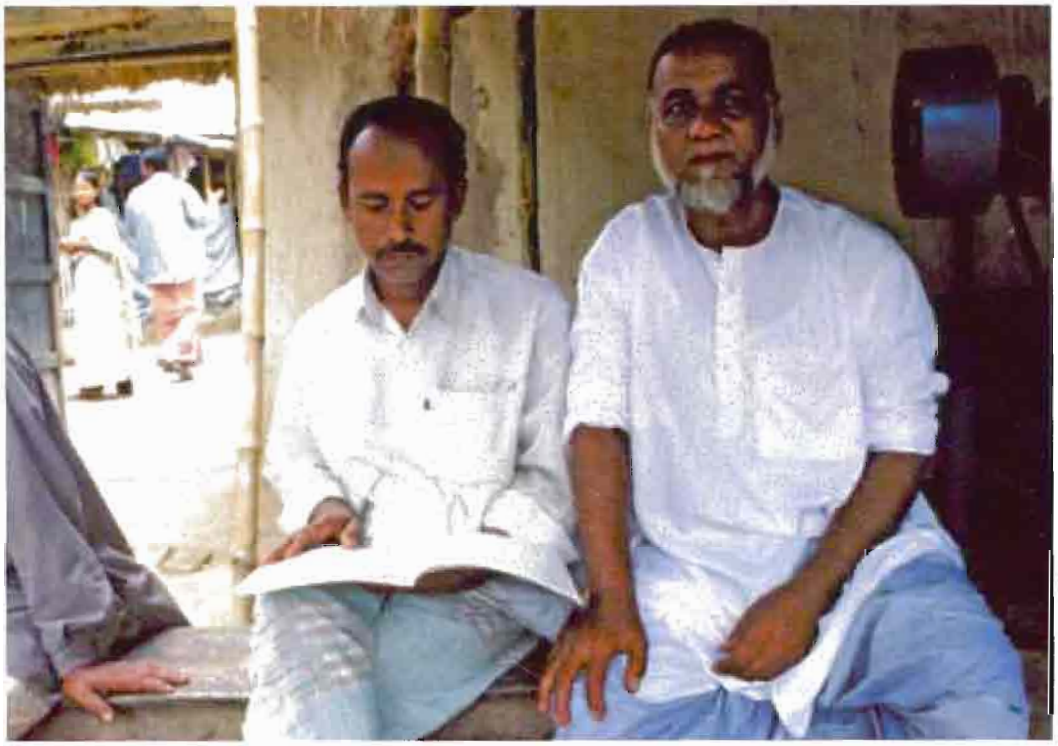
Achievements of the

Bangladesh CIMMYT Partnership

for Agricultural Research and Development



September 2008

CIMMYT Office in Bangladesh
House 104, Masjid Road
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Dhaka 1206

CIMMYT

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Prepared for the CIMMYT Impacts, Targeting and Assessment Unit
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Executive Summary

Bangladeshis do not want to live by rice alone. As the aspirations, incomes, and nutritional awareness of its people have increased since independence, other cereals and the various value-added food products from them have played an increasing role in the country. With land scarcity and high human population density, Bangladesh has always had to rely on imports for many foods, but there have been lots of opportunities to diversify and raise the production of basic crops domestically. Prominent among these emerging crops are wheat and maize, which grow particularly well in the moderately cool dry winter Rabi season. Over the years since CIMMYT established an office in Bangladesh in 1982, it has worked together with Government and other institutions. These joint programs have accumulated an impressive array of achievements and benefits that have helped to establish wheat and maize as the second and third most important cereals in Bangladesh, as well as addressing productivity and sustainability issues related to the broader farming systems in which farmers produce these crops.

Here we describe many of those products and impacts. We attempt to show how they have helped and are still helping the national agricultural research and development systems in Bangladesh to provide technologies and information that farmers and other entrepreneurs use to sustain or raise crop productivity, and their incomes and livelihoods from farming. Some new emerging constraints are described that if addressed can further improve wheat and maize crop production in Bangladesh. Possible interventions are suggested for policy makers, research and extension.

During the 1980s and 1990s, the substantial support that CIMMYT provided was almost entirely given to develop and promote wheat production in the country through germplasm provision, infrastructure development, agronomic research and training. During the 2000s, this support diversified with an increased emphasis on farm mechanization and conservation agriculture, maize improvement and training, agricultural databases, environmental concerns in intensifying cereal systems and fodder provision for livestock. The work of CIMMYT in Bangladesh has always been in very close partnership with a diverse array of local and international organizations including government agricultural research and extension institutes, universities, NGOs and private companies, and has been supported by several donors.

There is no doubt that through this last quarter century of work by a small team of dedicated CIMMYT staff and their colleagues in the Bangladesh NARS, CIMMYT has made a massive contribution to local and national income, food security, human nutrition and wellbeing. This is so

From 2002 to 2007, the CIMMYT Office in Bangladesh was able to substantially broadened its aspirations, its activities, its reach, and the types and depth of benefits it has had in Bangladesh. We did this mainly by the successful management and implementation of a well-resourced multi-component USAID project with a wide range of partners (including local community and NGO groups, government agencies, and international partners). That project conducted work on many issues from maize whole family training, farm mechanization and resource conservation technologies, databases and GIS, arsenic contamination in the food chain, and also gave support to papaya research.

Recent or current partnerships and linkages with international organizations include IRRI, ILRI, ICRISAT, IFDC and FAO; Murdoch University, ACIAR and CSIRO in Australia; Cornell University, Texas A and M University, Winrock International, Mud Springs Geographers, Helen Keller Foundation and USDA in the USA.

easily seen by any visitor to rural or urban areas of Bangladesh where nowadays many otherwise quite poor people regularly have wheat chapattis for their breakfast, a glass of milk from triticale fodder for their lunch and maize-fed chicken, eggs or fish for a nice dinner.

In the main body of this paper we describe many of the achievements and benefits that by working together, CIMMYT and its key partners have attained with this work for Bangladesh.

Here we give you some of the highlights:

- Bangladesh emerged on the map of significant wheat growing countries by the 1980s. Wheat became the second major cereal after rice, contributing to food security, human nutrition and livelihood improvement of resource poor farmers and urban consumers. Wheat production expanded in the 1980s and 1990s, reaching a peak of 1.9 million t of grain produced on 0.88 million ha in 1998-1999.
- A substantial amount of CIMMYT wheat germplasm was imported during the last forty years for the Wheat Research Center (WRC) of Bangladesh Agricultural Research Institute (BARI) to test and incorporate into the breeding program. These have been used in the development of 19 of the 24 wheat varieties so far released in Bangladesh. Large amounts of crop management and soils research for wheat was conducted in joint WRC-CIMMYT programs.
- Since the mid 1990s, maize area and production has increased tremendously in Bangladesh. In 1993-94, the maize area was just a few thousand ha, whereas by 2006-07 maize covered over 221,000 ha, with a total grain production of 1.27 million t. That achievement is due to high market demand for maize grain by the poultry sector, excellent climate and soils for maize production, widespread use of hybrid maize and associated intensive crop management practices.
- CIMMYT made important contributions during the 2000s to the expansion of maize production through the provision of germplasm, strengthening hybrid-based maize breeding and crop management research, policy level dialogue, marketing, and a widespread program of whole family training on maize production technologies that has raised the standards of maize production in Bangladesh.
- The BARI and Bangladesh Rural Advancement Committee (BRAC) maize breeding programs were able to use large numbers of suitable CIMMYT inbred lines and other materials. Six out of the seven maize hybrids released by BARI in the 2000s contain CIMMYT maize lines, and there is significant use of CIMMYT maize by emerging private breeding companies. BRAC released one maize hybrid, Uttoron, from CIMMYT inbred lines.
- The first trainee was sent to CIMMYT HQ in Mexico in 1969. Over the years since then, a total of 141 Bangladeshi wheat and maize scientists and extensionists have been trained in Mexico on various topics related to wheat and maize improvement, including breeding, agronomy, pathology, cereal technology, experiment station management, seed technology, economics, heat stress, and resource conserving technology.
- Over 750 Bangladeshi NARS scientists were supported in international exchange travel opportunities between the 1970s and 2000s, many with CIMMYT at its HQ, as visiting scientists, conference participants and international trainees, and many at other institutions where they gained valuable experience and ideas that were used on their return.
- Many of the crop production recommendations on how to grow productive and profitable wheat and maize crops in Bangladesh have come from a range of crop, soil and water management research that was conducted in cooperative projects between NARS and CIMMYT in Bangladesh in the last 20 years, and often combined with relevant information from elsewhere.
- A wide range of agricultural machinery (mostly mounted on diesel-engine two-wheel tractors) was developed and promoted, particularly for Rabi season crops, since 1995 in CIMMYT-related programs with BARI. Notable among these were power tiller operated seeders (PTOS) for wheat.
- About 450 PTOS are currently operating in Bangladesh from these programs, preparing around 28,000 ha of land each year for wheat and an increasing number of other crops including jute, lentil and maize, with big reductions in costs for farmers and benefits from earlier and faster planting.

- Each PTOS operator earns US$ 1,000-2,000 a year and helps 20-100 other farmers to reduce their crop turn-around-time by 50% (increasing cropping intensity), with 15-20% lower costs, 30% less irrigation water, 25% less seed, improved fertilizer use efficiency, and 20% increased crop productivity when growing wheat.
- Permanent-raised-bed and straw retention systems have been developed and tested that can quickly (within 2-3 years) improve the cumulative grain yields for intensive wheat-maize-rice crop sequences by around 50% compared with conventional tillage without straw retention for small-scale farmers. These are now being tested further on farm and promoted with farmers.
- CIMMYT and the WRC developed the whole-family-training approach for farmer crop production training and used it during the last 12 years to train over 16,000 farmers in wheat production, 11,000 farmers with maize and around 700 small-scale dairy farmers in triticale and maize fodder production.
- Whole family training has greatly raised farmer awareness, improved practices, and increased the productivity and incomes that farmers achieve with wheat and maize production. After training, maize farmers adopted a range of improved production practices, planted the crop on 0.09 ha more land and raised grain yields by 0.8 t/ha, and this improved their livelihoods.
- In the 2000s, the development of a comprehensive CD-based GIS database called the Bangladesh Country Almanac, along with a range of awareness and training activities to promote its use has greatly improved the archiving, sharing and use of agricultural and natural resource information among many institutions in Bangladesh.
- Triticale was identified as a source of high quality green fodder for small-scale dairy producers facing fodder shortages during the cool dry rabi season. Dual-purpose fodder and grain triticale was shown to produce 7-12 t/ha of fresh fodder (raising milk production and incomes for small dairy producers), and around 1-2 t/ha of grain for poultry feed or for chapattis in Bangladesh. Programs were conducted in the mid 2000s to demonstrate dual-purpose triticale with small dairy farmers in several parts of Bangladesh, with very good results.
- Cooperative research with various partners showed that arsenic contamination of crops, particularly irrigated (boro) rice, is significant in some parts of central Bangladesh. This is a worsening human health hazard, and is now also reducing rice and wheat crop growth and yields in some parts of Bangladesh. The planting of more wheat and maize along with various reduced irrigation management strategies like raised-bed planting systems were proposed as partial solutions to this serious bio-hazard.
- Since 1968, CIMMYT has been arranging high level policy planner and scientist exchange visits. Dr. Norman E. Borloug (Nobel Laureate for Peace), CIMMYT DG and Program Directors, as well as numerous reputed scientists of CIMMYT visited Bangladesh several times and met with important policy planners and research scientists including ministers, secretaries, and DGs of NARS institutes. Several high officials including Ministers of Agriculture, the Executive Chairman of BARC, DGs and Directors of Bangladesh NARS institutes visited CIMMYT HQ in Mexico and some regional offices. Their recommendations, guidance and support have helped to established wheat and maize programs in Bangladesh.

CIMMYT's Mission

CIMMYT's major mission in Bangladesh has been to increase and diversify wheat and maize system agricultural production for food security, poverty alleviation and enhanced farmers' incomes, while conserving natural resources and protecting the environment and human health. It has helped the Bangladesh Agricultural Research Institute (BARI) and other institutions of the National Agricultural Research System (NARS) of Bangladesh for more than 30 years to develop their wheat and maize research capabilities through collaborative agricultural research projects. One of the important missions of CIMMYT is to increase capacity building of NARS scientists, seed producers, and extension and NGO personnel through various human resource development activities. On behalf of the Government of the People's Republic of Bangladesh, the Bangladesh Agricultural Research Council (BARC) signed a Memorandum of Agreement with CIMMYT that established the Bangladesh office of CIMMYT in 1982. Under this MoA, CIMMYT has been working with the Bangladesh Agricultural Research Institute especially for wheat, maize, farm machinery, agronomy research and development work. It extended its partnership with Bangladesh Rice Research Institute for rice-wheat system research, the Department of Agricultural Extension, Bangladesh Livestock Research Institute, Soil Resource Development Institute, Department of Livestock Services, Bangladesh Agricultural Development Corporation, NGOs and various private sector organizations such as seed companies.

CIMMYT and its office in Bangladesh have these web sites:
http://www.cimmyt.org and http://www.cimmyt.org/bangladesh/

Programs and Projects of CIMMYT in Bangladesh

In the early years in Bangladesh, CIMMYT provided some core funding for its cooperative wheat work with BARI. However, during most of the 1980s, 1990s and 2000s almost all the support has come through funding from specific donor projects (particularly CIDA, AusAID, USAID, World Bank and ACIAR) for a wide range of activities with increasing numbers of partners in Bangladesh.

Since 1982, the CIMMYT Office in Bangladesh has handled over US $ 30 million in funding. Of this, about US $ 19 million were used for research and development activities of our many partner organizations, especially BARI, WRC, BRRI, Universities, NGOs and Private Sector organizations. These funds helped to develop physical facilities and human resources, station equipment and machinery, to assist specific research and development programs, system-based collaborative research, participatory research, the development of new agricultural machinery for resource conserving technologies, among others, directly with our many partners.

Establishment of Wheat as a Major Crop

During the 1980s and 1990s and into the 2000s, the CIMMYT Office in Bangladesh has been very closely associated with national partners (principally the Wheat Research Center of BARI) and international partners in developing wheat to become the second most important cereal crop in Bangladesh next to rice. Wheat plays a significant role in the diet of the people (with chapattis regularly eaten for breakfast) and in the food security of the country. The current annual consumption requirement of wheat in Bangladesh is about 3.6 million t and the work of CIMMYT and WRC have helped Bangladesh meet a third to half of this need through local production. There is however, an increasing shortfall of 2.0-2.5 million t per year, which is met through imports at a rising cost of approximately US$ 500 million to 700 million a year. The rate of increase in wheat consumption is about 3% per year and by 2020 the Bangladesh annual wheat requirement will be more than 4.0 million t.

Wheat production with high yielding varieties in Bangladesh began in 1975-76 when the country imported and planted 4000 t of Sonalika and Kalyansona seed from India. Wheat area and production increased during the 1980s and 1990s (Figure 1) helped by the widespread use of several high yielding varieties, particularly Sonalika in the 1980s and then Kanchan in the 1990s. Wheat production reached a peak in Bangladesh in 1998-1999 when 1.9 million t of grain were produced on 0.88 million ha (Figure 1), saving huge amounts of foreign exchange for imports.

Over the last 35 years, the biggest contribution from the CIMMYT Wheat Program has been the regular provision of bread wheat, triticale and durum wheat germplasm to strengthen the breeding programs of WRC-BARI and some universities. CIMMYT germplasm has been used in the development and release of 24 wheat varieties suitable for chapatti and confectionery bread as food and feed (Table 1).

Additionally, three promising triticale varieties have been identified. CIMMYT work with BARI has also included the development of technologies for improved wheat crop and soil management and the development, promotion and training of agricultural farm mechanization (including wheat and maize planters, harvesters, threshers or shellers, etc.) (see later sections).

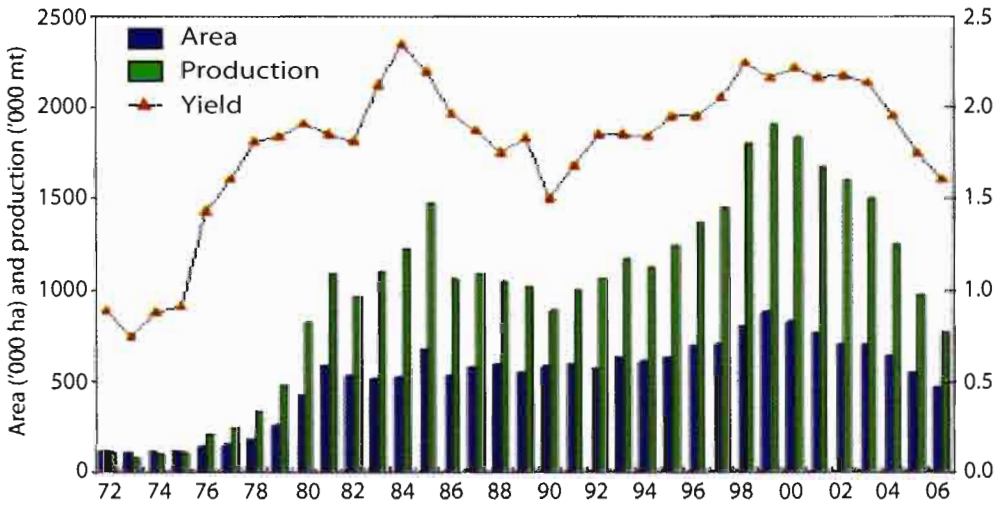

Figure 1: Yearly trends in Bangladesh wheat area, production and yield.

Wheat Varieties

Research on modern wheat varieties was initiated in Bangladesh (then East Pakistan) in 1965 just after a small quantity of seed of two Mexican varieties, Sonora 64 and Penjamo 62 was received from Mexico. Since then CIMMYT has sent thousands of sets of nurseries and segregating populations on a regular basis as part of its global wheat germplasm distribution and testing program. Numerous other special requests for specific germplasm were made and met, and CIMMYT helped obtain wheat germplasm from contacts in wheat breeding programs in many other parts of the world, including India, Pakistan and Australia. Selection and crossing from these many source materials led to the development and release of 24 high yielding wheat varieties in Bangladesh (Table 1). Of the 24 varieties released up to 2007, seventeen have been attributed to CIMMYT and two to a special program of CIMMYT in Nepal.

In the early 2000s, major breeding work took place in an attempt to address intensifying heat, disease and other problems, and this led to an array of new varieties that have been bred and released in recent years. Sourav, Gourab, Shatabdi, Sufi, Bijoy and Prodip are moderately tolerant to Bipolaris leaf blight and perform relatively well when late planted, often producing 20% higher grain yield than Kanchan. These newer varieties are now being aggressively promoted by extension services and by research staff to replace the susceptible variety Kanchan that gives increasingly low yields. A range of innovative seed production and distribution schemes are underway with wheat farmers.

Table 1. Name, pedigree, origin and year of release for wheat varieties released by the Wheat Research Center (WRC) of BARI, Bangladesh.

Variety	Source of germplasm	Year of release	Current (2007-08) coverage (%)	Peak year and coverage	Characteristics
Sonora 64	CIMMYT	1968	Nil		
Kalyansona	CIMMYT	1968	Trace		
Inia 66	CIMMYT	1972	Nil		
Norteno 67	CIMMYT	1972	Nil		
Sonalika	India	1973	2%	1982-87 (80%)	
Tanori 71	CIMMYT	1974	Nil		
Jupateco 73	CIMMYT	1974	Nil		
Pavon 76	CIMMYT	1979	Nil		
Balaka	India	1979	Nil		
Doel	CIMMYT	1979	Nil		
Kanchan	India	1983	30%	1990-2004 (85%)	Highly susceptible to BPLB.
Akbar	CIMMYT	1983	Trace		
Ananda	CIMMYT	1983	Nil		
Barkat	CIMMYT	1983	Nil		
Seri 82	CIMMYT	1987	Nil		
Aghrani	Pakistan	1987	Trace		
Sawgat	CIMMYT	1992	Nil		
Protiva	CIMMYT	1992	5%		
Sourav	CIMMYT	1998	2.5%		Medium sized grain, amber colour, good for Chapati making, wider adaptability.
Gourab	CIMMYT	1998	5%		Large attractive amber grain. Seedling stage lower leaves may become yellow under excess soil moisture.
Shatabdi	CIMMYT	2000	45%		Large grain, amber colour, sticky gluten not suitable for good bread making.
Sufi	Bangladesh	2005	Nil		Small grain, amber colour, strong gluten having good bread making.
Bijoy	CIMMYT-Nepal	2005	2%		Large attractive amber grain, seedling stage lower leaves may become yellow under excess soil moisture. Performs well under moderate to low saline soils.
Prodip	CIMMYT-Nepal	2005	4%		Low tillering, very large grain, amber colour, strong gluten. Good for bread making.

Maintaining wheat production in Bangladesh

On-going Research and Development Program

Current wheat research and development programs in BARI consist of varietal improvement, crop management, farm machinery, socio-economics, breeder seed production, and technology transfer.

The Wheat Research Center (WRC) of BARI has imported a wide range of germplasm mainly from CIMMYT HQ in Mexico, CIMMYT Nepal office, Australia, and Pakistan in the last few years. The germplasm is mainly to help with the selection of heat and disease tolerance, higher grain yield, and good physiological and agronomic traits. Selected germplasm is being used in the crossing block to develop suitable varieties. The locally developed advance lines are included in the Eastern-Gangetic Plains Screening Nursery. CIMMYT has also recently provided special nurseries such as those for screening for heat tolerance and resistance to the stem rust Ug-99.

On-going crop management research includes nutrient management in rice-wheat systems; developing attractive cropping patterns with wheat; improved wheat crop planting and establishment through bed planting, zero tillage, strip tillage and minimum tillage seeders; various socio-economic studies; and technology transfer initiatives, especially the promotion of seed of new wheat varieties.

Future Needs

Both domestic and international prices of rice and wheat have been rising during 2006-07 and that accelerated early in 2008. The national wholesale price of coarse rice increased by about 33% during the July-December 2007 period and the domestic wheat price increased by about 51% during the same period. The July-December 2007 period also saw the international price of wheat increase by 82%.

In 2006-07, a total of 2.42 million t of food grains was imported into Bangladesh; mostly as 1.7 million t of wheat grain. In 2006-07, just 0.74 million t of wheat grain was produced in Bangladesh. Very recently in 2007-08, Bangladesh has been facing a growing food deficit due to floods, and the effects of the severe cyclone 'Sidr' that affected southern coastal parts of the country in November 2007. As a result, many poor people, mainly women and children, are hungry and employment opportunities have decreased. There remains a huge potential to grow more wheat locally if a comprehensive program can be undertaken to promote wheat. That could help to reduce food gaps, create employment opportunities and improve human nutritional status.

To sustainably improve wheat area and production in Bangladesh, Bangladesh NARES and CIMMYT should undertake various forms of action. More consistent and sympathetic longer term support from international donors and Government sources would be required if there is serious expectation of meeting the challenges. Work should include:

Development of heat and disease tolerant varieties:

WRC has given more emphasis to the breeding of varieties with tolerance to terminal heat stress during grain filling. Two candidates, BAW 1059 and BAW 1064 have been found to perform well under late heat stress. BAW 1059 has also performed well when grown on moderately saline soils. To improve the existing germplasm, more support is needed for the development of high grain yield potential heat tolerant varieties with improved tolerance to foliar diseases like spot blotch. This should be the major breeding thrust for coming years. The program should be strengthening to collect suitable germplasm from regional and international sources and also strengthen the existing bilateral shuttle breeding programs.

Introduce wheat in new potential areas:

A vast area of land remains fallow after harvesting the monsoon aman rice crop in the greater Sylhet and Rahshahi (Barind) districts and in many

southern parts of the country due to lack of irrigation facilities, lack of knowledge by local farmers and some climatic and soil constraints. Past demonstration results from several areas of southern Bangladesh showed that 2.0-2.5 t/ha wheat grain yield can be obtained from crops grown with stored soil moisture or supplemented with one irrigation. Because wheat is facing severe competition from an expanding range of sometimes financially very attractive other rabi crops in traditional areas, this program to expand wheat production in these new potential areas where there is less competition, needs more emphasis and support.

Refinement of wheat production technologies:
Most of the developed wheat crop management technologies do not fit well in all conditions in which the crop is grown in Bangladesh. The existing technologies such as fertilizer rates and application practices, irrigation and water management, pest and disease management, and weed management should be refined for both traditional and the new non-traditional areas and cropping systems in which wheat will be grown in Bangladesh.

Awareness about new wheat varieties:
As indicated earlier, in recent years, the WRC has developed and released several high yielding, disease tolerant and moderately heat tolerant wheat varieties. These new varieties can yield 20% or more compared with Kanchan when grown under late planting conditions. Many farmers are still not well aware of the new wheat varieties and so many continue to grow old varieties. Often when asked, they request seed of the old varieties such as Kanchan that they are familiar with. Nevertheless, many farmers complain of low yields from old varieties and their poor experiences with Kanchan in recent seasons has been a major reason that many farmers switched from wheat to other more attractive rabi season crops such as maize, potato and vegetables.

A program should be undertaken to make farmers more aware of these new varieties and their benefits through demonstrations, seed exchange programs, whole family training programs and campaigns in the mass media using radio and TV broadcasts, posters, booklets, banners and signboards.

WRC has been conducting variety demonstrations of the new wheat varieties with the help of the Department of Agriculture Extension (DAE) and several NGO's. These programs should be expanded to include more field demonstrations of the new wheat varieties. That way farmers can see the better performance of the new varieties as well as preserve seed to grow and expand the area planted to new varieties quickly.

Introduction of agricultural machinery:
The optimum planting time for wheat in Bangladesh is a very short period of 15 days between November 15 and 30. Failure to sow wheat on time reduces wheat yields by 1.3% per day of delay in planting after December 1. Yet, over 50% of growers have to sow wheat after this date because of late harvest of previous crops (especially aman rice) or waterlogged fields. Growers can reduce the turnaround time by half by using implements mounted on two wheel tractors that are widely available in Bangladesh, decrease crop production costs by 15-20%, reduce irrigation water use by 30% for winter season crops, reduce seed rate by 25%; increase fertilizer efficiencies, increase cropping intensity and diversity, reduce weed infestation and increase crop productivity (by 20% for wheat). These types of equipment need further development and much more support and promotion to allow farmers to access them throughout Bangladesh. See a later section for more information.

Policy planning on wheat research and production:
To improve wheat promotion, several policy level issues should be taken care of by policy makers in the Government of Bangladesh. We propose the following policy level activities to increase wheat production:

- Availability of inputs and credit facilities at proper time
- Declaration of wheat procurement plan and price before planting season
- Strengthening basic and adaptive wheat research program
- Establish a Bangladesh Wheat and Maize Research Institute

Due to increases in production costs (including those for irrigation, fertilizer and labor), farmers are getting insufficient profit to grow crops that require high inputs, such as boro rice, maize and potato. Government has been reluctant to provide extra support with subsidized fertilizers due to local fertilizer production constraints and their import from abroad to meet the demand involves large amounts of local and foreign currency. Proper advocacy steps should be taken on the benefits of wheat promotion with policy planners and donors as wheat is relatively eco-friendly with lower water and other input requirements and similar net profit compared with boro rice.

Scientist exchange program and human resource development:
Human resources are one of the key elements of any organization. Expert visits between WRC and regional and international CIMMYT programs will improve research capacities and technical know-how among the scientists. In the 1980s, scientist exchange programs between CIMMYT and NARS gained momentum but after that such programs reduced due to funding constraints in the CGIAR system and a growing number of competing higher priority activities. This program should be continued with short term and long term training to improve the capabilities of scientists.

Expanding Maize Production

CIMMYT started to provide maize germplasm and maize technical support to Bangladesh in the mid 1970s. The Plant Breeding Division of BARI screened maize germplasm and released several open pollinated and synthetic maize varieties during the 1980s and 1990s. In the 2000s, CIMMYT has been closely involved with facilitating the recent emergence of hybrid maize as an important cereal in Bangladesh. The CIMMYT contribution to maize germplasm currently found on farmers' fields has been less than with wheat, but it has grown quickly in the last few years with the release by BARI of several successful maize hybrids that are based on CIMMYT maize lines (CMLs) and their seed production and marketing by Bangladesh Agricultural Development Corporation (BADC) and local seed companies.

The maize area planted in Bangladesh has risen from just a few thousand ha in 1993-94 to the 2006-07 cropping year when a total of 221,000 ha of maize was planted in Bangladesh (Figure 2). Maize continues to expand rapidly at an average rate of 20% per year. Approximately 1.27 million t maize grain were produced in 2006-07. Most maize is planted and produced in north western and south western districts of Bangladesh. Maize is now challenging wheat to be the second most important cereal crop after rice. A combination of high market demand with ease of production has generated tremendous interest by farmers in maize. Maize is well adapted to the Bangladesh climate and soils, and grain-yields of 8-10 t/ha in a 150-day season are commonly achieved in on-farm demonstrations. The estimated national mean grain yield is 5.7 t/ha, which is among the highest in Asia, and that compares with average on farm grain yields of around 2 t/ha for wheat or 3-4 t/ha with boro rice. Highest grain yields are obtained in north western and south western Bangladesh.

Increased planting of maize is mainly driven by high demand for feed grain from a rapidly expanding poultry industry and also maize grain is widely used in fish feed. Financial returns per ha from Rabi season maize are 2-3 times those of wheat or Boro rice. Other uses of maize are also expanding, including the mixture of maize flour with wheat for flat breads, roast maize cobs, popcorn confectionery, and as cattle fodder. In the Chittagong Hill Tract areas of south east Bangladesh, there is a long history of maize being grown by tribal people for human food. Previous maize research and extension in Bangladesh has been reported to have had a large impact and

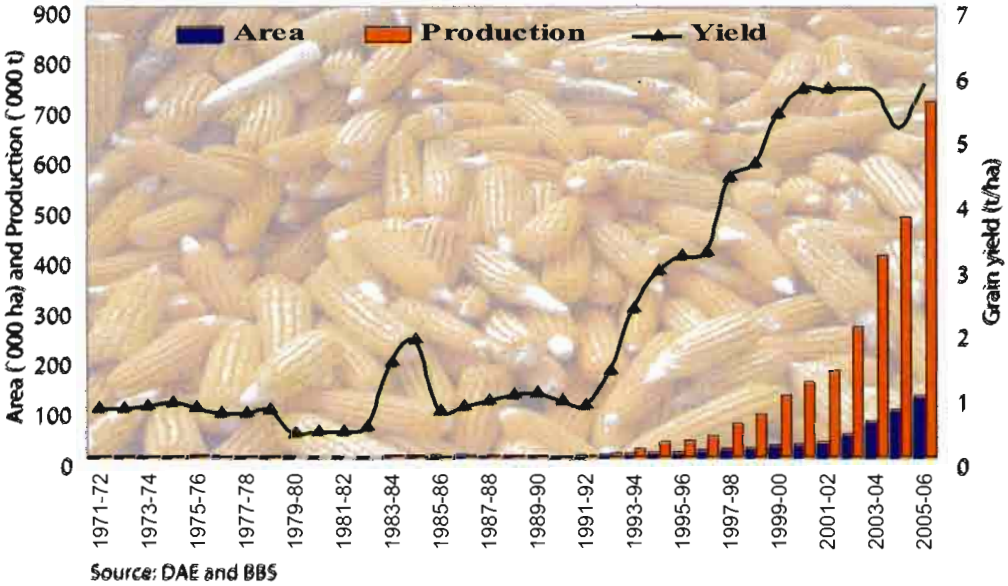

Figure 2. Yearly trends in Bangladesh maize area, production and yield.

there have been recommendations for additional investments in promoting the production and uses of the crop in this country.

Almost all the maize is grown as a high input (hybrid seed, large rates of fertilizer, irrigated) crop during the dry and cool winter Rabi season. Its production is in competition with a wide range of 'dryland' crops including wheat, tuber crops, pulses and vegetables or irrigated Boro rice. Maize is commonly grown in maize-fallow-transplanted monsoon (T. Aman) rice, potato-maize/relay maize-T. Aman rice, or maize/relay jute-T. Aman rice cropping patterns.

Maize Hybrids

In the 1990s and 2000s, CIMMYT made available large amounts of maize germplasm from its HQ-based CIMMYT Global Maize Breeding Programs through the international nurseries and testing program and these were imported and used in Bangladesh. Table 2 summarizes nurseries and trials that came to Bangladesh. The germplasm was used by maize breeders from the Plant Breeding Division of BARI to develop five open pollinated maize varieties and nine maize hybrids that were released for commercial cultivation in Bangladesh (Table 3). Additionally, BRAC has received maize germplasm from CIMMYT for its maize breeding program and has released a hybrid maize variety called Uttoron.

In 2006-07, BADC and seed marketing companies produced 331 t of BARI Hybrid Maize 3 and BARI Hybrid Maize 5 and this covered about 6% of the total maize area. Pacific hybrids covered about 40%, Syngenta (NK 40) 20%, Monsanto 15%, and others about 19%. The area planted to BARI hybrids is expected to increase rapidly as private seed companies begin to market those hybrids.

Table 2. A summary of the types of CIMMYT international maize nurseries and trials provided by CIMMYT to the BARI Plant Breeding Division in the 2000s. Many of these nurseries and trials have been supplied for multiple years.

Nursery or Trial Abbreviation	Description
CHTTW	Elite tropical late white normal and QPM hybrid trial
CHTTY	Elite tropical late yellow normal and QPM hybrid trial
SA14-HY	Tropical late yellow hybrid trial
CHTTY-A	Tropical yellow normal and QPM hybrid
TTWSCWL	Advanced tropical three-way and single crosses white normal and QPM late
TTWSCYL	Advanced tropical three-way and single crosses yellow normal and QPM late
TTWSCYL-A	Tropical three way and single cross yellow late normal and QPM trial
EVT 13Q	Tropical late yellow QPM synthetic
EVT 13	Tropical late yellow normal variety
CHTTWQ	Tropical white QPM
CHTSY	Sub tropical yellow
CHTHIY	
TTWCEY	
CHTTEY	
CHTSYQ	
CHTSY	
CHTTWQ	

Future Impacts with Maize

There is great potential for further impacts with maize. In 2005-06, local maize production met only around 40-50% of current demand (of over 1.3 million t grain per year). The remaining maize grain is imported, yet domestic production is very competitive with the imports (more so than for wheat). The present national requirement of maize for poultry feed alone is about 1.2 million t per year. Policy makers are now talking about maize areas of over 300,000 ha being likely in Bangladesh. There are about 2.8 million ha of land that is potentially suitable for maize cultivation in the country. There is potential for maize to be grown more widely during the pre-monsoon Kharif-1 (where competition from other crops is less intense) in many parts of the country and even during the monsoon (Kharif-2) season on shallow slope hillsides in the Chittagong Hill Tract areas. Maize is also likely to become more attractive because of problems with alternative Rabi/Kharif-1 cereal crops; particularly power and water shortages and arsenic contamination for Boro rice and the often low achieved yield of wheat.

Table 3. BARI maize hybrids and their parents. CML = CIMMYT Maize Line.

Name of the hybrid	Type of hybrid	Parents
BARI hybrid maize 1	3 way cross hybrid	(Ki32 X Ki 31) Ki 42
BARI hybrid maize 2	Single cross hybrid	CML 287 X CML 298
BARI hybrid maize 3	Single cross hybrid	CML 285 X CML 287
BARI hybrid maize 4	Top cross hybrid	BML 1 X Barnali
BARI hybrid maize 5	Single cross hybrid	CML 161 X CML 165
BARI hybrid maize 6	Single cross hybrid	CML 431 X CML 486
BARI hybrid maize 7	3 way cross hybrid	(CML 431 X CML 486) XCLO 2450

Farm Mechanization and Conservation Agriculture

Small Scale Farm Machinery

To intensify (i.e. plant crops more quickly and harvest on time) the existing rice-wheat cropping systems and to conserve agricultural resources, since 1995 CIMMYT and the WRC of BARI have developed and promoted a wide range of small-scale farm equipment that can be mounted on diesel-engine two-wheel tractors (called the Bangladesh Hand Tractor, BHT, although they are usually imported from China). Much of the equipment was initially developed for wheat.

Figure 3: A wheat crop planted by PTOS in Bangladesh.

Farm mechanization and resource conservation technologies were developed and tested through collaborative adaptive research programs with BARI, BRRI, several universities, NGOs and with farmers. These included a multi-crop seed drill, power-tiller-operated bed planter with universal tool bar frame, seed-drill-operated bed planter for permanent soil beds, strip till seed drill, zero till seed and fertilizer drill, cone type seed-drill-operated bed planter, high speed rotovator, rice-wheat reaper, rice-wheat thresher, maize sheller, mobile pump for irrigation, winnowers, and 4 m boom sprayers.

Various forms of small-scale conservation agriculture planting machinery are now available in small numbers, including a minimum till power-tiller-operated-seeder (PTOS) for planting wheat, jute and pulses that is mounted behind a 2-wheel tractor, soil bed planters and zero tillage planters. Larger numbers of rice-wheat threshers, maize shellers and high speed rotavators are available from the program.

Over 400 items of farm machinery were procured and demonstrated through a researcher-extensionist-farmer participatory demonstration and use program. Many tillage and crop establishment demonstrations and training events

Figure 4: Photographs of a self-propelled reaper (left), and the reaper in operation (right)

were conducted in various places in Bangladesh. 763 persons were trained in the CIMMYT machinery programs on the repair, operation and maintenance of the farm machinery. These helped more than 63,425 farmers bring 33,577 ha of various crops under farm mechanization.

CIMMYT Office in Bangladesh developed groups of interested farmers as small-farm-machinery-service-providers. These and their client farmers have received substantial benefits from this equipment. The Power-Tiller-Operated-Seeder (PTOS) has proved especially beneficial and popular with the farmers. About 350 PTOS are currently operating in Bangladesh from this program, preparing around 28,000 ha of land each year. Benefits have included a reduction in crop turn-around-time of about 50% allowing increased cropping intensity and diversity, 15-20% reduced crop production cost, 30% less irrigation water use for winter season crops, 25% reduced seed rate, increased fertilizer use efficiencies, reduced weed infestations by up to 80%, and increased crop productivity by up to 20% when growing wheat. Specifically, in 2007 the cost of planting 1 ha of wheat by PTOS was Tk 1553 compared with Tk 3180 using the conventional system. With maize the costs were Tk 3053 compared with Tk 6940. By providing planting and other services to neighboring farmers, the PTOS service-providers recovered their investment very quickly (within one to two crop seasons) and paid back their loans. One operator can get a net benefit of US$ 1,000-2,000 per year using this farm machinery. Each farmer-service provider is able to help 20 to 100 other farmers by providing them these tillage-planting services. The livelihoods and socio-economic status of the many farmers that received these machinery services has improved, natural resources have been conserved, and access to inter-institutional networks established, bringing together government organizations, NGOs and the private sector.

CIMMYT's work has successfully created far greater awareness on the benefits of small-scale farm mechanization in Bangladesh and there has been tremendous interest by farmers. Elements of a network have been built among the farmers and service providers, several small farm machinery marketing companies, some very small local machinery manufacturers, and research and extension organizations in 25 districts of Bangladesh. Access to interest-free loans has been facilitated, along with free training and advice from government agencies to farmers to access machinery. Repayment rates and timings in these pilot schemes have been excellent. In the last 2-3 years, at least one importer and distributor of the equipment, Green Machinery Stores, has now successfully arranged commercial loans for farmers to get planters. Thus the components for the sustainable introduction of such farm machinery on a commercial basis have been put in place in Bangladesh. The strong stakeholder partnerships needed to take this forward may best be brought together through the concept of Farm

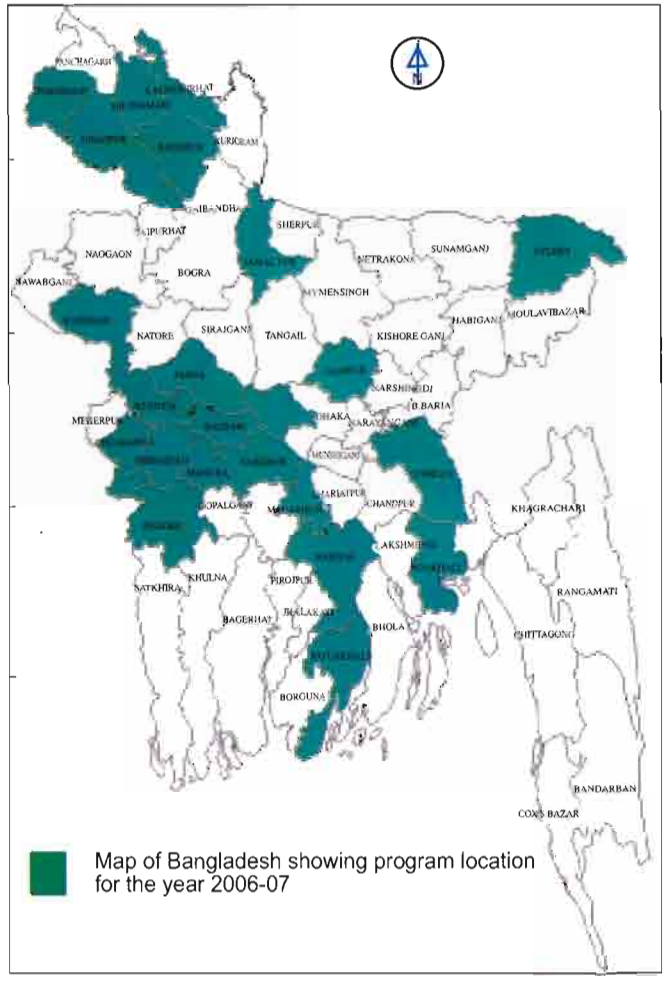

Figure 5: Map of districts where CIMMYT has promoted small-scale farm machinery in Bangladesh

Machinery Support Hubs for several selected districts where interest and needs are strongest. CIMMYT and BARI are well placed to help if resources can be found.

Conservation Agriculture Systems for Rice-Wheat-Maize Systems

Evidence of some longer-term productivity, intensification and sustainability benefits from permanent soil beds with crop residue management is emerging in Bangladesh. A 4-yr Wheat Research Centre (WRC)-Cornell-CIMMYT study at WRC Nashipur, Dinajpur compared the effects of permanent raised soil beds vs. conventional till on the flat in combination with straw retention and N fertilizer, in a wheat-maize-monsoon (Aman) rice cropping system.

The combination of permanent beds and 50-100% straw retention produced the highest grain yields for all three crops (wheat-maize-rice) in the sequence, giving the maximum grain yields of 11 to 21 t ha-1 per year compared with 7 to 15 t ha-1 for conventional tillage without straw retention. Straw retention was confirmed as an important component of soil restorative management, helping reduce soil moisture depletion and weed pressure and increasing N uptake. Soil organic matter in surface soil layers rose by 13-41% after four years when straw was retained with permanent beds and there were indications that N fertilizer application rates can be reduced when straw is retained. These benefits from straw retention with soil beds were established quickly; within 2-3 years.

Compared with conventional tillage on flat soil, the combination of permanent raised soil beds with retention of crop residues appears to be a promising technology to intensify in a sustainable way the wheat-maize-rice systems in Bangladesh. More work is required on farm to verify benefits, assess the practicality of the technologies under those conditions, and make adjustments before soil bed-residue retention systems are vigorously promoted. CIMMYT could help do that.

Resource Conserving Technology from the Rice-Wheat Consortium

In South Asia, CIMMYT has been well known for convening the Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plain (IGP), which includes Bangladesh as a member country, along with Pakistan, Nepal and India. The CIMMYT Office in Bangladesh has been, since the initiation of RWC-IGP, an active research and technology development partner as well as an efficient facilitator. It has been involved in planning exercises, financial management, and national and international liaison work contributing to the smooth functioning of the RW Consortium. CIMMYT in Bangladesh assisted the RWC-IGP Coordinator based in New Delhi, with international liaison and networking, organization and facilitation of national and international training, workshops and conferences. Resource conservation research and promotion initiatives of the Rice-Wheat Consortium in Bangladesh have included the leaf color chart for N fertilizer scheduling with rice, reduced and zero tillage equipment for planting wheat, and direct dry seeding of rice.

Bangladesh Country Almanac

CIMMYT has fostered the exchange of information about methodologies, practices and technologies related to wheat- and maize-based farming systems in Bangladesh through the development of web pages and innovative training materials, a wide range of scientific publications, and also the Bangladesh Country Almanac (BCA) from 2002 to 2006.

Bangladesh Country Almanac version 3.0 (Figure 8) was released in April 2006 to work with the powerful GIS based software AWhere-ACT 3.7.52. BCA 3.0 is the largest offline CD-based database in Bangladesh consisting of both spatial and attribute data on climate, land and soils, crops, demography, hydrography, irrigation, infrastructure, health, education, marketing, livestock, forestry, fisheries, and poverty. This final version of BCA was the result of five years of work by numerous organizations in Bangladesh.

Union and Mouza-based data and map information covering land and soil, growth center, socio-economic information, risk factors and other attributes were produced. BCA completed information on 129 Thana Nirdeshika in digital format and subsequently produced the complete 64-district national database. Land form, physiography, land type, land use, flood risk, drought, salinity, constraint areas, nutrition status and other attributes were updated and released. Fifty-eight crop and cropping pattern suitability maps were produced and released. To create awareness among users, many dissemination and training workshops were organized in recent years. The workshops enabled users to learn the basic functions of the BCA and encouraged them to apply BCA tools with their own databases to prepare maps and extract useful information. Over 2300 people throughout Bangladesh, representing government organizations, universities, NGO's, and private sector, have been exposed to and trained on BCA in training and dissemination workshops.

The BCA was developed and promoted in partnership with BARC as a user-friendly GIS tool for agricultural research and development and natural resource management to improve the access of diverse stakeholders to tools and data for spatial analysis.

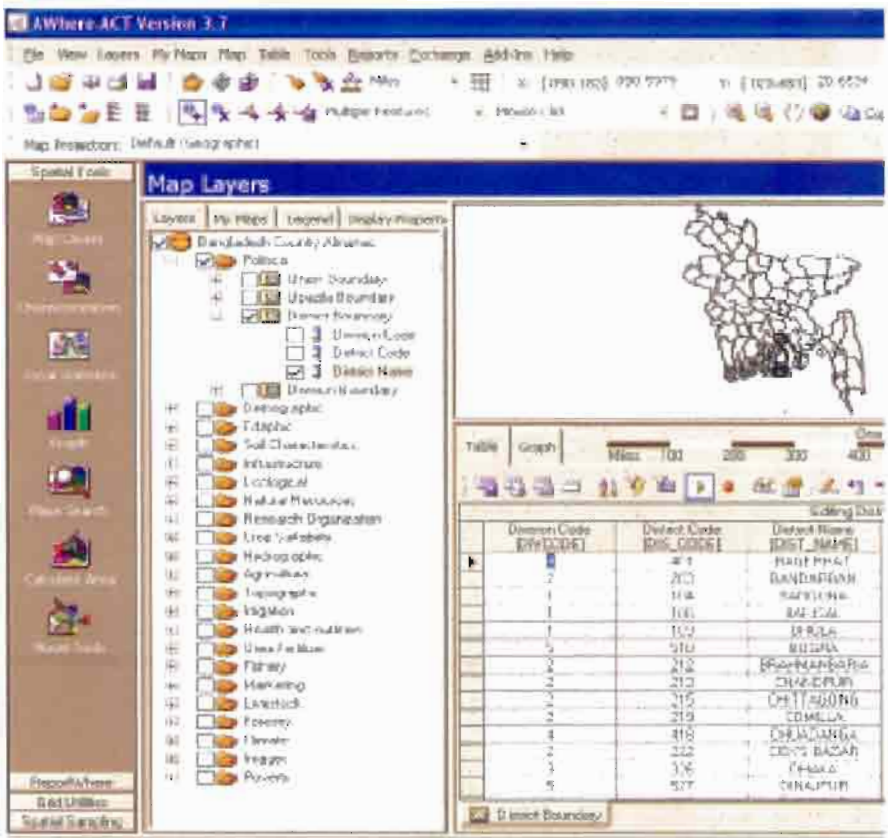

Figure 6: A sample layer of the Bangladesh Country Almanac BCA

Fodders and Dairying

To increase the availability of quality fodder and income benefits for small-scale dairy farmers and poultry producers, CIMMYT led work to promote dual-purpose fodder + grain triticale and maize fodders for small holder dairying during the winter lean seasons in several districts of north west Bangladesh from 2005 to 2007. Partners included the Bangladesh Livestock Research Institute (BLRI), BARI, and the Department of Livestock Services (DLS). During the 2005-06 Rabi and Kharif-1 seasons, the program worked in four selected districts (Rangpur, Joypurhat, Pabna and Sirajgonj), with 54 farm families in each district. This was expanded to six districts in 2006-07.

Whole family training materials on triticale and maize were prepared and three thousand copies of each manual printed for use in the training and for wider distribution. Videos of triticale production and utilization were made and telecasted and a high quality "Docu Drama" produced and used. Whole-family training on Triticale Production and Utilization took place during October and November with 168 farm families in four districts in 2005 and with 342 new farm families in six districts in 2006.

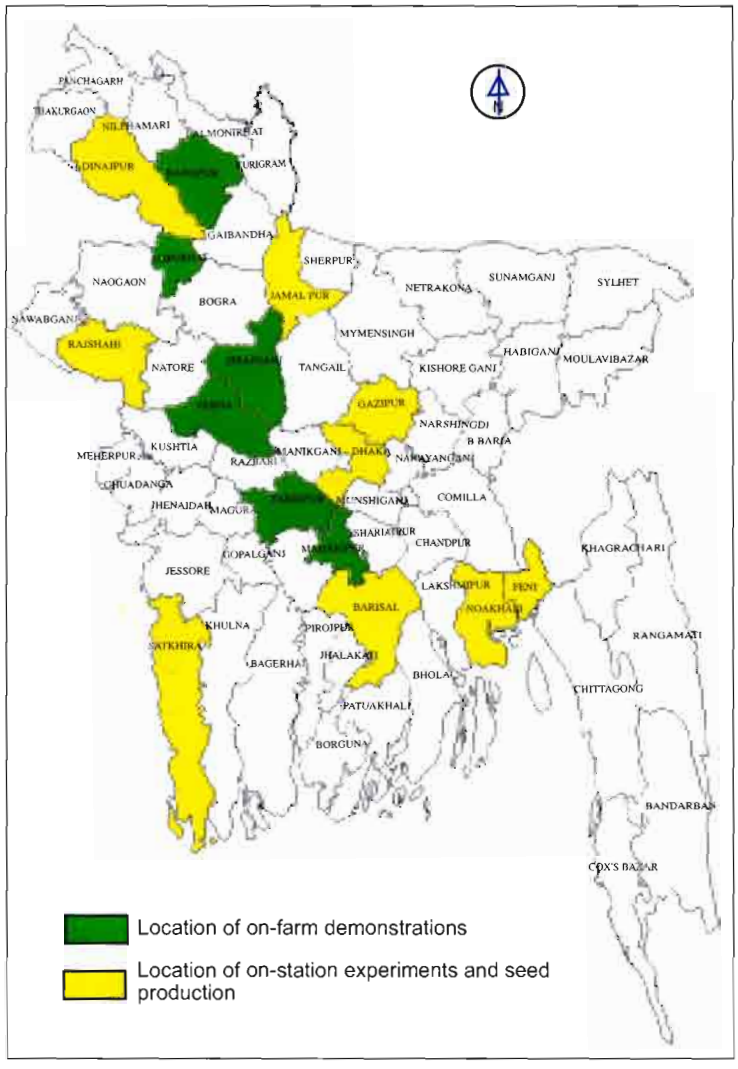

Figure 7: Map of Bangladesh showing districts where CIMMYT-related triticale and maize fodder promotion and research work was conducted, 2005-2007.

504 farm-families hosted an on-farm triticale demonstration in 2005-06 or 2006-07. All host families cut triticale as green fodder from their demonstrations once or twice and fed it to their cows from December to February each year. Triticale fodder yields of between 7 and 28 t/ha fresh mass were measured on farm in 2005-06 and 12 to 42 t/ha were harvested in 2006-07.

Average grain yields of 1.8 t/ha in 2005-06 and 2.8 t/ha in 2006-07 were recorded from crops that re-grew after cutting for green fodder. Straw yields of up to 7.1 t/ha were measured. Farmers were very interested in the triticale fodders and regularly mentioned benefits to their cows and increased milk production. Many farmers reported 30-100% increased milk yields during December 2005-February 2006 while feeding the triticale fodder.

A benefits survey in 2007 found:

- Dual-purpose triticale is a relatively simple technology that fits existing cropping systems in NW Bangladesh. It is often planted on otherwise fallow land. Participating farmers quickly showed high knowledge and skills on triticale production and utilization.
- Farmers observed increased milk yields (averaging 25%), reduced use and costs of concentrate feed, had increased their allocation of land for fodder production, made changes in the pattern and intensity of cropping, and increased their cash income. There were also indications of improved milk quality and cattle health.
- Costs of production for dual-purpose triticale were similar to those for wheat and maize, but higher than lentil.
- Dual-purpose triticale for fodder and grain had the highest gross return of several enterprise options studied.
- Dual-purpose triticale increased the profitability of small farms with a few cows. A farm can earn extra net farm income of Taka 3400 with two dairy cows for 30 days.
- The farmer drop-out rate from growing triticale (about 40%) was a concern and appears related to the tedium of producing triticale fodder and shortages of seed. Seed shortage also prevents many other farmers from using the technology.
- Overall, triticale fodder appears a useful and profitable technology that is raising the incomes and livelihoods of small scale dairy farmers in the project areas.
- A prototype diesel-engine-operated low-cost and mobile straw chopper was developed in 2006. Now manufactured, 25 have been sold by the Modern Engineering Workshop, Saidpur.
- The study concluded that the increased promotion and production of dual-purpose triticale will be very beneficial for smallholder dairying in Bangladesh.

Figure 8: A young farmer harvesting triticale fodder for cattle

Arsenic in Agricultural Systems

From 2002 through 2005, CIMMYT was a partner in a multi-organization project led by Cornell University on the Impact of Arsenic (As) Contamination on Agricultural Sustainability and Food Quality in Bangladesh.

Project outcomes and impacts included:

- Established the capability of the BARI-CIMMYT-Cornell Laboratory for As analysis which will continue to allow Bangladesh NARS scientists to conduct research on As contamination of agriculture and food and develop As management technologies.

Note: The man at the upper right hand side of the diagram is from a village of Faridpur, a badly arsenic affected district in central Bangladesh. High arsenic in the rice grain and also in drinking water was found. This man had "the arsenic disease" the symptoms of which is shown in the diagram.

systematic survey during indicated a buildup of s in soils and high s accumulation in rice grains in many of the parts of Bangladesh where wetland transplanted Boro rice irrigated winter rice has been grown each year for years with scharged irrigation water pumped out by shallow tube wells.

rsenic in soils was found to be mgkg and that in rice grains .. mgkg in some areas of the angetic Floodplain in central and south western Bangladesh. nitial assessments for wheat and maie showed much lower amounts in their grain.

High s in the irrigation watersoil environment is reducing the growth and yield of rice and wheat alarming for Bangladesh with an ever increasing demand for these staple food grains. ork in farmers fields with varying soil s levels in Faridpur in showed Boro rice yield was drastically reduced from . tha to . tha as the soil s level increased from to mgkg where the T irrigation water s concentration was . mg.

Thus irrigation with contaminated shallow tube wells year after year is leading to s accumulation in the soils which is resulting in elevated levels of this toic element in crops, especially rice, the staple food crop, and in reduced crop yields. This poses public health and food security risks that are additional to that of highs drinking water in many areas of Bangladesh.

Nonflooded dryland crops like maie and wheat may be good alternatives to Boro rice in an s management strategy because they grow in an aerobic environment where s becomes less bioavailable than with Boro rice and where less irrigation water is needed.

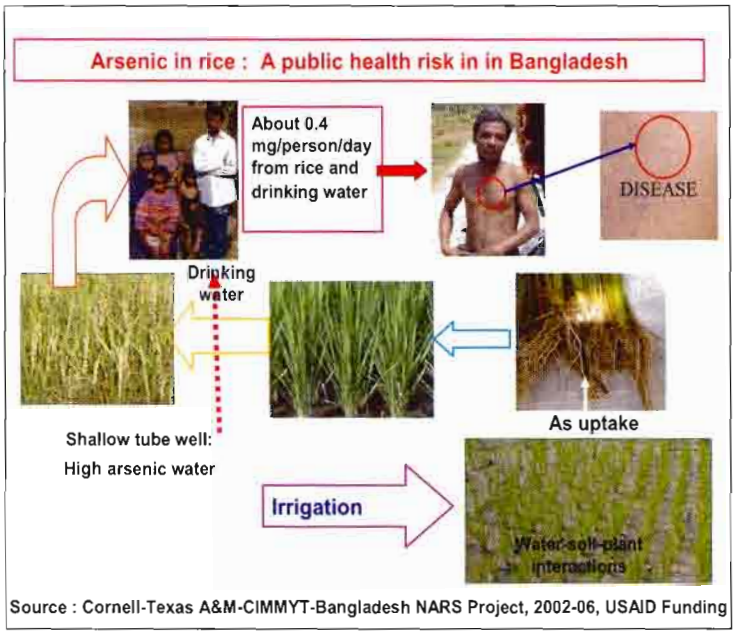

Figure 9: Arsenic in the food chain and its affect on humans

Scientist and Farmer Training

Scientific Capacity Building

CIMMYT has a long and successful record of accomplishment on training to develop the capacity of wheat and maize scientists, extensionists and farmers in Bangladesh. About 750 scientists were exchanged between the 1970s and 2000s, including with CIMMYT HQ in Mexico, as visiting scientists, conference participants and international trainees (see Table 4 for a summary of many of these).

A total of 141 Bangladeshi wheat and maize scientists were trained in Mexico on various topics as follows:

- Wheat improvement (breeding, agronomy, pathology, cereal technology, experiment station management, economics, advanced wheat improvement and resource conserving technology)
- Maize improvement (breeding, agronomy, pathology, economics, advanced maize improvement and resource conserving technology)
- Wheat scientists' analytical capacity improved through training on various statistical packages.
- Improved NARS scientist capability on computer use.
- Wheat and maize breeding and agronomy training at CIMMYT HQ was very popular in the 1970s, 1980s and 1990s, but opportunities have declined in the 2000s as funding (and perhaps the need) has diminished.
- CIMMYT arranged seven on-farm wheat survey and team building events with all Bangladesh wheat scientists.
- In relation to human resource development for the arsenic program, hands-on training on water, soil and plant sampling techniques and As analytical methodologies was provided to 15 staff of Bangladesh partner institutions. Four scientists were sponsored for PhD degree programs. Additionally, 55 Bangladeshi scientists participated in seven international symposia or conferences abroad and in Bangladesh between 2002 and 2006.
- With on farm machinery, CIMMYT organized traveling seminars where scientists, agricultural machinery manufacturers and marketers, farmers, extensionists and farmers with rice-wheat systems participated and exchanged knowledge related to farm machinery and resource conserving technologies. 28 NARS scientists were sent abroad on training events, on travelling seminars or presented papers at international conferences from 2002 to 2007.

CIMMYT started its human resource development program for Bangladeshi wheat and maize scientists in 1969 with the first trainee, Dr. Sufi M. Ahmed. After returning from CIMMYT HQ Mexico, Dr. Ahmed initiated a wheat breeding program by grouping parents on the basis of different traits in the crossing block as used in CIMMYT Mexico. Agronomic experiments for wheat cultivation were also conducted to develop and recommend wheat production practices. Under his leadership, four scientists, Drs. M.A. Razzaque, A.B.S. Hossain and Mainual Haque, along with Dr. Sufi, were awarded a Gold Medal in 1979 for outstanding contributions in the field of wheat research in Bangladesh. Dr. Sufi was also awarded a President Silver Medal in 1982.

Dr. Sufi is called "The Father of Wheat in Bangladesh" for his dedicated groundwork. The nucleus of scientists trained at CIMMYT led the highly respected wheat program in Bangladesh and later on more young scientists were trained and joined the program. Some of them became the Directors and Director General of Bangladesh Agricultural Research Institute.

Many other crop breeding programs of BARI and NARS institutes follow the approach used by the BARI wheat breeding program using CIMMYT methods.

- For the Bangladesh Country Almanac (BCA), over 2300 people throughout Bangladesh, representing government organizations, universities, NGO's, development partners and the private sector, have been exposed to and trained on BCA through training and dissemination workshops. Five members of the BCA team visited Cornell University, USA for higher level training on the software and database and to gather information from Country Almanac users in other countries.

Table 4. Bangladesh participants in various types of short and long term capacity building events overseas (Mexico, India, Australia, S. Africa, China, Philippines, Vietnam, Thailand, Nepal, Pakistan, etc) sponsored by CIMMYT from June 1973 to March 2007.

Type of Event	No. of participants
Wheat or maize conference or congress	30
Exchange visit to wheat or maize program	14
Wheat or maize meeting, visit or workshop	184
Wheat review workshop	23
Wheat, maize, RCT or fodder seminar/symposia	28
Short-term wheat training	87
Short-term maize training	27
Short-term bed planting and zero tillage	5
Short-term other training	8
Travelling seminar	16
Visiting scientists	31
Total:	**453**

Whole Family Farmer Training

The CIMMYT Office in Bangladesh and WRC of BARI can be credited with a major innovation in the training of farmers in wheat and maize production in Bangladesh. This is the development and use of the concept of 'Whole Family Training' (WFT) for the promotion of wheat, maize and other technologies. In collaboration with the country's wheat and maize scientists, between 1994 and 2006 CIMMYT trained more than 30,000 farm families in modern wheat and maize production techniques, the production and utilization of fodders, and various other practices, using the WFT approach. This has had a big positive impact on wheat and maize production.

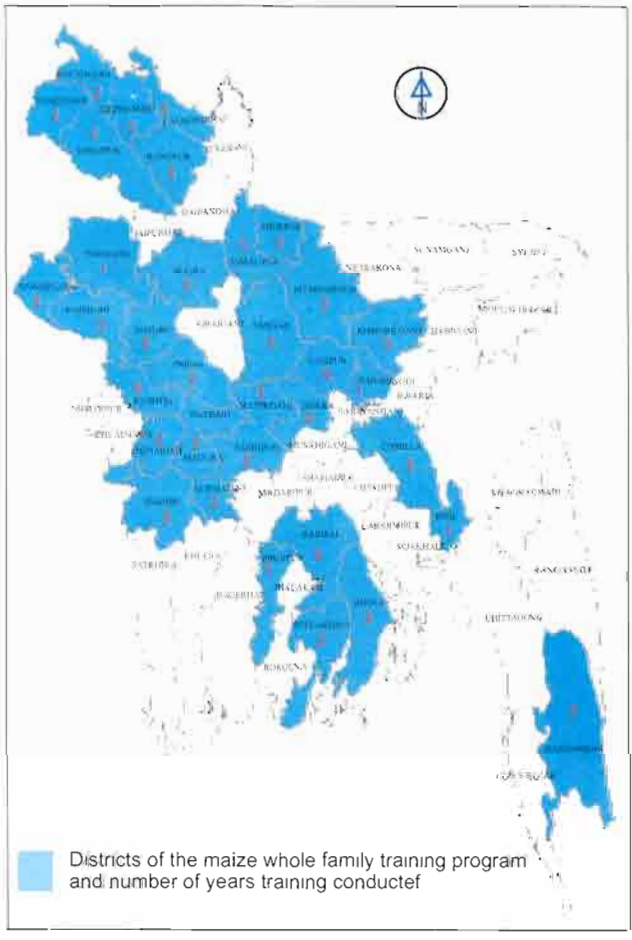

Figure 10: Map of Bangladesh showing districts where CIMMYT-related maize whole family training (MWFT) was conducted, 2002-2007. Numbers in red indicate the number of years that MWFT was conducted in that district.

The WFT approach is highly participatory (using the farm family as its target for training), it is gender unbiased (incorporating up to two adult males and two adult females who are actively engaged in agriculture per family) and it is cost effective. CIMMYT and WRC pioneered the WFT approach to show farm families how to successfully grow wheat. About 16000 families were trained on modern wheat production between 1995 and 2005.

Proof that WFT was useful came through an AusAID pilot project (during 1996-1998) in which 98% of the trained families adopted 95% of a range of wheat production and seed preservation technologies. Follow-up studies showed that they retained the technologies and methods. Wheat productivity increased by 30% with WFT families compared with that by untrained families. WFT was a major contributor to the large increases in wheat area and production that Bangladesh achieved during the second part of the 1990s. An important part of the success of WFT was the development and use of visual printed and video training materials that feature technical information on technologies and practices presented in ways that farmers can understand and relate to.

Figure 11: A Whole Family Training Session

USAID then supported four years of WFT for maize promotion. WFT was modified for maize production training and around 11000 farm families were trained from 2001 to 2006 on modern methods of producing maize. The maize WFT program has had a substantial impact on modern maize cultivation practices, and on the promotion and increased production of maize in the mid 2000s in Bangladesh. Training took place in 35 districts in Bangladesh and was again supported by a range of innovative printed and audio-visual electronic training materials. Most recently, to promote dual-purpose triticale and maize fodder for small-scale dairy farmers, around 700 farmers received WFT between 2005 and 2007 in a CIMMYT project funded by DANIDA.

Whole-family-trained farmers produced high yielding (6-10 t grain/ha) maize crops planted on about 0.09 ha more land per farm and obtained an average 0.8 t more grain yield per ha than those without training, which contributed to improved livelihoods. Trained farmers were more likely to have planted their maize in the optimal time period, applied more NPK fertilizer and compost, irrigated more frequently, and adopted optimal plant spatial arrangements and cropping patterns. They had also a better appreciation of production problems encountered with maize and the expected financial returns from maize.

Based on these successes, Winrock International, the Department of Agriculture Extension (DAE) and the World Fish Centre have also adopted the approach. Thus the WFT concept and program has proven to be very successful in Bangladesh for the promotion and adoption of productive wheat and maize technologies.

Major Publications

Publications and other items about CIMMYT work with partners in Bangladesh are maintained on the CIMMYT Office in Bangladesh website at: http://www.cimmyt.org/bangladesh/Programs/

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