) Seasonal dealers conference; (ii) Conducting motivational training for retailers; and (iii) Motivational meeting for dealers and retailers.

Hybrid rice seed promotion: Hybrid rice technology dissemination approaches and strategies unexpectedly promoted hybrid rice seed marketing in the country. Moreover, private seed companies also undertaken various hybrid rice seed marketing initiatives such as (i) distribution of promotional materials (Leaflet, booklet, posters, banner, festoon etc), (ii) special promotional item (Pen, bag, cap, umbrella etc), (iii) Arranging mini film show, folk songs on hybrid rice etc.

Agreement and seed supply: Each seed company sign an agreement with specified MOU with the selected/appointed seed dealers before delivering seed. Each seed company prepare hybrid rice seed selling plan few months advance of seed selling time for the rice cropping season, mainly for Boro season through collection of seed demand from individual appointed seed dealers of the network. As per agreement and demand, seed companies supply seed to their appointed dealers during seed selling season.

As per agreement, appointed dealers received commission on hybrid rice seed sale and incentive on the basis of sale performance during and end of the season. Seed company also support for seasonal man-power on the basis of seed sale target volume.

Hybrid seed packaging: From beginning private seed company use 1 Kg colorful posh packet for hybrid rice seed marketing. Quality of seed packet is also found attractive among the end user (farmers) beginning from hybrid rice seed marketing in Bangladesh.

Marketing staff: Each seed selling private seed company has reasonable marketing staff for selling hybrid rice seed. Such staffs are also responsible for selling other products of the company including various crop seed. Energy pack Agro Ltd (EAL) has 34 marketing staff for selling hybrid rice seed with target about 650 MT during 2010-11 cropping seasons. They are also responsible for selling other seed products of the company. More than 1000 marketing staffs are engaged directly and indirectly for selling about 10000 MT hybrid rice seed per year.

Hybrid rice seed marketing: There are globally recognized two seed systems, such as (i) formal and informal seed system in Bangladesh. In the formal seed system, Breeder Seed (BS), Foundation Seed (FS), Certified Seed (CS) and Truthfully Labelled Seed (TLS) are marketed by registered seed dealers of the Seed Wing, MOA by maintaining seed quality, labeling and packaging instructions and standard as fixed by the NSB. Since there is no approved policy, Rules and Act for hybrid rice seed classification like inbred rice seed, the F_1 rice hybrid seed has been selling as TLS by declaring its quality standards by the respective agency. In this regards Chinese hybrid rice seed standard may be taken into consideration for formulating seed standard on hybrid rice seed in Bangladesh (Annex.VIII.1& 2).

Market share: As per informal market analysis of A. Mannan, Marketing Manager, Getco (a hybrid rice seed selling company), market share of the total volume of hybrid rice seed is estimated (Figure.VIII.5 & Annex.VIII.3). On the basis of cumulative total hybrid rice seed sale during 2007-10, the highest market share is estimated for Supreme Seed (31.45%) followed by BRAC (18.02%), Lalteer (13.68%), Aftab (7.38%), Mollika seed (6.88%), others sellers (5.82%), EAL (5.61%), ACI (3.61%), United (2.97%), Ispahani (2.59%) for 2 years and Metal (1.98%). More or less similar trends of market share are estimated for individual year during 2007-8 to 2009-10.

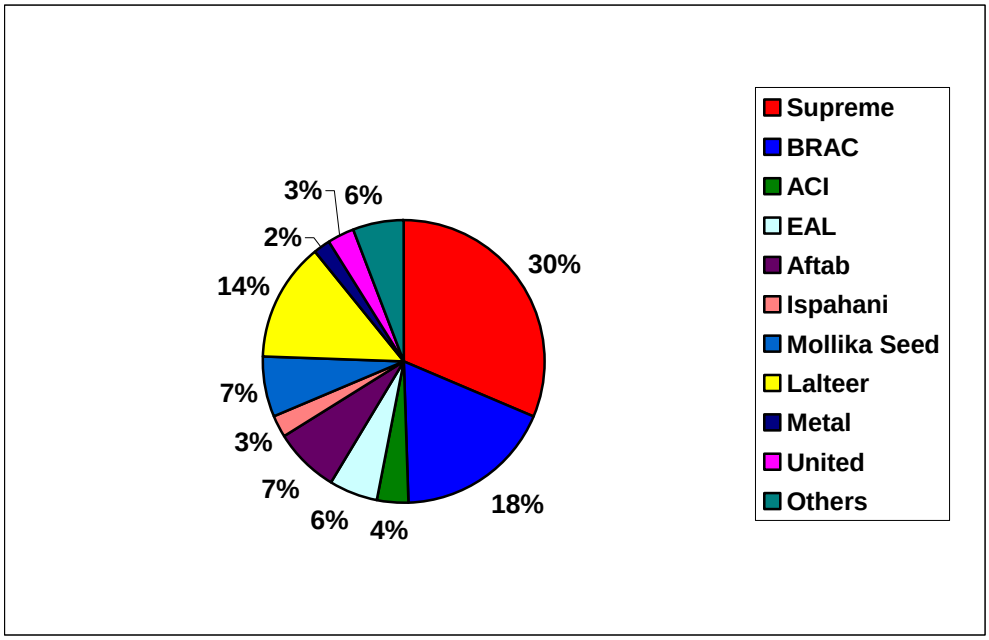


Figure.VIII.5: Market share of hybrid rice seed during 2007-10

Promotional discounts on inputs

There is no promotional discount on inputs for importing parent line seeds and other special chemical inputs like GA_3, local inputs like fertilizers, pesticides, and irrigation. The government is allowing subsidy on fertilizers and irrigation for all agricultural crops but no such subsidy is earmarked specifically for hybrid rice seed production or commercial cultivation of hybrid rice in the country. In this regards the Government of China, Vietnam and other countries providing especial incentive for local production of hybrid rice seed as well as commercial cultivation of hybrid rice. The incentives are providing by the Government of China, Vietnam and other countries with a view to popularizing hybrid rice to increase rice production for food security of the country.

Bangladeshi small farmers should get a more level playing field to access markets and credit for hybrid rice. The success of green revolution through development of HYVs/Modern varieties alone could not have provided to boost in rice production but it was a combination of success factors that included the Government's decision to support its rice farmers by providing fertilizer subsidy, price support and a ready market, in addition to irrigation, rural road communication and machinery and equipments. The similar types of subsidy/incentive being provided by the Government of China, Vietnam and other countries should be provided by the Government of Bangladesh for encouraging large-scale production of F_1 seed and increasing acreage under hybrid rice for the greater interest of food security of the country.

Support from cooperative societies and community organizations

Currently, in general cooperative societies are not playing any role in agricultural development in the country. But in past, cooperative societies under the direct supervision with Bangladesh rural development board (BRDB) used to play vital role in Deep Tube Well (DTW) management as Krishok Samobay Samity (KSS). Such DTW management was an artificial arrangement and finally they failed to manage the DTW. As a result government was decided to hand over/sell-out DTW, accordingly such decision was implemented from 1989. Cooperative societies are playing positive role in seed production and commercial production of hybrid rice in Vietnam. Unlikely in Vietnam, cooperative societies are not playing any role in seed production and commercial production of hybrid rice in Bangladesh. But community based organizations (CBO) are actively working with relevant public sector organizations (eg DAE), NGO and to some extend private seed companies. Sometimes, CBOs may be played important role in disseminating hybrid rice technology through supporting hybrid rice demonstration and commercial hybrid rice production at community. Such CBOs can be used in dissemination of hybrid rice on incentive basis approach and strategy. Even private seed company may work with such CBOs on incentive basis for hybrid rice seed production as well as selling seed for commercial production at community.

IX. Sources and supply of rice hybrids seed

From 1998-99 to 2009-10 a total of 85 rice hybrids have been released and notified for commercial cultivation and seed production in Bangladesh. Out of 77 imported rice hybrids, 66, 10, 8 and 1 from China, India and Philippines respectively. Out of total 85 released rice hybrids, of which 80 come from the private sector / NGO, and 5 from the public sector (4 from BRRI and one from BADC) for seed production and marketing in the country. Out of 85 rice hybrids, 83 hybrids released for Boro season (98%) and 2 hybrids released for Transplant Aman season. There are different types of rice hybrids according to grain size and bold varieties are dominating in hybrid rice acreage due to their yield potentiality in the list of released rice hybrids in the country.

Three categories of organizations such as public, private and NGO are involved in rice hybrids seed production and marketing. In this regards, private seed companies and NGOs have been playing important role in rice hybrids seed import, local F_1 seed production and supply of hybrid rice seed among the farmers through their established seed dealers' network in the country. Supply of hybrid rice seed increased about 2092% from 1998-99 to 2008-9 with average annual compound growth rate of 36% in Bangladesh. Subsequently, hybrid rice seed supply decreased its peak in 2008-9 by 32% in 2009-10.

According to Seed Wing, MOA, supply of total inbred rice seed from formal seed system increased about 510% from 2001-2 to 2009-10 with average annual compound growth rate of 25.36% and on the other hand estimated supply of inbred rice seed from formal seed system increased about 282% from 2001-2 to 2009-10 with average annual compound growth rate of 18.23% in the country. Incase of inbred rice seed supply, public sector (BADC) supplied maximum seed (from 90%-97%) of the total inbred seed supply and private sector supplied maximum hybrid rice seed (from 88% to 100%) of the total hybrid rice seed supply during 2001-2 to 2009-10

Overall average price as maximum retail price (MRP) of F_1 hybrid rice seed is estimated about Tk. 237/Kg during 2010-11 Boro season. Average Tk. 230/Kg (range Tk. 140-260/Kg) and Tk. 244/Kg (range Tk. 175-275/Kg) is estimated for bold grain and slender grain of hybrid rice seed during 2010-11 Boro season respectively. It appears from different private sector hybrid rice seed importers, the import price of hybrid rice F_1 seed varies from US $ 2.25-2.35 (Coarse grain) and US $ 2.40-2.60 (Slender grain). As per information of different public and private agencies the import price for parent lines reported, such as A-line US$ 7-20 per Kg, R-line US $ 2.5-5 per Kg. . Overall average price (MRP) of inbred rice seed is estimated about Tk. 48/Kg during 2010-11 cropping season. The highest price of inbred rice seed is estimated for foundation seed with 2 Kg plastic packet (Tk. 53/Kg) during 2010-11 Boro season. Overall foundation seed cost is estimated about 17% higher than other classes of seed. In general price difference between seed classes is estimated at minimum.

The successful commercialization of the hybrid rice production in Bangladesh needs to link with quality rice seed supply chain including hybrid rice seed production system development in the country. Both importing and in-country production of hybrid rice seed are equally important in the current seed supply chain. There are two sources of hybrid rice seed supply, they are imported seed (China & India) and in country production with various organizations (Public, Private and NGO) through using parental lines (A & R lines) of which maximum imported from overseas country and little from in country source. Maximum F_1

seed is supplied by the private sector seed companies/NGO and minimum from public sector (BADC). Major seed supply chain (pathway) for delivering hybrid rice seed among the farmers is through appointed dealers and their retailers of the seed marketing agencies in the country. However, major hybrid rice seed selling is found through large number of experienced seed dealers, which are the major players of the chain of hybrid rice seed supply all over the country.

Country-wise source of rice hybrids

From 1998-99 to 2009-10 a total of 85 rice hybrids have been released and notified for commercial cultivation and seed production in Bangladesh. Out of 77 imported rice hybrids, 66 (77.65%), 10 (11.76%), 8 (9.41%) and 1(1.18%) from China, India and Philippines respectively (Table.IX.1 & Annex.IX.1)

Table.IX.1: Country origin-wise and seed supplier-wise number of released rice hybrids during 1998-2010

Country origin	Rice hybrid released					
	All Supplier		Private & NGO		Public	
	Nr.	%	Nr.	%	Nr.	%
China	66	77.65	66	77.65	-	-
India	10	11.76	10	11.76	-	-
Philippines	1	1.18	-	-	1	1.18
Bangladesh	8	9.41	4[a]	4.71	4[b]	4.71
Total	**85**	**100**	**80**	**94.12**	**5**	**5.88**

[a/] Out of 4 rice hybrids, one private seed company developed 2 hybrids and one NGO developed 2 hybrids.

[b/] 4 rice hybrids developed by public sector research institute (BRRI)

Organizations and rice hybrids

Out of total 85 released rice hybrids, of which 80 come from the private sector / NGO, and 5 from the public sector (4 from BRRI and one from BADC) for seed production and marketing in the country. Total 80 rice hybrids released for private seed companies and NGOs, of which 66, 10 and 4 from China, India and Bangladesh respectively (Table.IX.1). Similarly 5 rice hybrids released from public organizations, of which 4 from BRRI from Bangladesh and 1 for BADC from Philippines. Irrespective of the country origin of rice hybrids, the highest number of hybrids were released with private seed companies (73) followed by NGOs (7), BRRI (4) and BADC (1). Three categories of organizations such as public, private and NGO are involved in rice hybrids seed production and marketing. In this regards, private seed companies and NGOs have been playing important role in rice hybrids introduction, enhancing the process of rice hybrid release, stimulating the relevant policy makers, seed import, local F_1 seed production and supply of hybrid rice seed among the farmers through their established seed dealers' network in the country. BRRI, a public sector rice research institute has developed 4 rice hybrids for seed production (Parent lines & F_1 seed) and

marketing in the country. Besides, BRRI's developed 4 rice hybrids, BADC has introduced SL-8H rice hybrid (a three-line hybrid has been selling as super hybrid rice) from Philippines, which has released and notified by the NSB in 2008. Organization type-wise number of released and notified rice hybrids is shown Table.IX.2 & Annex.IX.2.

Table.IX.2: Organization type-wise number of rice hybrids released from 1998-2010

Organization			Rice hybrids released	
Name/Type	**Nr.**	**%**	**Nr.**	**%**
BRRI (Public Research Institute)	1	2.27	4	4.70
BADC (Public Corporation)	1	2.27	1	1.18
Private Seed Company	40	90.91	73	85.88
NGO	2	4.55	7	8.24
Total	**44**	**100**	**85**	**100**

Cropping season and rice hybrids

There are three main rice cropping seasons in Bangladesh, namely (i) Boro (Transplanting: December-February), (ii) Transplant Aman (Transplanting: July-August), and ((iii) Transplant Aus (Transplanting: March-April). Out of 85 rice hybrids, 83 hybrids released for Boro season (98%) and 2 hybrids released for Transplant Aman season. It is revealed that the yield in Boro season hybrids is much higher (8-10 t/ha) than T.Aman season of hybrid rice (6.5 t/ha). Out of 2 rice hybrids released in T. Aman season, one hybrid is developed by BRRI and another one is developed by a private sector Seed Company namely Supreme Seed Company Limited. No hybrid is released for Aus season in Bangladesh as of 2010.

Grain size and quality

There are different types of rice hybrids according to grain size, such as (i) Bold; (ii) Slender; (iii) Short bold; (iv) Long slender; (v) Medium slender; and (vi) Medium bold and bold varieties are dominating in hybrid rice acreage due to their yield potentiality in the list of released rice hybrids in the country.

In Bangladesh the major source of rice hybrids introduced from China. The Chinese hybrids are mainly bold, medium bold, short bold, slender rice and medium slender. But the hybrid rice from India is mainly slender, medium slender and long slender. The hybrid introduced from the Philippines is as like as Chinese slender rice hybrid. It was observed in the fields that yield performance of Chinese hybrids are comparatively better than India, but only one rice hybrid released from the Philippines source is performing better in the field as reported by BADC. The Philippines origin hybrid rice namely SL-8H has imported by public sector organization-Bangladesh Agricultural Development Corporation (BADC) under the Ministry of Agriculture. The hybrid developed by Bangladesh Rice Research Institute (BRRI) particularly BRRI hybrid dhan 2 & 3 is mainly short and medium bold and similar to Chinese rice hybrid. It is revealed from different sources that the dissemination of rice hybrid is facing difficulty and the most important reasons behind this is comparatively low amylose content, unfavorable taste in cooking rice and comparative low grain price. However, a total of 85

rice hybrids are available for commercial seed sale and seed production in Bangladesh. Most of these hybrids are sticky rice with amylose content less than 25% and most are also bold grain type.

Source-wise quantity of hybrid and inbred rice seed supply

Hybrid rice seed supply: Supply of hybrid rice seed increased about 2092% (from 590 MT to 12935 MT) from 1998-99 to 2008-9 with average annual compound growth rate of 36% in Bangladesh. Subsequently, hybrid seed supply decreased its peak in 2008-9 by 32% (from12935MT to 8752 MT) in 2009-10. Similarly, estimated use of hybrid rice seed increased about 3366% (from 350 MT to 12132 MT) from 1998-99 to 2007-8 with average annual compound growth rate of 48% in Bangladesh. Later on, use of hybrid rice seed decreased its peak in 2007-8 by about 3% (12132 MT to 11738 MT) in 2008-9, and by 34% (12132 MT to 8000 MT) in 2009-10. Rice hybrids seed availability (import and local production) and seed used during 1998-99 to 2009-10 are provided in Figure.IX.1 and Annex.IX.3

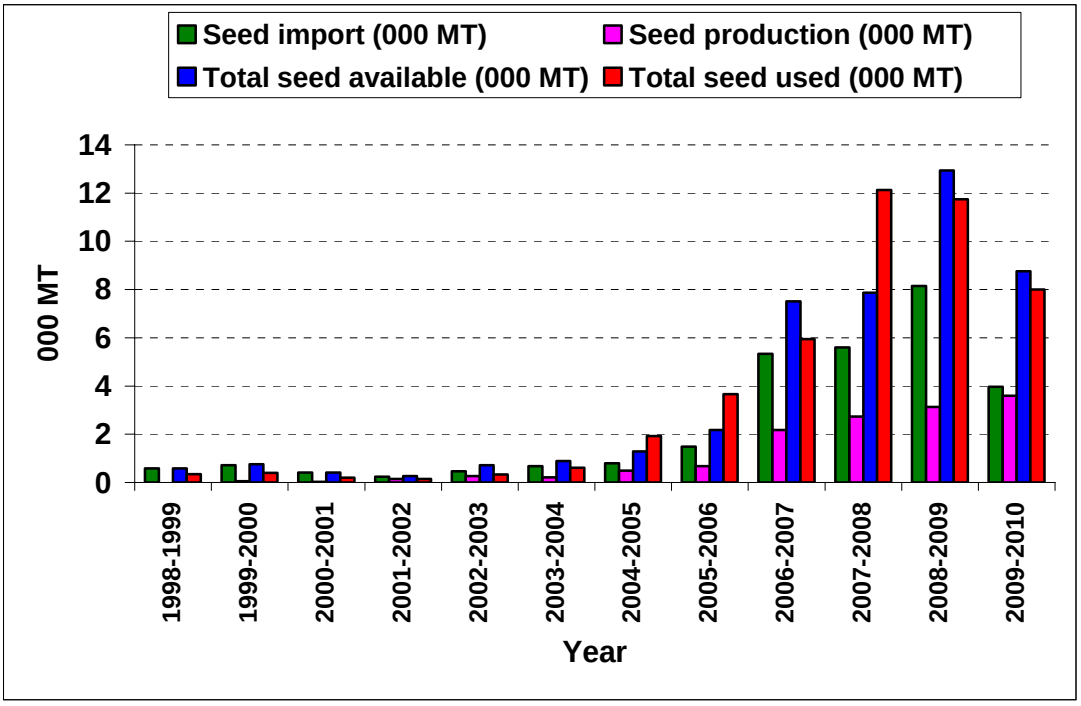


Figure.IX.1: Total seed import, Seed production, Seed availability & Seed used of rice hybrids during 1998-2010

Inbred rice seed supply

Supply of total inbred rice seed from formal seed system (data collected from Seed Wing, MOA) increased about 510% (from 16185 MT to 98686) from 2001-2 to 2009-10 with average annual compound growth rate of 25.36% in the country (Figure IX.2 & Annex.4).

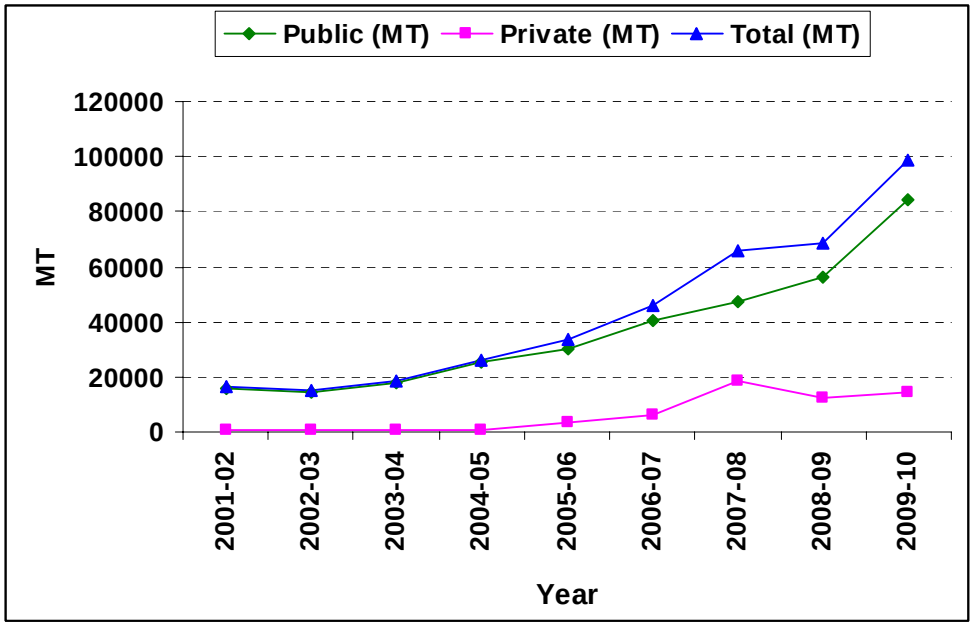


Figure.IX.2: Inbred rice seed supply from formal seed system, 2001-2010 (Seed Wing, MOA)

But the inbred seed supply data from private sector seed companies during 2005-6 to 2009-10 and public sector (BADC) during 2008-9 to 2009-10 was found as inflated. Accordingly, supply of inbred rice seed (Total, public and private) is present on the basis of data collected from marketing department of BADC and relevant private sector agencies (seed companies and NGOs) for better presentation on the inbred seed supply quantity during 2001-2 to 2009-10 of the country.

On the basis of estimated data, supply of inbred rice seed from formal seed system increased about 282% (from 16212 MT to 61878MT) from 2001-2 to 2009-10 with average annual compound growth rate of 18.23% in the country (Figure.IX.3 and Annex.IX.5).

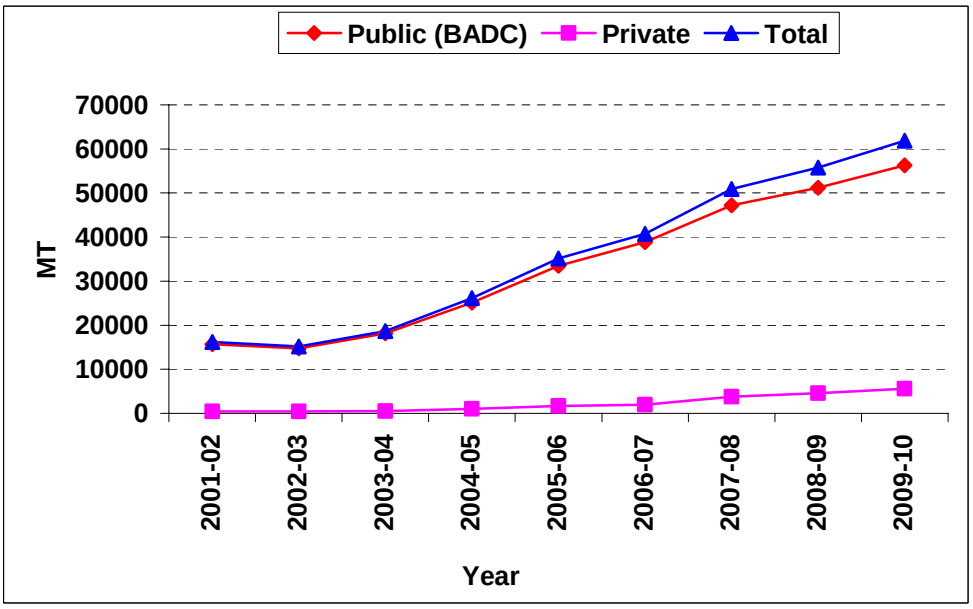


Figure.IX.3: Inbred rice seed supply from formal seed system, 2001-2010 (Estimated)

Comparative inbred and hybrid rice seed supply: Incase of inbred rice seed supply, public sector (BADC) supplied maximum seed (from 90%-97%) of the total inbred seed supply during 2001-2 to 2009-10. On the other hand, private sector supplied maximum hybrid rice seed (from 88% to 100%) of the total hybrid rice seed supply during 2001-2 to 2009-10 (Figures.4 & 5 and Annex. 4 & 5).

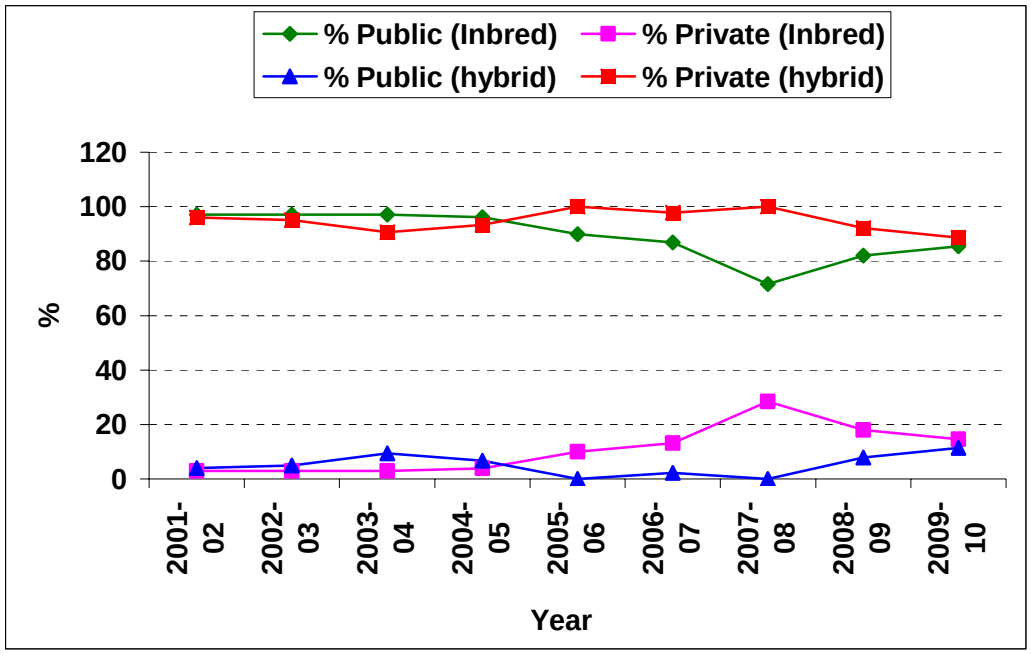


Figure.IX.4: Comparative seed supply proportion of inbred and hybrid from public and private sectors during 2001-2010 (Seed Wing, MOA)

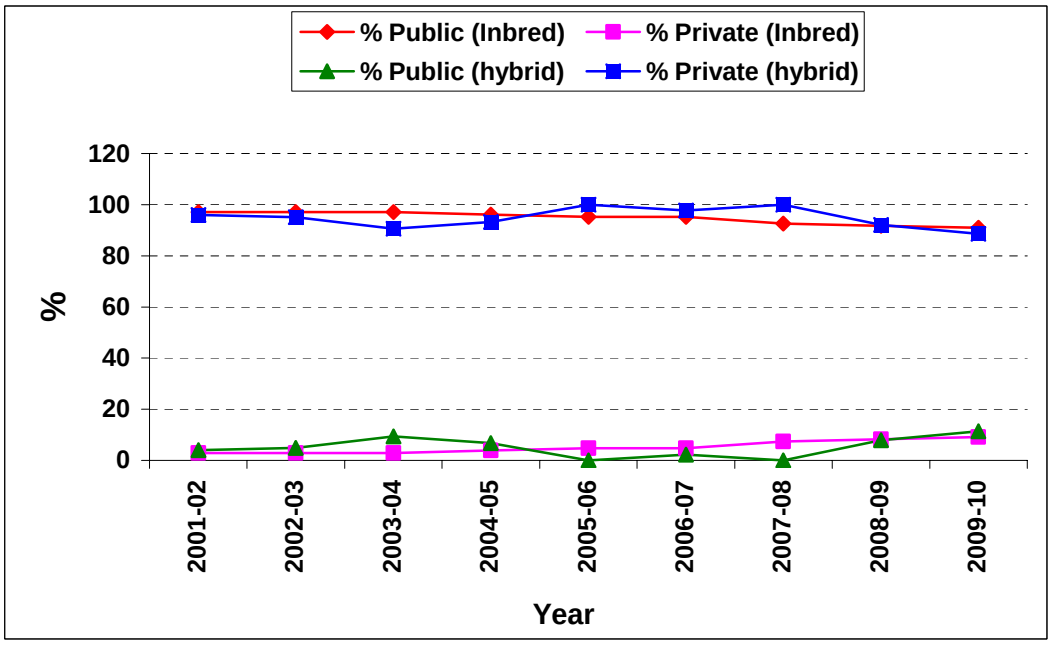


Figure.IX.5: Comparative seed supply proportion of inbred and hybrid from public and private sectors during 2001-2010 (Estimated)

Prices of hybrid rice seed

There are three categories of price for hybrid rice seed such as selling price (MRP) of F_1 seed, imported price of F_1 seed and parent lines seed (A & R lines) price for cultivation and F_1 seed production in Bangladesh.

F_1 hybrid rice seed selling price: Average price as maximum retail price (MRP) of F_1 hybrid rice seed is estimated about Tk. 237/Kg during 2010-11 Boro season. Average Tk. 230/Kg and Tk. 244/Kg is estimated for bold grain and slender grain of hybrid rice seed during 2010-11 Boro season respectively for public, private and NGO. Irrespective of seed sectors (public, private and NGO) the range of price for bold grain seed is estimated Tk. 140-260/Kg and Tk. 175-275/Kg for slender grain seed (Table.3 & Annex.IX.6).

Table.IX.3: Prices of rice hybrid seed during 2010-11 Boro season.

Grain type	Price (Tk./Kg)	
	Average	Range
Bold	230	140-260
Slender	244	175-275
Difference	14	-
% Difference	6	-

Import price of F_1 and parent lines of hybrid rice: The cost of imported F_1 hybrid rice seed is varied for grain size, country origin and mode of shipment. It appears from different private sector hybrid rice seed importers, the import price of hybrid rice F_1 seed varies from US $ 2.25-2.35 (Coarse grain) and US $ 2.40-2.60 (Slender grain). Import price of Sonarbangla F_1 hybrid rice seed of Mollika Seed Company (MSC) from 1998-99 to 2010-11 is provided in Figure.6 & Annex.IX.7.

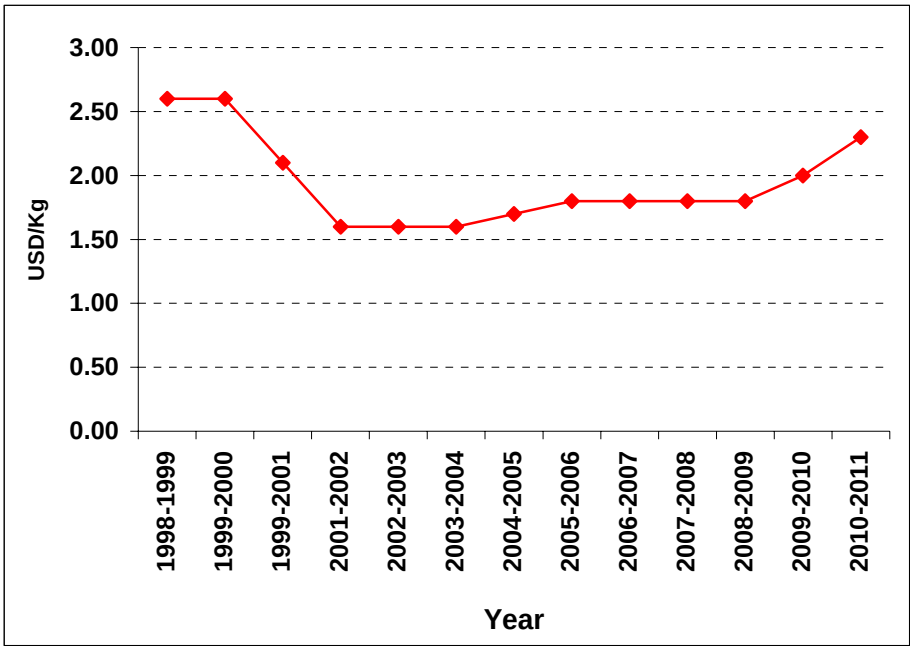


Figure.IX.6: Import price of Sonarbangla rice hybrid seed of MSC from 1998 to 2010

As per information of different public and private agencies the import price for parent lines and royalty reported, such as A-line US$ 7-20 per Kg, R-line US $ 2.5-5 per Kg and royalty from US$ 0.10 to 0.30 per Kg for F_1 seed production. Royalty is not applicable for all involved rice hybrid importers in Bangladesh.

Inbred rice seed price: Overall average price (MRP) of inbred rice seed is estimated about Tk. 48/Kg during 2010-11 cropping season. The highest price of inbred rice seed is estimated for foundation seed with 2 Kg plastic packet (Tk. 53/Kg) during 2010-11 Boro season. Overall foundation seed cost is estimated about 17% higher with 2 Kg poly bag than 10/12 Kg synthetic gunny bag. Price difference between seed classes is estimated at minimum (Table.IX.4 & Annex.IX.8).

Table.IX.4: Prices of inbred rice seed during 2010-11 cropping seasons

Season	Seed Class	Seed Price (Tk./Kg)		
		2 Kg Packet	10/12 Kg Packet	Overall
2010-11 Boro	FS	53	46	50
	CS/TLS	0	49	49
Average		53	48	50
2010 T.Aman	FS/CS	50	39	44
	TLS	0	37	37
Average		50	38	41
Average (Seasons)	FS	52	43	48
	TLS	0	43	43
Overall Average	-	52	43	48

Comparative price of hybrid and inbred rice seed: The price difference between hybrid and inbred rice seed is estimated about 404% (Tk. 190/Kg) during 2009-10. Such price difference between hybrid and inbred rice seed is estimated higher with public sector seed sellers (503%) than private sector seed sellers (398%). Incase of hybrid, 42% higher seed price (Tk. 74/Kg) is estimated for private sector seed sellers than public sector seed sellers. About 72% (Tk. 21/Kg) higher seed price is estimated for private sector seed sellers than public sector seed sellers with inbred rice seed (Table.IX.5).

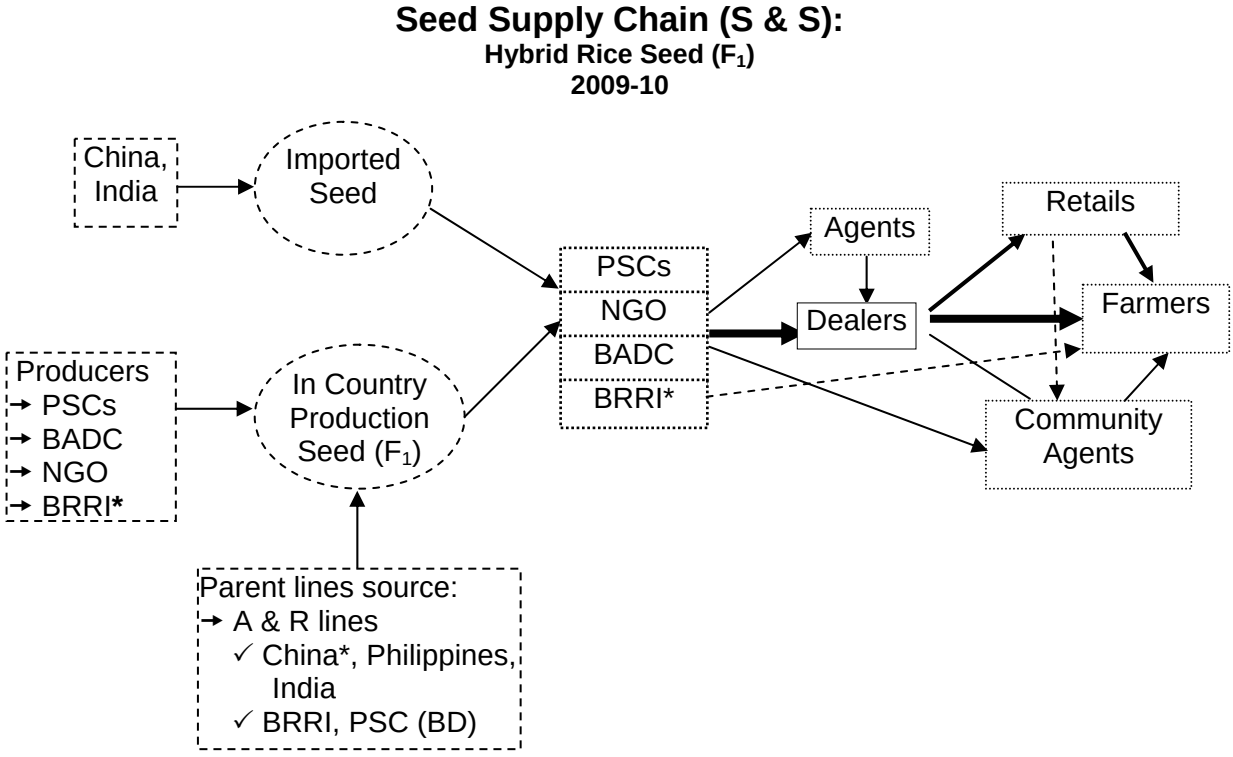
Table.IX.5: Comparative prices between hybrid and inbred rice seed during 2009-10

Seed type	Average Price (Tk/Kg)	Private & Public Sectors			
		Private (Tk/Kg)	Public Tk/Kg)	Diff	% Diff
Hybrid	237	249	175	74	42
Inbred	47	50	29	21	72
Difference	190	199	146	-	-
% Difference	404	398	503	-	-

Seed supply chain for hybrid rice

The successful commercialization of the hybrid rice production in Bangladesh needs to link with quality rice seed supply chain including hybrid rice seed production system development in the country. Both importing and in-country production of hybrid rice seed are equally important in the current seed supply chain.

The existing supply chain of rice hybrids seed (F_1) is divided into two parts, such as source of seed supply and seed supply pathway, which is called as S & S (source & supply) approach. There are two sources of hybrid rice seed supply, they are imported seed (China & India) and in country production with various organizations (Public, Private and NGO) through using parental lines (A & R lines) of which maximum from overseas country and little from in country source. Maximum F_1 seed is supplied by the private sector seed companies/NGO and minimum from public sector (BADC). However, hybrid rice seed marketing organizations have been selling their seed among the farmers through established seed dealers' marketing network since 1998-99 in the country. Major seed supply chain (Pathway) for delivering seed among the farmers is through appointed/agreed dealers and their retailers of the seed marketing agencies in the country. Sometimes, hybrid rice seed has been selling by the involved dealers/retailers through their trusted community agents. Few hybrid rice seed marketing organizations have been selling seed through their agents (Large whole sellers). However, major hybrid rice seed selling is found through large number of experienced seed dealers, which are the major players of the chain of hybrid rice seed supply all over the country. The existing model of seed supply chain (S & S) is provided below:



***Note: PSC** = Private seed company, **BADC** = Bangladesh Agricultural Development Corporation, **NGO** = Non-Govt. Organization, **BRRI** = Bangladesh Rice Research Institute*

Figure.IX.7: Seed supply chain (S & S) hybrid rice seed (F_1) during 2009-10

Rice seed replacement trends

Proportion of rice seed replacement (Total, Inbed & Hybrid) from formal seed system of the total national rice seed requirement is presented on the basis of seed wing, MOA data and estimated data during 2001-2010 of the country in Figures.IX.8 & 9 and Annex.IX.9. Total

rice seed replacement from formal seed system against total seed requirement (310000MT) is progressively increased for both cases of estimation from 2001-2002 to 2009-2010. Incase of seed wing data, rice seed replacement from formal seed system is progressively increased from 5.27% to 33.00% of the total national annual rice seed requirement during 2001-2 to 2009-10. Similarly, incase of estimation, rice seed replacement from formal seed system is progressively increased from 5.28% to 21.2% of the total national annual rice seed requirement during 2001-2 to 2009-10 (Figure.IX.8).

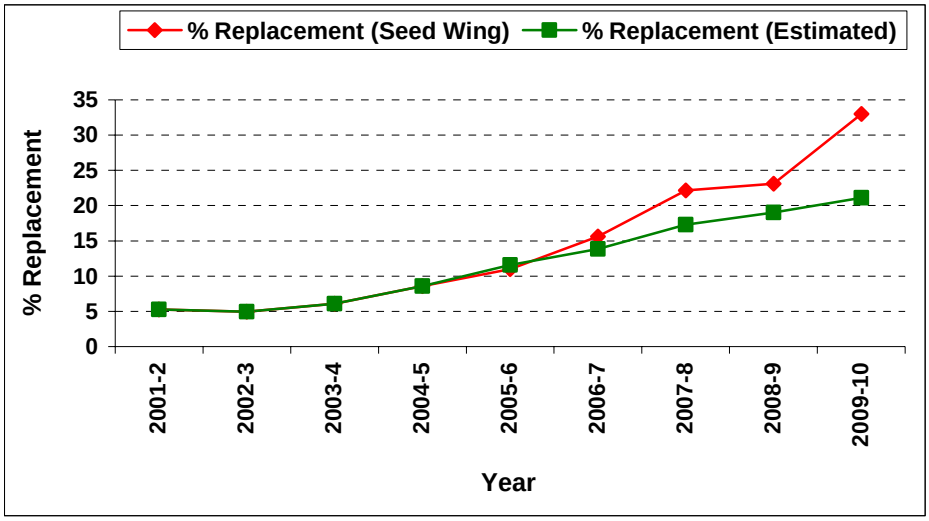


Figure.IX.8: Proportion of total rice seed replacement (Seed wing &Estimation data) of the total national rice seed requirement

Comparative proportion of seed replacement of inbred (Seed wing & Estimated) and hybrid rice seed from formal seed system of the total national rice seed requirement during 2001-2 to 2009-10 is presented in Figure.IX.9 & Annex.IX.9. Total replacement of inbred rice seed from formal seed system for both cases (Seed wing & estimated data) and hybrid is progressively increased from 2001-2 to 2009-10. But contribution of rice hybrid seed in national annual rice seed replacement is estimated very thin in comparing with contribution of inbred rice seed replacement during 2001- to 2009 in the country.

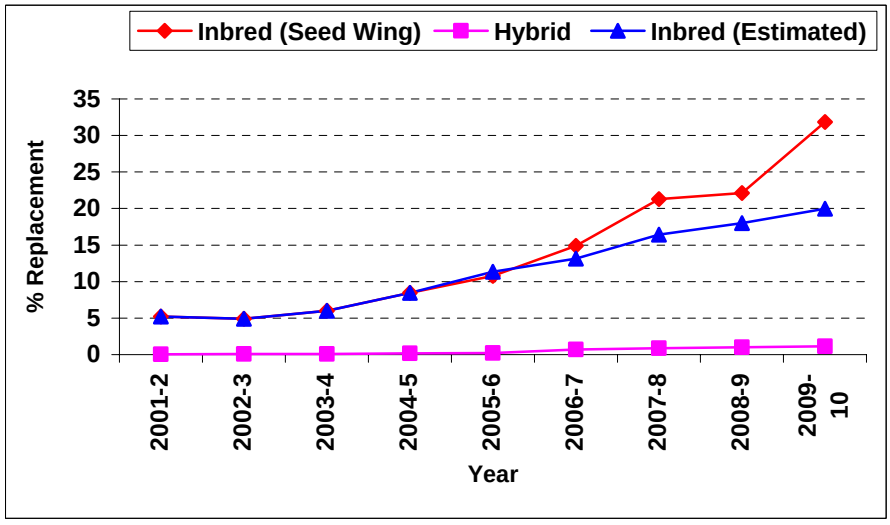


Figure.IX.9: Proportion of Inbred (Seed wing & Estimated) and hybrid rice seed replacement of the total national rice seed requirement

X. Status of hybrid rice seed production

The successful commercialization of hybrid rice in many parts of the world is linked to the development of hybrid seed production technology. Although rice is a self-pollinated crop, a hybrid seed production mechanism has been developed using cytoplasmic and environmentally sensitive genetic male sterility. Hybrid rice seed production technology is economically viable in China and other countries including Bangladesh with abundant and cheap labor, because it requires at least 100 days/ha more labor than normal rice cultivation. Hybrid rice seed production technology with male sterility is a complex and labor intensive activity. It also requires a sophisticated seed industry infrastructure (Virmani et al, 2002).

The system developed in China to produce hybrid rice seed is called the "three line" system, because it involves the use of male sterile (A), maintainer (B), and restorer (R) lines. Beginning in 1999-2000, Bangladesh has been producing F_1 hybrid rice seed in the Boro season using China's three-line system with cytoplasmic male sterility. Currently, some private seed companies, BRAC, and BADC produce commercial F_1 hybrid rice seed with imported A line (with cytoplasmic male sterility) and R line (restorer line) mostly from China, and also some from India and the Philippines. BRRI has been providing A and R lines to produce F_1 hybrid rice seed of its 4 released rice hybrids among BADC, Private Seed Companies, NGOs, model farmers etc. Organizations producing hybrid seed in Bangladesh find that the quality of A and R lines imported from China is sometimes questionable. This is also applicable for BRRI parental A and R lines in general and specifically for BRRI hybrid Dhan-2 beginning from the 2008-9 Boro season. Importing A and R line from China is costly at present, and is anticipated to be more costly in the future. Sometimes late supply and unable to supply against committed quantity of A and R lines from China creates difficulties for seed producers in Bangladesh. For successful F_1 hybrid rice seed production, several exotic chemicals are crucial, including gibberellic acid (Gavino, et.al.,2008), Tiaohuafei, Bacteriocides and specialized weedcides (for seedbeds). Bangladesh, average seed yield of hybrid rice increased 233% (0.9-3.0 t/ha) from 1999-2000 to 2009-10, with average annual compound growth of 13% due to rapid progress in seed technology among the organizations producing hybrid rice seed.

Besides development of rice hybrids, BRRI has developed a F_1 hybrid rice seed production package and provided various types of training in hybrid rice seed production for staff of BADC, private companies, NGOs, and progressive farmers. BRRI distributed booklets and leaflets on hybrid rice seed production technology in Bengali among the F_1 hybrid rice seed producers in the country. On the other hand, seed production staff from seed companies and BRAC received intensive long-term and short-term training on F_1 hybrid rice seed production practices in China. Presently, seed companies and BRAC have developed their own F_1 hybrid rice seed production guidelines on the basis of their practical knowledge earned during seed production with the guidance of Chinese experts. Most of the hybrid rice seed production staffs in Bangladesh readily acknowledge China’s contribution to seed production in Bangladesh. Large numbers of constraints are identified following framework of the GXEXMXS model (i.e., genetic background of parental lines, environmental conditions, management level during seed production and social issues) in hybrid rice seed production in Bangladesh.

.

Nearly all steps of hybrid rice seed production and parental line multiplication can affect seed quality and purity. Quality control is vital to the widespread adoption of hybrid rice.

Quality control needs to be done through the entire process of seed production (Seed wing, MOA, 2006). In Bangladesh such seed quality standards have not yet been developed for hybrid F_1 rice seed and parent lines.

Hybrid rice seed production started in greater Mymensingh district which currently comprises several districts, including Kishreganj, Tangail, Jamalpur and Mymensingh districts. Later rice hybrid seed production extended into several districts in different agro-ecological zones. Organizations producing hybrid rice seed are producing either through contract farmers or by leasing land for own management or by using both systems. Presently, about 300 technical staffs are working for hybrid rice seed production, of which more than 80% are field staff. Most of the field staffs have good practical knowledge in hybrid rice seed production and aim to harvest more than 4 t/ha using quality A & R lines with good management practices during Boro season in Bangladesh.

Current achieving rice hybrid seed yield is encouraging in the cost-return analysis; both bold and slender rice hybrids are included. On a full-cost basis, the average cost to produce hybrid rice seed is estimated at Tk. 78.41/kg and on a cash cost basis, average cost to produce hybrid rice seed is estimated at Tk. 54.71/Kg. Among seed producing organizations, the current seed procurement price is about Tk. 80/Kg, which is not profitable and attractive for the contract growers. Contract farmers would be encouraged by a seed procurement price of Tk. 100/Kg and for slender varieties of hybrid rice, the procurement price should be at least Tk. 120/Kg. Hybrid rice seed production through contract farming would be viable and profitable through contract farming working with farmers in a block. Such contract farming would be successful and profitable for both seed producing agencies and contract farmers with clear understanding and agreement on a long-term basis.

Hybrid rice seed production needs heavy investment along with intensive labor input to achieve higher seed yield and quality seed production in Bangladesh. The highest cost component is labor (averaging Tk. 63,497/ha) followed by seed of parental lines (averaging Tk. 36732/ha), other costs include land rent (Tk. 34,651/ha), fertilizer (Tk. 26,844/ha), and special chemicals use (Tk. 15,296/ha), with other costs less than Tk. 15,000/ha.

Trend of hybrid rice seed production

Four private seed companies – ACI, Ganges Development Corporation, MacDonld and Mollika Seed Company – initiated hybrid rice seed production in 1999-2000 with their approved rice hybrids on 52.63 hectares of land. Compared to the other 3 companies, ACI's seed production initiative with Aalok hybrid was more systematic on 40 ha of land. Average harvested seed yield was only about 0.9t/ha during the 1999-2000 Boro season (Table.X.1).

In the following 2000-2001 Boro season, BRAC started seed production on 18.90 ha of land with GB 4 rice hybrid, using imported A and R lines, and produced about 26 MT of F_1 seed. BRAC's average yield was about 1.38 t/ha. Mollika Seed Company also produced seed of Sonarbangla 1 on only 0.81 ha of land.

During 2001-2002 hybrid rice seed production reached 150.83 MT from 138 ha of land by 3 private seed companies, BRAC, and BADC, with a total of five rice hybrids. Average yield was 1.09 t/ha, which was about 20% less seed yield in 2000-01.

Total area, total production and yield of hybrid rice seed has progressively increased from 2001-2 Boro season to 2009-10 Boro season, with few exceptions (Table.X.1). From 1999-

2000, hybrid rice seed production area increased 2,180% (from 52.63 to 1,200 ha) with average annual compound growth of 36.71%. Similarly total in-country seed production increased 7,469% (from 47.56 MT to 3,600 MT) with estimated average annual compound growth of 54.14%. Average seed yield of hybrid rice increased 233% (0.9-3.0 t/ha), with estimated annual compound growth of 12.80%.

Aside from private seed companies, BADC and BRAC have played significant roles in hybrid rice seed production. In the 1999-2000 Boro season, 4 organizations – all private seed companies – produced hybrid rice seed. The number of organizations producing hybrid rice seed increased to 15 in the 2007-8 Boro season, and even more organizations are involved in the 2009-10 Boro season (Table.X.1).

In 1999-2000, the 4 private seed companies each produced seed for one rice hybrid. In the following year, seed for only two rice hybrids was produced in Bangladesh. The highest number of rice hybrids for which seed was produced in Bangladesh was 31 during 2007-8 Boro season followed by 23 during the 2006-7 Boro season, and 9 during the 2005-6 Boro season. During 2001-2 Boro season to 2004-5 Boro season, the number of hybrids for which seed was produced in Bangladesh varied from 4 to 5 (Table.X.1 & Annex.X.3).

The highest recorded yield of F_1 seed of hybrid rice was less than 1.3 t/ha during the 1999-2000 Boro season. On the best fields, hybrid rice seed production reached more than 4.0 t/ha during 2007-08 Boro season and subsequent seasons. Currently most organizations producing F_1 hybrid rice seed are aiming to achieve more than 4 t/ha seed yield. Their seed producing experts and field staffs are working hard to boost seed yields so as to reduce seed cost (Table.X.1).

Table.X.1: Year-wise area, production, average yield, recorded yield, number of hybrids, and number of organizations involved in hybrid rice seed production during 1999-2010.

Year	Area (ha)	Production (MT)	Av. yield (t/ha)	Highest yield (t/ha)	Organiza-tions (Nr.)	hybrids (Nr.)
1999-2000	52.63	47.56	0.9	< 1.3	4	4
2000-2001	19.71	26.80	1.36	> 1.5	2	2
2001-2002	138.00	150.83	1.09	> 1.5	5	5
2002-2003	166.83	262.89	1.58	> 2.0	4	4
2003-2004	143.61	212.40	1.48	> 2.3	5	5
2004-2005	272.53	490.80	1.80	> 2.5	5	5
2005-2006	448.05	681.14	1.52	> 3.0	7	9
2006-2007	789.81	2171.29	2.72	> 3.5	10	23
2007-2008	1129.56	2730.00	2.42	> 4.0	15	31
2008-2009	1117.50	3129.00	2.80	> 4.0	NA	NA
2009-2010	1200.00[1]	3600.00[1]	3.00[1]	> 4.0	NA	NA

[1] *Estimated figures of Area, Production and yield during 2009-10*

A total of 10 organizations (9 seed companies and BRAC) produced 2171 MT (average 2.72 t/ha) of F_1 hybrid rice seed during 2006-7 Boro season. Among the 10 organizations, BRAC produced the highest quantity of seed (1398 MT), followed by Supreme Seed (631 MT), Mollika Seed (88 MT), Aftab Seed (47.26 MT), and ACI (4.92 MT); and remaining five organizations produced negligible quantities. The highest seed yield was achieved by ACI (3.04 t/ha) followed by Supreme seed (2.96 t/ha), BRAC (2.77 t/ha), Mollika (2.01 t/ha), Aftab (1.50 t/ha), and Syngenta (1.25 t/ha); with less than 1 t/ha for the remaining four organizations. The highest land area was used by BRAC (504 ha) followed by Supreme Seed (213 ha), Mollika (44.36 ha), Aftab (31.50 ha), ACI (1.62 ha) and Chens Crop Science (1.05 ha), while others used less than 1 ha (Table.X.2)

Table.X.2: Area, production and yield of rice hybrids by organization during 2006-7 Boro season

Company	Rice hybrid variety	Area (ha)	Production (MT)	Yield (t/ha)
BRAC	GB 4, HB 8, BW 001	504.34	1397.48	2.77
Aftab	LP-50, LP-108, LP-106, LP-70, LP-05	31.50	47.26	1.50
Supreme Seed	99-5 (Heera), HS-273	213.25	630.76	2.96
Millika Seed	Sonarbangla 1 & 6	44.36	87.82	2.01
Chens Crop Science	Richer-101	1.05	0.71	0.73
Tinpata Quality Seeds	Tinpata-40, Tinpata-10, Tinpata-Super	0.84	0.69	0.82
ACI	ACI 1 & 2	1.62	4.92	3.04
Syngenta	Surma-2	0.80	1.00	1.25
East-west Seed	Douel, Moyna	0.49	0.30	0.61
North-South Seed	Gold, Tiya	0.56	0.29	0.52
Total	**23 varieties**	**798.81**	**2171.29**	**Av. 2.72**

Availability of parent lines

Private seed companies and BRAC (NGO) have been producing F_1 hybrid rice seed with A and R lines from their principal company, most often from China, with some from India and the Philippines. According to the business practices of the principal companies, they are not providing B lines to their partner agencies in Bangladesh. Moreover, Chinese law does not allow Chinese principal companies to export B lines. Recently, BADC is producing seed of the rice hybrid SL-8H with A & R lines from a Chinese seed company, SL Agro. Tech, based in the Philippines. BRAC initiated their hybrid rice R&D in collaboration with IRRI, which is sharing parental materials (germplasm). Besides importing parent lines, BRAC and Supreme Seed Company have been using their own producing parent lines (A&R lines) of their developed rice hybrids released by NSB. Besides imported parent lines, BRRI has been providing to local organizations it's own developed A & R lines after releasing 4 rice hybrids, and this has been a continuous process serving a large number of organizations all over the country.

Organizations producing hybrid seed in Bangladesh find that the quality of A and R lines imported from China is sometimes questionable. This is also applicable for BRRI parental A and R lines in general and specifically for BRRI hybrid Dhan-2 beginning from the 2008-9 Boro season. Importing A and R line from China is costly at present, and is anticipated to be more costly in the future. Sometimes late supply and unable to supply against committed quantity of A and R lines from China creates difficulties for seed producers in Bangladesh.

Availability of required chemicals

For successful F_1 hybrid rice seed production, several chemicals are crucial, including gibberellic acid (GA_3), Tiaohuafei, Bacteriocides and specialized weedcides (for seedbeds).

Up to 2009, GA_3 was available in the country for hybrid rice seed production, mostly from China, but not through authorized import channels. But from 2010, government has authorized several chemical companies, including High tech Agro, ACI and Petrochem, to import GA_3 to market for hybrid rice seed production.

Tiaohuafei is available in the country for F_1 hybrid rice seed production, but not through authorized import channels. Bacteriocides are available in the country, probably through authorized import channels. Specialized weedicides for seedbeds are not available in Bangladesh.

Progress in seed production technology

China's national average yields for hybrid rice seed production rose from 450 Kg/ha in the late 1970s to 3750 kg/ha in 2008, with the highest recorded yield reaching 7.4 t/ha. Because hybrid rice seed production is complex, many factors can affect seed yield as well as quality. The GXEXM model (i.e., genetic background of parental lines, environmental conditions and management level during seed production) should be considered to improve hybrid rice seed production. In China, hybrid rice seed yields increased 733% from 1976 to 2008 (at an average compound rate of 7%) due to progress in seed production technology. Similarly, in Bangladesh, average seed yield of hybrid rice increased 233% (0.9-3.0 t/ha) from 1999-2000 to 2009-10, with average annual compound growth of 13% due to rapid progress in seed technology among the organizations producing hybrid rice seed.

Besides development of rice hybrids, BRRI has developed an F_1 hybrid rice seed production package after releasing its first rice hybrid, BRRI hybrid dhan 1 in 2001. BRRI provided various types of training in hybrid rice seed production for staff of BADC, private companies, NGOs, and progressive farmers. BRRI also published booklets and leaflets on hybrid rice seed production technology in Bengali for distribution among the F_1 hybrid rice seed producers in the country.

At the initial stage, hybrid rice seed production experts from India and China provided in-field technical support on F_1 seed production for the involved private seed companies in Bangladesh. Later, private seed companies and BRAC arranged for Chinese seed production experts to come to Bangladesh during the seed production period to provide in-field advice and guidance, especially while sowing parent lines. Seed production staff from seed companies and BRAC received intensive long-term and short-term training on F_1 hybrid rice seed production practices in China. Presently, seed companies and BRAC have developed their own F_1 hybrid rice seed production guidelines on the basis of their practical knowledge earned during seed production with the guidance of Chinese experts. Most of the

hybrid rice seed production staffs in Bangladesh readily acknowledge China's contribution to seed production in Bangladesh (Mannan, M.A. 2009). Currently, the target for the best seed companies and for BRAC is to harvest more than 4 t/ha of F_1 hybrid rice during Boro season. From 2007-08, this target has been occasionally reached with bold hybrid rice varieties by the better seed companies and by BRAC. Several organizations achieved average yields of F_1 hybrid rice seed exceeding 3.5 t/ha during the 2009-10 Boro season.

Strategies for increasing seed yield

Currently a total about 20 million ha land is under hybrid rice cultivation in the world of which 18.60 million ha is in China. Presently, estimated hybrid rice seed requirement is about 330,000 MT in China, and about 70,000 MT outside China. This presents tremendous opportunities for producing and marketing good quality hybrid rice seeds in the countries growing hybrid rice, including China, Vietnam, India, Bangladesh, Philippines and Indonesia.

Estimated hybrid rice seed requirement is about 12,000-15,000 MT for transplanting on 0.8-1.0 million hectares in Bangladesh from 2007-8. This seed comes either from in-country production or from China. Thus, seed companies providing rice seed for Bangladeshi farmers are challenged to (i) establish an effective hybrid rice seed production system for the country, (2) find the best location for large scale seed production during Boro season, (3) train seed growers and field technicians/ supervisors, (4) refine seed production techniques/technology according to the environmental conditions of the various regions of Bangladesh, (5) improve the field management of seed production, including agronomic, pest and disease control practices, (6) supply parental lines (cytoplasmic male sterile line) with a high out-crossing rate and resistance to major pests and diseases for the various rice hybrids, (7) use purified seed parental and pollen parental lines, (8) use synchronous heading and flowering panicles within plants and between female and male parents, and (9) set up national purity standards for hybrid rice seed production. Nearly all steps of hybrid rice seed production and parental line multiplication are linked or affect seed quality, including purity. The GXEXM model influencing seed yield also affects hybrid rice seed quality.

Quality control for hybrid rice seed

Nearly all steps of hybrid rice seed production and parental line multiplication can affect seed quality and purity. Quality control is vital to the widespread adoption of hybrid rice. Quality control needs to be done through the entire process of seed production (including nucleus, breeder, foundation and certified seed production of both parental lines and F_1 hybrids). Seed quality standards are met by the close observation and the intensive elimination of "off-types" (from seeding to harvesting) and careful handling during harvesting, threshing, drying, cleaning, processing, bagging and labeling (Virmani et al, 2002).

Low quality of supplied F_1 hybrid rice seed since its introduction in Bangladesh from 1998-99 Boro season is an important concern among farmers. Seed producing organizations have similar concerns about the quality of parental lines for F_1 hybrid rice seed production imported from China as well as from in-country production by public sector organizations, primarily BRRI. Farmers and seed technicians in other Asian countries, such as Vietnam, Philippines, and Indonesia, are similarly worried about seed quality. China has a well-established hybrid rice seed industry and national standards for hybrid rice. Seed quality standards are in place and are strictly followed in China. In Bangladesh such seed quality

standards have not yet been developed for hybrid F_1 rice seed and parent lines. Hybrid rice seed (both imported and produced in-country) sells as "truthfully labeled" seed in Bangladesh, without any approved standard. Government of Bangladesh does, however, formally monitor the quality of F_1 hybrid rice seed (both Imported and in country production) and parental lines (A & R) for F_1 seed production.

Farmers' preference on seed source

In general, farmers believe that imported seeds are better than domestically produced seeds in terms of discoloration, grain size uniformity, presence of off-types, and germination rate. But the quality of domestically produced seeds has improved among the committed producers in Bangladesh. In some cases, seed quality of domestically produced is better than imported Chinese seed. At present, seed companies and NGOs are selling both imported and domestic seed in the same posh packet with same label and information. The principal companies in China also supply the required empty packets, and such packets are also produced outside China, and in Bangladesh as well. The price (MRP) is also the same for imported and domestically produced seed. Moreover, government (SCA/NSB) provides no guidelines to distinguish imported and domestically produced hybrid rice seed at the retail level.

Constraints in hybrid rice seed production

The GXEXMXS model (i.e., genetic background of parental lines, environmental conditions, management level during seed production and social issues) provides a framework to identify constraints in hybrid rice seed production in Bangladesh. From the beginning of commercial production of hybrid rice seed in Bangladesh in 1999-2000, seed production constraints can be summarized under these four issues, as follows.

Genetically constraints:

(i) Below standard and purity and genetically quality of A & R lines;
(ii) Low out-crossing rate of seed parental lines (CMS);
(iii) High cost of improved parent lines (A & R lines);
(iv) Delay supply of imported parent lines (A & R lines) from China;
(v) Available parent lines with low rate of out-crossing and lower number of pollens;
(vi) Lack of achieving synchronization in flowering of parental lines.

Environmental conditions:

(i) Year round hybrid rice seed production is not feasible in Bangladesh and only Boro season is found suitable for hybrid rice seed production;
(ii) Seedling production and vegetative crop growth stage some years suffered due to low temperature stress;
(iii) High temperature stress during reproductive stage of hybrid rice seed production fields is very common in Bangladesh during Boro cropping season and specially, when seedlings transplant in late. If flowering of crop is delayed then the seed crop suffer under unfavorable weather such as high daily temperature with very narrow diurnal difference in temperature, low humidity and very strong sun shine;
(iv) High risk with strong hailstorm and rainfall during reproductive and ripening stage of seed crop in general and specific for the late transplanting seed fields. Such risk is more frequent in north-eastern districts than south-west and north-western districts in Bangladesh during Boro season;

(v) High incidence of pests and diseases recorded on the hybrid seed crop on the basis of their favorable weather conditions. As result seed yield reduced and seed cost increased along with low seed quality is harvested in the bad years; and

(vi) Lack of understanding on location specific optimal time for seed sowing and seedlings transplanting (A & R lines) for F_1 seed yield maximization through perfect synchronization and highest possible out-crossing achievement under most favorable weather condition during reproductive phase in general and flowering stage of the crop in specific.

Management level

(i) Failure in achieving synchronization in flowering of parental lines due to lack of optimum level of relevant management practices;

(ii) Producing and transplanting bad-quality seedlings of parent lines due to use of poor management in seedling production practices including seedbed management techniques;

(iii) Low hybrid rice seed yield harvested with poor quality seed due to (a) use of in appropriate rate, method and application techniques of fertilizers; (b) bad water management practices; (c) inappropriate pest and disease management practices, (d) inappropriate rate and application techniques of GA_3 and other exotic chemicals; (e) insufficient supplementary pollination; (f) using poor harvesting, post harvesting and seed processing methods and techniques and so on.

Social issues

In Bangladesh, landholdings are highly fragmented into small plots. Thus it is difficult to establish a seed production block, either through contract farming or by renting land for centralized management. As a result maintaining isolation distances for hybrid rice seed production is difficult. Sometimes village politics plays a bad role. Sometimes, seed producers as outsiders face complex social issues in communities and villages. Such social complexities become more challenging when local thugs in collaboration with bad politicians work together against the seed producing organization. Such meddling can create lot of problems for seed producing organizations, and may try to extort large amounts of money. Involved field staff and their supervisors are always facing and solving such social problems to save their jobs with the seed producing agency. But this not a significant problem.

Custom seed production

Because of the constraints on hybrid rice seed production in Bangladesh, some companies are thinking to establish custom seed production outside Bangladesh. Such seed production system can be established by a Bangladesh seed company either in collaboration with an experienced seed company in the producing country, or by establishing its own seed production organization within the producing country.

Seed production area, system and staff strength

Hybrid rice seed production started mainly in greater Mymensingh district which currently comprises several districts, including Kishreganj, Tangail, Jamalpur and Mymensingh districts. Later hybrid seed production extended into several districts in different agro-ecological zones (Figure.X.1 shows current seed producing districts). Organizations

producing hybrid rice seed are producing either through contract farmers or by leasing land for own management or by using both systems. Presently, about 300 technical staffs are working for hybrid rice seed production, of which more than 80% are field staff. Most of the field staffs have good practical knowledge in hybrid rice seed production, and aim to harvest more than 4 t/ha using quality A & R lines with good management practices during Boro season in Bangladesh. Table.X.3 presents seed production district(s), seed production systems, and staff strength for seed producing organizations in 2009-10.

Table.X.3: Seed producing agencies, their seed producing districts, seed production system and staff strength (2009-10)

Seed Producing Agency	Seed production districts	Seed production system	Staff (Nr.)		
			National	Supervisor	Field
1. BRAC	Mymensingh, Gazipur, Bogra, Pabna, Rangpur, Dinajpur	CFS/OMS	5	5	50
2. Supreme Seed	Mymensingh, Tangail, Bogra	OMS / CFS	4	10	61
3. Mollika Seed	Rangpur	OMS	1	2	4
4. Aftab	Kishoreganj	OMS	1	1	25
5. ACI	Bogra, Pabna	OMS	3	6	30
6. EAL	Bogra	CFS	1	2	2
7. NICOL	Thakurgoan	OMS	1	1	3
8. Bayer	Natore	CFS	NA	NA	NA
9. BADC	Jhenaidah, Tangail, Pabna	BADC Farm	1*	50*	67*
10. BRRI	Comilla, Faridpur, Barisal, Habiganj, Satkhira, Gazipur	BRRI research Farm	3	8	7
11. Petrochem BD Ltd.	Dhaka	OMS	1*	1*	1
12. East-West Seed	NA	NA	NA	NA	NA
13. North South Seed	NA	NA	NA	NA	NA
14. Chens Crop Science	NA	NA	NA	NA	NA
15. Siddiques Seeds	NA	NA	NA	NA	NA
16. United Seed Store	NA	NA	NA	NA	NA
17. Kamal Seed Co.	NA	NA	NA	NA	NA
18. Metal Seed Co.	NA	NA	NA	NA	NA
19. National Seed	NA	NA	NA	NA	NA
Total			21	**86**	**250**

CFS *= Contract farming System,* ***OMS*** *= Own management system*

Hybrid rice seed production cost & benefit and procurement

Data on cost of production of hybrid rice seed is collected from seven seed producing organizations in Northwest and Northeast regions of the country. Average yield is estimated at 3,113 Kg/ha, ranging from 2,400-3,893 Kg/ha. These yields are encouraging. In this cost-return analysis, both bold and slender rice hybrids are included.

On a full-cost basis, the average cost to produce hybrid rice seed is estimated at Tk. 78.41/kg, ranging from Tk. 69.70 to Tk. 103.79/Kg. Similarly, on a cash cost basis, average cost to produce hybrid rice seed is estimated at Tk. 54.71/Kg, ranging from Tk. 45.37/Kg to Tk. 73.37/Kg during 2009-10 (Table.X.4).The production cost for hybrid rice seed depends on the yield along with costs per hectare. Among seed producing organizations, the current seed procurement price is about Tk. 80/Kg, which is not profitable and attractive for the contract growers. Contract farmers would be encouraged by a seed procurement price of Tk. 100/Kg after grading by seed producing organizations. But for slender varieties of hybrid rice, the procurement price should be at least Tk. 120/Kg after grading. Cost analysis using full costs is applicable for contract farmers in general. But cost analysis based on cash costs is applicable for small and marginal farmers owning land within the seed production block. They will be highly benefited through using their own land and employing their family labor throughout the seed production cycle. Hybrid rice seed production through contract farming would be viable and profitable through contract farming working with farmers in a block. Such contract farming would be successful and profitable for both seed producing agencies and contract farmers with clear understanding and agreement on a long-term basis. The most important element of such as the contract farming system would be to develop mutual trust and respect between seed producing organizations and contract farmers. Such mutual trust and respect are so far absent or and weak among contract farmers and seed producing organizations in Bangladesh.

Considering the following major factors, seed producing organizations is set-up the procurement price for F_1 rice hybrids before seed production season and accordingly, formal agreement is signed between contract farmers and seed producing organizations:

(i) Comparative price and returns (gross and net returns) of inbred paddy and F_1 hybrid seed of rice;

(ii) Cost of production of F_1 hybrid rice seed (Tk/Kg);

(iii) Returns from inbred rice seed production and its price are considered where inbred rice seed production activities or blocks are existed for BADC, private seed companies etc; and

(iv) Level of paddy price (Floor price or roof price or between the both).

On the other hand, the hybrid rice seed producing organizations (private companies and NGO) can go for seed production on leased-in land under their own management, and thereby establish suitable seed production blocks. Production cost will be a little higher than with contract farming, but even so, domestic production of quality hybrid rice seed with high yield would be cost-effective relative to the current practice of procuring most F_1 seed from China at higher prices.

Table.X.4: Total cost, seed yield and seed cost of hybrid rice of seed production organization during 2009-10 Boro season.

Item	Cost (Tk./ha)							
	NICOL	**EAL**	**SSCL**	**Aftab**	**ACI**	**BRAC**	**MSC**	**Average**
Total cost (Tk/ha)								
(a) Full cost basis	**273638**	**241005**	**199266**	**249102**	**240169**	**234661**	**229016**	238122.48
(b) Cash cost basis	**214758**	**164999**	**125649**	**176083**	**161043**	**161376**	**163298**	166743.56
F_1 seed cost (Tk./Kg)								
(a) Full cost basis	70.29	69.70	74.41	103.79	72.01	65.97	92.72	78.41
(b) Cash cost basis	55.17	47.72	46.92	73.37	48.29	45.37	66.11	54.71
F_1 Seed production (Kg/ha)	3893	3458	2678	2400	3335	3557	2470	3113.00

Hybrid rice seed production needs heavy investment along with intensive labor input to achieve higher seed yield and quality seed production in Bangladesh. The highest cost component is labor (averaging Tk. 63,497/ha) followed by seed of parental lines (averaging Tk. 36732/ha), other costs include land rent (Tk. 34,651/ha), fertilizer (Tk. 26,844/ha), and special chemicals use (Tk. 15,296/ha), with other costs less than Tk. 15,000/ha (Table.X.5 & 6 and Annex.X.1).

Estimated total labor use is about 432 days/ha, ranging from 413-457 days/ha. In total, an estimated 520000 days of labor were engaged for production of hybrid rice seed on 1,200 ha of land during the 2009-10 Boro season. Out of 520000 total labor man-days, about 230000 extra labor man-days was engaged in hybrid rice seed production in compared with modern (Inbred) rice production in the country during 200910 Boro season. Thus, rural labor job opportunity will be created through scale-up hybrid rice seed production in Bangladesh.

On average, a cost of Tk. 36,733/ha is estimated for procuring parent lines (A & R lines) mostly from China, with these costs ranging from Tk. 8892/ha to Tk. 54,958/ha. The lowest cost is estimated for Supreme Seed Company, due to use of their-own parent lines; their cost is very low compared with costs for imported Chinese parent lines.

Among the used special chemicals, GA_3 is the most important for synchronization of flowering time of two parent lines (Gavino,et. al 2008). Average used of GA_3 is estimated at 343 gm/ha, ranging from 267 gm/ha to 432 gm/ha during the 2009-10 Boro season, among seven responding seed producing organizations. Presently, GA_3 is available from China through authorized agencies for hybrid rice production.

Out of seven respondents, five used barriers for field isolation. The average cost estimated for field isolation barriers was about Tk. 3000/ha, ranging from Tk. 1235/ha to Tk. 9880/ha. The cost of field isolation barriers is about 1% of the total cost of F_1 rice seed production. Thus barrier cost should not be an issue for seed production in Bangladesh. Barrier use can be avoided through proper selection of rice hybrid seed production sites.

Table.X.5: Labor use, GA_3 use, parent lines cost and Barrier cost for hybrid rice seed production of seven seed producing organizations

Item	Cost (Tk./ha)							
	NICOL	EAL	SSCL	Aftab	ACI	BRAC	MSC	Average
Labor use (Nr./ha)	457	420	413	445	452	415	420	432
GA_3 use (gm/ha)	346	346	267	432	296	371	346	343
GA_3 cost (Tk/ha)	22,477	12,103	12,538	15,129	5,928	12,968	12,103	13,321
Barrier cost (Tk/ha)	9,880	1,235	0	0	2,964	2,470	4,446	2,999
Seed (Parent lines cost) (Tk/ha)	32,110	40,138	8,892	54,958	40,138	40,755	40,138	36,733

Comparison between hybrid and inbred seed production

Comparative cost of rice seed production: For seed producers, the highest cost difference between hybrid and inbred seed production is estimated at 1261% for hybrid parent lines vs inbred seed to multiply, followed by pesticides (333%), labor (85%), fertilizers (70%), land rent in (54%) and land preparation (45%). On the other hand, irrigation cost is estimated about 19% higher with inbred rice seed production than hybrid rice seed production. Four cost items are not applicable for inbred rice seed production; special chemicals and barriers for field isolation are very much needed for hybrid seed production. On a full cost basis, costs for producing hybrid rice seed are 138% higher than for inbred rice seed. On a cash cost basis, the difference is estimated at 314% (Table.X.6).

Table.X.6: Item-wise total cost along with their % difference of hybrid and inbred rice seed production during 2009-10 Boro season

Item	Cost/Return (Tk/ha)			
	Hybrid	Inbred	Difference	% Diff
Land rent in	34651	22500	12151	54
Land preparation	6535	4500	2035	45
Seed	36733	2700	34033	1260
Labor	63497	34313	29184	85
Fertilizers	26844	15825	11019	70
Pesticides	9732	2250	7482	333
Irrigation	10621	13125	-2504	-19
Exotic Chemicals	15297	0	15297	0
Field isolation	2999	0	2999	0
Agri-equipments	4587	0	4587	0
Post harvest operations	10014	0	10014	0
Total cost				
(a) Full cost basis	238122	99973	138149	138
(b) Cash cost basis	166744	40320	126424	314

Comparative net-profit of seed production: Contract growers' net returns for growing seed for hybrid rice competed to inbred rice vary much depending on the procurement price for hybrid seed. In this analysis, three prices are considered: Tk. 80/Kg, Tk. 90/Kg and Tk. 100/Kg. The current hybrid rice seed procurement price is about Tk. 80/Kg (in the 2009-10 boro season).

On a full-cost basis, with a procurement price of Tk 80/kg, farmers make 40% less net-return growing hybrid rice seed than seed of popular inbred varieties. On cash cost basis, with the same procurement price for hybrid rice (Tk 80/kg), contract farmers make an estimated 4% less net-return with hybrid rice seed than inbred rice seed. Thus, hybrid rice seed production is not profitable and attractive for the contract farmers at the present hybrid rice seed procurement price (Tk.80/kg).

With a procurement price of Tk. 90/Kg, net return for contract farmers is estimated to be 38% higher with hybrid rice seed than inbred rice seed on a full cost basis, and 27% higher on a cash cost basis. When the procurement price for hybrid rice seed is Tk. 100/Kg, then the net-return to contract growers is 117% higher with hybrid rice seed than inbred rice seed on a full cost basis, and 59% higher on a cash cost basis (Table.X.7).

Table.X.7: Comparative net-return of hybrid and inbred rice seed production during 2009-10 Boro season

Item	Cost Net-Return (Tk/ha)			
	Hybrid	**Inbred**	**Difference**	**% Diff**
Total cost (Tk/ha)				
(a) Full cost basis	2,38,122	99,973	1,38,149	138.19
(b) Cash cost basis	1,66,744	40,320	1,26,424	313.36
I. Procurement Price of hybrid seed: Tk. 80/Kg, Gross return: Tk. 2,62,025				
Net - Return (Tk/ha)				
(a) Full cost basis	23,903	39,752	-15,849	-39.87
(b) Cash cost basis	95,282	99,405	-4123	-4.15
II. Procurement Price of hybrid seed: Tk. 90/Kg, Gross return: Tk. 2,93,155				
Net - Return (Tk/ha)				
(a) Full cost basis	55,033	39,752	15,281	38.44
(b) Cash cost basis	1,26,411	99,405	27,006	27.17
III. Procurement Price of hybrid seed: Tk. 100/Kg, Gross return: Tk. 3,24,285/ha				
Net - Return (Tk/ha)				
(a) Full cost basis	86,163	39,752	46,411	116.75
(b) Cash cost basis	1,57,541	99,405	58,136	58.48

Comparative seed cost and seed yield: On a full-cost basis, seed production cost is estimated about 375% higher for hybrid rice seed (Tk.76/Kg) than for inbred seed (Tk. 16/Kg) as full cost basis during 2009-10 Boro season. On a cash-cost basis, production cost is about 783% higher with hybrid rice seed (Tk. 54/Kg) than inbred rice seed (Tk. 6/Kg) (Table.X.8).

Current hybrid rice seed procurement price before final grading is about Tk. 80/ha. At this price, contract growers find hybrid seed production less profitable than producing seed of inbred varieties. If the procurement price of hybrid rice seed is Tk. 100/Kg, then the net profit is found encouraging for contract farmers and contract growers after final grading and seed quality confirmation by seed producing organizations. Buying at this procurement price (Tk. 100/Kg) would be cost-effective relative to importing seed from China. Also, seed producing and marketing organizations can produce seed under their own management on seed production blocks using leased land in Northwest and Southwest regions of the country.

The seed yield calculated for hybrid rice (3,113 Kg/ha) is about 50% less than for the most popular inbred rice HYVs (BRRI dhan 28 & 29) during 2009-10 Boro season. Theoretically, if the out-crossing rate of the seed parental lines can reach 50%, and crop growth is similar to that of any inbred HYV, hybrid rice seed yield could equal 35-40% of the yield of the variety (Virmani *et al* 2003). After more than 20 years' efforts, nationwide hybrid rice seed yield in China has reached more than 3 t/ha, which is equal to 50% of the mean yield of inbred rice in China. Currently, nationwide hybrid rice seed yield in Bangladesh has reached about 3 t/ha, which is also about 50% of the yield of popular inbred rice varieties during Boro season under optimal management practices.

Table.X.8: Seed yield and seed cost of hybrid rice and inbred rice seed production during 2009-10 Boro season

Item	Cost (tk/kg)/ Yield (t/ha)			
	Hybrid	Inbred	Difference	% Diff
Seed cost (Tk./Kg)				
(a) Full cost basis	76	16	60	376
(b) Cash cost basis	54	6	47	783
Seed yield (Kg/ha)	3113	6225	-3112	-50

Note: Comparative detailed costs and returns for hybrid and inbred rice seed production during 2009-10 Boro season are provided in Annex. X.2

Future scene

Hybrid rice is commercialized in Bangladesh with about 1.0 million hectare of land, mainly in the Boro season. Hybrid rice seed production is also commercialized at a smaller scale, on about 1,200 ha of land with several organizations, including seed companies and NGO. The technology of hybrid rice seed production has been developed and practiced successfully by the involved seed companies and NGO. Technologically, there should not be serious problems for hybrid rice seed production in Bangladesh. But further fine-tuning is needed. Presently, average and maximum recorded yields of hybrid rice are economically viable. There are ample opportunities to increase seed production and yield beyond the present

levels. Developing skills of field staff and contract farmers is the foundation for further increasing and stabilizing hybrid rice seed yield.

Challenges to improve seed yield include: using high out-crossing CMS lines with good panicle exertion; achieving good synchronization of heading and flowering of panicles within and between parental lines; and using parents with long, exerted stigma, longer duration, and wider angle of floret opening. Similarly the pollen parent should have a high percentage of residual pollen per anther after anther exertion; high pollen shedding potential is attained by getting 2000-3000 spikelets/m^2 to bloom per hour during peak flowering period. To increase seed yield with low cost of production, Bangladesh seed producing organizations can collaborate with China to shift from the current three line system to two a line system.

The Ministry of Agriculture (MOA) can provide supportive policies as well as financial support for private organizations producing hybrid rice seed in Bangladesh. Hybrid rice seed standards need to be developed for widespread adoption of hybrid rice in Bangladesh. A participatory hybrid rice seed quality monitoring system needs to be developed. Genetically purity and physical quality of hybrid rice seed needs to be maintained both for seed produced in-country as well as for importing seeds.

The contract farming system can be developed for quality hybrid rice seed production in the country. Current hybrid rice seed procurement price (Tk. 80/Kg) is not profitable for the contract farmers. The procurement price should at least Tk. 100/Kg and Tk. 120/Kg for bold and slender varieties of hybrid rice. Such contract farming would be established through mutual trust and respect between contract farmers and seed producing organizations. Crop insurance may be introduced for contract farmers.

XI. Policy Issues for hybrid rice

Two seed systems are existed in Bangladesh such as (i) Formal seed system and (ii) Informal seed system for seed production, seed used, seed supply, seed sell and seed exchange of various crops. Thus farmer-retained seed and community-level seed production and distribution jointly constitute what are regarded as "informal seed system". On the other hand external source of seed for farmers is formal seed production and delivery system, involving specialized public and/or private seed producing and distributing enterprises. In the formal seed system, Breeder Seed (BS), Foundation Seed (FS), Certified Seed (CS) and Truthfully Labelled Seed (TLS) are marketed by registered seed dealers of the seed wing, MOA by maintaining seed quality as per standard fixed by the NSB.

Since 1977 there has been several regulatory frameworks, policy, Act and rules in Bangladesh mainly for agricultural crop variety improvement, research & development, variety release and notification, seed production, seed quanlity standardization, seed quality control, import and marketing. The Seeds Ordinace,1977 (Ordinace No. XXX III of 19977) was notified on the 13th July, 1977. The National Seed Policy, 1993 notified on 8 March 1993 followed by the seeds (Amendent) Act, 1997 notified on 13 March 1997. The Seed Rules, 1998 notified on 8 March 1998 followed by the seed (Amendent) Act, 2005 notified on 22 September 2005 (SCA, 2009). Both the Intellectual Property Rights and Plant Variety Protection Act (2009) and The Plant Quarantine Act (2010) are under process for notification.

The specific policy and guidelines on hybrid rice evaluation and registration were first formulated in the 40th Meeting of the NSB held on 9 September1998. In that initial guidelines the F_1 hybrid rice seeds were allowed to import for commercial cultivation for three years effective from 1998-99 Boro rice crop season and from the 4th year, hybrid rice seed will have to be produced locally otherwise the permission for hybrid rice seed import of the approved hybrid rice variety of the respective company/agency will be cancelled. The initial guidelines of 1998 were subsequently revised and modified, and accordingly the updated policy/guidelines were approved by the NSB in the 52nd Meeting held on July 20, 2003. The modified hybrid rice guidelines were approved in the name of *"Hybrid Rice Variety Evaluation and Registration Procedures, 2003,"* circulated by the Seed Wing, Ministry of Agriculture, and published in the *Bangladesh Gazettee, Wednesday, December 24, 2003.*In this modified procedure of 2003, the F_1 hybrid rice seeds were allowed to import for commercial cultivation for five years instead of initially allowed for three years in 1998, within this five year period hybrid rice seed will have to be produced locally and in the 6th year only parent lines (A-Line and R-Line) seed will be allowed to import but not for F_1 hybrid rice seed of the approved hybrid. Hybrid Rice Variety Evaluation and Registration Procedures, 2003 Bangladesh Gazettee, notified on 24 December 2003 and 6 April 2007.It may be noted here that the condition for allowing F_1 hybrid seed import for five years as approved in 2003 has been amended into 8 (eight) years in the 60th meeting of the NSB held on August 3, 2006, circulated on March 18, 2007, and it was published in the Bangladesh Gazettee on April 16, 2007 (SCA, 2009).

The National Seed Board (NSB) of the Ministry of Agriculture, Government of Peoples Republic of Bangladesh is the Central Regulatory Body on seed related matters of the Governmnet. Regarding variety development through breeding locally, and introduced from abroad as well as through local selection are evaluated and recommended by the Technical Committee (TC) and finally approaved for registration, release and notification are done by the NSB. As per decision of the 33rd NSB meeting held on March 8, 1995 the Chairman

Technical Committee (Executive Chairman, BARC) will constitute Variety Evaluation Team for Nine Agro-ecological Zones of the Country.

Milestone of hybrid rice introduction in Bangladesh: Public sector research and development (R&D) on hybrid rice was started in 1993 in Bangladesh Rice Research Institute (BRRI) a public sector research institute. But commercial basis hybrid rice was first officially introduced in 1998 with the approval of four exotic rice hybrids for private sector seed companies. Thus pioneering role was played by four private sector seed companies in introducing hybrid rice in Bangladesh. The National Seed Board (NSB) of the Ministry of Agriculture, Government of the Peoples Republic of Bangladesh was in favor of releasing four rice hybrids and allowed four private seed companies to import and marketing F_1 hybrid rice seeds for commercial cultivation in the country. There was a serious consideration about shortage of rice seeds for the ensuing 1998-99 Boro season after the devastating floods in the 1998. By keeping in view to increase the foodgrain production in the country as well as to cope with the food shortage through rigorous post-flood agricultural rehabilitation program in 1998, the hybrid rice technology was considered by the policy makers as an advanced technology for ensuring the food security of the country. However, a special evaluation committee was formed under the Seed Certification Agency (SCA) of the National Seed Board (NSB) to evaluate the results of the on-farm trials conducted by the private seed companies. This special committee recommended the release/introduction/import of seeds of rice hybrids based on the results of limited trials for only for one season.

As a result, the NSB, in its 40th meeting held on September 9, 1998, evaluated the trial performances of rice hybrids and for the first time temporarily approved four exotic rice hybrids and allowed four private sector companies to import and marketing of 2,200 tons of F_1 hybrid seeds for commercial cultivation in Bangladesh. Accordingly, GOB permitted four rice hybrids -- Aalok (HR 6021), Sonarbangla-1 (CNSGC-6), Loknath 503 and Amarsree-1 -- for seed sale during the 1998-99 Boro season based on the recommendation of the National Seed Board (NSB). As a result four seed companies --Mallika Seed Company, Advance Chemical Industries (ACI), Ganges Development Corporation (GDC), and MacDonald Bangladesh Private Ltd -- were permitted to import 2,200 metric tons of hybrid rice seed from China and India (1 hybrid from China and 3 from India). List of 4 released hybrid rice varieties is shown in Table.XI.1.

Table.XI.1: List of 4 rice hybrids, their country of origin and four Seed Companies allowed for importing of F_1 rice hybrids seed in 1998-99 Boro season.

Sl. No.	Private Seed Company	Rice hybrids released and notified	Country of origin	Released in Bangladesh (Year)	Quantity of F_1 hybrid rice seed approved (MT)
1	ACI Limited	Aalok-6201	India	1998	800
2	McDonald Bangladesh (Pvt.) Limited	Loknath-503	India	1998	100
3	Mollika Seed Company	CNSGC-6	China	1998	800
4	Ganges Development Corporation	Amarsree-1	India	1998	500
Total					**2,200**

Remarks: Condition was imposed by the NSB that the temporary permission is given for three years and from 4th year F_1 hybrid seed will have to be produced locally by the respective company; otherwise the permission will be cancelled.

Source: *Minutes of the National Seed Board Meeting of the Ministry of Agriculture*

The National Policy on Hybrid Rice in Bangladesh

In the 39th NSB meeting held on 18 March1998 the Hybrid Crop Variety Evaluation and Registration Procedure was approved in the name of **"Hybrid Crop Variety Release Procedure."** In this procedure it was not specifically mentioned for hybrid rice; the procedure was approved in general for all agricultural crop varieties.

The specific policy and guidelines on hybrid rice evaluation and registration were first formulated in the 40th Meeting of the NSB held on 9 September1998. In that initial guidelines the F_1 hybrid rice seeds were allowed to import for commercial cultivation for three years effective from 1998-99 Boro rice crop season and from the 4th year, hybrid rice seed will have to be produced locally otherwise the permission for hybrid rice seed import of the approved hybrid rice variety of the respective company/agency will be cancelled.

The initial guidelines as approved in 1998 on rice hybrids were as follows *(Source: Seed Wing, Minstry of Agriculture, 1998).*

i. The four private companies were temporarily allowed to import and sale a total quantity of 2,200 tonns of F_1 rice hybrid seeds of four hybrids during 1998-99 Boro rice season (irrigated rice).

ii. The temporary permission was given for three years period effective from 1998-99 Boro rice crop season, from the 4th year F_1 hybrid rice seed of approved rice hybrid variety will have to be produced locally by the respective company/agency otherwise the permission for importing F_1 hybrid rice seed of the approved hybrid rice variety will be cancelled.

iii. Final approval has to be taken by the respective company/agency from the NSB and local F_1 hybrid seed will have to be produced locally from the 4th year, if any company failed to locally produce hybrid rice seed of approved variety, the approval of the hybrid variety for respective company/agency will be cancelled and no F_1 hybrid seed will be allowed to import.

iv. For popularizing the approved rice hybrids, the respective company/agency will have to supply 1,000 kg hybrid seed to the Department of Agricultural Extension, Ministry of Agriculture at free of cost for conducting demonstrations at different agro-ecological locations of the country.

v. The F_1 hybrid seeds of the approved hybrid variety will have to be marketed under joint label as well as in secured packaging of the principal company who developed the hybrid and the local company who is importing the hybrid seed.

The initial guidelines of 1998 were subsequently revised and modified, and accordingly the updated policy/guidelines were approved by the NSB in the 52nd Meeting held on July 20, 2003. The modified hybrid rice guidelines were approved in the name of "**Hybrid Rice Variety Evaluation and Registration Procedures, 2003,"** circulated by the Seed Wing, Ministry of Agriculture, and published in the **Bangladesh Gazettee, Wednesday, December 24, 2003.**

With the formulation of policy on hybrid rice in 2003, the public agricultural research and agricultural universities, public sector seed organizations, private sector seed companies and NGOs were encouraged for investment in hybrid rice R&D, technology development and transfer, hybrid seed production, processing, preservation, quality control and making availability of F_1 hybrid rice seed to the farmers for commercial cultivation.

In this modified procedure of 2003, the F_1 hybrid rice seeds were allowed to import for commercial cultivation for five years instead of initially allowed for three years in 1998, within this five year period hybrid rice seed will have to be produced locally and in the 6th year only parent lines (A-Line and R-Line) seed will be allowed to import but not for F_1 hybrid rice seed of the approved hybrid.

Hybrid Rice Variety Evaluation and Registration Procedures, 2003 (*Source: The Bangladesh Gazettee, December 24, 2003 and Bangladesh Gazettee, April 16, 2007)*

1) Hybrid rice variety(s) develops in the country or import from abroad may be registered as per the law of the country after proper evaluation and can be cultivated at different locations of the country.
2) The person/research institute/private company/NGO will submit proposal in a prescrived Proforma for evaluation of the proposed hybrid rice variety to the Member-Director, Technical Committee of the National Seed Board and the Director, Seed Certification Agency (SCA) two months before the start of the rice plantation season.
3) The SCA after proper scrutinizing the application will inform the applicant within 15 days of application whethrer the application is acceptable or not. The applicant if qualified will submit required quantity of seed with fee and expenses for evaluation to the SCA within specified time.
4) (a) The applicant will have to supply required quantity of seed in packets to the SCA 15 days before setting up of trial for seed evaluation testing.

   (b) Required quantity of seed to be supplied to SCA on or before 1st November for Boro and 15th May for Aman season for evaluation trial and registration.

   (c) One applicant without taking any prior permission from the Seed Wing, Ministry of Agriculture can import F_1 hybrid seeds of maximum two hybrid varieties per season for the total quantity of 20kg seed of each hybrid variety for evaluation trial.

   In this regard, only import permit (IP) will have to be taken from the Plant Quarantine Department under the Plant Protection Wing of the Department of Agricultural Extension, Ministry of Agriculture

   (d) The applicant will have to inform the SCA within two months of import of hybrid seed on the status of actual use of imported hybrid seed.

   (e) Each person/company/institute can propose maximum two hybrids per season for evaluation and registration.
5) (a) The entry fee of Tk 2,000 (Taka two thousand) only for each hybrid to be deposited to SCA for evaluation and registration which has to be deposited to the Government Treasury by SCA.

   (b) An expenses of Tk 2,500 (Taka two thousand five hundred) only for trial of each hybrid for each location to be deposited to Director, SCA.
6) The evaluation trial would be conducted at least five out of total nine agro-ecological zones of the country. The each trial to be set up at **'on-station test plot'** and **'on-farm'** of at least nearby five fatmers' fields by following Randomized Complete Block Design (RCBD).

7) Keeping in view to interaction of hybrid variety and environment the trial to be conducted under the coordination of SCA for two years. Before submission of application to SCA for national evaluation trial and registration, each applicant will have to conduct their own trial and evaluation for at least one year of the proposed hybrid variety.

8) The hybrid seed importer and seed producer will have the following qualities and capabilities/ facilities:

   a) Necessary technical manpower for production of rice hybrid seed,

   b) Necessary own lands or leased lands,

   c) Own seed processing facility or source of availing seed processing facility,

   d) Capability for hybrid seed production and variety development through Joint Venture Program.

9) The test will have to be designed for proposed hybrid variety by selecting one locally developed hybrid (if available) and at least one open pollinated inbred variety as Standard Check variety. During Boro season, the check variety against the proposed hybrid variety having duration equal to or greater than 150 days should be BRRI dhan 29 and the check variety against the proposed hybrid variety hybrid having duration equal to or lower than 150 days should be BRRI dhan 28. Similarly for Aman season, the check variety against propsed hybrid variety having long duration should be BR11/BRRI dhan 30 and the check variety against propsed hybrid variety having short duration should be BRRI dhan 31/BRRI dhan 32.

   The proposed hybrid, if performed at least above 20% yield heterosis (standard heterisis) over the check variety in the more than one region at **'on-station'** and **'on-farm'** trials would be recommended for registration for maximum 5 (five) years.

   For this taking into consideration on the basis of first year seed import, the respective company/agency will have to produce hybrid seed of the approved hybrid variety locally by their own initiative/joint venture program within next five years. From the 6th year excepting import of parent lines seed (A-Line and R-Line) no F_1 hybrid seed of the registered/approved hybrid variety will be allowed to import.

   "It may be noted here that the condition for allowing F_1 hybrid seed import for five years as approved in 2003 has been amended into 8 (eight) years in the 60th meeting of the NSB held on August 3, 2006, circulated on March 18, 2007, and it was published in the Bangladesh Gazettee on April 16, 2007".

   As per the ***Amended Procedure, 2007***, the respective person/company/institute having necessary technical capacity/capability and facility for hybrid rice seed production locally is allowed to import F_1 hybrid seed of the hybrid variety released and notified for a period of maximum 8 (eight) years instead of five years (Procedure, 2003). Within this period of eight years the respective company/agency will have to go for locally F_1 hybrid rice seed production of their released and notified hybrid variety. From the ninth year they will be allowed to import only parent lines (A-Line and R-Line) seed but not for F_1 hybrid seed of the released and notified hybrid variety, if anybody failed, the registration of the hybrid variety of that company/agency will be cancelled.

Policies on Investment of Public and Private R&D for Hybrid Rice

(1) Equity & Entrepreneurship Fund (EEF) in Bangladesh Bank (Source: Bangladesh Bank, 2010): In Bangladesh there is no specific and separate investment policy on hybrid rice. However, the Bangladesh Bank (the Central Bank of Bangladesh) has created an avenue particularly for private sector investment through introducing specialized venture fund namely ***"EEF (Equity & Entrepreneurship Fund)" in 2002.*** The main objective of the 'EEF' is to encourage investment in the risk but potential and prospective industries like (i) Software, and (ii) Food processing & Agro-based industries. The EEF is applicable only for private investment to the private limited companies. The project cost should be minimum BDT 5 million to maximum BDT 100 million (One BDT is equivalent to US$ 70 in 2010). The EEF facility would be 49% or 1/3rd (33.33%) of the project cost, whichever is less. The EEF facility would be maximum 49% of the project cost in case of no Bank Loan is taken and the balance 51% would be the self investment by the applicant for the project. In 2009 a Memorandum of Understanding (MOU) was singed between the Bangladesh Bank and Investment Corporation of Bangladesh (ICB) of the Ministry of Finance, Government of the People's Republic of Bangladesh for overall policy, project approval, investment and performance monitoring of the EEF by the ICB as a Sub-Agent of the Bangladesh Bank.

Other than financing through **EEF**, the provision has also been made for financing in the agricultural sector through Agricultural/Rural Credit Policy Program. The Bangladesh Bank has categorized and listed "*34 numbers of Agro-processing and Agro-based Industries as "Priority and Thrust Sector Industries."* Under that Thrust Sector, the Hybrid seed production (Rice, Maize, Vegetables and Watermelon) has been included in 2008 for funding from the Bangladesh Bank. Investment in hybrid rice was introduced through EEF and Agricultural/Rural Credit Policy Program from 2008-09 crop season. "*It may be noted here that, in 2010,* ***Energypack Agro Limited****, a private company has so far could be able to availed the opportunity of EEF for local production of hybrid rice seeds of their hybrid rice vatiety released by the NSB".* The facility created by the Bangladesh Bank through EEF and facility under the Agricultural/Rural Credit Policy Program of the Government can be availed by the interested private sector agency for investment in hybrid rice.

(2) The Industrial Policy (Source: National Industrial Policy, 2010): Although Seed is considered as an industry but it has not yet been recognized in the Industrial Policy of Bangladesh. There is Industrial Policy inacted in 1999 and upgraded, modified and amended in 2005 and latest in 2009 which has finally approved in 2010. In the Industrial Policy, 2009, categorized and listed 33 numbers of industries as "Agro-based activities & Agro-products/Food processing Industries." In that list *"Seed Processing and Preservation"* has been included. In the up dated Industrial Policy, 2009, categorized and listed 28 numbers of industries as *"Thrust Sectors."* In that list of *"Thrust Sectors"* industries the *"Agro-based and Agro-products/Food Processing Industries,"* has been included but the "*Seed Processing and Preservation"* has not been included in the *"Thrust Sectors"* industries. The up-dated Industrial Policy, 2009, was approved in the Inter-Ministerial Meeting held in the Month of September, 2010, but no specific Policy was incorporated in that Industrial Policy, 2009 particularly for hybrid rice. If hybrid rice was included in the Industrial Policy, 2009 and provisions were made for investment on hybrid rice, local and foreign direct as well as joint venture investment by the private investors would have been encouraged to large-scale investment particularly on research & development (R&D) for hybrid rice. The government of Bangladesh should rethink to incorporate hybrid rice in the Industrial Policy which will help the country to ensure food security by increasing more rice productoion in the limiting land and water resources of the country.

Investment in Hybrid Rice Research & Development

In pursuance to the hybrid rice variety evaluation and registration procedure, 2003, amended in 2007, it is mandedtory for the public and private agency and NGO for production of hybrid rice seed locally by developing their own technical capabilities/ through joint venture program with their foreign principal. A good number of private agency and one NGO have come forward and started their investment on research & development (R&D) for hybrid variety improvement with the technical support and cooperation of their counterpart principals. The International Rice Research Institute (IRRI) has ben playing commendable role in cooperating by supplying germplasm/parent materials and other technical supports to the public research institute-Bangladesh Rice Research Institute for developing and improving hybrid rice. Since inception in 1998 to 2010, the private and public agencies also started local production of hybrid seed of their released rice hybrid varieties.

It may be noted here that few private company and one NGO have also achieved an appreciable performances by developing new rice hybrid variety locally which have also been released and notified by NSB. Out of 85 hybrid varieties released since 1998 to 2010, a total of 8(eight) hybrid rice varieties have ben developed locally, one private agency has developed 2 hybrids, one NGO has developed 2 hybrids, and one public research institute BRRI has developed 4 hybrid varieties. These achievements could be possible and successful by investing in research & development (R&D) by the respective agencies.

The progress of investment and achievement in hybrid rice research & development in public, private and NGO are cited here. Most of the involved organizations (Public & Private agencies and NGO) have started R & D mainly on variety development through pilot testing/trial for their proposed and released varieties of hybrid rice. Other than BRRI (the only public research institute), Supreme seed and BRAC, no large-scale investment has been made by the private seed companies in R & D for hybrid rice variety improvement and technology development. In private sector, Supreme Seed Company Limited and BRAC (NGO) have been in leading position by investing in R & D for hybrid rice. Both Supreme Seed Company Limited and BRAC have their modest investment on R & D for hybrid rice variety improvement and technology development. They have their investment in the field of technical manpower recuitment, capital investment for land development and other infrastructure development. The Bangladesh Rice Research Institute in continuing their research activities started with the financial and technical support from multilateral donor organizations such as FAO, ADB and IRRI, has been successfully implementing their “Hybrid Rice Project” funded under the Annual Development Program (ADP) of the Ministry of Agriculture (MoA), Government of Bangladesh (GoB) since 2005. Similarly, another public agency like BADC (Bangladesh Agricultural Development Corporation) has been implementing a project on “Hybrid Rice Seed Production, Processing and Preservation” funded under the ADP of MoA, GoB in collaboration and technical support from their Principal Company “SL Agro Tech" of the Philippines since 2008-09. Since 1998 to as of 2010, a total of 44 number of public, private and NGOs has been engaged in hybrid rice seed activities in Bangladesh. Out of 44 agencies, 40 agencies are private, 2 NGOs, one public research institute (BRRI) and one public seed corporation (BADC) is engaged in hybrid rice seed activies and business. Besides 2 public agencies (BRRI & BADC) only one private seed company (Supreme Seed Company) and one NGO (BRAC) have invested in hybrid rice R & D program (Annex.XI.1).

Promotion and multiplication of locally developed rice hybrids

Since 1998 to 2010, a total number of 85 hybrid rice varieties have been released in Bangladresh. Out of 85 rice hybrids released, of which 8 rice hybrids developed in Banladesh by public, private and NGO (4 rice hybrids developed by BRRI, 2 hybrids developed by Supreme Seed Company and 2 hybrids developed by BRAC and 77 rice hybrids are imported from China, India and Philippines (Table.IX.2 & 3).

BRRI has been supplying parent lines and F_1 seeds of released rice hybrids (BRRI hybrid dhan 1, 2, 3, & 4) among the trained agencies (BADC, private seed companies, NGOs etc) and farmers for F_1 seed production and dissemination of BRRI's developed rice hybrids in the country. On the other hand private seed company and NGO are producing F_1 seed of their developed rice hybrids and they are selling their own produced F_1 seed through their existing seed dealers' network in the country. There is a lacking in policy to support for investment in R & D for in-country development of rice hybrids. Moreover, there is no financial support from GOB on R & D seed production and marketing for rice hybrids for private seed companies. In Bangladesh, there should be strong policy and financial support from the Government in fovour of investment in R & D, F_1 seed production and marketing of released rice hybrids like China, Vietnam etc.

Seed system

There are two seed systems are existed in Bangladesh such as (i) Formal seed system and (ii) Informal seed system for seed used, seed supply, seed sell and seed exchange of various crops. Thus farmer-retained seed and community-level seed production and distribution jointly constitute what are regarded as "informal seed system". On the other hand external source of seed for farmers is formal seed production and delivery system, involving specialized public and/or private seed producing and distributing enterprises. Formal and informal seed system may be complementary with several issues of the seed production and supply. Whether or not formal seed producers and distributors can effectively compete with informal arrangement with depend upon the farmers' cost efficiency, their quality of seed and their effectiveness in reaching farmers and promoting their products (Jeffee and Srivastava, 1992).

Formal seed system: In the formal seed system, Breeder Seed (BS), Foundation Seed (FS), Certified Seed (CS) and Truthfully Labelled Seed (TLS) are marketed by registered seed dealers of the NSB by maintaining seed quality as per standard fixed by the NSB. The seed dealers follow the rules and regulations of the National Seed Policy, the Seed Rules and the Seed (Amendment) Act, 2005. The Breeder Seed, Foundation Seed and Certified Seed are duly certified by the Seed Certification Agency and the certification of Truthfully Labelled Seed is declared by the seed companies and NGOs by following the standard of certified seed. The seeds are marketed through labeling and packaging as per the legal rules and regulations for the seed. As per the Seed (Amendment) Act, 2005, the regulations of sale of seeds of any kind or variety are as follows:

- The **'seed dealer'**-means a person or a company or an organization involved in production of seeds or carrying on the business of importing, selling, hoarding for sale, bartering or otherwise supplying any seed of any kind or variety for agricultural purpose unless:

    a) Such seed is identified as to its kind or variety

b) Such seed conforms at least to the minimum limits of germination percentage, purity percentage, moisture content and such other components of seed quality with respect to any seed of any kind or variety

c) The mark or label to indicate that such seed conforms to the standard specified under this Act and such other requirements as may be prescribed.

Informal seed system: The informal seed system is such that the **'farmer' means** other than **'seed dealer'** producing or hoarding seeds partly for his own use and partly for sale in the local hats and bazaars by himself or through any other person, in small quantities. In this informal seed system the seed standard as prescribed in the Seed (Amendment) Act, 2005 and the Seed Rules, 1998 and the National Seed Policy, 1993 are not followed by the farmer during using his own saved seed or selling or exchanging. Since the prescribed seed standard is not followed as such the quality of this informal seed is considered poor.

Recently, seed experts from public, private and NGO are proposing to introduce an alternate seed system in Bangladesh as "Semi informal seed system" in a view to supply and sell the seed of various crop, which can't be sell as formal seed source. To over come, this Constraint, "Truthfully Labelled Seed" was proposed in early 1990s in the draft seed rules of MOA, later which was included in the seed rules, 1998 (Ahmed & Islam, 2009). Accordingly, any quality seed can be sold by the seed marketing agencies/dealers as Truthfully Labelled Seed. Thus beside formal and informal seed, introduction of "Semi informal seed system" will create confusion among the seed men in the country. Moreover, F_1 seed of hybrid rice has been selling as Truthfully Labelled Seed due to lack of policy, rules and guidelines for the same since 1998.

Seed Sector in Bangladesh

In Bangladesh seed sector is organized in accordance with The National Seed Policy, 1993, The Seed Ordinance, 1977, Amendmended Act, 2005, and The Seed Rules, 1998. Under formal seed system, quality seeds are produced, distributed and marketed for replacement of informal poor quality of seeds. In Bangladesh there are four classes of seeds approved by the NSB. The four classes are (i) Breeder Seed (BS), (ii) Foundation Seed (FS), (iii) Certified Seed (CS), and (iv) Truthfully Labelled Seed (TLS). These classifications of seeds are applicable to inbred varieties but for hybrid rice classification of seed has yet not been approved. Hybrid rice seed is produced and marketed only as TLS F_1 hybrid rice seed. The organized quality rice seed supplying players are public sector BRRI (supplying BS), BADC (supplying FS, CS, and TLS) and private agencies including NGOs (supplying FS/CS/TLS). The major role playing in seed supply for inbred rice is public sector BADC followed by private agencies and NGOs. But in case of hybrid rice seed, the private agencies is playing major role for F_1 seed supply in the country.

Rice Seed (inbred & hybrid) Marketing Policy

As per "The Seed Rules, 1998," the seeds of inbred varieties are marketed in the name of following four classes:

i. **Breeder Seed (BS)**-the BS provides the source of the first and the recurring increase of foundation seed.
ii. **Foundation Seed (FS)**-the FS shall be the progeny of BS or be produced from FS which can be clearly traced to BS.
iii. **Certified Seed (CS)**-the CS shall be the progeny of FS that is so handled as to maintain genetic identity and purity according to standards specified for the particular

crop being certified. There is a provision that CS may be progeny of CS in case of necessity provided it will not exceeds three generations and the genetic purity will be properly maintained.

iv. **Truthfully Labelled Seed (TLS)**-the TLS shall be progeny of FS, CS, labelled or any other seed to be specified from time to time, the container of which has a label indicating as to its quality in a way as prescribed.

"In case of inbred rice, the above mentioned classes of seeds are maintained for seed marketing but for hybrid rice seed marketing no classification has yet not been defined in Bangladesh. Hybrid seeds are selling as self declared "Truthfully Labelled Seed." For hybrid seed marketing the Amendment in "The Seed Rules, 1998" is needed. The hybrid rice seed is marketed in the name of hybrid seed only without mentioning class of seed in the label of container/packaging".

Policy on Import of Hybrid Rice Seed

Since 1998-99, hybrid rice seed has been importing from China, and India. Within the provision of the policy, F_1 and parent lines (R-Line and A-Line) seeds are allowed to import for the approved, released and notified rice hybrids for the respective agencies. Before planting season, the concerned agencies applied to the NSB for allowing import of F_1 hybrid rice seed and parent lines seed for the released rice hybrids. The condition is that respective agencies will have to show their technical ability to produce F_1 hybrid seed in the country within eight years of releasing hybrid variety for the respective agency.. The import barrier is that the principal Companies in China have monopolized their technical and trade barriers by charging high prices for F_1 seed and royalty for parent line seeds. Recently (2009-10 and 2010-11), the Chinese Companies have imposed technical barrier that they would not supply F_1 hybrid seed if any importing agency is discontinued to import parent lines due to developing own parent lines for production of F_1 hybrid rice seeds in Bangladesh. To overcome this barriers the Government support is needed for technical capacity building up of Bangladesi Companies for local production of hybrid seed.

Regarding Plant Quarantine issue (Plant Quarantine Act, 2009), at present the policy is that any agency is allowed to apply for Import Permit for importing maximum 20 kg of hybrid seed for one variety and the maximum limit for importing two hybrid varieties for National Hybrid Rice Evaluation Trial. Further, any agency is allowed to apply for Import Permit for importing limited quantity of F_1 hybrid seed and parent lines seed on the basis of approval given by the NSB for the hybrid variety (s) released by the NSB. In this regard, this policy need to be modified and simplified for encouraging the private agencies by allowing to import more than two hybrid varieties for their own adaptive trials at least one year before submitting best performing hybrid to the SCA for National Evaluation Trials and there should not be any limit in quatity for importing F_1 hybrid seed of released hybrid rice varieties.

Regarding Intellectual Property Rights and Plant Variety Protection Act (Plant Variety and Farmers' Rights Protection Act, 2009), the Act has not yet been approved in the National Parliament of Bangladesh. The Act need to be modified for inclusion of hybrid rice in the Act and should be approved in the National Parliament immediately.

Policy, Act and Rules on Agricultural Crops

(**Source:** the National Seed Board of the Ministry of Agriculture**)**

In Bangladesh there has been Policy, Act and Rules on agricultural crops since 1977. The seed related legal issues are regulated by the National Seed Board (NSB) of the Ministry of

Agriculture, Government of the Peoples Republic of Bangladesh. The policies on hybrid rice were initiated in 1998. The detailed information on Policy, Act and Rules on Agricultural Crops are incorporated hereunder as ready references for better understanding on its historical background.

The National Seed Board (NSB): The Seed related all policies and rules are regulated by the *"National Seed Board (NSB)"* and all technical matters are evaluated, verified, and monitored by the *"Technical Committee (TC)"* of the Ministry of Agriculture, Government of the Peoples Republic of Bangladesh.

The National Seed Board (NSB) of the Ministry of Agriculture, Government of Peoples Republic of Bangladesh is the Central Regulatory Body on seed related matters of the Government. The main functions of the NSB are to advise the Government on matters arising out of the administration of the Seed Related Policy, Act and Rules and to carry out the other functions assigned to it by the Government. The Secretary, Ministry of Agriculture shall be the Chairman of the NSB. The NSB was first constituted on 22 September 1973 with ten member committee. Subsequently in Pursuance to the Seed Ordinance, 1977 the NSB was reconstituted with 16 (sixteen) member committee. As per latest the Seeds (Amendment) Act, 2005 the NSB is constituted with 20 (twenty) member committee. The modified NSB constituted in 2005 is shown in Annex.XI.2.

The Technical Committee (TC)

Regarding variety development through breeding locally, and introduced from abroad as well as through local selection are evaluated and recommended by the Technical Committee (TC) and finally approved for registration, release and notification are done by the NSB. The Technical Committee was first constituted with 18 members by the National Seed Board in its 30th Meeting held on 26 October 1993. In the 50th NSB Meeting held on 10 April 2002 the Technical Committee was further constituted with 16 members. The modified Technical Committee constituted in 2002 is shown in Annex.XI.3.

Variety Evaluation Team

As per decision of the 33rd NSB meeting held on March 8, 1995 the Chairman Technical Committee (Executive Chairman, BARC) will constitute Variety Evaluation Team for Nine Agro-ecological Zones of the Country. The Additional Director, DAE of the respective Region shall be the Team Leader who will submit the evaluation report to the Director, SCA who is Member-Secretary of the Technical Committee.

Policy, Act and Rules

In Bangladesh, agricultural crops are classified into two different classes: (a) Notified crops, and (b) Non-Notified crops. The five crops are declared as **"Notified crops"**; the five notified crops are (i) Rice, (ii) Wheat, (iii) Jute, (i) Potato, and (v) Sugarcane. As of 2010 as many as 74 crops have been enlisted under non-notified crops other than five notified crops by the NSB and also standardized their field standard and seed standard for variety development, seed production, seed import, quality control and marketing of seeds. Variety development, research, technology, seed production, seed import, seed export, seed certification, seed quality control, and seed marketing are regulated by the NSB through Policy, Act and Rules(SCA, 2009). The agricultural crop variety and seed related regulatory frameworks are as follows:

1. The National Seed Policy, 1993 (*Notification No. 19, dated January 25, 1993, Ministry of Agriculture, Government of the Peoples Republic of Bangladesh)*.
2. The Seed Ordinance, 1977 (*Notification No. 617-Pub, dated July 19, 1977, Ministry of Law and Parliamentary Affairs, Government of the Peoples Republic of Bangladesh).*
3. The Seeds (Amendment) Act, 1997 (*Published in The Bangladesh Gazettee, dated March 13, 1997, Bangladesh National Parliament)*.
4. The Seed Rules, 1998 (*Published in The Bangladesh Gazettee, dated July 13, 1998, Ministry of Agriculture, Government of the Peoples Republic of Bangladesh).*
5. The Seeds (Amendment) Act, 2005 (Published in *The Bangladesh Gazettee, dated September 22, 2005, Bangladesh National Parliament)*.
6. The Intellectual Property Rights and Plant Variety Protection Act (Ministry of Agriculture, 2009)
7. The Plant Quarantine Act (Ministry of Agriculture, 2010)

The Seed related all policies and rules are regulated by the *"National Seed Board (NSB)"* and all technical matters are evaluated, verified, and monitored by the *"Technical Committee (TC)"* of the Ministry of Agriculture, Government of the Peoples Republic of Bangladesh.

The National Seed Policy, 1993

In "The National Seed Policy, 1993," the persons, public, private companies and other agencies as well as NGOs are encouraged to undertake plant breeding programs and also allowed to import parent lines, breeder seeds/foundation seeds/certified seed/truthfully labelled seeds of any kind or variety of agricultural crops for the purpose of variety improvement, variety development and promotion. The relevant policy and legal issues on seed industry development are as follows:

Variety Release, Registration and Notification

A. As per*The National Seed Policy, 1993,* five crops like (i) Rice, (ii) Wheat, (iii) Jute, (iv) Potato, and (v) Sugarcane are declared as *"Notified Crops."* The Variety Release and Notification of these notified crops are regulated by the National Seed Board (NSB) on the basis of recommendations made by the Technical Committee (TC) of the National Seed Board.

B. As per *The National Seed Policy, 1993,* all crops other than five Notified crops are declared as *"Non-Notified Crops."* As of 2010 as many as 74 crops have been enlisted under non-notified crops. The Variety Release of Non-Notified crops are regulated by the National Seed Board (NSB) on the basis of recommendation by the TC.

C. According to "The Seeds (Amendment) Act, 2005," the power to regulate quality seeds of any kind or variety to be as follows:

1. The Government shall regulate the quality of seed of any kind or variety to be sold and used for the purposes of agriculture. If the Government after consultation with the Board (NSB) of opinion that it is necessary or expedient to regulate sale, distribution, bartering or otherwise supplying, and import of seed of any kind or

variety, it may, by notification in the Official Gazette, specify such kind or variety to be a notified kind or variety for the purpose of this Act and different kinds or varieties may be notified for different areas.

2. New varieties of *'non-notified crops'* developed by public or private agencies will be subject to approval and certification by the NSB before being released.
3. New varieties of *'notified crops'* developed by public agencies will be subject to approval by, and be registered with the NSB before being released.
4. Varieties of *'non-notified crops***'** those are imported or locally developed by a private agency shall be registered with the NSB giving prescribed cultivar description.
5. In the event of a seed of any kind or variety is found to be harmful or potentially harmful in any way, the NSB may prohibit the sale, distribution, bartering, or otherwise supplying, import and use of that variety and may take any other action in the interest of agriculture.
6. The functions of NSB and TC on *'variety release'* and *'variety notification'* have been separated.

   (i) The NSB shall notify varieties of seeds under the provisions of the Seed (Amendment) Act, 2005. The release of varieties of any kind or variety of crops shall vest in a *"Technical Committee."*

   (ii) Any proposal for release of new variety of notified crops shall be examined by a Technical Committee headed by the Executive Chairman, Bangladesh Agricultural Research Council (BARC), and members of the TC consisting of representatives of National Agricultural Research System (NARS), Seed Certification Agency (SCA), Department of Agricultural Extension (DAE), Bangladesh Agricultural Development Corporation (BADC), and representatives from Private sector Seed Growers and Farmers Associations and make recommendation to the Board (NSB).

   (iii) Proposal for release of new varieties of non-notified crops developed by any public agency shall be subject to examination by the *Technical Committee*.

7. Import and Export of Seeds

   i. The *'seed dealer'* registered with the NSB is allowed to import seed of any kind or variety of agricultural crops subject to taking *'import permit'* from the Plant Quarantine Department of Plant Protection Wing of the Department of Agriculture under the Ministry of Agriculture as per the provision of the Destructive Insects and Pests Rules (Plant Quarantine), 1966, amended in 1989 and further revised in 2009 as Plant Quarantine Act, 2009 (the Act 2009 is yet to be approved by the Government).

   ii. No person shall export or import or cause to be exported or imported any seed of any kind or variety unless it conforms to the standards of seeds quality, and the container of such seeds bears, in the prescribed manner, the mark or label containing the correct particulars thereof specified for that seed.

   iii. Seeds of approved varieties of all notified crops may be imported for commercial sale. Registered seed dealers may be permitted to import small quantities of such varieties not approved by NSB for the purpose of research and adaptability testing.

   iv. There shall be no restriction on import of seeds of non-notified crops, except for ensuring prescribed quality.

8. Seed Dealer

   Seed Dealer means a person or a company or an organization involved in production of seeds or carrying on the business of importing, selling, hoarding for sale, bartering or otherwise supplying any seed of any kind or variety for agricultural purpose must be registered with the NSB.
   But the farmer producing or hoarding seeds partly for his own use and partly for sale in the local market by himself or through any other person, in small quantities shall not be treated as Seed Dealer.

9. Seed Certification Agency

   The Seed Certification Agency (SCA) is the Legal Certification Agency of the Ministry of Agriculture. The main functions of SCA in seeds related matters are as follows:

   i. To Certify all Breeder Seed, Foundation Seed and Certified Seed of Notified Crops.
   ii. To coordinate the variety evaluation and release system for Notified Crops.
   iii. To collect market monitor on the quality of seeds for notified and non-notified crops.
   iv. To collect samples of truthfully labelled seed and very their declared quality standard by appropriate testing and report to the NSB.
   v. To enforce the rules and regulations of The National Seed Policy, 1993, The Seeds (Amendment) Act, 2005 and The Seed Rules, 1998.

10. Labelling of Seeds

    Seed packaging in containers shall have a label containing batch identification, net weight or count, minimum germination percentage, physical purity, name and address of the company packaging the seed, the date of packaging and date of expire.

Intellectual Property Rights and Plant Variety Protection Act

No separate Plant Variety and Farmers' Rights Protection Act has yet been formulated and approved separately for hybrid rice in Bangladresh. Keeping in view of protecting the new crop varieties and encouraging plant breeders the first time initiative was taken in the line of Convention of Biodiversity (CBD) by the National Committee on Plant Genetic Resources (NCPGR) for formulation of the Plant Variety Protection Act in 1998. In the line of WTO's the Trade Related Aspects of Intellectual Property Rights (TRIPS) clause 27-3(b) and like other countries and taking into consideration of socio-economic aspects a draft on *Plant Variety Protection Act (PVPA)* was prepared by *NCPGR* (the National Committee on Plant Genetic Resources), Dhaka, 29 September 1998 and submitted to the Ministry of Agriculture in 1998. The Agriculture Ministry constituted a six member committee in 2003 with the convener of Dr. Lutfor Rahman, Professor, Genetics and Plant Breeding Department of Bangladesh Agricultural University for review and revising the draft *PVPA*. The Committee after thorough reviewing, revising, and modification submitted the *PVPA* to the Ministry of Agriculture on 27 March 2003. It was reviewed that the necessity and importance of Plant Variety Protection Act had been under consideration of the Ministry of Agriculture since 1995-96 and finally a draft was prepared and submitted by a committee on 27 March 2003 to the Ministry of Agriculture. The draft was sent to seven different Ministries and 26 various institutions/departments/organizations for their opinion and comments. The PVPA was discussed in a workshop held on 8 June 2003 participated by in-country and international experts and specialists, and it was further modified and with the recommendation of the

workshop the name of the PVPA was changed into “Plant Variety and Farmers’ Rights Protection Act, 2003.” The revised Plant Variety and Farmers’ Rights Protection Act, 2003 was discussed in the 54th NSB meeting held on 19 June 2004 and in the 55th NSB special meeting held on 4/8/2004. It was reviewed in the 55th NSB meeting that the necessity and importance of Plant Variety Protection Act had been under consideration of the Ministry of Agriculture since 1995-96 and finally a draft was prepared and submitted by a committee on 27 March 2003 to the Ministry of Agriculture. The draft was sent to seven different Ministries and 26 various institutions/departments/organizations for their opinion and comments. The draft was further sent to 5 different Ministries and 22 various institutions, departments and organizations for reviewing, opinion, comments and recommendations.

It was further discussed in the 56th NSB meeting held on 31 December 2004 and the Act was prepared as “Plant Variety and Farmers’ Rights Protection Act, 2004.” It was submitted and discussed in the Inter-Ministerial Meeting held on 21 October 2004 and the draft was approved. Further a special Inter-Ministerial Meeting was held on 6 Jannuary 2005 in the Conference Room of Ministry of Agriculture and finally approved as “Plant Variety and Farmers’ Rights Protection Act, 2004.” The detailed on Plant Variety and Farmers’ Rights Protection Act, 2009 is shown in Annex.XI.4:

It may be noted here that further the Act was prepared in 2009 as “Plant Variety And Farmers’ Rights Protection Act, 2009.” The Preamble of the Act is “*An Act to provide protection of the rights of plant breeders and farmers with regard to plant varieties.* Bangladesh has been sharing hybrid rice technology with the world through international hybrid rice training at IRRI and experts’ direct R&D activities to Bangladesh. In recent years, great progress has been made in Vietnam, India, the Philippines, Bangladesh, and the U.S. However, this is still far from “developing hybrid rice to benefit people all over the world,” a slogan coined by Yuan Longping. There are persisting problems such as slow international efforts and many barriers. Some developing countries, especially those beset by food shortages, have been showing interest in trying this technology to increase rice production potential. At the same time, more and more foreign technical assistance is being sought every year. Hybrid rice technology could thus be used as a main component of foreign agricultural assistance of the Bangladesh government. This not only fosters friendship between Bangladesh and other countries, it could also be a good source of international business. So, it would have important political and economic implications for the state to encourage the development of hybrid rice internationally. Implementing hybrid rice diplomacy results in a win-win situation provided the following measures are taken:

i. First, we should strengthen the protection of intellectual property and international patent declarations to ensure benefits to Bangladesh.
ii. Second, we should encourage hybrid rice research centers and enterprises to engage in research and exploitation of hybrid rice abroad, and the government should give them financial and policy support.
iii. Third, we should remove the policy barrier on exporting hybrid rice techniques.
iv. We should fully encourage germplasm and information exchange under international and country IP laws.
v. To satisfy research requirements, the export of a small amount of hybrid rice seeds and breeding materials should be allowed.
vi. Fourth, we should share established hybrid rice techniques to ensure the sustainability of technology development.

The Collaboration and the Intellectual Property Rights and Hybrid Rice of IRRI

The International Rice Research Institute (IRRI), as of today does not collaborate directly with the private sector on hybrid rice although it recognizes the role of the private sector in developing and transferring hybrid rice technology. The IRRI, in of any request from private sector on hybrid rice germplasm from IRRI, advice them to get the facility for hybrid rice germplasm from NARS of the home country. Very recently IRRI has defined its Policy on Intellectual Property Rights and Hybrid Rice. The IRRI's Policy is as follows:

i. IRRI adheres to the policy of free availability of the breeding lines, elite germplasm, and parental lines produced in its breeding program.

ii. IRRI will not seek intellectual property protection on the breeding lines, elite germplasm, and parental lines emanating from its breeding program.

iii. IRRI recognizes that the private sector is likely to play an important role in the development of hybrid rice technology.

iv. IRRI will provide hybrid rice parental lines (and other elite materials) to both public sector institutions and private organizations on the understanding that the material is not intended for exclusive use by a single organization, that IRRI retains the right to distribute the same material to other organizations, and that the use of IRRI materials will be recognized when a hybrid rice variety is released.

v. Collaboration with profit-making organizations for the development of hybrid rice technology will proceed after consultation, where appropriate, with the authorities in the respective host country.

In view of the above mentioned IRRI's Policies on hybrid rice, IRRI should extend its collaboration and support to the private sector organization those have their financial and technical capabilities as well as infrastructure for hybrid rice variety development and seed production.

Plant Quarantine Act, 2009

In Bangladesh there is Plant Qurantine Act applicable for all agricultural crops for importing and exporting agricultural crops seed and planting materials. The same regulations are applicable for hybrid rice. No separate plant quarantine regulations have yet been formulated for hybrid rice. Detailed on Plant Quarantine Act, 2009 is shown in Annex.XI.5.

As per the Plant Quarantine Act, 2009, it is expedient and necessary to prevent, in the context of international traffic in plant materials, the introduction into Bangladesh of pests, to prevent the spread thereof and to provide for other matters incidental and ancillary thereto. The Plant Protection Wing, Department of Agricultural Extension, as the National Plant Quarantine Authority, shall administer and enforce the provisions of this Act.

(1) The National Plant Quarantine Authority, shall-

a) inspect seeds, growing plants, areas under cultivation, and plant materials in storage or locally in transit, in order to report the existence, outbreak and spread of pests and to control pests;

(b) in respect of plant material moving in international traffic-

i. prevent the introduction of quarantine pests into Bangladesh from outside the country by regulating the import of plant materials, beneficial organisms and packaging material;
ii. regulate the export of plant material, pests, beneficial organisms and packaging material, to meet the importing country's requirements in accordance with international agreements, and to discharge such obligations under those international agreements;
iii. inspect consignments of plant material and, where appropriate, inspect consignments of other articles and commodities moving in international traffic under conditions where they may Act incidentally as carriers of pests;
iv. issue phytosanitary certificates in accordance with the requirements of importing countries;
v. disinfest or disinfect consignments of plant materials, as well as their containers, packaging, storage places or transport facilities;
vi. regulate the introduction of beneficial organisms;
vii. designate any area to be a controlled area or a quarantine area;
viii. conduct post-entry quarantine research and implement post-entry quarantine measures;
ix. undertake Pest Risk Analysis and Pest Risk Management;
x. undertake regular review and revision of lists of plant material, pests and beneficial organisms the importation of which into Bangladesh is prohibited or restricted with a view to update and harmonize phytosanitary measures;
xi. interact with international, regional or other National Plant Protection Organizations to stay abreast with the latest developments in the field of plant quarantine;

(c) carry out diagnostics, detection and identification of particular pests.
(d) promote integrated pest management and control in Bangladesh;
(e) carrying out and coordinating research in the plant quarantine and biodiversity protection;
(f) undertake risk analysis for the introduction of Genetically Modified Organisms (GMOs), Living Modified Organisms (LMOs) and Alien Invasive Species;
(g) undertake surveys, surveillance and conduct research on pests present in Bangladesh;
(h) distribute information within Bangladesh about pests of plant material and how to prevent infestation or infection and how to control them;
(i) ensure for technical expertise in plant quarantine;
(j) provide assistance for the phytosanitary management, operation and requirements in plant quarantine; and any other such matters as may be deemed necessary.

Prohibition to import - No person, company or organization shall import into Bangladesh any plant material, pest, beneficial organism or packaging material except in accordance with this Act.

Permits and certificates

1) Subject to the provisions of subsection 5(2), any plant material, beneficial organism or packaging material shall only be imported into Bangladesh through a point of entry designated by the Government from time to time, and upon importation shall be declared and submitted to a Plant Quarantine Officer together with the permits and certificates issued by the competent authority of the country of origin for examination.

2) The National Plant Quarantine Authority may, by notification published in the Gazette exempt certain plant material from the requirement to be declared on importation.

3) The National Plant Quarantine Authority may, by notice issued in the Gazette establish the details of the conditions under which and, or, treatments that any plant material, originating from such countries and, or, areas, as may be specified in the notice, has to be subjected to, prior to or after importation, including post-entry quarantine.

Inspection: The person in charge of any conveyance transporting or storing anything required to be declared under subsection 5(1) shall make the conveyance and its contents available for inspection and treatment by a Plant Quarantine Officer in accordance with this Act and the rules made there under.

Notification to Plant Quarantine Officer: Any person in Bangladesh who receives any plant material, pest, beneficial organism or packaging materials from outside Bangladesh whether or not that person consented to it being dispatched, shall, on receipt, immediately notify a Plant Quarantine Officer and carry out the Plant Quarantine Officer's instructions regarding its destruction, disposal or treatment if so required to the satisfaction of the Plant Quarantine Officer.

Seizure of plant harboring a pest: Anything imported into Bangladesh, in transit through Bangladesh or moved from one part of Bangladesh to another, in contravention of this Act or the rules made there under, together with any container used to transport it or any other thing reasonably suspected of harboring any pest, may be refused entry, seized, destroyed, disposed of, treated or otherwise dealt with as a Plant Quarantine Officer thinks fit, subject to the provisions of this Act and the rules made there under.

Import Permit

1) The National Plant Quarantine Authority may, by notice published in the Gazette, require that any plant material, pest, beneficial organic packaging material shall not be imported into Bangladesh from such countries or areas, as may be specified in the notice, except with an import permit and in strict compliance with the terms of the permit.

2) The National Plant Quarantine Authority may-

   a) issue, refuse to issue, or cancel an import permit; or

   b) prescribe in any import permits such terms and conditions as it deems appropriate and at any time, whether before or after importation, vary or add to the terms or conditions.

Phytosanitary Certificate: The National Plant Quarantine Authority may, by notice published in the Gazette, require that any plant material, as shall be specified in the notice, shall not be imported except with a phytosanitary certificate issued by the competent authority of the exporting country and which conforms in all material respects with either the phytosanitary certificate for export or for re-export.

Pre-export examination

1) Any person, company or organization intending to a consignment of plant material to another country shall submit the consignment to a plant Quarantine Officer for pre-export examination.

2) Each consignment submitted shall be examined by a Plant Quarantine Officer within fourteen days of the date of export in accordance with the requirements of the country of destination and if the Plant Quarantine Officer is satisfied that the requirements for the issue of a phytosanitary certificate have been met, the Plant Quarantine Officer shall issue a phytosanitary certificate in accordance with this Act and the rules made there under.

Tariffs and non-tariff barriers on imported agricultural inputs

It may be noted here that no specific Rules and Regulations in relation to Tariff and Non-Tariff Barriers has yet been formulated separately for Hybrid Rice Seed Import and Marketing in Bangladesh. The existing regulations are applicable and followed for Hybrid Rice import and marketing in Bangladesh. Detailed on Tariffs and Non-tariff barriers on imported agricultural inputs is shown in Annex.XI.6.

The existing Tariff and Non-Tariff Barriers on Imported Agricultural Inputs are as follows:

Natural barriers

i. Natural barriers typically include the transportation and shipping costs of engaging in international trade, which add to the cost of a good exported rather than retained for domestic consumption.

ii. Another natural barrier to trade of particular importance to seed is the adaptability of certain varieties for use in different agro-environments.

Manmade barriers

i. Manmade barriers also affect seed availability and/or prices. Tariffs and other barriers that raise the price of imported seed are usually not high enough to reduce trade significantly below what would have otherwise occurred.
ii. When reducing imports is the policy objective, most countries opt for non-tariff barriers that directly limit or preclude availability rather than rely on tariffs and the price mechanism.
iii. The developing countries use a wide range of Non-Tariff Trade Barriers (NTBs) to control trade in seed; total prohibition of most types of seed imports exists in many of these countries. In addition, trade barriers tend to have a negative effect on the quality of seed available to the farmer.

Non-tariff barriers

i. Non-tariff barriers includes all those restrictions other than traditional customs duties which distort international trade, such as impediments at national boarders, all types of domestic laws and regulations which discriminate against imports as well as subsidies aimed at stimulating domestic production.
ii. A non-tariff measure is defined as any device or practice other than a tariff which directly impedes the entry of imports into a country and / or which discriminates against imports-it means it does not apply with equal force on all domestic production or distribution.

Non-Tariff Barriers to Seed Industry in Bangladesh

i. Opening of Letter of Credit (L/C)
ii. Import Permit

Opening of Letter of Credit (L/C)

i. No consignment of plants or plant products or other regulated articles (seeds) shall be imported into Bangladesh without a valid Import Permit (IP) before opening L/C.

ii. This IP is issued by the Plant Quarantine section of the Plant Protection Wing of the Department of Agricultural Extension under the Ministry of Agriculture, Government of Bangladesh.

iii. No consignment shall be imported unless accompanied by a Phytosanitary Certificate issued by an authorized officer in the country of origin (The principal objective of Phytosanitary Certificate is to ensure the seed health of imported seed).

iv. On the basis of Phytosanitary Certificate of the Country of Origin of imported seed the Plant Quarantine Official at the Port of arrival in Bangladesh should issue clearance certificate.

v. But the fact is that the Plant Quarantine Official at the Port usually create problem by retaining seeds for the purpose of testing seed germination which needs at least seven to ten days.

vi. As a result of delaying the consignment for germination testing, the importers have to incur huge penalty for delaying clearing of consignments at the ports as well as farmers are also deprived of to get quality seed in time.

vii. This system can be simplified by collecting samples for germination testing and the whole consignments should be released outright without making any delay.

Harmonizing SPS Measures

i. The World Trade Organization (WTO) created a new era of international trade, inter alia, two new Agreements dealing with Technical Regulations and Standards:

ii. The Sanitary and Phytosanitary (SPS), and

iii. The Technical Barriers to Trade (TBT) Agreements.

The SPS Agreement

i. The SPS Agreement has been in force in many countries since 1996-97 and they are reforming their SPS measures/quarantine laws in order to conform to the WTO regime on SPS measures, as they understand the consequences of non-compliance.

ii. The SPS Agreement seeks to encourage harmonization of national SPS standards with international standards for the purpose of uniformity, with view to promoting trade and discourage protection of domestic food and agriculture industry from competition.

The Technical Barriers to Trade (TBT) Agreements

The TBT Agreements also recognizes the concept of equivalence in Article 2.7, which requires “members to give positive consideration to accepting as equivalent, technical regulations to other members, even if these regulations differ from their own, provided they are satisfied that the regulations adequately fulfill the objectives of their own regulations.”

Quarantine Regulations

i. Quarantine Regulations can help manage SPS issues.

ii. But in Bangladesh the SPS Agreements and the TBT issues have not yet been upgraded /amended in the line of WTO frameworks.

Tariff barriers

i. Tariffs are tax imposed on imported goods as they enter into customs territory.
ii. For many countries, tariff levels are low or zero, but for others the rates are moderately high and pose real barriers to trade, as in case of Bangladesh.

Tariff Barriers to Seed Trade in Bangladesh

In Bangladesh, the Seed Industry Development is seriously hampering because of Tariff-barriers. Tariff-barriers include:

i. Customs Duty (CD)
ii. Supplementary Duty (SD)
iii. Advance Income Tax (AIT)
iv. Advanced Trade VAT (ATV)
v. Total Tax Incidence (TTI)

Strengthening policy support to participate in the international trade system: First, Bangladesh should join in efforts to constitute new rules of rice trade, try to introduce initiatives, and participate in multilateral trade negotiations about market access and tariff quotas. Second, we should be familiar with WTO and international trade rules; our production and operations should coincide with international trade norms, technology standards, and financial standards. The laws and policies of our country should be adjusted to strengthen the competitiveness of hybrid rice. Finally, we should know the current technology advances, adjust the structure of export commodities, eliminate out-of-date methods of production and products, overcome all kinds of trade barriers, and try to avail of more market space and trade opportunities.

It may be noted here that although The Seed Ordinance, 1977 has amended first in 1997 as The Seeds (Amendment) Act, 1997 and second in 2005 as The Seeds (Amendment) Act, 2005, but no amendment has yet been made in The National Seed Policy, 1993, and The Seed Rules, 1998. The existing Seed related Legal Frameworks of Bangladesh may be improved, modified, up-graded and amended on the basis of demand-led and demand-driven basis.

Implication of Public Private Partnership (PPP)

The concept of Public-Private-Partnership (PPP) was for the first time formulated in the National Budget of Bangladesh in 2009-10 by the Finance Minister of the People's Republic of Bangladesh. Similarly, in the National Budget of 2010-11, a separate budget provision for PPP has also been made (Ali,M.S.2010). But in that PPP no allocation of Budget or any indication was given specifically on hybrid rice and there was no allocation or indication for investment under PPP for the private sector hybrid seed industry development in general. Detailed on PPP is shown in Annex.XI.7.

In the PPP Budget of 2009-10 a tune of US$ 357.14 million (BDT 25,000 million) has been allocated in the following areas of development:

i. PPP Technical Assistance US$ 14.29 million (BDT 1,000 million),

ii. PPP Viability Gap Funding as Subsidy US$ 42.86 million(BDT 3,000 million)

iii. PPP Infrastructure Investment Fund US$ 300 million (BDT 21,000 million)

In the 2009-10 budgets, an allocation for PPP was US$357.14 million (BDT 25,000 million). But due to absence of an integrated policy on PPP, there was, hardly any investment made in this sector during 2009-10 fiscal period.

In 2010-11 budgets, two initiatives have been outlined: (i) PPP Guidelines incorporating new policies, strategies and procedures for selection and approval of projects by replacing the existing regulatory framework, (ii) Steps are being taken to establish PPP office and to engage suitable experts. An allocation of US$428.57 million (BDT 30,000 million) has been placed in 2010-11 against BDT 2,500 milllion placed in 2009-10. A fund namely **"Bangladesh Infrastructure Finance Fund (BIFF),"** has been created with an allocation of US$228.57 million (BDT 16,000 million) in 2010-11.

It may be noted here that, no allocation has been made in the PPP Budget for Agriculture sector which is the largest economic growth contributing sector in Bangladesh. There was no specific allocation for private or public sector agricultural research & development, and technology dissemination, investment were outlined in 2010-11 PPP budget.

Scope of Public-Private-Partnership in hybrid rice

Since the varietal improvement, R&D, technology development, hybrid rice seed production, processing, and quality control are highly expensive and needs huge financial investment, so, the implication strategy of PPP may greatly help enhancement and promoting this hybrid rice technology. There is enormous scope for the government to allocate necessary budget provision in the PPP for hybrid rice technology in general and hybrid rice seed production in particular.

Hybrid rice seed production is carried out in areas where the agro-climatic conditions and agro-ecological locations are highly congenial and potential for better performance of hybrid seed production and achieving higher F_1 seed yields.

Currently private seed companies and BRAC are playing major roles in F_1 hybrid rice seed production through contract farmering or by leasing land for own management or by using both systems in the country. BADC has been producing F_1 seed of hybrid rice since 2001 in its seed multiplication farmers. BRRI produces F_1 seed of its released rice hybrids in the research farmers for promotional distribution.

The growth of hybrid rice dissemination particularly in the public sector BRRI developed rice hybrid is not encouraging, but BADC has undertaken a five year visionay program for expansion of their own introduced hybrid **'SL- 8H'** to the farmers. Both BADC and BRRI public sector organizations are getting financial project support from the government budget.

XII. Response of policy makers to hybrid rice

Policy Makers: The policy makers in crop agricultural are mainly from Ministry of Agriculture (MOA) and has delegated to the National Seed Board (NSB) and Technical Committee (TC). The NSB constituted with the Secretary, MOA and members from the National Agricultural Research System (NARS) and other related persons and organizations/agencies (Annex.XI.2.). The TC constituted with the Executive Chairman, Bangladesh Agricultural Research Council (BARC) and members from NARS and other related persons and organizations/agencies (Annex.XI.3). The Agricultural crops and seed related policy and legal affairs Regulatory Body in Bangladesh is the National Seed Board (NSB) of the Ministry of Agriculture. The Seed related all policies and rules are regulated by the NSB and all technical matters are evaluated, verified, and monitored by the *"Technical Committee (TC)"* under the guidance of NSB of the Ministry of Agriculture, Government of the Peoples Republic of Bangladesh.

The NSB of the Ministry of Agriculture, Government of Peoples Republic of Bangladesh is the Central Regulatory Body on seed related matters of the Government. The main functions of the NSB are to advise the Government on matters arising out of the administration of the Seed Related Policy, Act and Rules and to carry out the other functions assigned to it by the Government. The Secretary, Ministry of Agriculture shall be the Chairman of the NSB. The NSB was first constituted on September 22, 1973 with ten members committee. Subsequently in Pursuance to the Seed Ordinance, 1977 the NSB was reconstituted with 16 members committee. As per the Seeds (Amendment) Act, 2005 the NSB is constituted with 20 members committee. The Secretary, Ministry of Agriculture is the Chairman of the NSB. Regarding variety development through breeding in the country and introduced from abroad as well as through local selection are evaluated and recommended by the Technical Committee (TC) and finally approved for registration, release and notification are done by the NSB. The Technical Committee was first constituted with 18 members by the National Seed Board in its 30th Meeting held on October 26, 1993. In the 50th NSB Meeting held on April 10, 2002 the Technical Committee was further constituted with 16 members. The Executive Chairman, Bangladesh Agricultural Research Council is the Chairman of the Technical Committee.

The response of policy markers for hybrid rice technology introduction, disseminations and development through R & D, seed production, seed importing and marketing in the country is briefly elucidated in the following sub-sections:

During hybrid rice introduction: The National Seed Board (NSB) of the Ministry of Agriculture, Government of the Peoples Republic of Bangladesh was in favor of releasing four rice hybrids and allowed four companies to import and marketing F_1 hybrid rice seeds for commercial cultivation in the country. After devastating floods in the 1998, the hybrid rice technology was contemplated by the policy makers as an advance technology for ensuring the food security of the country. However, a special evaluation committee was formed under the Seed Certifying Agency (SCA) of the NSB to evaluate the results of the on-farm trials conducted by the private seed companies. This special committee recommended release/import of seeds of rice hybrids based on the results of limited trials for only one season by the private sector companies. Thus, it indicated that the policy makers' response was reasonably positive towards hybrid rice technology introduction in Bangladesh. Thus, this initiative for releasing four rice hybrids was a milestone for introduction of hybrid rice technology in the country.

During hybrid rice adoption: The policy makers were supportive during adoption stage of hybrid rice technology in the country for both public and private sectors. Accordingly, hybrid rice acreage has reached about 1 million hectare from about 23,500 ha during1998-99 Boro to 2007-8 Boro season in Bangladesh. In view to large scale adoption of hybrid rice, the policy makers have changed the condition for allowing F_1 hybrid rice seed import from 3 years to 8 years from 1998-2006 for ensuring the supply of quality rice hybrid seed for commercial cultivation through import along with hybrid rice F_1 seed production in the country.

Hybrid rice R & D: BRRI, a public sector rice research institute, Supreme Seed Company (a private seed company) and BRAC (NGO) have been conducting R & D on hybrid rice technology development. Both Supreme Seed Company and BRAC have been in leading position by investing in R & D for hybrid rice technology development. Accordingly, 4, 2 & 2 rice hybrids are developed by BRRI, Supreme Seed Company and BRAC respectively for commercial cultivation in Bangladesh through release and notification by NSB respectively. But BRRI has been conducting R & D on hybrid rice through funding support from donors and GOB with qualified and trained experts (Plant Breeders). On the other hand, Supreme Seed Company and BRAC have been conducting R & D on hybrid rice using their own fund with reasonable man-power. Besides policy support, GOB is not providing any financial support to private seed company (Supreme Seed Company) and NGO (BRAC). In this regards, Government financial support for private sector and NGO will further enhance R & D on hybrid rice technology.

Hybrid rice seed production: From beginning of hybrid rice introduction in Bangladesh, the policy makers convened that country should not be banked on import of hybrid rice seed from foreign country. Accordingly, initially they imposed restraint on import of seed after 3 years and permitted agency will have to go for hybrid rice seed production in the country. As a result, currently private seed companies and BRAC are producing more than 3000 MT F_1 seed of rice hybrids without any funding support from GOB and donors with an exception with EAL. More than 300 skilled man-powers have developed on hybrid rice seed production with private seed companies, BRAC and BADC. BADC has funding support from GOB for its hybrid rice seed production. The policy makers are very much relaxed on imposing any policy restriction on hybrid rice seed production in the country getting parent lines from abroad (mainly China) and in the country sources. Accordingly, private seed company, BRAC and BADC have been producing F_1 hybrid rice seed as Truthfully Labelled Seed (TLS). BRAC and Supreme Seed Company established seed processing centers for their produced rice hybrid seed processing and preservation as a part of maintaining standard quality of seed for marketing for commercial production in the country. Besides policy support from GOB, private seed company and NGO are not getting financial support from GOB for developing hybrid rice seed production system along with infrastructures establishment for hybrid rice seed processing and preservation facilities in the country with level playing field for both private and public sector.

Rice hybrids release and notification: As per positivistic response from policy makers, a total of 85 rice hybrids have been released with 44 agencies during 1998 to 2010, out of which 77 imported and 8 from Bangladesh. Large number of rice hybrid have been (Average 7 rice hybrids/yr) released, this might be happened due to liberalization and positive response from policy makers beginning from the introduction of rice hybrids in 1998.

The specific policy and guidelines on hybrid rice evaluation and registration were first formulated in the 40th Meeting of the NSB held on 9 September1998. In that initial guidelines the F_1 hybrid rice seeds were allowed to import for commercial cultivation for three years

effective from 1998-99 Boro rice crop season and from the 4th year, hybrid rice seed will have to be produced locally otherwise the permission for hybrid rice seed import of the approved hybrid rice variety of the respective company/agency will be cancelled. The initial guidelines of 1998 were subsequently revised and modified, and accordingly the updated policy/guidelines were approved by the NSB in the 52nd Meeting held on July 20, 2003. The modified hybrid rice guidelines were approved in the name of *"Hybrid Rice Variety Evaluation and Registration Procedures, 2003,"* circulated by the Seed Wing, Ministry of Agriculture, and published in the *Bangladesh Gazettee, Wednesday, December 24, 2003.* In this modified procedure of 2003, the F_1 hybrid rice seeds were allowed to import for commercial cultivation for five years instead of initially allowed for three years in 1998, within this five year period hybrid rice seed will have to be produced locally and in the 6th year only parent lines (A-Line and R-Line) seed will be allowed to import but not for F_1 hybrid rice seed of the approved hybrid. Hybrid Rice Variety Evaluation and Registration Procedures, 2003 Bangladesh Gazettee, notified on 24 December 2003 and 6 April 2007. It may be noted here that the condition for allowing F_1 hybrid rice seed import for five years as approved in 2003 has been amended into 8 years in the 60th meeting of the NSB held on August 3, 2006, circulated on March 18, 2007, and it was published in the Bangladesh Gazettee on April 16, 2007. Considering reasonable growth of hybrid rice F_1 seed production in the country, policy makers have relaxed on the condition of F_1 hybrid rice seed import duration from 3 years to 5/8 years, probably to ensure the supply of quality seed of the farmers' accepted rice hybrids, primarily from china.

Marketing rice hybrids seed: Private seed companies and NGO (BRAC) are the major agencies in hybrid rice seed marketing and BADC is the only agency from public sector for marketing rice hybrid seed in the country. Hybrid rice seed marketing agencies have been using various approaches and strategies for seed marketing from late 1990s. All involved agencies are selling rice hybrids seed as Truthfully labelled Seed (TLS) within the provision of existing seed policy, Act and Rules in the country. Policy makers are quite supportive for marketing of rice hybrids seed in the country.

The industrial Policy: Although seed is considered as an industry but it has not yet been recognized in the industry policy of Bangladesh. The Industrial Policy enacted in 1999 approved in 2010 in the country, but no specific policy was incorporated in that Industrial Policy, 2009 particularly for hybrid rice. If hybrid rice was included in the Industrial policy, 2009 and provisions were made for investment on hybrid rice for local and foreign investment by the private investors would have been encouraged to large-scale investment particularly on research & development (R & D) for hybrid rice on long-term basis.

Public-Private-Partnership (PPP): The concept of Public-Private-Partnership (PPP) was for the first time formulated in the National Budget of Bangladesh in 2009-10 by the Finance Minister of the People's Republic of Bangladesh. Similarly, in the National Budget of 2010-11, a separate budget provision for PPP has also been made. But in that PPP no allocation of Budget or any indication was given specifically on hybrid rice and there was no allocation or indication for investment under PPP for the private sector hybrid seed industry development in general.

Since the varietals improvement, R&D, technology development, hybrid rice seed production, processing, and quality control are highly expensive and needs huge financial investment, so, the implication strategy of PPP may greatly help for enhancement and promoting this hybrid rice technology. There is enormous scope for the government to allocate necessary budget provision in the PPP for hybrid rice technology in general and hybrid rice seed production in particular.

X.III. Policy Recommendations

The policy recommendations are bestowed in this section on the considerations for key issues, research status, institutional issues, seed supply and marketing, policy issues etc on the basis of contribution of hybrid rice technology in national rice production and food security of the country. The key policy recommendations for hybrid rice technology development, introduction, large scale dissemination, quality seed supply and marketing in the country are presented below:

It may be noted here that The Seed Ordinance, 1977 has amended first in 1997 as The Seeds (Amendment) Act, 1997 and second in 2005 as The Seeds (Amendment) Act, 2005, but no amendment has yet been made in The National Seed Policy, 1993 and The Seed Rules, 1998. The existing seed related legal frameworks (Policy, Act, Rules and guidelines) of Bangladesh might need to be improved, modified, up-graded and amended in general for seed sector and in particular for demand-led hybrid rice technology development and its large scale dissemination in the country.

Development of demand-led rice hybrids: For further expansion of hybrid rice acreage to increase national food production, new rice hybrids should be developed with characteristics valued by farmers, consumers, traders and millers, including especially non-sticky rice (>25% amylose content), desirable size (bold, slender and long slender), short duration, tolerant to biotic (pests and diseases) and abiotic stress (eg salt tolerant), free from physiological disorders (eg resistant to lodging, no shattering, no viviparous germination etc), and yielding at least 20% more than the existing popular inbred. Target-oriented and time-bound research to develop such hybrids should be undertaken by Bangladesh Rice Research Institute (BRRI), competent private seed companies, and NGOs, with funding support from Government of Bangladesh (GOB) and interested donors under the supervision of Ministry of Agriculture (MOA).

In this regards, skilled, devoted and committed rice hybrid plant breeders need to be procured and deployed with BRRI, private seed companies and NGOs. The breeders' capacity has to be developed through in-country and overseas (especially in China) practical short-term and long-term training. Moreover, Bangladesh and China need to develop collaborative research with ambitious targets to develop rice hybrids with appropriate characteristics for Bangladesh. In this regards, under the leadership of MOA, and with potential donor support, BRRI, BADC, private seed companies, and NGOs can look for ways to establish collaboration with Chinese scientists and institutions.

Current status of research on hybrid rice technology development is much slower than our demand with public sector research institutes, private sector seed companies and NGOs in the country. On the other hand, China's public and private breeders are far and away the world's leaders in hybrid rice, having developed more than 1000 hybrids with three lines and two lines systems. Thus, collaborative research with China would normally take place in both countries, with the location depending on the activity. The important challenge is to develop hybrids that are better suited to the Bangladesh market. With that goal, MOA and other involved Bangladeshi organizations may work out various arrangements to share breeding and seed production activities between the two countries, and also to ensure that the returns from the investment benefit all parties.

As an assertive initiative, MOA with GOB may invite Chinese rice hybrid companies to establish subsidiaries and joint ventures in Bangladesh, with the commitment that such companies would then breed for Bangladesh and other markets that prefer indica rice. GOB may discuss with the capable Chinese companies to resolve their concerns, and to ensure that incentives are sufficient to ensure committed research and market development from subsidiaries in Bangladesh. In this regards, GOB may develop favorable rice hybrid seed policy, rules and guidelines. So that Chinese rice hybrid seed companies will feel comfortable to establish their research, seed production and seed marketing system in Bangladesh. Intellectual property rights and plant variety protection needs to be ensured. This could be done through enforcement of trade secrets, but is better done through passing the pending "Plant Variety and Farmers' Rights Protection Act, 2009".

Rice hybrid release guidelines: The formal seed system is controlled by the existing seed policy, rules and acts of the country. Within this framework, some minor adjustments could facilitate faster introduction of new rice hybrids with characteristics to suit local demand, as well as hybrid rice quality seed production in Bangladesh. Current practices for government to test rice hybrid performance as a condition for government approval to introduce the hybrid may be revised to give companies a larger role in testing their own hybrids, with less reliance on results from government tests (which are not always carried out in a quality-assured manner). Such policy liberalization is needed to ensure that breeding organizations are confident to develop and introduce new hybrids designed for the Bangladesh market. Accordingly, existing guidelines for releasing rice hybrid in the name of *"Hybrid Rice Variety Evaluation and Registration Procedures, 2003"* need to be adjusted and up-graded to enhance the rice hybrid releasing process in Bangladesh. Moreover, policies should be adjusted with an eye to encourage interested of foreign seed companies to bring some of their R & D, seed production and marketing expertise to Bangladesh. For both local and foreign companies, protection of intellectual property through passage of the "Plant Variety and Farmers' Rights Protection Act, 2009" could encourage more investment in in-country R&D.

Hybrid rice seed production: Nearly all steps of hybrid rice seed (F_1) production and parent line multiplication can affect seed quality and purity. Quality control needs to be done through the entire process of seed multiplication, including production of nucleus, breeders, foundation and certified seed. Current hybrid rice F_1 seed production is risky due to the current unreliable supply of quality seed of parental lines. Accordingly, MOU's should be developed between suppliers of quality parental lines (A and R lines) and rice hybrid seed (F_1) producing organization in Bangladesh. Such MOUs should establish incentives for all parties, including those that supply parental lines, and F_1 seed producers.

Ambitious initiative needs to be taken to improve the skill of seed production agronomists and technicians through short-term and long term-field based practical training on improved F_1 seed production with maximal yield target. Besides seed production staffs, involved farmers' practical knowledge should be developed through practical training. Existing F_1 seed production guidelines/manuals with seed producing organizations need to be unified into a single document, with fine-tuning the recommended production practices with higher seed yield target. Such training and manual preparation could be done with funding support from a donor or from GOB.

Quality F_1 seed production of rice hybrids can be done either through contract farming or own management on leased land, establishing a seed production block. Working capital support for contract farmers as well as seed production organizations is crucial for quality F_1

seed production. An attractive seed procurement price is important to produce good quality F_1 seed through contract farmers. Policy and guidelines should be developed on hybrid rice seed production through contract farming for encouraging both seed production organizations and contract farmers on the basis of incentive for the both parties. Infrastructure development – policies, standards, and scientific back-stopping and advice – is an inherent part of the development of hybrid rice production in Bangladesh. Infrastructure development for hybrid rice seed processing and specialized preservation is necessary with funding support from donors or Equity and Entrepreneurship Fund (EEF) of Bangladesh Bank, GOB. In this regards, Government and donors have important roles to play to support private hybrid rice seed production in Bangladesh. Even implementation of public private partnership (PPP) concept would be efficacious in this regards.

As an alternative to in-country F_1 seed production, seed companies in Bangladesh could arrange "c*ustom seed production"* in another country. A Bangladeshi seed company could do so either in collaboration with an experienced seed company in the producing country, or by establishing its own seed production system within the producing country.

Grain quality test: Since rice consumers in Bangladesh prefer non-sticky rice, NSB should arrange for all candidate hybrids to be tested for their physicochemical properties including amylose content before submitting seed to SCA for field trials. Such physicochemical tests will guide for selection of hybrids with grain quality acceptable to consumers in Bangladesh. In addition, NSB should also introduce genetic finger printing to identify released and proposed rice hybrids

Level playing field: Also, a level playing field should be created for the rice hybrids development, seed production, seed marketing and carryover seed management for the involved public seed organization (BADC), private seed company and NGO in the country, with similar enforcement of truth-in-labeling for all parties, and without distorting subsidies. Currently, there is no specific policy and guidelines for rice hybrids development, seed production, seed quality control, marketing and carry over seed management in the country. In this regards, GOB (NSB) needs to develop policy and guidelines, which will be equally applicable for public sector and private sector/NGO in the country.

Seed quality monitoring: Seed policy adjustments – especially some additional standards and rules and better enforcement of truth-in-labelling – could also support hybrid rice seed production and seed marketing in the country. With their existing authority, SCA with NSB could establish hybrid rice seed quality standards for parental lines and F_1 seed, and could enforce these standards through truth-in-labelling. Such minor adjustments in SCA practices could shine a light on quality issues, and both guide and force companies to address them as well. In this scenario, SCA shines a light on what is happening – testing and reporting – but does not act like a policeman. A monitoring system needs to be developed for the quality control of rice hybrid seed (parental lines and F_1 seed) production, importing and marketing for the involved public and private organizations and NGOs in the country. Such monitoring should be implemented through involvement of the relevant public and private organizations and NGOs to ensure the supply of quality seed in the seed supply chain in the country

GOB paddy procurement: To encourage the hybrid rice growers, special emphasis should be given with reasonable policy support for hybrid paddy procurement from all categories of farmers within 2 months of crop harvest under GOB food grain procurement program in the country. GOB intending favorable hybrid rice paddy procurement initiatives will further accelerate the adoption of hybrid rice from current stage of the adoption. Accordingly, MOA

may take initiative to develop guidelines and policy for hybrid paddy procurement with Ministry of Food, who is responsible for procuring food grain within the country.

Rice hybrid data based: Seed Certifying Agency (SCA) under the guidance of NSB and overall supervision of Seed Wing, MOA in collaboration with the involved organizations of public, private/NGO should be collected and documented the relevant data/information such as seed enterprise-wise total seed production, seed import (F_1 and parent lines), seed sale, carry over seed (quantity, management and quality), problems encounter during F_1 seed production, post seed sale problems etc under pre-decided guidelines. Accordingly, SCA can develop data based hybrid rice information flow system for the involved organizations of public, private and NGOs on the demand driven basis. In this regards enterprise secrecy must be maintained. Thus, NSB should be developed guidelines implying the relevant involved organizations of public and private/NGO.

"Among the policy recommendations, development of demand-led rice hybrid is prioritized as the highest followed by rice hybrid release guidelines, hybrid rice seed production, grain quality test, level playing field, seed quality monitoring, GOB paddy procurement and rice hybrid data based".

Future study: An in-depth field study could be undertaken to assess the performance of rice hybrids in the country on the basis of response from hybrid rice growers (farmers), seed producing farmers, seed dealers, seed entrepreneurs, consumers, traders and millers on routine basis in the country. However, hybrid rice acreage progressively decreased from its peak in 2007-8 by 7% in 2008-9 and 34% in 2009-10. Probably, hybrid rice acreage will be less during this current 2010-11 Boro season than the last 2009-10 Boro season. Accordingly, a special study is essential to be conducted to find-out the actual reasons and their behavior for such disadoption trends of hybrid rice technology in the country. The findings of the study will be useful for the policy makers, involved agencies (private/NGO and public) and all other relevant stakeholders for their better understanding and preparation of future work/business plan on hybrid rice in the country.

Reference

Abedin, M.Z., Laptin, J. and H, Miah. 2010. Food Security, Poverty and IRRI in Bangladesh. In: Souvenir: Celebration of 50th Anniversary of IRRI, 13-14 July 2010. IRRI, Dhaka

Alam, A. 2008. Hybrid Rice Seed Production in Bangladesh. In. Souvenir: National Seed Conference and Fair 2008, 30 June-2 July 2008. Dhaka, Bangladesh

Ali, M.S. 2010. Public-Private-Partnership in the Seed Industry Development of Bangladesh. In. Souvenir: National Seed Conference and Fair 2010, 9-11 March 2010. pp.82-86. Dhaka, Bangladesh

Bangladesh Bureau of Statistic. 2006. Year Book of Agricultural Statistics of Bangladesh. Ministry of Planning, Dhaka, Bangladesh. web: www.bbs.gov.bd

Bangladesh Bureau of Statistic. 2008. Year Book of Agricultural Statistics of Bangladesh. Ministry of Planning, Dhaka, Bangladesh. web: www.bbs.gov.bd

Bangladesh Rice Research Institute (BRRI). 2007. Annual Internal Review of BRRI, Gazipur

Bangladesh Rice Research Institute (BRRI). 2008. Annual Internal Review of BRRI, Gazipur

Bangladesh Rice Research Institute (BRRI). 2009. Annual Internal Review of BRRI, Gazipur

Bangladesh Rice Research Institute (BRRI). 2010. Annual Internal Review of BRRI, Gazipur

Cookson, F, E.Haque, H. Rashid and Z. Haque. 2009. Final Report: Issues in Food Prices Determination in Bangladesh.

Deb, U. 2008. Input Delivery Strategy for Higher Boro Production. Centre for Policy Dialogue (CPD), paper presented at seminar, 9 February 2008, CIRDAP Auditorium, Dhaka. Web: www. cpd-bangladesh.org

Deb, U. 2009. Achieving Boro Rice Production Targets in F Y 2009-10: Challenges and Action Required. Centre for Policy Dialogue (CPD), paper presented at seminar, 23 December 2009. CIRDAP Auditorium, Dhaka. Web: www. cpd-bangladesh.org

Department of Agriculture Extension (DAE). 2010. Krishi Diary, AIS, Ministry of Agricultural (MOA)

Food and Agriculture Organization. 2008. FAOSTAT, FAO Statistic Division, Rome.

Gavino, R.B., Pi, Y. and C.C Abon. 2008. Application of gibberellic acid (GA3) in dosage for three hybrid rice seed production in the Philippines. Journal of Agricultural Technology 4(1): pp.183-192.

Grilliches, Zvi. 1957. Hybrid Corn an exploration in the economics of technological change. Econometrica 25: 501-522 (cited: Janaiah, A and Hossain, M. 2005. Hybrid Rice Research: Will it have an Impact on India's Rice Economy?)

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

Hossain, M. 2009. Pumping up Production: Shallow tube wells and rice in Bangladesh. In. The impact of shallow tube wells and boro rice on food security in Bangladesh. IFPRI Discussion paper. Washington, D.C: International Food Policy Research Institute.

Hossain, M. and M. Akash. 1994. Public Rural Works for Relief and Development. IFPRI working paper on Food Subsidy, No. 7, Washington, D.C : IFPRI

Hossain, M., M.A. Quasem, M.A. Jabbar and M.M. AKash 1994. Production environments, modern variety adoption and income distribution in Bangladesh. In. David.C.C. and K. Otsuka (eds). Modern Rice Technology and Income Distribution in Asia. Boulder, Colorado. Lyne Renner publishers.

Husain, M., Hossain, M. and A. Janaiah 2001. Hybrid Rice Adoption, M., Hossain, M. and Janaiah, A. 2001, Hybrid Rice Adoption in Bangladesh: A Socioeconomic Assessment of Farmers' Experiences. Research Monograph Series No. 18. BRAC, Dhaka

Jaffee S. and Srivastava J. 1992. Seed System Development: The Appropriate Roles of the Private and Public Sectors. The World Bank, Washington, D.C

Janaiah, A. 1995. Economic Assessment of Hybrid Rice Potential in India: An Ex-ante Study, Institute of Agricultural Sciences, Varanasi: Banaras Hindu University

Janaiah, A. 2000. Economic impact of crop management on performance of hybrid and inbred varieties of rice (*Oryza sativa*) in India: Evidences from farm level study. Indian Journal of Agricultural Science 70(2): pp 77-84.

Janaiah, A. and M. Hossain 2005. Hybrid Rice Research: Will it have an impact on India's Rice Economy? PP 37-55. In: Impact of Agricultural Research: Post-Green Revolution Evidence from India (Joshi, P.K., Pal, S., Birthat, P.S., and Bantilan, M.C.S eds.) New Delhi, India

Janaiah, A., Hossain M. and Husain M. 2002. Hybrid rice for tomorrow's food security: Can the Chinese miracle be replicated in other countries? Outlook on Agriculture Vol 31, No 1, 2002 PP 23-33

Kabir. H. and H. Rashid 2004. Prospect and potentials of Rice Hybrids in Bangladesh: A special study. AAS, Dhaka

Krishi diary 2010. Published by Agricultural Information Service, Department of Agricultural Extension, Khamarbari, Farmgate, Dhaka

Li, J., Xin, Y. and L.P. Yuan 2009. Hybrid Rice Technology Development: Ensuring China's Food Security. IFPRI Discussion Paper: 00918 (Millions Fed: Proven Successes in Agricultural Development. 2020. Vision, IFPRI)

Manan, M.A. 2009. Small Investment Scope in Hybrid Rice Seed Production in Bangladesh. In.Souvenir: National Seed Conference and Fair 2009, 28-30 April 2009. Dhaka, Bangladesh.

Mao C. X. and S.S.Virmani 2003. Opportunity for and challenges to improving hybrid rice seed yield and seed purity. In: Virmani S.S., Mao C.X. and B. Hardy (eds). HYrbid Rice Food Security, Proverty Alleviation, and Environmental Protection, PP.85-95. IRRI, Metro Manila, Philippines.

Mao, C. X. 2010. Developing indica-type hybrid rice China (Country report). In: Xe, F and B. Hardy (eds). Accelerating Hybrid rice development, PP 581-592. IRRI, Metro Manila, Philippines

NHRYT, 2007. National Hybrid Rice Yield Trial, conducted by Seed Certification Agency at Bangladesh Rice research Institute. Report collected from Seed Certification Agency, Gazipur.

NHRYT, 2008. National Hybrid Rice Yield Trial, conducted by Seed Certification Agency at Bangladesh Rice research Institute. Report collected from Seed Certification Agency, Gazipur.

NHRYT, 2009. National Hybrid Rice Yield Trial, conducted by Seed Certification Agency at Bangladesh Rice research Institute. Report collected from Seed Certification Agency, Gazipur.

Nuruzzaman, 2009. Production of Seed of the released Hybrids of public sector. In. Souvenir: National Seed Conference and Fair 2009, 28-30 April 2009. Dhaka, Bangladesh.

Parvez, M.M., H. Rashid, S.S. Parvez and, M.T. Islam 2003. Performance of Hybrid Rice in Bangladesh: A Comparative study. Japanese Journal of Tropical Agriculture: Vol. 47 (3): pp.215-221

Rashid, .H. 2008. Cost and Return Analysis: Selected crop and their varieties during 2006-7 and 2007-8 cropping seasons. Research Development Center (RDC) and Agricultural Advisory Society (AAS), Dhaka.

Rashid, H. 2004. Performance of Six Rice Hybrids under Bangladesh conditions during 2003-4 Boro season. AAS, Dhaka

Rashid, H. 2007. Experimentation on ways of using the Bangladesh Rice Knowledge Bank. Final Technical Report for IRRI/AAS

Rashid, H., Islam, A.J..M.A and ANM. Karim 1999. Performance of Rice Hybrids under Bangladesh conditions during 1998-99 Boro season. AAS, Dhaka.

Rashid. H. 2002. Performance of BRRI hybrid dhan1 in Rajshahi Region during 2001-2 Boro season. AAS, Dhaka

Seed Certifying Agency. 2009. The National Seed Policy and Seed Ordinance, Acts & Rules (Compiled and edited: Ahmed, D.N. and M.S. Islam)

SCA, 2010. Seed Certification Agency, report collected from hybrid rice registration section, SCA, Gazipur.

Seed Wing, Ministry of Agriculture. 2006. Manual for Seed Quality Control (ed. Huda, M.N., M.A. Halim, M.A. Razzaque, M.M. Haque and M.A Hossain.)

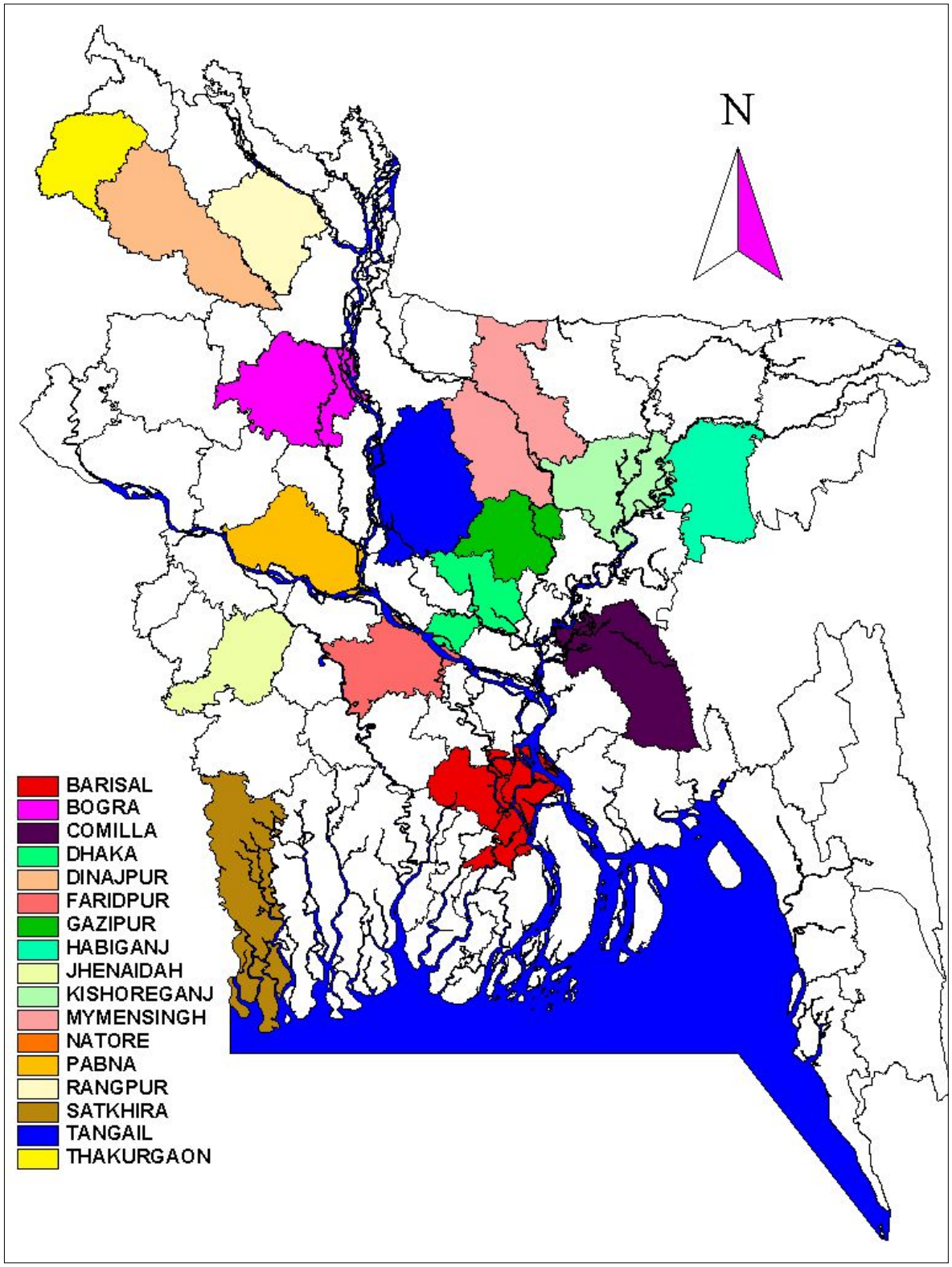
United State Department of Agriculture (USDA). 2009. USDA, PSD online, June 10, 2009 access

Virmani S.S., C.X. Mao, R.S. Toledo, M. Hossain and A. Janaiah. 2002. Hybrid Rice Seed Production Technology and its impact on Seed Industries and Rural Employment Opportunities in Asia. http.://www.agnet.org/Library

Virmani, S.S., Mao C.X. and B. Hardy. 2003. Hybrid Rice for Food Security Poverty Alleviation and Environment Protection

Yuan, L.P. 2010. In The China Daily: 2010. Economy: China to finish work on new hybrid rice in 2012. Dated: 21June 2010. web: www.chinadaily.com.cn

Fig.X.1: Bangladesh Map, showing districts with hybrid rice seed production (2009-10)



Annex.II.1: Import quantity (ton) of wheat and rice in Bangladesh during 1982-1983 to 2010

Sl #	Year	Wheat	Rice	Total
1	1982-1983	1527186	317473	1844659
2	1983-1984	1876580	179888	2056468
3	1984-1985	1898325	690092	2588417
4	1985-1986	1163500	38821	1202321
5	1986-1987	1506194	261177	1767371
6	1987-1988	2328797	582409	2911206
7	1988-1989	2076892	61389	2138281
8	1989-1990	1233875	300375	1534250
9	1990-1991	1566407	10856	1577263
10	1991-1992	1525144	37994	1563138
11	1992-1993	1164051	19587	1183638
12	1993-1994	892121	73979	966100
13	1994-1995	1754422	793023	2547445
14	1995-1996	1287341	1123932	2411273
15	1996-1997	931475	33559	965034
16	1997-1998	847644	1085207	1932851
17	1998-1999	2422630	3063598	5486228
18	1999-2000	1670911	432288	2103199
19	2000-2001	981065	560819	1541884
20	2001-2002	1663888	125639	1789527
21	2002-2003	1652043	1556606	3208649
22	2003-2004	1984982	801067	2786049
23	2004-2005	2078117	1294425	3372542
24	2005-2006	2029948	531976	2561924
25	2006-2007	1699985	720504	2420489
26	2007-2008	1411410	2058631	3470041
27	2008-2009	2425413	602569	3027982
28	2009-2010	3363281	91767	3455048

Annex. II.2: Area (million ha), rough rice production (million t), rough rice yield (t/ha) (USDA)

Year	Area	Production	Yield
1960	8.86	14.52	1.64
1961	8.48	14.44	1.70
1962	8.69	13.32	1.53
1963	9.01	15.95	1.77
1964	9.23	15.77	1.71
1965	9.36	15.77	1.68
1966	9.07	14.38	1.58
1967	9.89	16.77	1.70
1968	9.74	17.03	1.75
1969	10.31	18.03	1.75
1970	9.91	16.73	1.69
1971	9.26	14.91	1.61
1972	9.63	15.15	1.57
1973	9.88	17.88	1.81
1974	9.79	16.95	1.73
1975	10.33	19.16	1.86
1976	9.88	17.65	1.79
1977	10.03	19.47	1.94
1978	10.11	19.29	1.91
1979	10.06	19.13	1.90
1980	10.31	20.84	2.02
1981	10.46	20.47	1.96
1982	10.59	21.35	2.02
1983	10.55	21.75	2.06
1984	10.14	21.93	2.16
1985	10.40	22.56	2.17
1986	10.61	23.11	2.18
1987	10.32	23.12	2.24
1988	10.22	23.33	2.28
1989	10.48	26.79	2.56
1990	10.44	26.78	2.57
1991	10.24	27.38	2.67
1992	10.16	27.51	2.71
1993	9.98	27.06	2.71
1994	9.92	25.25	2.55
1995	9.94	26.53	2.67
1996	10.41	28.33	2.72
1997	10.26	28.30	2.76
1998	9.69	29.78	3.07
1999	10.71	34.60	3.23
2000	10.89	37.63	3.46
2001	10.67	36.47	3.42
2002	10.78	37.78	3.51
2003	10.90	39.23	3.60
2004	11.00	38.40	3.49
2005	11.10	43.14	3.89
2006	11.20	43.50	3.88
2007	11.10	46.90	3.89
2008	11.60	47.97	4.01
2009	12.25	51.30	4.19

a Source: *USDA, PSD Online, June 10-2009 access,* ***b Source:*** *DAE, 2010*

Annex.II.3: Compound annual growth rate of area, rough rice production and yield during 1960-2009

Duration	Area	Production	Yield
1960-1970	1.13	1.43	0.30
1970-1980	0.40	2.22	1.05
1980-1990	0.42	2.54	2.44
1990-2000	0.13	3.46	3.02
2000-2009	1.32	3.50	2.15
1960-2009	0.66	2.61	1.93
1960-2008	0.56	2.52	1.88
1960-1965	1.10	1.67	0.48
1966-1970	2.24	3.86	1.70
1966-1980	0.92	2.69	1.77
1970-1980	0.40	2.22	1.80
1970-1985	0.32	2.01	1.68
1980-1988	-0.11	1.42	1.53
1988-1998	-0.53	2.47	2.35
1980-2007	0.27	3.05	2.46
1980-2009	0.60	3.16	2.55
1998-2007	1.52	5.18	2.67
1998-2009	2.15	5.07	2.87
1999-2009	1.35	5.08	2.64

Annex.II.4: Area, production and seed used of hybrid rice in Bangladesh during 1998-2010

Year	Area (ha)	Growth rate (%)	Production (000' MT)	Growth rate (%)	Seed used MT)	Growth rate (%)
1998-1999	23500[1]	-	110	-	350[1]	-
1999-2000	26700[1]	13.62	124	12.73	400[1]	14.29
2000-2001	13400[1]	-49.81	62	-50.00	200[1]	-50.00
2001-2002	10000[1]	-25.31	47	-24.19	150[1]	-25.00
2002-2003	28000[2]	180.00	131	178.72	337[2]	124.67
2003-2004	50000[2, 3]	78.57	235	79.39	614[2]	82.20
2004-2005	128000[3]	156.00	595	153.19	1920[6]	212.70
2005-2006	244000[3]	90.63	1135	90.76	3660[6]	90.63
2006-2007	394000[4]	61.48	1852	63.17	5950[6]	62.57
2007-2008	1011000[4]	156.60	4805	159.45	12132[6]	103.90
2008-2009	939000[4]	-7.12	4312	10.26	11738[6]	-3.25
2009-2010	670000[4]	-28.65	3158	26.76	8000[6]	-31.85
Total	**3537600**		**16566**		**45451**	
Growth Rate:						
I. 1998-99 to 2007-08	-	51.89	-	52.14	-	48.29
II. 2007-08 to 2009-2010	-	-22.84	-	23.35	-	23.15
III. 1998-99 to 2009-2010	-	35.60	-	38.69	-	32.91
IV. 1998-99 to 2004-05	-	32.65	-	32.49	-	32.80

[1] Estimated on the basis of involved seed companies

[2] AAS estimated during a Special study, 2004

[3] BRRI's document

[4] DAE's document

[5] Estimated on the basis of yield figures of DAE during 2006-7 Boro season-2009-10 Boro season

[6] Seed used estimated between 12-15 Kg seed/ha during 2004-5 Boro season to 2009-10 Boro season

Annex.IV.1: Hybrid rice experts engaged in hybrid rice research and seed production in Public and Private Organizations in Bangladesh (2010).

Organization	Experts Education level				Total
	Ph. D	M. S	BSc	Diploma	
Public Organization					
Bangladesh Rice research Institute (BRRI)					
Research	2	5	2	11	20
Seed Production	2	3	1	7	13
Total	4	8	3	18	33
Bangladesh Agriculture Development Corporation (BADC)					
Research	-	3	6	10	19
Seed Production	-	22*	48*	67*	137*
Total		25	54	77	156*
NGO					
Bangladesh Rural Advancement Committee (BRAC)					
Research	2	3	5	9	19
Seed Production	-	6	7	13	26
Total	-	9	12	22	45
Private Seed Company					
Supreme seed co. Ltd.					
Research	1	4	-	3	8
Seed Production	-	12	27	36	75
Total	1	16	27	39	83
ACI Ltd.					
Research	-	-	-	-	-
Seed Production	-	3	5	12	20
Total	-	3	5	12	20
Energ pac Agro Ltd.					
Research					
Seed Production	1	2	3	7	13
Total	1	2	3	7	13
Aftab Bohumuki Farm Ltd.					
Research	-	-	-	-	-
Seed Production		4	5	8	17
Total		4	5	8	17
Lal Teer Seed Limited					
Research	-	2	-	3	5
Seed Production	1	3	-	6	10
Total	1	5		9	15
Mollika seed Co. Ltd.					
Research	-	-	-	-	-
Seed Production		1	2	3	6
Total		1	2	3	6
Universities					
Bangladesh Agricultural University (BAU)					
Research	1	2	4	2	9
Seed Production	-	-	-	-	-
Total	1	2	4	2	9
Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU)					
Research	2	3	7	3	15
Seed Production	-	-	-	-	-
Total	2	3	7	3	15
Research	**8**	**22**	**24**	**41**	**95**
Seed Production	**4**	**56**	**98**	**159**	**317**
Total	**12**	**78**	**122**	**200**	**412**

Source: *Personal communication*

** Part time involved in hybrid rice seed production*

Annex. IV.2: List of agencies (public and private) and model farmers received parent lines and F_1 seed of BRRI hybrid dhan 2 for seed production and commercial hybrid rice production during 2009-10 Boro season

Sl. No	Name of seed recipient	Quantity of seed supplied			
		Area	F_1 Seed	A-Line seed	R-Line seed
		(Acre)	(kg)	(kg)	(kg)
1	Bangladesh Agricultural Development Corporation (BADC)	12.5	-	100	25
2	Barendra Multipurpose Development Authority (BMDA)	1.00	6	-	-
3	BRRI Regional Office, Comilla	1.25	-	10	3
4	BRRI Regional Office, Bhanga	1.25	-	10	3
5	BRRI Regional Office, Barisal	1.25	-	10	3
6	BRRI Regional Office, Habiganj	1.25	-	10	3
7	BRRI Regional Office, Sathkhira	1.25	-	10	3
8	BRRI, Agronomy Division, Gazipur	1.00	6	-	-
9	BRRI, Applied Research Division, Gazipur	6.00	36	-	-
10	Syngenta Bangladesh Limited	3.75	-	30	9
11	Northern Agricultural and Industrial Company Limited (NAICOL)	3.75	-	30	9
12	Hitech Agro	0.375	-	3	1
13	Seem Seeds and Agro Limited	0.25	-	2	0.750
14	P.A. Agri Com Limited	1.625	5	5	1.5
15	Northern Seed Limited	1.25	-	10	3
16	Prodential Agro Products Limited	0.25	-	2	0.750
17	Sabuj Bangla Agri Concern Limited	0.25	-	2	0.750
18	Hossain Ali Agricultural Research Development and Seed Farm (HAARDS)	6.25	15	30	8
19	Petrochem (Bangladesh) Limited	1.67	4	8	2.5
20	Aoss Bangla Agro	1.295	4	5	2

Annex.IV.2: Contd

	Name of seed recipient	Quantity of seed supplied			
		Area	F_1 Seed	A-Line seed	R-Line seed
		Ac	(kg)	(kg)	(kg)
21	M/S Islam Agro Seed	0.705	2	3	1
22	Asa Agro Limited	0.705	2	3	1
23	National Hybrids Seeds (Private) Limited	0.58	2	2	0.750
24	Hitech Agro Products Limited	0.955	2	5	2
25	Golden Valley Agro Source Limited	0.58	2	2	0.750
26	Md. Choyenuddin Sarkar, Gurudaspur, Natore	0.67	4		
27	Md. Akkas Ali, Jesoore	1.375	6	3	1
28	Md. Jalal Ahammad Akand, Barisal	0.125	-	1	0.500
29	Md. Abu Daowood, Dhaka	1.00	6	-	-
30	Dr. Md. Ansar Ali, PSO, Plant Pathology Division, BRRI, Gazipur	0.33	2	-	-
31	Md. Jahurul Islam, Proprietor: A Hoque and Seed Store, Gaibandha	0.705	2	3	1
32	M/S Jahangir Bahumukhi Seed Beetan, Shibganj, Bogra	0.67	4	-	-
33	Md. Siraj Mia, Kaliganj, Gazipur	0.33	2	-	-
34	Md. Abdul Halim, Gobindaganj, Gaibandha	0.33	2	-	-
35	Md. Nurul Momin, Trishal, Mymensingh	0.33	2	-	-
36	Md. Moniruzzaman, Gazipur	0.33	2	-	-
37	Md. Kaikobad, Joint Secretary, MOA, Dhaka	0.33	2	-	-
38	Deputy Secretary, Ministry of Establishment, Dhaka	0.67	4	-	-
39	Md. Humayun Kabir, PSO, Applied Research Division, BRRI, Gazipur	1.00	6	-	-
40	Md. Siraj Uddin, Kapasia, Gazipur	2.5	15	-	-
	Total area under both F_1 Hybrid rice cultivation and F_1 Hybrid rice seed production.	61.69			

Annex.IV.3: List of agricultural inputs used for rice hybrid seed production, commercial hybrid rice cultivation, inbred and local varieties of rice cultivation

Inputs	**Hybrid seed**	**Hybrid grain**	**Inbred**	**Local variety**
1. Seed	A & R lines seed	F_1 seed	Seed	Seed
2. Exotic chemicals				
(a) GA3	✓	-	-	-
(b) Alcohol	✓	-	-	-
© Tiaohuafei	✓	-	-	-
3. Organic fertilizer	✓	✓	✓	✓
4. Chemical fertilizers				
(a) Urea	✓	✓	✓	✓
(b) TSP	✓	✓	✓	✓
(c) MOP	✓	✓	✓	✓
(d) Gypsum	✓	✓	✓	✓
(e) Zinc Sulphate	✓	✓	✓	✓
(f) Borax	✓	✓	-	-
5. Pesticides				
(a) Insecticides	✓	✓	✓	✓
(b) Fungicides	✓	✓	✓	✓
(c) Bactericides	✓	✓	-	-
6. Weedicide	✓	✓	✓	✓
7. Irrigation	✓	✓	✓	✓

Annex.V.1: Yield and yield components of the promising hybrids at locations during 2006 T.Aman season (BRRI)

Sl. #	Designation	Days to maturity (days)	Plant height (cm)	Tiller/m^2	Spikelet fertility (%)	Yield (t/ha)
Gazipur						
1	BRRI1A/BR827R	121	127	252	76	5.8
2	BRRI1A/BR168R	123	115	253	82	5.1
3	BRRI dhan-31	134	128	223	73	4.3
4	BRRI dhan-32	134	125	250	88	4.6
5	BRRI dhan-33	124	115	216	76	4.4
Barisal						
1	BRRI1A/BR827R	118	109	176	82	4.4
2	BRRI1A/BR168R	119	105	187	77	4.7
3	BRRI dhan-31	125	115	154	48	3.1
4	BRRI dhan-32	123	113	154	80	3.3
5	BRRI dhan-33	115	108	165	83	2.9
Satkhira						
1	BRRI1A/BR827R	126	101	234	83	5.5
2	BRRI A/BR168R	125	109	218	83	5.1
3	BRRI dhan-31	130	115	194	79	4.4
4	BRRI dhan-32	138	109	214	88	4.3
5	BRRI dhan-33	130	99	244	79	2.6
Rangpur						
1	BRRI1A/BR827R	120	109	270	85	5.6
2	BRRI A/BR168R	122	100	262	73	5.3
3	BRRI dhan-31	129	114	244	70	4.2
4	BRRI dhan-32	131	118	235	78	4.5
5	BRRI dhan-33	113	100	237	61	4.2

Annex.V.2: Yield and ancillary characters of Multi location trial of promising hybrids at 5 locations during 2007 T. Aman (BRRI)

Sl. #	Designation	Days to maturity (days)	Plant height (cm)	Pan/ m^2 (Nr.)	Spikelet fertility (%)	Yield (t/ha)	Yield advantage (t/ha)
Gazipur							
1	BRRI 1A/BR827R	118	114	286	74.85	3.74	1.3 over BRRI dhan 33
2	BRRI 1A/BR168R	119	109	251	76.12	3.67	
3	BG 407	126	120	209	62.70	3.02	
3	BRRI dhan-30	133	128	229	80.66	3.17	
4	BRRI dhan-33	118	113	204	76.06	2.44	
5	BRRI dhan-39	122	114	211	73.96	2.71	
Barisal							
1	BRRI 1A/BR827R	119	124	338	75.00	4.65	1.55 over BRRI dhan 33
2	BRRI 1A/BR168R	120	114	327	71.00	4.11	
3	BRRI dhan-30	151	117	205	72.00	3.20	
4	BRRI dhan-33	127	118	219	61.00	3.10	
5	BRRI dhan-39	126	120	258	68.00	3.40	
Comilla							
1	BRRI 1A/BR827R	109	95	365	73.00	5.35	0.7 over BRRI dhan 33
2	BRRI 1A/BR168R	110	96	352	77.00	5.09	
3	BRRI dhan-30	129	116	308	57.00	3.74	
4	BRRI dhan-33	112	98	256	75.00	4.65	
5	BRRI dhan-39	126	103	270	78.00	4.55	
Rangpur							
1	BRRI 1A/BR827R	124	109	339	26.00	4.55	0.87 over BRRI dhan 33
2	BRRI 1A/BR168R	125	95	336	30.00	4.40	
3	BRRI dhan-30	131	94	287	35.00	3.78	
4	BRRI dhan-33	118	109	257	34.00	3.68	
5	BRRI dhan-39	120	107	270	34.00	3.70	
Satkhira							
1	BRRI 1A/BR827R	120	99.83	360	72.00	4.10	1.13 over BRRI dhan 33
2	BRRI 1A/BR168R	122	96.63	310	69.00	3.95	
3	BRRI dhan-30	133	104.60	233	79.67	3.00	
4	BRRI dhan-33	120	92.27	225	80.33	2.97	
5	BRRI dhan-39	125	96.07	214	66.33	2.65	

Annex.V.3: Yield and ancillary characters of Multi location trial of promising hybrids at 10 locations (on-station & On-farm) during T.Aman 2008 (BRRI)

Entry no.	Designation	Days to maturity	Plant height (cm)	Panicle / m2	SF (%)	Yield (t/ha)	Yield advantage over checks (t/ha)
GAZIPUR (On-station)							
1	IR 58025A/BRRI 10R	110	104.04	271	75	6.24	2.22 over @ BRRI dhan33
2	BRRI 10A/BRRI 10R	112	108.27	213	74	6.80	2.78 over @ BRRI dhan33
3	BRRI dhan 31(Ck-1)	134	125.8	182	72	4.69	-
4	BRRI dhan33 (Ck-2)	114	112.73	201	64	4.02	-
5	BRRI dhan39 (Ck-3)	118	111.13	185	66	3.88	-
GAZIPUR (On-farm)							
1	IR 58025A/BRRI 10R	109	101.67	213	74	5.14	1.56 over @ BRRI dhan33
2	BRRI 10A/BRRI 10R	112	103.27	191.4	82	6.52	2.94 over @ BRRI dhan33
3	BRRI dhan 31(Ck-1)	134	108.13	163	64	4.12	-
4	BRRI dhan33 (Ck-2)	111	99.73	175	66	3.58	-
5	BRRI dhan39 (Ck-3)	122	99.33	180	67	3.69	-
1	IR 58025A/BRRI 10R	109	101.67	213	74	5.14	1.56 over @ BRRI dhan33
RANGPUR (On-station)							
1	IR 58025A/BRRI 10R	113	92	158	76	4.35	1.00 over @ BRRI dhan33
2	BRRI 10A/BRRI 10R	114	99	147	77	4.88	1.53 over @ BRRI dhan33
3	BRRI dhan 31(Ck-1)	130	99	150	72	2.67	-
4	BRRI dhan33 (Ck-2)	115	89	164	75	3.35	-
5	BRRI dhan39 (Ck-3)	122	92	158	72	3.35	-
RANGPUR (On-farm)							
1	IR 58025A/BRRI 10R	117	90	161	80	4.17	0.71 over @ BRRI dhan39
2	BRRI 10A/BRRI 10R	116	97	167	80	4.23	0.77 over @ BRRI dhan39
3	BRRI dhan 31(Ck-1)	128	103	150	72	2.65	-
4	BRRI dhan33 (Ck-2)	110	86	169	76	3.41	-
5	BRRI dhan39 (Ck-3)	123	90	153	75	3.46	-
COMILLA (On-station)							
1	IR 58025A/BRRI 10R	110	97	279	78	5.14	3.23 over BRRI dhan33
2	BRRI 10A/BRRI 10R	118	100	261	76	4.88	2.68 over BRRI dhan33
3	BRRI dhan 31(Ck-1)	138	113	240	56	3.59	-
4	BRRI dhan33 (Ck-2)	110	103	255	47	1.91	-
5	BRRI dhan39 (Ck-3)	119	104	193	50	2.20	-

Annex.V.3: Contd.

Entry no.	Designation	Days to maturity	Plant height (cm)	Panicle / m2	SF (%)	Yield (t/ha)	Yield advantage over checks (t/ha)
COMILLA (On-farm)							
1	IR 58025A/BRRI 10R	112	98	272	79	5.09	2.79 over BRRI dhan33
2	BRRI 10A/BRRI 10R	117	101	255	77	4.89	2.40 over BRRI dhan39
3	BRRI dhan 31(Ck-1)	138	114	179	69	2.57	-
4	BRRI dhan33 (Ck-2)	112	102	158	45	2.30	-
5	BRRI dhan39 (Ck-3)	111	98	174	46	2.49	-
SATKHIRA(On-station)							
1	IR 58025A/BRRI 10R	112	105.00	264	77	4.34	0.96 over BRRI dhan33
2	BRRI 10A/BRRI 10R	111	107.83	237	82	2.90	1.52 over BRRI dhan33
3	BRRI dhan 31(Ck-1)	137	107.50	259	72	4.30	-
4	BRRI dhan33 (Ck-2)	118	100.50	253	77	3.38	-
5	BRRI dhan39 (Ck-3)	124	110.17	264	70	4.03	-
SATKHIRA(On-farm)							
1	IR 58025A/BRRI 10R	114	107.70	270	74	4.88	1.55 over BRRI dhan33
2	BRRI 10A/BRRI 10R	112	115.83	290	79	4.70	1.37 over BRRI dhan33
3	BRRI dhan 31(Ck-1)	135	108.33	240	73	4.20	-
4	BRRI dhan33 (Ck-2)	115	102.50	249	69	3.33	-
5	BRRI dhan39 (Ck-3)	122	112.17	250	70	4.00	-
RAJSHAHI(On-station)							
1	IR 58025A/BRRI 10R	106	111.27	251	71	4.67	0.30 over @ BRRI dhan33
2	BRRI 10A/BRRI 10R	105	112.03	227	72	4.50	0.13 over @ BRRI dhan33
3	BRRI dhan 31(Ck-1)	115	115.80	231	71	4.13	
4	BRRI dhan33 (Ck-2)	108	112.87	261	72	4.37	-
5	BRRI dhan39 (Ck-3)	109	110.87	245	67	4.07	-
RAJSHAHI(On-farm)							
1	IR 58025A/BRRI 10R	112	119.53	226	74	4.57	0.17 over @ BRRI dhan39
2	BRRI 10A/BRRI 10R	112	111.63	215	77	4.70	0.30 over @ BRRI dhan39
3	BRRI dhan 31(Ck-1)	120	112.93	237	78	4.80	-
4	BRRI dhan33 (Ck-2)	111	113.23	238	78	4.47	-
5	BRRI dhan39 (Ck-3)	112	111.0	212	65	4.40	-

Annex.V.4: Yield and ancillary characters of Multi location trial of promising hybrids at 5 locations during T. Aman 2009 (BRRI).

Sl.#	Designation	Days to maturity (days)	Plant height (cm)	Pan/m^2	Spikelet fertility (%)	Yield (t/ha)	Yield advantage over BRRI dhan39 (t/ha)
GAZIPUR							
1	BRRI9A/ BRRI 12R	102	114.87	216	79	4.84	1.15
2	BRRI 9A/ BRRI15R	102	112.57	218	79	4.81	1.12
3	BRRI10A/ BRRI15R	109	114.6	224	87	4.88	1.19
4	BRRI dhan31	129	122.87	227	72	3.96	-
5	BRRI dhan39	118	115.27	242	83	3.69	-
COMILLA							
1	BRRI9A/ BRRI 12R	107	126	262	74	5.38	2.27
2	BRRI 9A/ BRRI15R	105	132	275	72	5.20	2.09
3	BRRI10A/ BRRI15R	110	125	274	67	4.81	1.70
4	BRRI dhan31	132	130	253	58	3.60	-
5	BRRI dhan39	118	118	253	60	3.11	-
SATKHIRA							
1	BRRI 9A/BRRI 12R	114	106.73	152	77	3.04	-
2	BRRI 9A/ BRRI15R	114	109.53	132	82	2.57	-
3	BRRI10A/ BRRI15R	115	109.4	145	91	4.19	-
4	BRRI dhan31	135	116.13	179	54	4.60	-
5	BRRI dhan39	136	96.87	246	88	3.92	-
BARISAL							
1	BRRI 9A/BRRI 12R	114	96.73	188	81	4.27	-
2	BRRI 9A/ BRRI15R	113	99.00	205	80	4.13	-
3	BRRI10A/ BRRI15R	116	99.93	232	87	5.34	0.98
4	BRRI dhan31	139	109.73	187	75	4.04	-
5	BRRI dhan39	123	96.87	195	81	4.36	-
RANGPUR							
1	BRRI 9A/BRRI 12R	104	114	180	70	3.85	-
2	BRRI 9A/ BRRI15R	105	117	175	74	4.13	-
3	BRRI10A/ BRRI15R	109	115	178	72	4.26	-
4	BRRI dhan31	132	113	167	68	4.56	-
5	BRRI dhan39	116	112	211	58	4.09	-

Annex.V.5: Yield and ancillary characters of promising hybrids at 5 locations during Boro 2006-07 (BRRI)

Sl. #	Designation	Days to maturity (days)	Plant height (cm)	Spikelet fertility (%)	Yield (t/ha)	Yield advantage (t/ha)
Gazipur						
1	BRRI 1A/BR827R	142	92	94	8.3	2.2 @ BRRI dhan28
2	BRRI 1A/BR168R	141	85	92	7.9	1.8 @ BRRI dhan28
3	SL-8	145	97	74	7.9	1.8 @ BRRI dhan28
4	BRRI dhan28	139	100	88	6.1	
5	BRRI dhan29	155	101	73	7.3	
6	BRRI hybrid dhan1	157	98	87	7.3	
Barisal						
1	BRRI 1A/BR827R	138	102	85	8.4	1.8 @ BRRI dhan28
2	BRRI 1A/BR168R	132	92	86	8.2	1.6 @ BRRI dhan28
3	BRRI dhan28	133	106	87	6.6	
4	BRRI dhan29	149	114	62	7.1	
5	BRRI hybrid dhan1	154	112	55	7.0	
Satkhira						
1	BRRI 1A/BR827R	134	92	76	7.7	1.75 @ BRRI dhan28
2	BRRI 1A/BR168R	132	89	79	7.0	1.05 @ BRRI dhan28
3	BRRI dhan28	141	104	68	5.95	
4	BRRI dhan29	142	111	82	7.6	
5	BRRI hybrid dhan1	155	103	73	6.5	
Comilla						
1	BRRI 1A/BR827R	135	96	88	8.7	2.2 @ BRRI dhan28
2	BRRI 1A/BR168R	131	86	85	7.8	1.3 @ BRRI dhan28
3	BRRI dhan28	131	100	81	6.5	
4	BRRI dhan29	145	101	85	7.6	
5	BRRI hybrid dhan1	146	98	88	8.6	
Rangpur						
1	BRRI 1A/BR827R	146	89	86	7.2	1.9 @ BRRI dhan28
2	BRRI 1A/BR168R	143	83	85	7.0	1.7 @ BRRI dhan28
3	BRRI dhan28	143	98	84	5.3	
4	BRRI dhan29	163	98	72	6.6	
5	BRRI hybrid dhan1	163	98	79	6.8	

Annex.V.6: Yield and yield contributing characters of promising hybrids at 5 locations during Boro season 2007-08 (BRRI)

Sl. #	Designation	Days to maturity (days)	Plant height (cm)	Panicle /m^2 (No.)	Spikelet fertility (%)	Yield (t/ha)	Yield advantage over checks (t/ha)
Gazipur							
1.	BRRI 1A/BR168R	144	91.27	310.20	85.64	7.67	2.25@BRRI dhan28
2.	BRRI 10A/BRRI 10R	148	104.10	303.60	75.41	7.90	2.48@BRRI dhan28
3.	IR58025A/ BRRI 10R	148	106.07	332.20	73.98	8.24	0.94 @BRRIhybrid dhan 1
4.	RP-703	150	97.35	303.10	69.74	6.13	
5.	RP-704	144	104.4	209.00	70.69	6.24	
6.	BRRI hybrid dhan1	154	111.9	343.20	69.13	6.07	
7.	BRRI dhan28	140	103.3	347.60	91.24	5.42	
8.	BRRI dhan29	156	101.9	352.00	83.92	7.30	
Barisal							
1	BRRI 1A/BR168R	140	92.00	337	84	7.90	1.50@BRRI dhan28
2	BRRI 10A/BRRI 10R	147	109.00	288	87	8.40	2.00@BRRI dhan28
3	IR58025A/ BRRI 10R	154	106.00	312	84	8.99	1.57@BRRI dhan29
4	BRRI hybrid dhan1	155	108.00	328	86	8.30	
5	BRRI dhan28	139	108.00	308	88	6.40	
6	BRRI dhan29	158	119.00	293	81	7.42	
Comilla							
1	BRRI 1A/BR168R	144	84.00	409	80	7.40	2.28@BRRIdhan 28
2	BRRI 10A/BRRI 10R	148	96.00	395	75	7.14	2.02@BRRIdhan 28
3	IR58025A/ BRRI 10R	151	94.00	405	76	7.23	1.06@BRRIdhan 28
4	BRRI hybrid dhan1	151	102.00	378	67	6.16	
5	BRRI dhan28	141	99.00	388	72	5.12	
6	BRRI dhan29	155	100.00	386	73	6.17	
Rangpur							
1	BRRI 1A/BR168R	143	77	264	77.30	6.02	1.07 @ BRRI dhan28
2	BRRI 10A/BRRI 10R	147	92	226	68.84	7.65	2.70 @ BRRI dhan28
3	IR58025A/ BRRI 10R	152	97	253	67.59	8.89	1.56 @ BRRI dhan29
4	BRRI hybrid dhan1	156	99	336	66.97	7.17	
5	BRRI dhan28	141	94	259	69.85	4.95	
6	BRRI dhan29	162	91	292	77.91	7.33	
Satkhira							
1	BRRI 1A/BR168R	141	90.43	335	85	8.25	1.98 BRRI dhan28
2	BRRI 10A/BRRI 10R	145	102.50	308	79	8.70	2.43 BRRI dhan28
3	BRRI hybrid dhan1	154	109.60	332	75	7.16	
4	BRRI dhan-28	140	117.90	325	82	6.27	
5	BRRI dhan-29	156	118.00	325	77	6.44	

Annex.V.7: Yield and ancillary characters of promising hybrids at 5 locations during 2008-2009 Boro season (BRRI)

.

Sl.#	Designation	Days to maturity (days)	Plant height (cm)	Pan/ m^2	Spiket fertility (%)	Yield (t/ha)	Yield advantage over checks (t/ha)
GAZIPUR							
1	BRRI 9A/BRRI 11R	145	92	251	78	8.02	1.75@BRRIdhan28
2	Gan 46A/BRRI 10R	144	95	275	82	8.33	2.06@BRRIdhan28
3	BRRI 11A/BRRI 15R	149	90	293	77	7.98	1.71@BRRIdhan28
4	BRRI hybrid dhan2	148	97	314	92	8.48	
5	BRRI dhan28	141	98	333	80	6.27	
6	BRRI dhan29	159	98	325	75	7.08	
COMILLA							
1	BRRI 9A/BRRI 11R	141	107	364	78	8.15	2.57@BRRIdhan28
2	Gan 46A/BRRI 10R	140	109	350	89	8.08	2.50@BRRIdhan28
3	BRRI 11A/BRRI 15R	145	93	344	85	8.20	2.62@BRRIdhan28
4	BRRI hybrid dhan2	147	100	338	84	8.10	
5	BRRI dhan28	139	90	363	71	5.58	
6	BRRI dhan29	156	99	379	72	6.44	
SATKHIRA							
1	BRRI 9A/BRRI 11R	142	99	235	73	5.96	1.81@BRRIdhan28
2	Gan 46A/BRRI 10R	139	96	250	77	5.81	1.66@BRRIdhan28
3	BRRI 11A/BRRI 15R	144	87	277	81	5.42	1.27@BRRIdhan28
4	BRRI hybrid dhan2	148	95	255	86	6.36	
5	BRRI dhan28	140	91	319	82	4.15	
6	BRRI dhan29	155	91	325	70	5.95	
BARISAL							
1	BRRI 9A/BRRI 11R	138	98	241	83	7.68	1.41@BRRIdhan28
2	Gan 46A/BRRI 10R	137	100	256	85	8.01	1.74@BRRIdhan28
3	BRRI 11A/BRRI 15R	138	92	287	82	7.76	1.49@BRRIdhan28
4	BRRI hybrid dhan2	144	102	260	88	8.52	
5	BRRI dhan28	135	101	329	81	6.27	
6	BRRI dhan29	153	101	333	80	7.35	
RANGPUR							
1	BRRI 9A/BRRI 11R	145	90	181	76	5.19	0.60@BRRIdhan28
2	Gan 46A/BRRI 10R	145	92	197	78	4.92	0.33@BRRIdhan28
3	BRRI 11A/BRRI 15R	151	87	206	76	5.55	
4	BRRI hybrid dhan2	151	95	217	72	6.55	
5	BRRI dhan28	139	90	178	73	4.59	
6	BRRI dhan29	157	88	225	62	5.27	

Annex.V.8: Yield and ancillary characters of promising hybrids at 5 locations during 2009-10 Boro season (BRRI)

Sl. #	Designation	Days to maturity (days)	Plant height (cm)	Pan/m^2	Spikelet fertility (%)	Yield (t/ha)	Yield Advantage over check
GAZIPUR							
1	BRRI 1A/BRRI 12R	135	103.00	291.00	95.43	7.05	2.31 @ BR28
2	BRRI 10A/BRRI 12R	140	109.07	298.10	89.89	6.87	2.13 @ BR28
3	II32A/BRRI 15R	140	108.33	248.60	85.84	6.78	2.04 @ BR28
4	II32A/BRRI16R	141	110.67	275.00	88.52	6.88	2.14 @ BR28
5	II32A/BRRI 10R	141	103.33	242.00	87.83	6.95	2.21 @ BR28
6	II32A/BRRI 12R	141	109.07	270.60	84.67	6.96	2.22 @ BR28
7	BRRI 10A/BRRI 13R	141	109.00	264.00	94.32	6.27	1.53 @ BR28
8	BRRI 9A/BRRI15R	137	111.00	264.00	84.46	5.89	1.15 @ BR28
9	BRRI dhan28	134	101.67	231.00	90.41	4.74	
10	BRRI dhan29	152	106.33	301.40	84.39	6.47	
BARISAL							
1	BRRI 1A/BRRI 12R	140	98.67	255.33	90.00	6.55	1.91 @ BR28
2	BRRI 10A/BRRI 12R	149	109.00	233.00	87.33	6.38	1.74 @ BR28
3	II32A/BRRI15R	148	112.00	227.00	86.00	6.01	1.37 @ BR28
4	II32A/BRRi16R	147	110.67	217.67	88.00	5.85	1.21 @ BR28
5	II32A/BRRI 10R	149	111.33	228.67	91.00	7.07	2.43 @ BR28
6	II32A/BRRI 12R	146	110.33	220.33	89.33	6.35	1.71 @ BR28
7	BRRI 10A/BRRI 13R	148	111.67	228.00	90.33	6.57	1.93 @ BR28
8	BRRI 9A/BRRI15R	141	107.33	231.67	84.67	6.12	1.48 @ BR28
9	BRRI dhan28	139	104.00	296.00	87.67	4.64	
10	BRRI dhan29	155	109.33	322.00	75.67	6.48	
SATKHIRA							
1	BRRI 1A/BRRI 12R	138	97	215	89	7.29	1.38 @ BR29
2	BRRI 10A/BRRI 12R	144	110	217	86	6.87	0.96 @ BR29
3	II32A/BRRI 15R	143	112	201	90	6.82	0.91 @ BR29
4	II32A/BRRI16R	143	116	211	89	6.50	0.59 @ BR29
5	II32A/BRRI 10R	142	105	218	91	6.91	1.0 @ BR29
6	II32A/BRRI 12R	144	113	213	82	6.39	0.48 @ BR29
7	BRRI 10A/BRRI 13R	145	138	210	86	6.72	0.81 @ BR29
8	BRRI 9A/BRRI15R	141	112	174	86	6.70	0.79 @ BR29
9	BRRI dhan28	138	112	286	97	7.27	
10	BRRI dhan29	150	104	290	72	5.91	
COMILLA							
1	BRRI 1A/BRRI 12R	141	102.00	264.00	92.33	7.68	2.02 @ BR28
2	BRRI 10A/BRRI 12R	148	107.67	239.67	88.33	7.56	1.90 @ BR28
3	II32A/BRRI 15R	147	113.00	231.67	95.00	7.69	2.03 @ BR28
4	II32A/BRRI16R	148	115.00	257.00	88.33	7.34	1.68 @ BR28
5	II32A/BRRI 10R	146	112.33	232.00	85.33	7.58	1.92 @ BR28
6	II32A/BRRI 12R	147	113.33	220.67	87.00	7.43	1.77 @ BR28
7	BRRI 10A/BRRI 13R	148	113.33	285.33	82.00	8.22	2.56 @ BR28
8	BRRI 9A/BRRI15R	142	112.33	236.00	80.33	7.20	1.54 @ BR28
9	BRRI dhan28	138	112.67	298.00	64.33	5.66	
10	BRRI dhan29	151	110.33	334.33	65.33	6.56	
RANGPUR							
1	BRRI 1A/BRRI 12R	151	97	215	89	6.34	
2	BRRI 10A/BRRI 12R	155	110	217	86	5.80	
3	II32A/BRRI 15R	155	112	201	90	5.37	
4	II32A/BRRI16R	157	116	211	89	5.73	
5	II32A/BRRI 10R	158	105	218	91	5.94	
6	II32A/BRRI 12R	156	113	213	82	5.25	
7	BRRI 10A/BRRI 13R	158	138	210	86	5.85	
8	BRRI 9A/BRRI15R	153	112	174	86	5.86	
9	BRRI dhan28	141	112	286	97	4.62	
10	BRRI dhan29	162	104	290	72	6.18	

Annex.V.9: Comparison of means of paddy yield of 6 cultivars tested in 3 regions (AAS, 2004)

Variety	Paddy Yield (ton/ha)							
	Northeast		Northwest		Southwest		Average	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Sonarbangla-1	7.11	18.08	8.35	13.93	8.18	12.61	7.88	8.50
Jagoran 1	6.75	17.36	8.12	14.53	7.61	12.90	7.49	9.21
Hira (99-5)	7.59	15.75	8.32	11.30	7.90	12.00	7.94	4.66
Aftab LP 50	7.08	15.24	8.46	15.80	8.00	12.76	7.85	8.92
Richer 101	7.11	15.43	8.38	15.31	7.99	14.12	7.83	8.30
BRRI hybrid dhan 1	6.61	28.41	7.65	16.08	6.64	17.30	6.97	8. 46

Source: *Rashid, H. 2004*

Annex.V.10: Comparison of average field duration of 6 cultivars (AAS, 2004)

Variety	Field duration (days)	
	Mean	CV (%)
Sonarbangla-1	103.40	2.55
Jagoran1	104.04	2.33
Hira (99-5)	104.38	2.09
Aftab LP 50	104.58	2.18
Richer 101	104.91	2.43
BRRI hybrid dhan1	112.88	2.50

Source: *Rashid, H. 2004*

Annex.V.11: Maximum tillers, panicles production and % effective tiller production of 6 cultivars (AAS, 2004)

Variety	Max. Tillers/hill (Nr.)		Panicles/hill (Nr.)		% Effective tiller	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
Sonarbangla-1	18.30	14.10	13.55	14.20	74.66	9.22
Jagoran1	17.93	12.77	13.39	12.70	75.43	7.19
Hira (99-5)	17.39	7.53	13.30	10.83	77.00	6.86
Aftab LP-50	18.06	14.62	13.57	13.26	75.47	7.09
Richer 101	18.06	14.95	13.54	12.04	75.55	7.93
BRRI hybrid dhan 1	20.34	15.83	14.40	16.25	71.61	13.95

Source: *Rashid, H. 2004*

Annex.V.12: Comparative performance of hybrid rice over the popular modern HYVs (BRRI dhan 28 & 29) in 10 regions of Bangladesh during 2007-8 to 2009-10 Boro seasons (DAE)

Season / Variety	Comilla	Mymensingh	Dhaka	Chittagong	CHTs	Sylhet	Rajshahi	Rangpur	Jessore	Barisal	Average	Standard Error	CV (%)
	I. 2007-8 Boro season												
BRRI dhan 28	6.82	4.09	4.41	4.60	4.33	3.90	4.85	6.08	6.80	7.60	5.35	0.43	25.15
BRRI dhan 29	6.57	4.52	4.88	4.50	4.71	4.25	5.80	7.40	7.92	7.90	5.85	0.47	25.38
Av. Inbred	6.70	4.31	4.65	4.55	4.52	4.08	5.33	6.74	7.36	7.75	5.60	0.44	24.87
Hybrid	8.32	5.38	4.36	5.50	6.91	5.98	6.30	9.64	8.90	7.50	6.88	0.54	24.62
Yield Difference	1.62	1.07	-0.29	0.95	2.39	1.90	0.97	2.90	1.54	-0.25	1.28	0.32	80.18
% Difference	24.18	24.83	-6.24	20.88	52.88	46.57	18.20	43.03	20.92	-3.23	24.20	6.16	80.48
	II. 2008-9 Boro season												
BRRI dhan 28	6.96	4.08	4.42	4.50	5.29	3.72	4.80	5.80	7.05	7.50	5.41	0.43	24.97
BRRI dhan 29	7.27	4.43	4.93	4.90	3.68	4.25	5.60	6.85	7.50	7.80	5.72	0.48	26.36
Av. Inbred	7.12	4.26	4.68	4.70	4.49	4.12	5.20	6.33	7.28	7.65	5.58	0.43	24.54
Hybrid	8.01	5.19	4.20	5.70	7.56	5.30	6.30	7.90	9.00	8.50	6.77	0.52	24.15
Yield Difference	0.89	0.93	-0.48	1.00	3.07	1.18	1.10	1.57	1.72	0.85	1.18	0.28	74.90
% Difference	12.50	21.83	-10.26	21.28	68.31	28.64	21.15	24.80	23.63	11.11	22.30	6.19	87.79
	III. 2009-10 Boro season												
BRRI dhan 28	6.43	3.94	4.51	4.90	5.46	3.80	4.64	6.50	6.75	8.00	5.49	0.44	25.08
BRRI dhan 29	7.50	4.58	5.00	4.95	5.88	4.30	5.47	7.37	7.20	7.80	6.01	0.42	22.28
Av. Inbred	6.97	4.26	4.76	4.93	5.67	4.05	5.06	6.94	6.98	7.90	5.75	0.43	23.39
Hybrid	7.80	5.61	3.71	5.80	7.00	5.32	5.55	7.60	9.00	8.75	6.61	0.53	25.55
Yield Difference	0.83	1.35	-1.05	0.87	1.33	1.27	0.49	0.66	2.02	0.85	0.86	0.25	93.14
% Difference	11.91	31.69	-22.06	17.65	23.46	31.36	9.68	9.51	28.94	10.76	15.29	5.03	104.04
	Average (3 Years)												
BRRI dhan 28	6.74	4.04	4.45	4.67	5.03	3.81	4.76	6.13	6.87	7.7	5.42	0.42	24.70
BRRI dhan 29	7.11	4.51	4.94	4.78	4.76	4.36	5.62	7.21	7.54	7.83	5.866	0.44	23.73
Av. Inbred	6.93	4.28	4.70	4.73	4.89	4.08	5.18	6.67	7.21	7.77	5.644	0.43	23.99
Hybrid	8.04	5.39	4.09	5.61	7.16	5.53	6.05	8.38	8.97	8.25	6.747	0.52	24.14
Yield Difference	1.11	1.11	-0.61	0.97	2.27	1.45	0.87	1.71	1.76	0.48	1.112	0.25	71.42
% Difference	16.02	25.94	-12.98	19.87	46.42	35.54	16.80	25.64	24.41	6.18	20.384	5.09	78.92

Annex.V.13: Performance of 16 rice hybrids against 2 check varieties for 3 years on station and on farm trials in 6 regions during 2004-7 Boro season (SCA)

Variety	Regional mean yield (t / ha)												Average Yield (Kg/ha)						
	Dhaka		Mymensingh		Comilla		Jessore		Rajshahi		Rangpur		OS	SE	OF	SE	Overall	SE	CV (%)
	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF							
Bijoy 4	7,530	7,301	6,520	8,439	7,822	9,370	7,137	6,683	6,489	7,381	6,083	7,190	6,930	275.59	7,727	403.56	7,329	262.14	7.69
Heera 6 (HS 48)	7,632	7,560	7,187	8,076	8,213	8,310	6,893	6,317	6,039	6,733	6,185	7,224	7,025	341.63	7,370	313.80	7,197	227.18	3.39
CNR 5104 (Lily 1)	6,246	6,782	7,224	8,437	7,075	10,153	6,843	9,100	6,615	7,310	5,838	7,759	6,640	213.74	8,257	505.25	7,449	357.49	15.35
DU 527 (Lily 7)	8,227	6,443	7,627	8,053	8,264	8,927	6,837	7,780	6,459	6,965	5,485	7,833	7,150	446.32	7,667	354.40	7,407	282.65	4.94
HRM 03 (kANOK 8)	8,268	5,334	7,448	8,416	7,703	8,480	7,473	6,033	6,786	7,113	5,964	6,636	7,274	326.40	7,002	518.05	7,138	294.76	2.69
Agro-G-1 (EAL 9201)	7,596	6,138	7,621	8,015	7,408	8,570	6,573	6,053	5,779	7,425	5,583	6,545	6,760	376.07	7,124	425.44	6,942	276.21	3.71
Bijoy 5	7,309	7,156	7,830	8,153	6,787	7,947	6,247	8,817	5,910	7,763	5,742	5,996	6,638	335.61	7,639	395.59	7,138	289.73	9.92
Pena-1	7,750	6,170	8,001	8,250	7,698	7,677	7,083	6,530	5,601	5,670	6,753	6,899	7,148	362.67	6,866	391.66	7,007	257.99	2.84
Barkat	7,446	6,448	7,420	8,085	8,168	8,870	7,030	7,360	5,343	6,840	6,235	7,722	6,940	410.28	7,554	356.50	7,247	275.15	5.99
HM-07 (Aromatic)	7,393	5,457	6,098	7,653	6,630	7,637	6,730	6,940	5,808	6,401	6,395	6,221	6,509	224.96	6,718	351.46	6,614	201.42	2.24
Raja	7,463	6,349	7,512	9,099	8,519	7,950	6,933	6,707	5,976	6,166	6,248	7,135	7,109	379.99	7,234	454.69	7,171	283.13	1.24
Agro-G-2 (EAL 9202)	7,282	6,447	8,792	7,960	7,839	8,123	7,290	6,393	5,540	6,289	5,795	6,648	7,090	503.79	6,977	340.74	7,033	290.45	1.14
HM 08	7,306	6,312	7,040	8,168	7,674	8,977	6,960	6,663	5,690	7,603	5,543	6,978	6,702	358.60	7,450	408.57	7,076	282.63	7.47
Bijoy 3	6,698	6,392	6,427	7,073	6,425	7,487	5,593	6,560	5,349	6,478	4,734	6,302	5,871	313.18	6,715	189.67	6,290	216.03	9.49
Super Hybrid SL-8H	6,895	6,223	6,583	7,220	7,236	9,187	7,277	6,110	6,768	7,240	6,117	6,896	6,813	177.04	7,146	453.42	6,979	237.43	3.38
Hi-Tech 1 (Bumper Dhan 5)	7,160	6,329	7,528	8,398	7,339	8,400	7,447	7,420	5,969	8,154	5,743	7,323	6,864	324.12	7,671	330.57	7,268	251.97	7.84
Average Hybrid	**7,388**	**6,428**	**7,304**	**8,093**	**7,550**	**8,504**	**6,897**	**6,967**	**6,008**	**6,971**	**5,903**	**6,957**	**6,841**	**294.03**	**7,320**	**325.35**	**7,080**	**221.15**	4.78
Standard Error	**126.50**	**145.24**	**167.79**	**120.82**	**152.36**	**179.79**	**117.45**	**230.80**	**119.96**	**164.00**	**115.40**	**137.80**	**84.70**	**21.17**	**105.90**	**19.93**	**72.89**	**9.27**	20.57
BRRI dhan 28	5,669	6,253	5,654	6,230	6,840	6,593	6,137	7,453	4,982	6,419	4,861	5,945	5,691	300.70	6,482	213.19	6,086	212.42	9.20
BRRI dhan 29	6,583	5,867	6,403	7,140	7,545	8,313	6,803	7,750	6,613	7,393	6,209	6,165	6,693	189.28	7,105	381.91	6,899	212.49	4.22
Average Inbred	**6,126**	**6,060**	**6,029**	**6,685**	**7,193**	**7,453**	**6,470**	**7,602**	**5,798**	**6,906**	**5,535**	**6,055**	**6,192**	**237.81**	**6,793**	**270.53**	**6,493**	**194.21**	6.55
Standard Error	**457.00**	**193.00**	**374.50**	**455.00**	**352.50**	**860.00**	**333.00**	**148.50**	**815.50**	**487.00**	**674.00**	**110.00**	**501.08**	**55.71**	**311.25**	**84.36**	**406.50**	**0.03**	33.02

Annex.V.14: Average yield of 81 varieties of hybrid rice, BRRI dhan 28 and 29 trial on farm and on station in six regions with 42 agencies during 2005-2007 Boro seasons (SCA)

Sl. #	Name Company	Name of Variety	Source of Seed	Mean Yield (Kg/ha)
1	East West Seed Bangladesh	HTM 202 (Doyel)	China	7,435.00
2	North South Seed Ltd	HTM 707 (Teeya)	China	7,526.00
3	Sea Trade Fertilizer	LP 108	China	7,269.00
4	Aftab Bahumuhki Farms Ltd	LP 70	China	7,436.00
5	Mollika Seed Co.	HTM 4 (Sonarbangla 6)	China	7,485.00
6	BRAC	HB 8 (Jagoron 2)	China	7,345.00
7	North South Seed Ltd	HTM 606 (Gold)	China	7,415.00
8	East West Seed Bangladesh	HTM 303(Moyna)	China	7,300.00
9	National Seed Co. Ltd	Taj 2 (GRA 3)	China	7,275.00
10	Tinpata Quality Seed Ltd	Tinpata 10	China	7,425.00
11	National Seed Co. Ltd	Taj 1 (GRA 2)	China	7,333.00
12	Supreme Seed Co.	HS 273 Supreme Hybrid 2)	China	7,140.00
13	Aftab Bahumuhki Farms Ltd	LP 05	China	7,211.00
14	BRAC	BWOO1 (Jagoron 3)	China	6,808.00
15	Aftab Bahumuhki Farms Ltd	LP 106	China	7,858.00
16	Tinpata Quality Seed Ltd	Tinpata Super	China	7,709.00
17	Mukterpur Bhander	S-2B (Krishan-2)	China	7,420.00
18	Ayesha Abed Foundation	HB 09 (Alloron 2)	China	7,455.00
19	Kamal Seed Co.	Ruposhibangla 1	China	7,100.00
20	United Seed Store	WBR 5(Madhumoti 5)	China	7,515.00
21	Ayesha Abed Foundation	HB 13 (Aloron 3)	China	7,451.00
22	Alamgir Seed Co.	Chamak 1	China	6,955.00
23	Supreme Seed Co.	Supreme Hybrid 5 (Heera 5)	China	6,860.00
24	Alpha Seed International	Solon 2 (Golden B)	China	7,153.00
25	Metal Seed Co.	HRM 02 (Sharathi 14)	China	7,398.00
26	Alpha Seed International	Solon 1(Golden A)	China	7,012.00
27	Syngenta Bangladesh Ltd	HR 422 (Surma 4)	China	7,261.00
28	Alamgir Seed Co.	Sonali 1	China	7,460.00
29	Mukterpur Bhander	SL 3A (Krishan 1)	China	7,180.00
30	Sopan Seed	HE-U 8 (Bijoy 2)	China	7,294.00
31	United Seed Store	WBR 2(Madhumoti 2)	China	7,092.00
32	Metal Seed Co.	HRM 01 (Agroni 7)	China	6,855.00
33	Foundation for Economic Development	TK 1 (Bumper dhan 1)	China	7,242.00

Annex.V.14: Contd.

Sl. #	Name Company	Name of Variety	Source of Seed	Mean Yield (Kg/ha)
34	Syngenta Bangladesh Ltd	Surma 7 (HF 40)	China	6,174.00
35	Bayer Crop Science	ARIZE Tej (96114016)	China	6,865.00
36	BRRI	BRRI Hybrid Dhan 2	BRRI	7,422.00
37	Syngenta Bangladesh Ltd	Surma 6 (Ziyou 27))	China	6,477.00
38	Nipa Trading International Ltd	TK 7 (Bumper Dhan 4)	China	7,500.00
39	United Seed Store	WBR 7	China	6,478.00
40	Bayer Crop Science	ARIZE Dhani (93024518)	China	6,952.00
41	Krishi Banijya Protisthan	Meghna (QDR 2)	China	6,840.00
42	Nipa Trading International Ltd	TK 6 (Bumper Dhan 3)	China	7,574.00
43	Siddiquis Seeds Co.	HG 202 (Manik 2)	China	7,719.00
44	Auto Crop Care Ltd	Jamuna (QDR 3)	China	7,258.00
45	Foundation for Economic Development	TK 2 (Bumper Dhan 2)	China	7,121.00
46	Dhaka Seed Center	US 312	China	6,692.00
47	Krishi Banijya Protisthan	Padma (QDR 1)	China	7,241.00
48	Siddiquis Seeds Co.	HG 101 (Manik 1)	China	7,063.00
49	A.R. Malik & Co.	Bijoy 4	China	7,329.00
50	Mitali Agro Seed Industries	Heera 6 (HS 48)	China	7,197.00
51	Lily & Co.	CNR 5104 (Lily 1)	China	7,449.00
52	Lily & Co.	DU 527 (Lily 7)	China	7,407.00
53	Metal Seed Co.	HRM 03 (Kanok 8)	China	7,138.00
54	Energypack	Agro-G-1 (EAL 9201)	China	6,942.00
55	A.R. Malik & Co.	Bijoy 5	China	7,138.00
56	M/S Quality Seed Co.	Pena-1	China	7,007.00
57	Carbel International	Barkat	China	7,247.00
58	Alpha Agro Ltd	HM-07 (Aromatic)	China	6,614.00
59	Carbel International	Raja	China	7,171.00
60	Energypack	Agro-G-2 (EAL 9202)	China	7,033.00
61	Alpha Agro Ltd	HM 08	China	7,076.00
62	Sopan Seed	Bijoy 3	China	6,290.00
63	BADC	Super Hybrid SL- 8H	China	6,979.00
64	Uniconsult International	Hi-Tech 1 (Bumper Dhan 5)	China	7,268.00
65	ACI Ltd	Ropa 1	China	7,131.00
66	ACI Formulation	Sampad	China	7,131.00
67	Apex Leather Craft Ltd	Rabi	China	7,199.00

Annex.V.14: Contd.

Sl. #	Name Company	Name of Variety	Source of Seed	Mean Yield (Kg/ha)
68	Bashundhara Horticulture Ltd	Bashundhara 2 (SL C3)	China	6,978.00
69	Carnel International	Maya (Ziyou 48)	China	7,280.00
70	Bashundhara Horticulture Ltd	Bashundhara 1 (SL D4)	China	6,942.00
71	Apex Leather Craft Ltd	Seera	China	7,730.00
72	ACI Agro Chemicals	Falon	China	7,436.00
73	ACI Ltd	Ropa 7	China	7,432.00
74	Uniconsult International	Hi-Tech 14 (Bumper Dhan 6)	China	7,125.00
75	ACI Agro Chemicals	Chitra	China	7,053.00
76	Carnel International	Kajol (SM 88)	China	5,793.00
77	Chens Crop Science Bangladesh Ltd	Sabujsathi	China	7,312.00
78	ACI Formulation	Rajkumer	China	7,253.00
79	Supreme Seed Co.	HS-06- 5(Heera 3)	China	7,134.00
80	Mitali Agro Seed Industries	HS- 49(Heera 7)	China	7,505.00
81	Supreme Seed Co.	HS- Q-1(Heera 4)	China	7,188.00
	Average			**7,172.30**
	Standard Error			**38.04**
	CV (%)			**4.77**
82	BRRI	BRRI dhan 28	BRRI	6,189.00
83	BRRI	BRRI dhan 28	BRRI	6,070.00
84	BRRI	BRRI Dhan 28	BRRI	5,941.00
85	BRRI	BRRI dhan 28	BRRI	6,086.00
86	BRRI	BRRI dhan 28	BRRI	6,100.00
	Average			**6,077.20**
	Standard Error			**39.81**
	CV (%)			**1.46**
87	BRRI	BRRI dhan 29	BRRI	7,056.00
88	BRRI	BRRI dhan 29	BRRI	6,887.00
89	BRRI	BRRI dhan 29	BRRI	6,738.00
90	BRRI	BRRI dhan 29	BRRI	6,899.00
91	BRRI	BRRI dhan 29	BRRI	6,799.00
	Average			**6,875.80**
	Standard Error			**53.86**
	CV (%)			**1.75**

Annex.V.15: Comparative yield performance of 48 hybrids and 1 inbred (BRRI dhan 28) during 2005-6 Boro season (SCA)

Variety /Hybrid Code	Dhaka		Mymensingh		Comilla		Jessore		Rajshahi		Rangpur		Mean	
	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF
BRRI dhan 28	5.10	6.84	3.62	5.69	5.92	4.83	6.17	6.48	6.26	6.70	5.93	5.76	5.50	6.05
H-121	5.24	7.00	5.90	7.53	9.42	9.18	7.28	7.56	9.50	9.55	4.07	6.17	6.90	7.83
H-122	4.94	7.96	6.38	6.57	6.91	7.30	7.15	8.41	7.04	7.85	3.64	6.08	6.01	7.36
H-123	5.28	7.51	6.53	6.54	7.97	7.64	6.90	8.05	8.00	8.72	6.80	7.14	6.91	7.60
H-124	5.54	7.24	4.88	6.22	7.10	6.84	6.95	7.94	6.62	7.71	6.05	6.20	6.19	7.03
H-125	5.68	8.15	4.75	7.30	7.83	7.25	7.09	7.81	6.88	8.30	5.65	6.58	6.31	7.57
H-126	5.61	7.97	4.43	6.17	7.02	8.07	6.70	8.25	6.85	7.87	6.39	6.61	6.17	7.49
H-127	5.00	7.33	5.00	6.61	8.13	6.30	7.07	7.71	7.49	7.83	6.40	8.11	6.52	7.32
H-128	5.00	7.98	4.99	6.26	7.53	5.91	7.25	7.75	7.86	7.99	3.71	6.61	6.06	7.08
H-129	5.37	7.71	4.91	6.25	7.45	7.86	6.07	7.66	7.27	7.26	6.10	6.90	6.20	7.27
H-130	5.25	8.02	4.29	6.16	7.52	6.42	6.33	8.20	7.49	7.41	6.95	7.45	6.31	7.28
H-131	5.76	7.79	5.40	6.30	7.53	6.47	6.70	8.46	8.46	9.15	4.66	7.33	6.42	7.58
H-132	5.38	8.30	5.09	6.41	8.53	5.72	6.68	8.43	7.01	8.91	3.97	3.97	6.11	6.96
H-134	6.40	8.44	5.39	6.22	7.83	7.57	6.55	7.32	7.92	7.05	6.69	7.17	6.80	7.30
H-135	5.84	7.98	4.86	7.14	6.85	7.28	6.95	8.46	6.91	8.22	4.16	6.19	5.93	7.55
H-136	5.84	7.57	5.09	6.86	7.40	6.09	6.34	8.26	6.69	8.19	4.16	6.54	5.92	7.25
H-137	5.57	7.37	5.61	6.64	7.87	10.44	6.65	7.89	7.82	7.00	6.90	6.87	6.74	7.70
H-138	5.16	5.67	3.93	6.77	6.78	9.83	6.72	7.10	7.60	6.75	4.33	6.17	5.75	7.05
H-139	5.61	6.12	4.47	6.92	7.56	8.33	7.77	7.75	8.77	8.58	7.62	6.39	6.97	7.35
H-140	6.61	6.74	4.84	6.51	7.32	7.54	7.17	7.32	9.12	8.19	6.32	7.16	6.90	7.24
H-141	5.88	6.32	6.41	8.36	7.06	9.38	5.97	9.13	7.96	7.09	4.30	6.48	6.26	7.79
H-142	4.71	6.43	4.04	6.43	7.71	6.67	7.80	7.87	6.89	5.57	3.84	5.41	5.83	6.40
H-143	5.36	5.53	4.98	7.95	7.70	8.56	6.94	8.47	7.37	6.35	4.26	6.61	6.10	7.25
H-144	5.45	6.21	6.36	8.18	9.20	10.01	7.76	8.95	7.90	9.83	4.66	6.87	6.89	8.34
H-145	5.62	6.14	6.10	7.38	7.85	10.21	7.53	8.01	7.98	7.87	4.63	7.65	6.62	7.88
H-146	6.49	8.63	6.83	7.63	8.08	9.55	7.59	7.77	8.72	8.43	5.35	7.13	7.18	8.19
H-147	5.49	6.25	4.84	6.35	7.76	9.58	7.17	7.77	7.49	7.30	4.53	7.19	6.21	7.41
H-148	5.27	6.70	4.88	7.72	7.58	8.90	7.57	7.56	7.50	7.40	3.74	6.39	6.09	7.45
H-149	5.90	6.40	5.31	8.38	7.64	9.23	6.60	8.88	8.97	7.59	5.02	7.55	6.57	8.01
H-150	5.90	6.05	5.70	8.03	8.01	7.70	6.95	8.53	7.76	6.94	4.40	6.88	6.45	7.36

Annex.V.15: Contd.

Variety /Hybrid Code	Dhaka		Mymensingh		Comilla		Jessore		Rajshahi		Rangpur		Mean	
	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF	OS	OF
H-151	5.61	6.88	4.63	6.76	7.16	7.12	7.12	8.50	7.34	6.51	3.72	6.81	5.93	7.10
H-152	6.25	5.88	4.69	8.13	7.30	8.85	7.17	8.11	8.00	6.62	4.19	6.54	6.27	7.36
H-153	6.73	5.84	4.54	8.02	7.55	8.91	7.93	8.47	9.60	7.88	4.27	7.08	6.77	7.70
H-154	6.30	7.33	6.10	7.17	6.81	9.19	7.57	6.89	7.59	8.59	4.27	6.35	6.44	7.59
H-155	7.16	6.11	7.19	8.41	10.05	9.97	7.36	6.57	9.09	9.87	4.94	6.82	7.63	7.96
H-156	6.55	7.15	5.10	7.18	7.22	9.60	6.72	7.43	6.90	7.49	7.08	6.70	6.60	7.59
H-157	6.97	7.62	5.04	7.91	7.61	8.81	7.97	6.98	7.45	8.41	4.62	6.57	6.61	7.72
H-158	6.60	7.27	5.18	7.80	6.93	10.11	6.40	7.52	7.80	8.00	3.98	6.15	6.15	7.81
H-159	6.34	6.73	5.68	7.47	9.86	10.39	6.85	7.05	10.33	9.19	4.19	5.86	7.21	7.78
H-160	7.35	6.49	5.19	7.74	7.84	10.25	7.04	6.92	6.44	7.37	6.29	6.94	6.69	7.62
H-161	5.61	7.58	4.65	4.92	6.57	5.82	6.35	7.37	6.56	6.18	5.69	5.10	5.91	6.16
H-162	5.98	7.09	6.53	8.27	9.09	10.61	7.23	7.65	7.96	9.09	5.46	6.59	7.04	8.22
H-163	6.46	6.48	6.15	8.14	7.37	9.61	6.77	7.42	7.97	7.84	4.97	7.07	6.62	7.76
H-164	6.73	6.21	4.92	7.68	7.96	9.62	7.02	7.53	7.90	7.90	5.51	6.18	6.67	7.52
H-165	5.12	6.18	4.04	7.33	6.15	5.23	6.47	7.71	5.57	7.43	2.53	5.15	4.98	6.51
H-166	5.65	5.75	3.82	4.67	5.11	5.00	5.00	6.55	6.24	5.81	3.19	4.24	4.84	5.34
H-167	5.93	6.90	4.24	6.63	7.58	7.95	6.34	6.83	7.95	7.94	2.70	4.90	5.79	6.86
H-168	6.80	6.83	4.56	7.45	7.44	10.11	6.74	6.81	8.36	7.89	4.66	6.88	6.43	7.66
H-169	6.87	7.81	4.84	6.66	7.69	8.08	7.04	6.89	10.24	9.14	6.61	6.68	7.22	7.54
Mean	**5.88**	**6.99**	**5.19**	**7.09**	**7.63**	**8.27**	**6.94**	**7.76**	**7.77**	**7.83**	**4.96**	**6.51**	**6.40**	**7.41**
SE	**0.09**	**0.12**	**0.12**	**0.12**	**0.12**	**0.23**	**0.08**	**0.09**	**0.14**	**0.14**	**0.18**	**0.12**	**0.08**	**0.08**
SD	**0.64**	**0.82**	**0.80**	**0.86**	**0.86**	**1.57**	**0.56**	**0.64**	**0.99**	**0.98**	**1.23**	**0.81**	**0.53**	**0.53**
CV (%)	**10.96**	**11.78**	**15.43**	**12.15**	**11.31**	**18.98**	**8.03**	**8.19**	**12.74**	**12.51**	**24.69**	**12.47**	**8.31**	**7.15**

OS = On station, **OF =** On farm

Source: SCA seasonal trial reports, 2005-6 Boro season

Annex.VI.1: Cost and return analysis of hybrid and inbred rice for 3 Boro season during 2007-2010 Boro seasons (CPD)

SL#	Item	2007-8 Boro		2008-9 Boro		2009-10 Boro		Average	
		Hybrid	Inbred	Hybrid	Inbred	Hybrid	Inbred	Hybrid	Inbred
A. Cost (Tk/ha)									
1	Land Preparation	5434.00	6175.00	5434.00	6175.00	5434.00	6175.00	5434.00	6175.00
2	Labor	31943.00	27788.00	27664.00	24206.00	27664.00	24206.00	29090.33	25400.00
3	Seed	2964.00	1853.00	2964.00	1544.00	2964.00	1544.00	2964.00	1647.00
4	Fertilizers	10547.00	9156.00	11905.00	10206.00	9139.00	7909.00	10530.33	9090.33
5	Pesticides:	2470.00	1235.00	2470.00	1235.00	2470.00	1235.00	2470.00	1235.00
6	Irrigation	12350.00	12350.00	12350.00	12350.00	12350.00	12350.00	12350.00	12350.00
7	Land rent in	13585.00	13585.00	13585.00	13585.00	13585.00	13585.00	13585.00	13585.00
8	Interest on working capital (5%)								
	a) Full cost basis	3964.65	3607.1	3818.6	3465.05	3680.3	3350.2	3821.18	3474.12
	b) Cash cost basis	1688.25	1538.45	1756.15	1575.50	1617.85	1460.65	1687.42	1524.87
9	Total Cost:								
	a) Full cost basis	83257.65	75749.10	80190.60	72766.05	77286.30	70354.20	80244.85	72956.45
	b) Cash cost basis	35453.25	32307.45	36879.15	33085.50	33974.85	30673.65	35435.75	32022.20
B. Gross return (Tk/ha)[1]		120873.00	109758.00	82526.00	81600.00	117539.00	111240.00	106979.33	100866.00
C. Net return (Tk/ha)									
	a) Full cost basis	37615.35	34008.90	2335.40	8833.95	40252.70	40885.80	26734.48	27909.55
	b) Cash cost basis	85419.75	77450.55	45646.85	48514.50	83564.15	80566.35	71543.58	68843.80
D. Cost Benefit Ratio									
	a) Full cost basis	1.45	1.45	1.03	1.12	1.52	1.58	1.33	1.38
	b) Cash cost basis	3.41	3.40	2.24	2.47	3.46	3.63	3.04	3.16
E. Paddy cost (Tk/Kg)									
	a) Full cost basis	12.48	13.33	12.02	12.27	11.59	11.87	12.03	12.48
	b) Cash cost basis	5.32	5.69	5.53	5.58	5.09	5.17	5.31	5.48
F. Paddy yield (Kg/ha)[1]		6669	5681	6669	5928	6669	5928	6669.00	5845.67

[1] *Estimated figures*

Annex.VI.2: Net-return and total cost under full cost and cash cost basis of hybrid and inbred rice, average paddy price and source of data during 1998-2010.

Season	Net return (Tk./ha)						Total cost (Tk/ha)						Average paddy price (Tk/ha)		Data Source
	Full cost basis			Cash cost basis			Full cost basis			Cash cost basis					
	Hybrid	Inbred	% Diff	Hybrid	Inbred	% Diff	Hybrid	Inbred	% Diff	Hybrid	Inbred	% Diff	Hybrid	Inbred	
1998-99 Boro	23227	18026	28.85	38515	32942	16.92	30720	26587	15.55	15432	11671	32.23	6.75	6.73	AAS
1998-99 Boro	24260	16376	48.14	-	-	-	26187	22294	17.46	-	-	-	6.46	6.36	IRRI / BRAC
1998-99 Boro	19207	17606	9.09	-	-	-	23451	19121	22.64	-	-	-	6.55	6.33	IRRI / BRAC
1998-99 Boro	28359	17141	65.45	-	-	-	25032	21148	18.37	-	-	-	6.55	6.33	IRRI / BRAC
2003-4 Boro	29649	17368	70.71	-	-	-	26082	23387	11.52	-	-	-	6.13	6.13	AAS / IRRI
2006-8 Boro	68547	39931	71.66	97052	83314	16.49	80283	77504	3.59	35958	34951	2.88	14.26	15.09	AAS / RDC
2007 T. Aus	31078	24310	27.84	59841	47769	25.27	53850	44451	21.14	25087	20992	19.51	15.88	15.96	AAS / RDC
2007 T.Aman	41076	23393	75.79	67797	57974	16.94	56627	59140	-4.25	29905	24560	21.76	15.97	15.97	AAS / RDC
2008 Boro	52309	48868	7.04	-	-	-	40902	38826	5.35	-	-	-	11.25	11.25	BRRI
2007-8 Boro	37615	34009	10.60	85420	77451	10.29	83258	75749	9.02	35453	32308	9.73	17	18	CPD
2008-9 Boro	2335	8834	-73.57	45647	48515	-5.91	80191	72766	10.20	36879	33086	11.46	11.25	12.50	CPD
2009-10 Boro	40253	40886	-1.55	83564	80566	3.72	77286	70354	8.97	33975	30674	10.76	16.50	17.50	CPD
2009-10 Boro	20070	23345	-14.03	68195	86148	-20.84	107101	101174	5.86	43706	38371	13.90	16.00	18.25	EAL / AAS

Annex.VI.3: Yearly national average price of coarse rice during 1998-99 to 2010 (Department of Food).

Period	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	Mean
1998-1999	12.47	12.93	14.29	13.81	14.21	14.46	14.44	14.49	14.43	14.19	12.43	11.97	13.68
1999-2000	12.01	11.77	12.26	11.83	11.44	11.31	11.31	11.79	12.08	12.20	11.87	14.21	12.01
2000-2001	11.48	11.10	11.44	11.44	11.44	11.31	11.47	11.56	11.80	12.14	11.65	12.21	11.59
2001-2002	11.05	10.65	11.14	11.14	11.68	11.68	12.07	12.58	12.58	12.78	12.33	11.90	11.80
2002-2003	12.31	12.52	12.99	12.72	12.96	12.39	13.04	13.69	13.64	13.37	12.36	12.28	12.86
2003-2004	12.56	12.41	12.80	12.81	12.96	12.80	12.83	12.96	13.29	13.31	13.10	12.80	12.89
2004-2005	13.96	13.51	13.97	15.09	15.17	15.89	16.78	17.01	16.55	16.18	16.18	15.22	15.46
2005-2006	15.97	16.27	16.21	15.97	15.59	16.16	16.51	16.51	16.51	16.62	16.36	14.26	16.08
2006-2007	15.23	15.26	15.54	15.35	16.24	17.33	17.96	17.33	19.14	19.55	19.79	19.87	17.38
2007-2008	20.63	23.43	23.89	24.17	27.50	28.11	30.13	24.42	31.09	32.10	29.76	29.90	27.09
2008-2009	32.03	31.95	30.72	30.08	27.82	26.32	24.88	21.64	21.54	19.24	19.22	19.27	25.39
2009-2010	19.19	19.04	19.16	20.59	20.61	22.35	25.06	26.31	26.10	25.89	26.00	26.86	23.10
2010-2011	28.46	29.47	30.15	31.61	32.25	32.50	0.00	0.00	0.00	0.00	0.00	0.00	26.35
Mean	**16.72**	**16.95**	**17.27**	**17.43**	**17.68**	**17.89**	**17.21**	**16.69**	**17.40**	**17.30**	**16.75**	**16.73**	

Source: MISM, Department of Food, Ministry of Food & Bander Thake. Bander, ed. Mohafez Ali

Annex.VIII.1: Seed Quality Standard for Hybrid Rice in China

Line	Grade	Purity >%	Cleanliness >%	Germination >%	Moisture content <%	Weed Seeds <(no./kg)
A-Line (CMS Line)	FS	99.9	99.0	90.0	13.0	0
	1st Class	99.5	99.0	90.0	13.0	0
	2nd Class	99.0	97.0	85.0	13.0	5
B-Line (Maintainer Line)	FS	99.9	99.0	96.0	13.0	0
	1st Class	99.5	99.0	96.0	13.0	0
	2nd Class	99.0	97.0	93.0	13.0	5
R-Line (Restorer Line)	FS	99.8	99.0	96.0	13.0	0
	1st Class	99.5	99.0	96.0	13.0	0
	2nd Class	99.0	97.0	93.0	13.0	5
F_1 Hybrid	1st Class	98.0	98.0	93.0	13.0	0
	2nd Class	96.0	97.0	90.0	13.0	5

Note: *FS: Foundation Seed. Source: Chinese Academy of Agricultural Sciences (CAAS), 1992.*

Annex.VIII.2: The criteria for Breeder Seed (BS) and Foundation Seed (FS) for Three Lines Hybrid Rice in China

Parent	Grade	Purity	Cleanliness	Germination	Moisture	Sterility	Restoring Ability	Weed Seeds
		>%	>5	>%	<%	>%	>%	(no./kg)
A Line	BS	100	99.8	93	13	99.9		0
	FS	99.9	99.0	90	13	99.9		0
B Line	BS	100	99.8	98	13			0
	FS	99.9	99.0	96	13			0
R Line	BS	100	99.8	98	13		85	0
	FS	99.9	99.0	96	13		85	0

Annex.VIII.3: Market share of hybrid rice seed (%) during 2007-8 to 2009-10 in Bangladesh

Company / NGO	Market share (%)			
	2007 - 2008	2008 - 2009	2009 - 2010	Total[1]
Supreme	36.73	28.35	29.69	31.45
BRAC	17.76	18.90	17.29	18.02
ACI	2.67	4.13	3.96	3.61
EAL	2.67	6.38	7.65	5.61
Aftab	5.17	6.80	10.20	7.38
Ispahani	0.00	1.77	6.07	2.59
Mollika	10.02	6.85	3.83	6.88
Lalteer	14.56	15.95	10.29	13.68
Metal	1.34	2.36	2.18	1.98
United	2.40	3.54	2.90	2.97
Others	6.68	4.96	5.94	5.82
Total	**100.00**	**100.00**	**100.00**	**100.00**

[1/] Proportion of total market share is estimated on the basis of total quantity seed for 3 years

Source: A. Mannan, Marketing Manager, Getco (PPP at Business Planning Meeting)

Annex.VIII.4: Acreage category-wise districts and their hybrid rice acreage during 2007-8 Boro and 2008-9 Boro seasons (DAE)

2007-2008 Boro season			2008-2009 Boro season		
Acreage Category (ha)	**Districts**	**Hybrid (ha)**	**Acreage Category (ha)**	**Districts**	**Hybrid (ha)**
50-100	Munsiganj,	51	50-100	Barguna	70
	Barguna	83		Munsiganj	90
101-1000	Patuakhali	164	101-1000	Patuakhali	138
	Bandarban	441		Bandarban	435
	Khagrachari	941		Jhalokathi	478
	Jhalokathi	972		Faridpur	606
1001-5000	Shariatpur	1506		Shariatpur	787
	Narayanganj	1510	1001-5000	Rajbari	1029
	Nowabganj	1889		Nowabganj	1163
	Faridpur	1951		Narayanganj	1319
	Feni	2097		Khagrachari	1321
	Rajbari	2117		Manikganj	1858
	Pirojpur	2259		Rangamati	2514
	Rangamati	2405		Maulavibazar	2930
	Maulavibazar	2856		Feni	2949
	Madaripur	2862		Sylhet	2949
	Sylhet	2968		Kushtia	3107
	Bhola	3069		Dhaka	3108
	Manikganj	3269		Jhenaidah	3468
	Kushtia	3806		Madaripur	3510
	Dhaka	4047		Meherpur	3614
	Lakshmipur	4466		Lakshmipur	4341
	Meherpur	4626		Pirojpur	4469
	Pabna	4836	5001-10000	Bhola	5068
5001-10000	Cox's Bazar	5628		Cox's Bazar	5173
	Chittagong	6091		Pabna	5688
	Barisal	6362		Chandpur	5851
	Chuadanga	6988		Chuadanga	6489
	Chandpur	7312		Narsingdi	6960
	Narsingdi	8514		Barisal	7124
	Brahmanbaria	8534		Chittagong	7551
	Sunamganj	8850		Brahmanbaria	8174
	Sirajganj	9340		Magura	8586

Annex.VIII.4: Contd.

10001-20000	Jhenaidah	10204	10001-20000	Rajshahi	10440
	Thakurgaon	11753		Thakurgaon	11872
	Magura	11814		Gazipur	12720
	Natore	11935		Natore	13037
	Sathkhira	11951		Sathkhira	13234
	Gazipur	12271		Sherpur	13498
	Rajshahi	12573		Khulna	13502
	Khulna	12581		Sunamganj	13720
	Bagerhat	13287		Bagerhat	14468
	Tangail	16510		Tangail	15152
	Narail	17136		Narail	15307
	Sherpur	17332		Habiganj	16948
	Noakhali	18781		Noakhali	19119
	Nilphamari	19209		Naogaon	19270
	Naogaon	19275		Jamalpur	19443
	Habiganj	19492		Sirajganj	19810
	Lalmonirhat	19656	20001-40000	Panchagarh	20457
20001-40000	Panchagarh	22103		Lalmonirhat	21899
	Jamalpur	22632		Gopalganj	22066
	Gopalganj	22704		Nilphamari	22654
	Kurigram	24008		Kurigram	26287
	Netrokona	25992		Joypurhat	27533
	Joypurhat	26194		Comilla	28492
	Kishoreganj	26482		Mymensingh	29117
	Comilla	27816		Jessore	30680
	Jessore	29328		Kishoreganj	31145
	Mymensingh	29381		Netrokona	32096
	Gaibandha	31089		Gaibandha	32599
	Bogra	39271		Dinajpur	39398
	Dinajpur	39314	40001-60000	Rangpur	42615
40001-50000	Rangpur	46824		Bogra	52620

Annex.VIII.5: Number of districts under 7 acreage categories of hybrid rice during 2007-8 and 2008-9 Boro seasons (DAE)

Acreage Category (ha)	**Districts (Nr.)**		**Difference**
	2007-8	**2008-9**	
50-100	2	2	0
101-1000	4	5	1
1001-5000	18	16	-2
5001-10000	9	10	-1
10001-20000	17	16	1
20001-40000	13	13	0
40001-60000	1	2	-1
Total	**64**	**64**	**-**

Annex. IX.1: List of rice hybrids released by NSB with country of origin and year of release (1998-2010) for 44 organizations in Bangladesh

Sl. #	Name of released rice hybrid	Country of origin of rice hybrid	Name of Institute/Organization/ Seed Company/NGO	Year of Release of rice hybrid
1	Aalok-6201	India	ACI Limted	1998
2	Loknath-505	India	McDonald Bangladesh (Private) Limited	1998
3	Amarsree-1	India	Ganges Development Corporation	1998
4	CNSGC-6 (Sonarbangla-1)	China	Mollika Seed Company	1998
5	IAHS-100-001	India	Aftab Bahumukhi Farms Limitedimited	2000
6	IR-69690 (BRRI hybrid dhan-1)	Bangladesh	BRRI, Bangladesh	2001
7	ZF-31	China	Aftab Bahumukhi Farms Limited	2001
8	ZF-37	China	Aftab Bahumukhi Farms Limitedimited	2001
9	Richer-101	China	Chens Crop Science Bangladesh Limited	2002
10	HS-273 (Heera-2)	China	Supreme Seed Company Limited	2003
11	Aalok-93024	India	ACI Limited	2003
12	GB-4 (Jagoron)_	China	BRAC	2003
13	Hybrid rice no. 99-5 (Heera)	China	Supreme Seed Company Limited	2003
14	LP-50	China	Aftab Bahumukhi Farms Limited	2003
15	Taj-1 (GRA-2)	China	National Seed Company Limited	2006
16	Taj-2 (GRA-3)	China	National Seed Company Limited	2006
17	HTM-4 (Sonarbangla-6)	China	Mollika Seed Company	2006
18	HTM-606(Gold)	China	North South Seed Company	2006
19	HTM-707(Tiya)	China	North South Seed Company	2006
20	LP-108	China	Sea Trade Fertilizer Limited	2006
21	LU YOU-3 (Surma-2)	China	Syngenta Bangladesh Limited	2006
22	LU YOU-2 (Surma-1)	China	Syngenta Bangladesh Limited	2006
23	Tinpata-10	China	Tinpata Quality Seed Bangladesh Limited	2006
24	Tinpata-40	China	Tinpata Quality Seed Bangladesh Limited	2006
25	Tinpata Super	China	Tinpata Quality Seed Bangladesh Limited	2006
26	HTM-202 (Doyel)	China	East West Seed (Bangladesh) Limited	2006
27	HTM-303 (Moyna)	China	East West Seed (Bangladesh) Limited	2006

Annex. IX.1: Contd.

Sl. #	Name of released rice hybrid	Country of origin of rice hybrid	Name of Institute/Organization/ Seed Company/NGO	Year of Release of rice hybrid
28	LP 70	China	Aftab Bahumukhi Farms Limited	2006
29	ACI-1	China	ACI Limited	2006
30	ACI-2	China	ACI Limited	2006
31	BW 001 (Shakti)	China	BRAC	2006
32	HB-08 (Aloron)	China	BRAC	2006
33	LP 106	China	Aftab Bahumukhi Farms Limited	2007
34	HR 422 (Surma 4)	China	Syngenta Bangladesh Limited	2007
35	S- 2B (Krishan 2)	China	Mukterpur Bhander	2007
36	HRM 01 (Agrani 7)	China	Metal Seed Company Limited.	2007
37	HRM 2 (Sharathi 14)	China	Metal Seed Company Limited.	2007
38	Ropushe Bangla 1	China	Kamal Seed Company Limited.	2007
39	HB 09 (Aloran 2)	China	Ayesha Abed Foundation	2007
40	Supreme hybrid 5 (Heera 5)	China/Bangladesh	Supreme Seed Company Limited	2007
41	WBR- 2 (Modhumoti 2)	China	United Seed Store	2007
42	HG- 202 (Manik 2)	China	Siddiquis Seed	2007
43	WBR -5 (Modhumoti 5)	China	United Seed Store	2007
44	LP 05	China	Aftab Bahumukhi Farms Limited	2007
45	Arise (Tej 96110)	India	Bayer Crop Science	2008
46	Jamuna (QDR 3)	China	Auto Crop Care Limited	2008
47	Heera 6 (HS 48)	China	Mitali Agro Seed Industries	2008
48	Heera 4 (HSQ 1)	China	Sepreme Seed Company Limited	2008
49	Lily 1 (CNR 5104)	China	Lily And Company	2008
50	Rajkumar (GH 14)	China	ACI Formulation Limited	2008
51	Sampod (93024)	China	ACI Formulation Limited	2008
52	Falon (GH 12)	China	ACI Agro Chemicals Limited	2008
53	TK-6(Bumper-3)	China	Nipa Trading International Limited	2008
54	Sera (BRS 696)	China	Apex Craft Limited	2008
55	AgroG-1 (EAL 9201)	China	Energypack Agro Limited	2008
56	AgroG-2 (EAL 9202)	China	Energypack Agro Limited	2008
57	Panna 1 (CGSC 1)	China	Quality Seed Company	2008
58	TY-102 (Chamak-1)	China	Alamgir Seed Company Limited	2008
59	BRRI hybrid dhan-2	Bangladesh	BRRI	2008
60	SL-8H	Philippines	BADC	2008
61	Rupa (Folon-2 BRS 694)	China	ACI Limited	2009
62	Arize dhanny (H-07002)	India	Bayer Crop Science	2009

Annex. IX.1: Contd.

Sl. #	Name of released rice hybrid	Country of origin of rice hybrid	Name of Institute/Organization/ Seed Company/NGO	Year of Release of rice hybrid
63	BRRI hybrid dhan 3	Bangladesh	BRRI	2009
64	WBR-8 (Maloti-8)	China	United Seed Store Limited	2009
65	China King-2(LE YOU 5178)	China	Corbel International Limited	2009
66	BRAC-5(Shakti-2)	China/Bangladesh	BRAC	2009
67	Metal seed-1(HRM-604)	China	Metal Seed Company Limited	2009
68	Golden-1	India	Alfa Seed International	2009
69	BRAC-6 (Shakti-3)	China/Bangladesh	BRAC	2009
70	Sachal (RN-001)	China	Northern Seed Limited	2009
71	Shankor-3(Heijia-101)	China	Aci Formulation Limited	2009
72	Mongol (Heijia-909)	China	Northerm Seed Limited	2009
73	Lili-10(CN-81010	China	Tropical Agro Tech	2009
74	BRRI hybrid dhan 4	Bangladesh	BRRI	2010
75	Heera 10	China/Bangladesh	Supreme Seed Company Limited	2010
76	Agomoni (JBS-17-4)	China	Ispahani Mercel Limited	2010
77	Radder (NK 5017)	India	Syngenta Bangladesh Limited	2010
78	Monihar-5 (LE-008)	China	Himadri Limited	2010
79	Monihar-6 (LE-021)	China	Himadri Limited	2010
80	Balia-1 (JBS-17-3)	China	Northern Agricultural and Industrial Company Limited	2010
81	Balia-2 (JBS-17-1)	China	Northern Agricultural and Industrial Company Limited	2010
82	NAFCO-108 (Q 108)	China	NAFCO Private Limited	2010
83	Safollya -1 (JKRH-401)	India	Metal Seed Company Limited	2010
84	Mitaly 12 (HSN-2)	China	Mitali Agro Seed Industries	2010
85	Rupali (HE-88)	China	Ayesha Abed Foundation	2010

Annex.IX.2: List of 44 agencies and their number of rice hybrid(s) registered with NSB from 1998 to 2010 and status of the released rice hybrids

Sl. No.	Name of Agency	Status of the agency	Number of hybrid rice registered	Status of released rice hybrid
1.	BRRI	Public (Research Institute)	4	Local production and distribution to different agencies
2.	BADC	Public (Seed Organization)	1	Local production and marketing
3.	ACI Limited	Private	5	Import, production and marketing
4.	ACI Formulation Limited	Private	3	Import and production
5.	ACI Agro Chemicals Limited	Private	1	Import
6.	Supreme Seed Company Limited	Private	5	Import, production and marketing
7.	Mollika Seed Company	Private	2	Import, production and marketing
8.	East West Seed (Bangladesh) Limited	Private	2	Import, production and marketing
9.	Aftab Bahumukhi Farms Limited	Private	7	Import, production and marketing
10.	Energypack Agro Limited	Private	2	Import, production and marketing
11.	Metal Seed Company Limited	Private	4	Import, production and marketing
12.	Auto Crop Care Limited	Private	1	Import, production and marketing
13.	United Seed Store	Private	3	Import, production and marketing
14.	McDonald Bangladesh (Private) Limited	Private	1	Import
15.	Ganges Development Corporation	Private	1	Import, production and marketing
16.	Sea Trade Fertilizer Limited	Private	1	Import
17.	Chens Crop Science Bangladesh Limited	Private	1	Import, production and marketing
18.	Tinpata Quality Seed Bangladesh Limited	Private	3	Import, production and marketing
19.	North South Seed Company Limited	Private	2	Import and production
20.	National Seed Company Limited	Private	2	Import and production
21.	Siddiquis Seed	Private	1	Import and production
22.	Mukterpur Bhander	Private	1	Import and production

Annex.IX.2: contd.

Sl. No.	Name of Agency	Status of the agency	Number of hybrid rice registered	Status of released rice hybrid
23.	Mitali Agro Seed Industries	Private	1	Import and production
24.	Lily and Company	Private	1	Import, production and marketing
25.	Nipa Trading International Limited	Private	1	Import, production and marketing
26.	Apex Craft Limited	Private	1	Import
27.	Quality Seed Company	Private	1	Import, production and marketing
28.	Alamgir Seed Company	Private	1	Import and Local production
29.	Corbel International Limited	Private	1	Import
30.	Alfa Seed International	Private	1	Import and marketing
31.	Northern Seed Limited	Private	2	Import and marketing
32.	Tropical Agrotech	Private	1	Import, production and marketing
33.	Bayer Crop Science	Private	2	Import, production and marketing
34.	Syngenta Bangladesh Limited	Private	4	Import, production and marketing
35.	Kamal Seed Company Limited	Private	1	Import, production and marketing
36.	BRAC	NGO	5	Import, production and marketing
37.	Ayesha Abed Foundation	NGO	2	Import and production
38	Northern Agricultural and Industrial Company Limited	Private	2	Varieties recommended in the TC meeting on 3/8/2010
39	Ispahani Mercel Limited	Private	1	Variety recommended in the TC meeting on 3/8/2010
40	NAFCO	Private	1	Variety recommended in the TC meeting on 3/8/2010
41	Himadri Limited	Private	2	Variety recommended in the TC meeting on 3/8/2010
44	Mitali Agro Seed Industries	Private	1	Variety recommended in the TC meeting on 3/8/2010
Total			**85**	

Annex.IX.3: Rice hybrids seed availability (import and local production) and seed used during 1998-99 to 2009-2010

Year	Seed import (MT)	Growth rate (%)	Seed production (MT)	Growth rate (%)	Total seed available (MT)	Growth rate (%)	Total seed used (MT)	Growth rate (%)
1998-1999	590	-	0	-	590	-	350	-
1999-2000	710	20.34	47.56	-	760.52	28.90	400	14.29
2000-2001	406.25	-42.78	26.80	-43.65	406.25	-46.58	200	-50.00
2001-2002	244.33	-39.86	150.83	462.80	271.50	33.17	150	-25.00
2002-2003	458.42	87.62	262.89	74.30	721.31	165.68	337	124.67
2003-2004	674.42	47.12	212.40	19.21	886.82	22.95	614	82.20
2004-2005	797.83	18.30	490.80	131.07	1288.63	45.31	1920	212.70
2005-2006	1489.09	86.64	681.14	38.78	2170.23	68.40	3660	90.63
2006-2007	5336.19	258.35	2171.29	218.77	7507.48	245.93	5950	62.57
2007-2008	5600.96	4.96	2730.00	25.73	7871.96	4.86	12132	103.90
2008-2009	8150.63	45.53	3129.00	14.62	12934.63[1]	64.31	11738	-3.25
2009-2010	3968.00	51.32	3600.00	15.05	8752.00	32.34	8000	-31.85
Growth Rate:								
I. 1998-99 to 2009-10	18.92	-	7.47	-	24.87	-	32.91	-
II. 1998-99 to 2007-8	28.40	-	65.91	-	33.36	-	48.29	-
III. 2007-8 to 2009-10	15.83	-	14.83	-	5.45	-	-18.80	-

[1] *Including 1655 MT carryover seed*

Annex.IX.4: Inbred and hybrid rice seed supply from formal seed system (Public and Private Sectors) during 2001-2 to 2009-10 (Seed wing, MOA)

Year	Inbred rice seed (MT & %)					Hybrid rice seed (MT & %)		
	Public (MT)[1]	%	Private [2] (MT)	%	Total (MT)	Total (MT)	Public (%) (BADC)	Private (%)
2001-2	15714	97.09	471	2.91	16185	151	3.97	96.03
2002-3	14717	97.08	442	2.92	15159	263	4.94	95.06
2003-4	18121	97.03	554	2.97	18675	212	9.40	90.60
2004-5	25156	96.16	1006	3.84	26162	491	6.72	93.28
2005-6	30026	89.96	3350	10.04	33376	681	0	100.00
2006-7	40133	86.86	6070	13.14	46203	2171	2.26	97.74
2007-8	47200	71.52	18800	28.48	66000	2730	0	100.00
2008-9	56175	81.99	12338	18.01	68513	3129	7.89	92.11
2009-10	84348	85.47	14338	14.53	98686	3600	11.39	88.61
Growth rate (%)	23.37		53.26		25.36	48.65	-	-

Annex.IX.5: Inbred and hybrid rice seed supply from formal seed system (Public and private sectors) during 2001-2 to 2009-10 (Estimated inbred seed quantity for private sector)

Year	Inbred rice seed (MT)					hybrid rice seed (MT)		
	Public (BADC)	%	Private[1]	%	Total	Total	Public (BADC)	Private (%)
2001-2	15714	97.10	471	2.90	16212	151	3.97	96.03
2002-3	14717	97.08	442	2.92	15159	263	4.94	95.06
2003-4	18121	97.08	544	2.92	18665	212	9.40	90.60
2004-5	25156	96.15	1006	3.85	26162	491	6.72	93.28
2005-6	33486	95.24	1674	4.76	35160	681	0	100.00
2006-7	38823	95.24	1941	4.76	40764	2171	2.26	97.74
2007-8	47163	92.60	3770	7.40	50933	2730	0	100.00
2008-9	51191	91.76	4600	8.24	55791	3129	7.89	92.11
2009-10	56253	90.91	5625	9.09	61878	3600	11.39	88.61
Growth rate (%)	17.28	-	36.34	-	18.23	48.65	-	-

[1] *Estimated seed quantity*

Annex. IX.6: Seed supply organization-wise price of rice hybrids seed (F_1) during 2010-11 cropping seasons.

Organization	Variety name	MRP (Tk/Kg)
BADC	SL-8H, BRRI hybrid dhan 2	175[1/]
GETCO	Ruposhi, Rupali, Shahjalal	230
NICOL	BRRI hybrid dhan 2, Balia 2	140[2/]
Mollika Seed Co.	Sonarbangla 6	250
Ispahani	Rajkumar, Agomoni, ACI-2	235
Aftab	LP 70, LP 106,	260
	LP 108	275
Supreme	Heera 1,2,3 & 5	235
	Heera 4	250
ACI	ACI 1, Shera	235
	Shankar, 93024 (Aalok)	250
EAL	AgroG1	240
	AgroG2	235
	AgroG3 (Mongal)	250
Lal Teer	Moyna, Tia, Gold, Richer	245
Metali	Agrani 7	235
Bayer	Jej 96110	270

[1] Public sector rice hybrid, [2] In country produced seed under test marketing

Annex.IX.7: Import price (US$/Kg) of Sonarbangla hybrid rice seed of MSC during 1998-2010

Year	Import Price Seed [(C & F) (US$/Kg)]
1998-1999	2.60
1999-2000	2.60
1999-2001	2.10
2001-2002	1.60
2002-2003	1.60
2003-2004	1.60
2004-2005	1.70
2005-2006	1.80
2006-2007	1.80
2007-2008	1.80
2008-2009	1.80
2009-2010	2.00
2010-2011	2.30

MSC= Mollika Seed Company

Annex.IX.8: Seed supply organization-wise price of inbred rice seed during 2010-11 cropping seasons

Season	Variety	Seed class	Seed price (Tk/Kg)	
			2 Kg Packet	10/12 Kg Packet
A. Organization: NICOL				
2010-11 Boro	BR 14, BR 16, BRRI dhan 28, 29, 45, 47 & 50	FS	60	50
	Do	CS	-	45
B. Organization: GETCO				
2010-11 Boro	BRRI dhan 28 & 29	FS	55	50
-T.Aman	BR 11	FS		40
C. Organization: Ispahani				
2010-11 Boro	BRRI dhan 28	FS	52.50	48
	BRRI dhan 29	FS	52.50	45
	BR 14	FS	-	48
	BR 16	FS	-	50
2010 T.Aman	BR 10, BR 11, BR 23, BRRI dhan 30,33,34,41, 49 & 32	TLS	-	40
D. Organization: Aftab				
2010-11 Boro	BRRI dhan 28 & 29	CS		55
	BRRI dhan 28 & 29	TLS		50
2010 T.Aman	BR 11	CS		40
E. Organization: BRAC				
2010-11 Boro	BRRI dhan 28 & 29	FS	50	-
Boro	BRRI dhan 28 & 29	TLS	-	45
F. Organization: ACI				
2010-11 Boro	BRRI dhan 28 & 29	FS	52.5	45
2010 T.Aman	BR 11	FS	50	45
G. Organization: BADC				
2010-11 Boro	BR 16, BRRI dhan 28 & 29 etc	FS	-	35
	BR 16, BRRI dhan 28 & 29 etc	CS/TLS	-	35
2010 T.Aman	BR 10, 11, BRRI dhan 30, 33 etc	FS	-	24
	BR 10, 11, BRRI dhan 30, 33 etc	CS/TLS	-	23
H. Organization: EAL				
2010-11 Boro	BRRI dhan 28 & 29, BR 16	FS/CS	52.5	45
2010 T.Aman	BR 11, Bina 7, BRRI dhan 33, 41, BR 23	FS/CS	50	45
I. Organization: MetalL				
2010-11 Boro	BRRI dhan 28	FS	60	-
	BRRI dhan 29	FS	58	-
J. Organization: Auto				
2010-11 Boro	BRRI dhan 28 & 29	TLS	-	52
K. Organization: Syngenta				
2010-11 Boro	BRRI dhan 28 & 29	TLS	-	60
2010 T.Aman	BR 11	TLS	-	50

Annex.IX.9: Proportion of annual rice seed replacement (Total, Inbred &Hybrid) of the total national rice seed requirement during 2001-2 to 2009-10

Year	Seed wing, MOA						Estimated					
	Inbred Seed (MT)	Hybrid Seed (MT)	Total Seed (MT)	% Replacement			Inbred Seed (MT)	Hybrid Seed (MT)	Total Seed (MT)	% Replacement		
				Total	Inbred	Hybrid				Total	Inbred	Hybrid
2001-2	16185	151	16336	5.27	5.22	0.05	16212	151	16363	5.28	5.23	0.05
2002-3	15159	263	15422	4.97	4.89	0.08	15159	263	15422	4.97	4.89	0.08
2003-4	18675	212	18887	6.09	6.02	0.07	18665	212	18877	6.09	6.02	0.07
2004-5	26162	491	26653	8.60	8.44	0.16	26162	491	26653	8.60	8.44	0.16
2005-6	33376	681	34057	10.99	10.77	0.22	35160	681	35841	11.56	11.34	0.22
2006-7	46203	2171	48374	15.60	14.90	0.70	40764	2171	42935	13.85	13.15	0.70
2007-8	66000	2730	68730	22.17	21.29	0.88	50933	2730	53663	17.31	16.43	0.88
2008-9	68513	3129	71642	23.11	22.10	1.01	55791	3129	58920	19.01	18.00	1.01
2009-10	98686	3600	102286	33.00	31.83	1.16	61878	3600	65478	21.12	19.96	1.16

Note: Total estimated rice seed requirement is 310000 MT per year from 2001-2.

Annex.X.1: Hybrid rice seed production cost during 2009-10 Boro season for 7 seed production organizations

Item	Cost (Tk./ha)							
	NICOL	**EAL**	**SSCL**	**Aftab**	**ACI**	**BRAC**	**MSC**	**Average**
Land rent in	29640	37050	37544	34580	37050	37050	29640	34651
Land preparation	11856	5187	5558	6175	6422	5360	5187	6535
Seed (parent lines)	32110	40138	8892	54958	40138	40755	40138	36733
Labor	50265	67308	61874	66690	73112	62244	62985	63497
Fertilizers	43460	23502	27713	23391	26059	21652	22131	26844
Pesticides	12622	9880	5483	6669	13585	11239	8645	9732
Irrigation	16055	11856	11856	8892	3458	11115	11115	10621
Exotic Chemicals	26676	15191	13205	16240	7287	15388	13091	15297
Field isolation	9880	1235	0	0	2964	2470	4446	2999
Agri-equipments	7410	4940	3705	3705	3705	3705	4940	4587
Post harvest operations	14573	7904	9534	10423	9633	7311	10720	10014
Cost (Full cost basis)	**254547**	**224191**	**185364**	**231723**	**223413**	**218289**	**213038**	221509
Cost (Cash cost basis)	**199774.5**	**153487**	**116883**	**163798**	**149807**	**150117**	**151905.5**	155110
Interest on working capital								
(a) Full cost basis	**19091**	**16814**	**13902**	**17379**	**16756**	**16372**	**15978**	16613
(b) Cash cost basis	**14983**	**11512**	**8766**	**12285**	**11236**	**11259**	**11393**	11633
Total cost								
(a) Full cost basis	**273638**	**241005**	**199266**	**249102**	**240169**	**234661**	**229016**	238122
(b) Cash cost basis	**214758**	**164999**	**125649**	**176083**	**161043**	**161376**	**163298**	166744
F_1 seed cost (Tk./Kg)								
(a) Full cost basis	70.29	69.70	74.41	103.79	72.01	65.97	92.72	78
(b) Cash cost basis	55.17	47.72	46.92	73.37	48.29	45.37	66.11	55
F1 Seed production (Kg/ha)	3893	3458	2678	2400	3335	3557	2470	3113

NICOL = Northern Agricultural and Industrial Ltd.
EAL = Energypac Agro Ltd
SSCL = Supreme Seed Co. Ltd
ACI = Advanced Chemical Industries
BRAC = Bangladesh Rural Advancement Committee
MSC = Mollika Seed Co.
Aftab = Aftab Bahumukhi Farm Ltd.

Annex.X.2: Item-wise comparative cost and return of hybrid and inbred rice seed production during 2009-10 Boro season

Item	Cost/Return (Tk/ha)			
	Hybrid	**Inbred**	**Difference**	**% Diff**
Land rent in	34651	22500	12151	54
Land preparation	6535	4500	2035	45
Seed	36733	2700	34033	1260
Labor	63497	34313	29184	85
Fertilizers	26844	15825	11019	70
Pesticides	9732	2250	7482	333
Irrigation	10621	13125	-2504	-19
Exotic Chemicals	15297	0	15297	0
Field isolation	2999	0	2999	0
Agri-equipments	4587	0	4587	0
Post harvest operations	10014	0	10014	0
Total cost[1/]				
(a) Full cost basis	238122	99973	138149	138
(b) Cash cost basis	166744	40320	126424	314
Gross return	**262025**	**139725**	122300	88
Net return			0	0
(a) Full cost basis	23903	39752	-15849	-40
(b) Cash cost basis	95282	99405	-4123	-4
Seed cost (Tk./Kg)			0	0
(a) Full cost basis	76	16	60	376
(b) Cash cost basis	54	6	47	783
Seed yield (Kg/ha)	3113	6225	-3112	-50
Seed Price (Tk./Kg)	84.17[2/]	22.45[2/]	61.72	275

[1/] Total cost is estimated from several agencies with different varieties of hybrid and inbred rice including interest of working capital during 2009-10 Boro

[2/] Seed procurement price (Tk.Kg) is estimated from several agencies with different varieties of hybrid and inbred rice during 2009-10 Boro season

Annex.X.3: Hybrid rice seed production area and seed production by organization and rice hybrid variety during 1999-2000 to 2007-8

Year		Company	Hybrid Variety	Parent line Area (Ha)	Seed production (MT)	Yield (t/ha)
1999-2000	1	ACI	Aalok	40	40	1.00
	2	Ganges Development Corporation	Amarsree	10.93	6.83	0.62
	3	MacDonald	LP50	0.85	0.53	0.62
	4	Mollika Seed Co.	Sonarbangla 1	0	0.2	
	Total			**51.78**	**47.56**	**0.92**
2000-2001	1	BRAC	GB-4	18.9	26	1.38
	2	Mallika Seed Co.	Sonarbangla 1	0.81	0.8	0.99
	Total			**19.71**	**26.8**	**1.36**
2001-2002	1	BADC	BHD 1	14.23	7.87	0.55
	2	BRAC	BHD 1	7.49	11.5	1.54
	3	BRAC	GB-4	114.57	129.1	1.13
	4	Mollika Seed Co.	Sonarbangla 1	1.21	1.5	1.24
	5	ACI	Aalok	0.4	0.6	1.50
	6	Supreme Seed	Hira	0.1	0.26	2.60
	Total			**138**	**150.83**	**1.09**
2002-2003	1	BRAC	GB-4	159.29	251.50	1.58
	2	Aftab	LP-50	0.13	0.20	1.54
	3	Supreme Seed	No. 99-5 (Heera)	4.98	9.89	1.99
	4	Mollika Seed	CNSGC-6 (Sonarbangla-1)	2.43	1.30	0.53
	Total			**166.83**	**262.89**	**1.58**
2003-2004	1	BRAC	GB-4	101.61	138.30	1.36
	2	Aftab	LP-50	9.53	13.00	1.36
	3	Supreme Seed	No. 99-5 (Heera)	21.47	49.00	2.28
	4	Mollika Seed	CNSGC-6 (Sonarbangla-1)	9.50	10.20	1.07
	5	Chens Crop Science	Richer -101	1.50	1.90	1.27
	Total			**143.61**	**212.40**	**1.48**
2004-2005	1	BRAC	GB-4	155.07	192.51	1.24
	2	Aftab	LP-50	11.50	17.87	1.55
	3	Supreme Seed	No. 99-5 (Heera)	60.61	172.00	2.84
	4	Mollika Seed	CNSGC-6 (Sonarbangla-1)	40.49	100.4	2.48
	5	Chens Crop Science	Richer -101	4.86	8.02	1.65
	Total			**272.53**	**490.80**	**1.80**

Annex.X.3: Contd.

Year		Company	Hybrid Variety	Parent line Area (Ha)	Seed production (MT)	Yield (t/ha)
2005-2006	1	BRAC	GB-4	192.80	247.12	1.28
	2	BRAC	HB-8	73.98	129.29	1.75
	3	Aftab	LP-50	20.00	30.14	1.51
	4	Supreme Seed	No. 99-5 (Heera)	80.36	160.28	1.99
	5	Supreme Seed	HS -273	30.40	60.52	1.99
	6	Mollika Seed	CNSGC-6 (Sonarbangla-1)	30.36	31.87	1.05
	7	Chens Crop Science	Richer -101	18.00	20.00	1.11
	8	Tinpata Quality Seeds	Tinpata-40	2.02	1.80	0.89
	9	Ganges Development Corporation	Manik-1 (Amrshree-1)	0.13	0.12	0.92
	Total			**448.05**	**681.14**	**1.52**
2006-2007	1	BRAC	GB-4	53.44	78.40	1.47
	2	BRAC	HB-8	442.80	1,312.08	2.96
	3	BRAC	BW 001	8.10	7.00	0.86
	4	Aftab	LP-50	30.00	45.00	1.50
	5	Aftab	LP-108	0.29	0.44	1.52
	6	Aftab	LP-106	0.40	0.60	1.50
	7	Aftab	LP-70	0.63	0.95	1.51
	8	Aftab	LP-05	0.18	0.27	1.50
	9	Supreme Seed	No. 99-5 (Heera)	122.77	363.90	2.96
	10	Supreme Seed	HS -273	90.48	266.86	2.95
	11	Mollika Seed	CNSGC-6 (Sonarbangla-1)	29.72	57.95	1.95
	12	Mollika Seed	HTM-4 (Sonarbangla-6)	14.64	29.87	2.04
	13	Chens Crop Science	Richer -101	1.05	0.77	0.73
	14	Tinpata Quality Seeds	Tinpata-40	0.28	0.23	0.82
	15	Tinpata Quality Seeds	Tinpata-10	0.28	0.23	0.82
	16	Tinpata Quality Seeds	Tinpata-Super	0.28	0.23	0.82
	17	ACI Ltd	ACI-1	0.95	2.94	3.09
	18	ACI Ltd	ACI-2	0.67	1.98	2.96
	19	Syngenta	Surma-2	0.80	1.00	1.25
	20	East-West Seed	Douel	0.21	0.12	0.57
	21	East-West Seed	Moyna	0.28	0.18	0.64
	22	North-Sout Seed	Gold	0.28	0.20	0.71
	23	North-Sout Seed	Teeya	0.28	0.09	0.32
	Total			**798.81**	**2,171.29**	**2.72**

Annex.X.3: Contd.

Year		Company	Hybrid Variety	Parent line Area (Ha)	Seed production (MT)	Yield (t/ha)
2007-2008	1	BRAC	GB-4	2.04	-	0.00
	2	BRAC	HB-8	355.07	-	0.00
	3	BRAC	BW 001	24.09	-	0.00
	4	BRAC	HB-9	2.15	-	0.00
	5	Aftab Bahumukhi Farms Ltd	LP-50	7.00	-	0.00
	6	Aftab Bahumukhi Farms Ltd	LP-108	-	-	
	7	Aftab Bahumukhi Farms Ltd	LP-106	-	-	
	8	Aftab Bahumukhi Farms Ltd	LP-70	48.00	-	
	9	Aftab Bahumukhi Farms Ltd	LP-05	-	-	
	10	Supreme Seed	No. 99-5 (Heera)	121.81	-	
	11	Supreme Seed	HS -273	107.07	-	
	12	Mollika Seed Co.	CNSGC-6 (Sonarbangla-1)	-		
	13	Mollika Seed Co.	HTM-4 (Sonarbangla-6)	101.21	-	
	14	Chens Crop Science	Richer -101	234.82	-	
	15	Tinpata Quality Seeds	Tinpata-40	-	-	
	16	Tinpata Quality Seeds	Tinpata-10	-	-	
	17	Tinpata Quality Seeds	Tinpata-Super	-	-	
	18	ACI Ltd	ACI-1	50.61	-	
	19	ACI Ltd	ACI-2	48.58	-	
	20	ACI Ltd	93024	2.02	-	
	21	Syngenta Bangladesh Ltd	SURMA-2 (LIU-3)	3.24	-	
	22	East-West Seed	DOYEL	3.24	-	
	23	East-West Seed	MOYNA	3.24	-	
	24	North-Sout Seed	GOLD	3.24	-	
	25	North-Sout Seed	TIYA	3.24	-	
	26	Siddiquis Seeds Ltd	HG-2 (MANIK-2)	1.01	-	
	27	National Seed Co.	TAJ (GRA-2)	4.05	-	
	28	United Seed Store	MADHUMOTI-2	0.50	-	
	29	United Seed Store	MADHUMOTI-3	0.50	-	
	30	Kamal Seed Co.	RUPOSHI BANGLA-1	2.02	-	
	31	Metal Seed Co. Ltd	AGRANI-7	0.81	-	
	Total			**1,129.56**		

Annex.XI.1: Status of investment in hybrid rice R&D (as of 2010)

Sl. No.	Name of Agency	Status of Agency	Source of investment	Type of investment
1	Bangladesh Rice Research Institute (BRRI)	Public research institute	Hybrid Rice Project funded through Annual Development Program (ADP) of the Ministry of Agriculture	R&D on hybrid rice variety improvement and parent lines development and F_1 seed production
2	Bangladesh Agricultural Development Corporation (BADC)	Public sector corporation	Hybrid Rice Seed Production, Processing & Preservation Program funded through Annual Development Program (ADP) of the Ministry of Agriculture	Hybrid rice seed production, processing & preservation, variety testing/trial and development
3	Supreme Seed Company Limited	Private sector seed company	Own source	Hybrid rice variety improvement and parent lines development and F_1 seed production
4	ACI Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
5	Mollika Seed Company	Private sector seed company	Own source	Hybrid rice variety improvement through trial
6	East West Seed (Bangladesh) Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
7	Aftab Bahumukhi Farms Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
8	Metal Seed Company Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
9	Energypack Agro Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
10	Auto Crop Care Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
11	United Seed Store	Private sector seed company	Own source	Hybrid rice variety improvement through trial
12	Chens Crop Science Bangladesh Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
13	Tinpata Quality Seed Bangladesh Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial

Annex. XI.1: Contd

Sl. No.	Name of Agency	Status of Agency	Source of investment	Type of investment
14	Bayer Crop Science	Private sector seed company	Own source	Hybrid rice variety improvement through trial and F_1 seed production
15	Syngenta Bangladesh Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial and F_1 seed production
16	Ganges Development Corporation	Private sector seed company	Own source	Hybrid rice variety improvement through trial
17	North South Seed Company Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
18	National Seed Company Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
19	Siddiquis Seed	Private sector seed company	Own source	Hybrid rice variety improvement through trial
20	Mukterpur Bhander	Private sector seed company	Own source	Hybrid rice variety improvement through trial
21	Mitali Agro Seed Industries	Private sector seed company	Own source	Hybrid rice variety improvement through trial
22	Lily and Company	Private sector seed company	Own source	Hybrid rice variety improvement through trial
23	Nipa Trading International Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
24	Quality Seed Company	Private sector seed company	Own source	Hybrid rice variety improvement through trial
25	Alamgir Seed Company	Private sector seed company	Own source	Hybrid rice variety improvement through trial
26	Tropical Agrotech	Private sector seed company	Own source	Hybrid rice variety improvement through trial
27	Kamal Seed Company Limited	Private sector seed company	Own source	Hybrid rice variety improvement through trial
28	BRAC	NGO	Own source	R&D Hybrid rice variety improvement and F_1 seed production
29	Ayesha Abed Foundation	NGO	Own source	Hybrid rice variety improvement through trial

Annex.XI.2:

The National Seed Board

As per The Seeds (Amendment) Act, 2005 the NSB is constituted as follows:

Sl. No.	Name	Organization	Portfolio	Remarks
1	Secretary	Ministry of Agriculture (MOA)	Chairman	
2	Vice Chancellor	Bangladesh Agricultural University (BAU)	Member	
3	Executive Chairman	Bangladesh Agricultural Research Council (BARC)	Member	
4	Chairman	Bangladesh Agricultural Development Corporation (BADC)	Member	
5	Director General	Department of Agricultural Extension (DAE)	Member	
6	Director General	Bangladesh Rice Research Institute (BRRI)	Member	
7	Director General	Bangladesh Agricultural Research Institute (BARI)	Member	
8	Director General	Bangladesh Jute Research Institute (BJRI)	Member	
9	Director General	Bangladesh Institute of Nuclear Agriculture (BINA)	Member	
10	Director General	Bangladesh Sugarcane Research Institute (BSRI)	Member	
11	Executive Director	Cotton Development Board (CDB)	Member	
12	Member-Director (Seed and Horticulture)	Bangladesh Agricultural Development Corporation (BADC)	Member	
13	Director	Seed Certification Agency (SCA)	Member	
14	Director	Soil Resources Development Institute (SRDI)	Member	
15	Director	Plant Protection Wing, DAE	Member	
16	A representative from	Finance Division, Ministry of Finance	Member	Not below the rank of Joint Secretary
17	A representative from	Private Seed Dealers and Merchant Association	Member	
18	A representative from	Private Seed Growers	Member	
19	A representative from	Farmer's Community	Member	
20	Director General (Seed)	Seed Wing, MOA	Member Secretary	

Note*: Government may, at any time, terminate the appointment of a member of the Board without assigning any reason. The tenure of the members of the Board representing Private Seed Dealers and Merchants, Private Seed Growers, and Farmer's Community shall be for a period of three years*

Annex.XI.3:
The Technical Committee

In the 50th meeting of National Seed Board held on April 10, 2002 the Technical Committee of the NSB is constituted as follows:

Sl. No.	Name	Organization	Portfolio
1.	Executive Chairman	Bangladesh Agricultural Research Council (BARC)	Chairman
2.	Head, Department of Genetics and Plant Breeding	Bangladesh Agricultural University (BAU)	Member
3.	Head, Department of Genetics and Plant Breeding	Bangabandhu Sheikh Mujibor Rahman Agricultural University (BSMRAU)	Member
4.	Director General	Bangladesh Sugarcane Research Institute (BSRI)	Member
5.	Director (Field Services Wing)	Department of Agricultural Extension (DAE)	Member
6.	Director (Agriculture)	Bangladesh Jute Research Institute (BJRI)	Member
7.	Director (Research)	Bangladesh Agricultural Research Institute (BARI)	Member
8.	Director (Research)	Bangladesh Rice Research Institute (BRRI)	Member
9.	Member-Director (Crops)	Bangladesh Agricultural Research Council (BARC)	Member
10.	General Manager (Seed)	Bangladesh Agricultural Development Corporation (BADC)	Member
11.	Director (Research)	Bangladesh Institute of Nuclear Agriculture (BINA)	Member
12.	Chief Seed Technologist	Seed Wing, MOA	Member
13.	Cotton Agronomist	Cotton Research & Training and Cotton Seed Multiplication Farm (CRTSMF)	Member
14.	Representative from	Seedmen's Society of Bangladesh	Member
15.	Representative from	Farmers Association	Member
16.	Director	Seed Certification Agency (SCA)	Member-Secretary

Annex. XI.4: Plant Variety and Farmers' Rights Protection Act, 2009

- plant breeding has made an impressive contribution to agricultural development and national food security and has the potential to continue to do so in the future when effectively encouraged;

- the commercialisation of seed production and trade, as outlined in the National Seed Policy, 1993 that is to effectively carry the results of breeding and selection to farmers, requires some further guidance and support;

- farmers and communities have to be protected from the misuse of their knowledge and plant genetic resources with regard to formal sector variety development;

- Bangladesh, having ratified the Act that establishes the World Trade Organisation, wants to comply with the Agreement on Trade Related Aspects of Intellectual Property Rights;

- Bangladesh, having ratified the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture, wishes to protect Farmers' Rights with regard to plant varieties and associated local knowledge; and

- to effectively implement this Act there is a necessity for establishing the Plant Variety and Farmers' Rights Protection Authority.

Now therefore, it is expedient to provide protection of the rights of farmers and breeders with respect to plant varieties in order to promote the sustainable use of plant genetic resources in the public and private domains, to comply with international development.

No separate Plant Variety and Farmers' Rights Protection Act has been formulated and approved separately for hybrid rice in Bangladresh.

Annex.XI.5: Plant Quarantine Act, 2009

In Bangladesh there is Plant Qurantine Act applicable for all agricultural crops for importing and exporting agricultural crops seed and planting materials.

As per the Plant Quarantine Act, 2009, it is expedient and necessary to prevent, in the context of international traffic in plant materials, the introduction into Bangladesh of pests, to prevent the spread thereof and to provide for other matters incidental and ancillary thereto. The same regulations are applicable for hybrid rice. No separate plant quarantine regulations have yet been formulated for hybrid rice. The Plant Protection Wing, Department of Agricultural Extension, as the National Plant Quarantine Authority, shall administer and enforce the provisions of this Act.

Whereas It is expedient and necessary to prevent, in the context of international traffic in plant materials, the introduction into Bangladesh of pests, to prevent the spread thereof and to provide for other matters incidental and ancillary thereto;

National Plant Quarantine Authority and Its Function

National Plant Quarantine Authority:

(1) Plant Protection Wing, Department of Agricultural Extension, as the National Plant Quarantine Authority, shall administer and enforce the provisions of this Act.

(2) The National Plant Quarantine Authority, shall-

b) inspect seeds, growing plants, areas under cultivation, and plant materials in storage or locally in transit, in order to report the existence, outbreak and spread of pests and to control pests;

(b) in respect of plant material moving in international traffic-

i. prevent the introduction of quarantine pests into Bangladesh from outside the country by regulating the import of plant materials, beneficial organisms and packaging material;

ii. regulate the export of plant material, pests, beneficial organisms and packaging material, to meet the importing country's requirements in accordance with international agreements, and to discharge such obligations under those international agreements;

iii. inspect consignments of plant material and, where appropriate, inspect consignments of other articles and commodities moving in international traffic under conditions where they may Act incidentally as carriers of pests;

iv. issue phytosanitary certificates in accordance with the requirements of importing countries;

v. disinfest or disinfect consignments of plant materials, as well as their containers, packaging, storage places or transport facilities;

vi. regulate the introduction of beneficial organisms;

vii. designate any area to be a controlled area or a quarantine area;

viii. conduct post-entry quarantine research and implement post-entry quarantine measures;

ix. undertake Pest Risk Analysis and Pest Risk Management;

x. undertake regular review and revision of lists of plant material, pests and beneficial organisms the importation of which into Bangladesh is prohibited or restricted with a view to update and harmonize phytosanitary measures;

xi. interact with international, regional or other National Plant Protection Organizations to stay abreast with the latest developments in the field of plant quarantine;

(k) carry out diagnostics, detection and identification of particular pests.

(l) promote integrated pest management and control in Bangladesh;

(m) carrying out and coordinating research in the plant quarantine and biodiversity protection;

(n) undertake risk analysis for the introduction of Genetically Modified Organisms (GMOs), Living Modified Organisms (LMOs) and Alien Invasive Species;

(o) undertake surveys, surveillance and conduct research on pests present in Bangladesh;

(p) distribute information within Bangladesh about pests of plant material and how to prevent infestation or infection and how to control them;

(q) ensure for technical expertise in plant quarantine;

(r) provide assistance for the phytosanitary management, operation and requirements in plant quarantine; and any other such matters as may be deemed necessary.

Importation

Prohibition to import.- No person, company or organization shall import into Bangladesh any plant material, pest, beneficial organism or packaging material except in accordance with this Act.

Permits and certificates

4) Subject to the provisions of subsection 5(2), any plant material, beneficial organism or packaging material shall only be imported into Bangladesh through a point of entry designated by the Government from time to time, and upon importation shall be declared and submitted to a Plant Quarantine Officer together with the permits and certificates issued by the competent authority of the country of origin for examination.

5) The National Plant Quarantine Authority may, by notification published in the Gazette exempt certain plant material from the requirement to be declared on importation.

6) The National Plant Quarantine Authority may, by notice issued in the Gazette establish the details of the conditions under which and, or, treatments that any plant material, originating from such countries and, or, areas, as may be specified in the notice, has to be subjected to, prior to or after importation, including post-entry quarantine.

Inspection: The person in charge of any conveyance transporting or storing anything required to be declared under subsection 5(1) shall make the conveyance and its contents available for inspection and treatment by a Plant Quarantine Officer in accordance with this Act and the rules made there under.

Notification to Plant Quarantine Officer: Any person in Bangladesh who receives any plant material, pest, beneficial organism or packaging materials from outside Bangladesh whether or not that person consented to it being dispatched, shall, on receipt, immediately

notify a Plant Quarantine Officer and carry out the Plant Quarantine Officer's instructions regarding its destruction, disposal or treatment if so required to the satisfaction of the Plant Quarantine Officer.

Seizure of plant harboring a pest: Anything imported into Bangladesh, in transit through Bangladesh or moved from one part of Bangladesh to another, in contravention of this Act or the rules made there under, together with any container used to transport it or any other thing reasonably suspected of harboring any pest, may be refused entry, seized, destroyed, disposed of, treated or otherwise dealt with as a Plant Quarantine Officer thinks fit, subject to the provisions of this Act and the rules made there under.

Import Permit

3) The National Plant Quarantine Authority may, by notice published in the Gazette, require that any plant material, pest, beneficial organic packaging material shall not be imported into Bangladesh from such countries or areas, as may be specified in the notice, except with an import permit and in strict compliance with the terms of the permit.

4) The National Plant Quarantine Authority may-

   c) issue, refuse to issue, or cancel an import permit; or

   d) prescribe in any import permits such terms and conditions as it deems appropriate and at any time, whether before or after importation, vary or add to the terms or conditions.

Phytosanitary Certificate: The National Plant Quarantine Authority may, by notice published in the Gazette, require that any plant material, as shall be specified in the notice, shall not be imported except with a phytosanitary certificate issued by the competent authority of the exporting country and which conforms in all material respects with either the phytosanitary certificate for export or for re-export.

Prohibition or Restriction

1) Notwithstanding anything contained in this Act, the National Plant Quarantine Authority may, by notice in the Gazette, prohibit or restrict the entry, introduction, sale, cultivation, propagation or movement of any plant material, pest, genetically modified organisms, living modified organisms, alien invasive species, beneficial organism, packaging materials or any other thing capable of harboring or spreading a pest.
2) Any notice given under subsection 11(1) shall be reviewed on a regular basis.

Assistance: All officers of Customs, Coast guard, Police, Bangladesh Rifles, Post Office, Port Authorities, Civil Aviation Authorities, Railway departments, Shipping agencies, Airlines and other such institutions shall assist the National Plant Quarantine Authority in preventing the importation into Bangladesh of anything contrary to this Act, and shall extend cooperation to any Plant Quarantine Officer in the discharge of duties and exercising of powers vested upon a Plant Quarantine Officer by this Act, by providing such facilities and assistance as may be deemed necessary.

Moving or handling of any container

1) Subject to the provisions of subsection 13(2), no plant material, pests, beneficial organisms or packaging materials under examination or liable to be examined by a Plant Quarantine Officer shall be moved or handled in any way, nor shall any

container be opened, except in accordance with the permission of a Plant Quarantine Officer.

2) An officer of Customs or of the Post Office may move and handle a thing referred to subsection 13(1) to the extent necessary for the proper performance of that officer's duties provided that the enforcement and attainment of the objects of this Act are not prejudiced.

Examination and sampling: Any person, company or organization who has imported any plant material, pest, beneficial organism or packaging material shall, on demand by a Plant Quarantine Officer, allow the imported things to be examined and samples to be taken by a Plant Quarantine Officer at any reasonable time to enable the Plant Quarantine Officer to determine whether or not this Act or any rules made there under, and any permit issued under it, has been complied with and whether or not further action should be taken.

Export

Pre-export examination

3) Any person, company or organization intending to a consignment of plant material to another country shall submit the consignment to a plant Quarantine Officer for pre-export examination.
4) Each consignment submitted shall be examined by a Plant Quarantine Officer within fourteen days of the date of export in accordance with the requirements of the country of destination and if the Plant Quarantine Officer is satisfied that the requirements for the issue of a phytosanitary certificate have been met, the Plant Quarantine Officer shall issue a phytosanitary certificate in accordance with this Act and the rules made there under.

Containment and Eradication of Pests

Declaration regarding Quarantine pests

1) The National Plant Quarantine Authority may, by notice published in the Gazette, declare any pest to be a quarantine pest if it presents, or is likely to present, a threat to the production of or trade in plant materials, to beneficial organisms or to the natural environment and if it is either not known to be established in Bangladesh or is established in Bangladesh but is the subject of measures for its eradication or confinement.
2) The occupier or owner of any land or premises on which a pest is found which is identified as, or is suspected to be, a quarantine pest shall immediately notify an officer of the National Plant Quarantine Authority.

Declaration regarding infected areas: The National Plant Quarantine Authority may, by notice published in the Gazette, provide for-

a) the declaration of any area in Bangladesh which is infected or is suspected of being infected with any pest, to be an infected area;
b) the declaration of any land or premises which is infected or is suspected of being infected with any pest, to be under quarantine;
c) prescribe any measures for the treatment, destruction or disposal of plant material, pests or packaging material, and the treatment of conveyances or

storage places suspected of being or having been used for the transport or storage of anything likely to be infected, in order to limit the spread of the pest;

d) provide for the prohibition, restriction and, or, regulation of the cultivation and harvesting of crops for the whole or part of an infected place or area under quarantine if, in the opinion of the Authority, a pest cannot otherwise be readily or adequately controlled or eradicated, and prescribe the period within which such prohibition, restriction and, or, regulation shall remain in force.

Written notice: If the National Plant Quarantine Authority is satisfied that a quarantine pest is present at any place, the National Plant Quarantine Authority may cause a written notice to be served on the owner or occupier of such place and, if he deems it appropriate for the purposes of this Act, on the owner or occupier of any land or premises in the vicinity, ordering each of them, within a period specified in the notice, to take whatever measures on their land and premises the National Plant Quarantine Authority considers appropriate to eradicate, contain or restrict the spreading of the quarantine pest.

Non-compliance: If an owner or occupier either cannot comply with any term of a notice issued under section 18 or is unable to comply within the stipulated period and in either case advises the National Plant Quarantine Authority accordingly, the National Plant Quarantine Authority may enter upon the land or premises in question and take whatever measures may be appropriate to carry out the requirements of the notice.

Review: The National Plant Quarantine Authority shall regularly review the situation in respect of any land or premises placed under quarantine and, when satisfied that either the relevant pest has been eradicated or that after consideration of all relevant circumstances it would be inappropriate to continue to maintain the quarantine restrictions in respect of part or all of the land under quarantine, the National Plant Quarantine Authority shall, by notice published in the Gazette and by notice served on all affected owners or occupiers of the land, declare that from a specified date any land identified in the notice shall no longer be under quarantine.

Compensation:

1) Subject to the provision of subsection 21(2), where any plant material or other thing is destroyed or harmed by any measures taken to eradicate, contain or limit the spread of a quarantine pest, the National Plant Quarantine Authority may compensate the owner of the plant material or item destroyed or harmed from monies made available for that purpose at the discretion of the Authority.
2) The National Plant Quarantine Authority shall not be obliged to compensate any person who has suffered loss as a result of action authorized under this Act if the action was taken to remedy a situation caused wholly or partially by that person's negligence, failure to comply with lawful instructions or contravention of this Act.
3) The National Plant Quarantine Authority shall, determine the amount of compensation payable in the circumstances of the case, and may, by notice published in the Gazette, prescribe the procedures to be followed to claim compensation.

The above mentioned Plant Quarantine Act, 2009 are applicable for hybrid rice also because no specific or separate Act has been formulated in Bangladesh.

Annex.XI.6: Tariffs and non-tariff barriers on imported agricultural inputs

It may be noted here that no specific Rules and Regulations in relation to Tariff and Non-Tariff Barriers has yet been formulated separately for Hybrid Rice Seed Import and Marketing in Bangladesh. The existing regulations are applicable and followed for Hybrid Rice import and marketing in Bangladesh.

The existing Tariff and Non-Tariff Barriers on Imported Agricultural Inputs are as follows:

There are both natural and manmade barriers to trade. Natural barriers typically include the transportation and shipping costs

There are both natural and manmade barriers to trade

Natural barriers

i. Natural barriers typically include the transportation and shipping costs of engaging in international trade, which add to the cost of a good exported rather than retained for domestic consumption.

ii. Another natural barrier to trade of particular importance to seed is the adaptability of certain varieties for use in different agro-environments.

Manmade barriers

i. Manmade barriers also affect seed availability and/or prices. Tariffs and other barriers that raise the price of imported seed are usually not high enough to reduce trade significantly below what would have otherwise occurred.
ii. When reducing imports is the policy objective, most countries opt for non-tariff barriers that directly limit or preclude availability rather than rely on tariffs and the price mechanism.
iii. The developing countries use a wide range of Non-Tariff Trade Barriers (NTBs) to control trade in seed; total prohibition of most types of seed imports exists in many of these countries. In addition, trade barriers tend to have a negative effect on the quality of seed available to the farmer.

Two aspects of seed production create important qualifications to customary free trade principles:

i. A large part of the value added in improved seed is knowledge that can be embodied in the seed at very low cost once the initial research expenses have been met.
ii. Open-pollinated seed can be reproduced by the farmer at little additional cost after the improved seed has been purchased once.

Non-tariff barriers

i. Non-tariff barriers includes all those restrictions other than traditional customs duties which distort international trade, such as impediments at national boarders, all types of domestic laws and regulations which discriminate against imports as well as subsidies aimed at stimulating domestic production.
ii. A non-tariff measure is defined as any device or practice other than a tariff which directly impedes the entry of imports into a country and / or which discriminates against imports-it means it does not apply with equal force on all domestic production or distribution.

The various Non-tariff barriers and distortions are organized into five categories

i. Import controls.
ii. Health and performance standards.
iii. Structural and economic barriers.
iv. Political barriers, and
v. Export subsidies.

Non-tariff barriers

1. Import Controls

i. Variable levies and special charges
ii. Quotas and prohibitions
iii. Import licenses
iv. Domestic content restrictions
v. Domestic processing requirements
vi. Product/import ratios
vii. Actions based on various GATT/WTO articles

2. Health and performance standards

i. Phytosanitary regulations
ii. Certification
iii. Tests, proof of superiority
iv. Cataloguing, inscription
v. Packaging and labeling restrictions
vi. Documentation requirements

3. Structural and economic barriers

i. State trading agencies
ii. Inconvertible
iii. Price controls
iv. Marketing and distributional restrictions
v. Domestic research subsidies
vi. Domestic production subsidies
vii. Domestic credit preferences

4. Political barriers

i. Boycott
ii. Embargo on exports of germplasm

5. Export subsidies

i. Tied aid and grants
ii. Gifts in kind
iii. Foreign exchange or credit preference for exports

iv. Export production subsidies
v. Dumping
vi. Export research subsidies

Non-Tariff Barriers to Seed Industry in Bangladesh

i. Opening of Letter of Credit (L/C)
ii. Import Permit

Opening of Letter of Credit (L/C)

i. No consignment of plants or plant products or other regulated articles (seeds) shall be imported into Bangladesh without a valid Import Permit (IP) before opening L/C.

ii. This IP is issued by the Plant Quarantine section of the Plant Protection Wing of the Department of Agricultural Extension under the Ministry of Agriculture, Government of Bangladesh.

iii. No consignment shall be imported unless accompanied by a Phytosanitary Certificate issued by an authorized officer in the country of origin (The principal objective of Phytosanitary Certificate is to ensure the seed health of imported seed).

iv. On the basis of Phytosanitary Certificate of the Country of Origin of imported seed the Plant Quarantine Official at the Port of arrival in Bangladesh should issue clearance certificate.

v. But the fact is that the Plant Quarantine Official at the Port usually create problem by retaining seeds for the purpose of testing seed germination which needs at least seven to ten days.

vi. As a result of delaying the consignment for germination testing, the importers have to incur huge penalty for delaying clearing of consignments at the ports as well as farmers are also deprived of to get quality seed in time.

vii. This system can be simplified by collecting samples for germination testing and the whole consignments should be released outright without making any delay.

Harmonizing SPS Measures

i. The World Trade Organization (WTO) created a new era of international trade, inter alia, two new Agreements dealing with Technical Regulations and Standards:
ii. The Sanitary and Phytosanitary (SPS), and
iii. The Technical Barriers to Trade (TBT) Agreements.

The SPS Agreement

i. The SPS Agreement has been in force in many countries since 1996-97 and they are reforming their SPS measures/quarantine laws in order to conform to the WTO regime on SPS measures, as they understand the consequences of non-compliance.
ii. The SPS Agreement seeks to encourage harmonization of national SPS standards with international standards for the purpose of uniformity, with view to promoting trade and discourage protection of domestic food and agriculture industry from competition.

The Technical Barriers to Trade (TBT) Agreements

The TBT Agreements also recognizes the concept of equivalence in Article 2.7, which requires "members to give positive consideration to accepting as equivalent, technical regulations to other members, even if these regulations differ from their own, provided they are satisfied that the regulations adequately fulfill the objectives of their own regulations."

Quarantine Regulations

i. Quarantine Regulations can help manage SPS issues.
ii. But in Bangladesh the SPS Agreements and the TBT issues have not yet been upgraded /amended in the line of WTO frameworks.

Tariff barriers

i. Tariffs are tax imposed on imported goods as they enter into customs territory.
ii. For many countries, tariff levels are low or zero, but for others the rates are moderately high and pose real barriers to trade, as in case of Bangladesh.

Tariff Barriers to Seed Trade in Bangladesh

In Bangladesh, the Seed Industry Development is seriously hampering because of Tariff-barriers. Tariff-barriers include:

i. Customs Duty (CD)
ii. Supplementary Duty (SD)
iii. Advance Income Tax (AIT)
iv. Advanced Trade VAT (ATV)
v. Total Tax Incidence (TTI)

Key Tariff Barriers to Seed Industry in Bangladesh

i. Indiscriminate duties are implied during importing seeds.
ii. The duties are comparatively high in case of importing wrapped/canned seed but duties are low while importing non-wrapped/non-canned i.e. bulk seeds.
iii. There is discrimination on importing rice seed (especially hybrid rice), 3% AIT is charged during importing hybrid rice seed.
iv. To promote seed industry, all categories of duties both in wrapped/canned and in non-wrapped/non-canned (bulk) seeds should be waived.

Strengthening policy support to participate in the international trade system: First, Bangladesh should join in efforts to constitute new rules of rice trade, try to introduce initiatives, and participate in multilateral trade negotiations about market access and tariff quotas. Second, we should be familiar with WTO and international trade rules; our production and operations should coincide with international trade norms, technology standards, and financial standards. The laws and policies of our country should be adjusted to strengthen the competitiveness of hybrid rice. Finally, we should know the current technology advances, adjust the structure of export commodities, eliminate out-of-date methods of production and products, overcome all kinds of trade barriers, and try to avail of more market space and trade opportunities.

Annex.XI.7: Subsidy and other facilities in agriculture allocated in the National Budget 2010-11

- Program to distribute organic, green and bio-fertilizers distribution to 97 lakhs families in the country to popularize the use of natural fertilizers for increasing agricultural production.

- Distribution of agro-inputs distribution cards among 1.82 crore farmer families throughout the country.

- An amount of US$ 107.14 million (BDT 7500 milion) has been distributed among 92 lakh boro farmers across the country during 2009-2010 boro season.Showing this agro-input card, farmers are now able to open a bank account with only US$ 0.143 (BDT 10). By utilizing this card, the government will be able to bring agro-input assistances in a more transparent manner directly to the farmers' doorsteps.

- An allocation of US$ (514.29 million (BDT 36,000 million) was made in the 2009-10 budget for granting subsidy on fertilizers and other agricultural programs to reduce the cost of profuction in agricultural sector. Later the amount of this subsidy was increased to US$707.14 million (BDT 49,500 million).

- This year in the budget of 2010-11 an allocation of US$ 571.43 (BDT 40,000 million) subsidy has been made for fertilizer and other program.

- Another major input of agriculture is seed. Under the program of supplying high yielding variety seeds to the farmers, in 2010-11 fiscal year target have been fixed to produce and distribute 1.18,450 tons and 84,838 tons of high yielding variety of seeds through BADC and DAE respectively.

- Besides, actions are being taken to increase the capacity of seed storage from 40000 tons to 100000 tons.

- In 2010-11 a scheme have been undertaken to grow hybrid paddy in 12 lakh hectares and salinity resistant BRRI dhan 47 in 50 % of salinity affected 10 lakh hectares of land .

- Allocation have been made of US$ 61 million (BDT 4,270 million) in the last year's 2009-10 budget to expand irrigation facilities in southern part of Bangladesh by utilizing surface water, mitigating water logging problems in the south-west region and widening the area of cultivable land and facilitating multi-crop production through draining out water in haor areas. To achieve this, implementation of 66 programs at an estimated cost of US$54.14 million (BDT 3790 million) is going on speedily. As a part of future plan for this sector, an allocation of US$ 42.86 million (BDT 3000 million) in the next fiscal year 2010-11.

- As of April 2010, agricultural loan of US$ 1278.43 million (BDT 89490 million) has been distributed against a target of US$ 1644.57 million (BDT 115120) through public and private sector banks and financial institutins. This is 16% higher than that of the corresponding period of last year. In the next year 2010-11 the target for agricultural loan will raise to US$1714.29 million (BDT 120000).

- Allocation for agricultural research of US$ 26.46 million (BDT 1852.1) was for the last budget 2009-10 to develop high yielding variety of crops and improved method of production, salinity and flood tolerant variety of rice.

- The agricultural research fund for next fiscal year 2010-11 is US$ 58.86 million (BDT 4120 million). The research proposals have been invited in order to utilize allocations made under endowment fund for enhancing agricultural productivity through crop diversification.

- Fair prices for the agricultural produces through organizing 'farmers marketing group' and 'farmers club' throughout the country along with developing 128 agro-markets at the upazila level and 30 such bazaars at the district level to facilitate marketing of agricultural produces. There is a provision for one wholesale market infrastructure in each 15 districts and 60 growers' market in another 16 districts of northern regions. Also developed a central market at Gabtoli in Dhaka to establish linkage with all these markets.

- Fund for next fiscal year 2010-11 is US$58.86 million (BDT 4120 million). The research proposals have been invited in order to utilize allocations made under endowment fund for enhancing agricultural productivity through crop diversification.

- Fair prices for the agricultural produces through organizing 'farmers marketing group' and 'farmers club' throughout the country along with developing 128 agro-markets at the upazila level and 30 such bazaars at the district level to facilitate marketing of agricultural produces. There is a provision for one wholesale market infrastructure in each 15 districts and 60 growers' market in another 16 districts of northern regions. Also developed a central market at Gabtoli in Dhaka to establish linkage with all these markets.