Food Security in Bangladesh:
Improving Wheat, Maize and Papaya Production and Impacts of Arsenic Contamination

July 2005-June 2006

Annual Report

USAID Grant No: 388-G-00-02-00070-00

Submitted by
International Maize and Wheat Improvement Center (CIMMYT)
August 2006

USAID FROM THE AMERICAN PEOPLE

CIMMYT

Table of Contents

	Page
Table of Contents	i
Introduction	1
Executive Summary	2
1. Facilitation and Promotion for Adoption of Mechanization by Growers	6
1.1 Equipment Procurement and Distribution	6
1.2 Equipment Usage and Area Coverage	7
1.3 Research on Bangladesh Hand Tractor (BHT) Equipment	8
Experiment 1: Modification and improvement of power tiller operated bed planter	8
Experiment 2: Improvement of power tiller operated zero tillage planters	9
Experiment 3: Accelerate and popularize use of RCT machinery by small land holders of Bangladesh	10
Experiment 4: Adaptation of high speed rotary tiller for dry land cultivation	12
1.4 Training	13
1.5 Field Days	13
1.6 Sustainability of PTOS	13
2. GIS-Bangladesh Country Almanac (BCA): A User Friendly GIS Tool for Agricultural and Natural Resource Management	14
2.1 Technical Implementation Committee (TIC)	14
2.2 Release of BCA V3.0	15
2.3 AWhere-ACT Software version 3.7.52	15
2.4 Database Development and Upgrading	15
2.5 Software License	19
2.6 Dissemination and Training Workshops organized in different locations from July 2005-June 2006	19
2.6.a One-day Dissemination Workshops	20
2.6.b Two-day Training Workshops	22
2.7 Some Achievements and Applications of BCA during 2005-06	30

Page

3. Whole Family Training in Maize 31

3.1 Introduction 31

3.2 Whole Family Training (WFT) 31

3.3 Distribution of Training Materials and Seeds 32

3.4 Training Assessment on Maize Cultivation Knowledge 33

3.4.a Area under maize cultivation 33

3.4.b Planting time 34

3.4.c Irrigation of maize 34

3.4.d Fertilizer in maize 35

3.4.e Maize based cropping patterns 35

3.5 Research and Demonstration Results for 2005 - 06 35

3.5.a Hybrid variety demonstrations 35

i) Variety demonstrations by OFRD of BARI 35

ii) Variety demonstrations by DAE 36

iii) Variety demonstrations by Winrock International 37

iv) Variety demonstrations by BRAC 37

3.5.b Planting time effect on the yield of hybrid maize 37

3.5.c Synchronization of N application to maize growth stage 38

3.5.d Development of potential maize based intercropping systems 38

3.5.e Development of maize + potato intercropping system 39

3.5.f Seed production of BARI hybrid maize 39

3.5.g Tolerance of BARI hybrid maize varieties to variable population densities 40

3.5.h Productivity of recycled seeds (F_2) of different hybrids compared to F_1 seeds 40

3.5.i Evaluation of imported maize hybrids 41

3.6 Maize Germplasm Importation and Distribution 41

3.7 Expansion of Whole Family Training Concept 42

3.8 Scientist Exchange and Visit Program 42

3.9 Field Days 42

3.10 High Officials Visit Maize Fields 43

4. Development of Ring Spot Virus Resistant Transgenic Papaya for Bangladesh 45

4.1 Activities Performed in 2005-06 45

Page

4.1.a Work on regulatory and bio-safety guidelines 46

4.1.b Transformation of Bangladeshi strains at USDA, Hawaii 46

4.1.c Engineer coat protein (CP) gene of Bangladeshi strains to develop transgenic plants at Hawaii 46

4.1.d Development of transgenic papaya plants and their multiplication through tissue culture and establishment of plantlets at USDA 47

4.1.e Testing of transgenic lines at USDA/ BARI 47

4.2 Variety 48

4.3 Transgenic Variety Development 48

4.4 Ph.D Research Work in Collaboration with Cornell University 48

Financial Report 50

Introduction

From July 2005 to June 2006, the CIMMYT Office in Bangladesh and its local and international partners continued to implement several parts of the USAID-funded project entitled "Food Security in Bangladesh: Improving Wheat, Maize and Papaya Production, and Impacts of Arsenic Contamination". The goal of the project is the "Enhancement of food production in Bangladesh through improving efficiency and profitability in crop production and sustainable use of natural resources".

CIMMYT has been implementing the project in cooperation with national and international agricultural research and educational institutions including leading institutions of the National Agricultural Research System (NARS), universities, NGO's, private entrepreneurs and farmer groups in Bangladesh, and Cornell University and Texas A and M University of the USA.

The project has received financial assistance from USAID since July 2002. However, in 2004 and 2005, reduced funding necessitated a reduction in the size and scope of our program from its original eight components.

During 2005-06, we deployed remaining funds onto the following four components that are most likely to achieve the project goal and maximum impact:

1. Facilitation and Promotion for Adoption of Mechanization by Growers
2. GIS-Bangladesh Country Almanac
3. Whole Family Training in Maize
4. Papaya Improvement Through Viral Disease Resistance

Additionally, some work covering Impacts of Arsenic Contamination on Agricultural Sustainability and Food Quality continued in 2005-06 with alternative funding.

Highlights of the work from July 2005 to June 2006 are given in the Executive Summary. The following chapters give more detailed information about the work undertaken and completed during 2005-06 and the benefits it is having in Bangladesh.

CIMMYT and its partners are very grateful to USAID for the substantial financial support received during 2005-06. We look forward to completing the remaining components of the project into 2007 and developing new work.

Stephen R. Waddington
Regional Agronomist
CIMMYT Office in Bangladesh
Dhaka, August 2006

Executive Summary of Progress and Achievements

a) Facilitation and promotion for adoption of mechanization by growers

Increasing shortage of animal draft power and human labor for farming operations, and the need for reducing the turnaround time between wet season rice and the following wheat or other non-rice crops, necessitated we initiate an agricultural machinery development, promotion and adoption program. The major objectives of the program are intensification and diversification of the existing cropping systems and conservation of agricultural resources for sustainable productivity and livelihood improvement. The program continued through 2005-06 with the following progress made:

- A total of 8,394 hectares of land were brought under the mechanization program with 5,000 hectares cultivated by power tillers for various crops. Wheat and maize accounted for 15% of this area. More than 15,000 farmers used a range of Bangladesh Hand Tractor (BHT) accessories for different crop production activities.
- New diesel-engine operated BHT equipment was developed which included a reaper, bed planter, zero tillage equipment, high speed rotovator, thresher and maize sheller.
- Fifty power tiller operated seeders were procured and distributed to different stakeholders.
- A total of 0.8 hectare of land was planted with direct seeded *boro* rice using a modified Power Tiller Operated Seeder (PTOS) in an on-farm experiment. With this method, yields were similar to transplanted rice, but substantial savings of irrigation water and labor were made.
- One hundred and fourteen participants including farmers, NGO workers, private sector staff, and research organizations received in-service training on i) Power tiller operation and maintenance, ii) Multiple seed drill operation and maintenance, iii) Multi-crop reaper operation and maintenance, iv) Bed planting/formation, and v) other agricultural accessories.
- Five field days were organized on the establishment of wheat, jute, onion, sesame and potato in five locations. More than 600 persons from multiple disciplines participated in the field days.

Hundreds of farmers are interested to buy a PTOS for the 2006-07 Rabi season. A private entrepreneur, Green Machinery Stores, has agreed to import and sell the agricultural equipment to farmers on a credit basis with technical help from BARI and CIMMYT.

b) Bangladesh Country Almanac (BCA)

The Bangladesh Country Almanac (BCA) is a user-friendly spatial database for Bangladesh locations within licensed mapping software AWhere-ACT from a US-based software firm, Mud Springs Geographers, Inc. The BCA project is

implemented through the Bangladesh Agricultural Research Council (BARC), Soil Resource Development Institute (SRDI) and Bangladesh Rice Research Institute (BRRI). Some key activities and achievements during this report period are described below:

- Bangladesh Country Almanac version 3.0 (BCA V3.0) with the database driving software called AWhere-ACT 3.7.52 was released. This version comes with an upgraded, updated and new spatial and non-spatial database.
- Four one-day dissemination workshops and eight two-day training workshops were organized. A total of 385 participants attended the dissemination workshops and 308 participants attended the training workshops.
- One of the minigrant outputs "*Identification of Potential Extrapolation Domain for Photosensitive MV T. Aman*" has been used to prepare the National Action Plan designed to increase agricultural production of Bangladesh by 20% by the year 2009.
- Soil Resource Development Institute (SRDI) officially decided to use BCA as a platform to deliver data from field locations to its HQ.
- Department of Agricultural Extension (DAE) agreed to change its block concept to match the administrative boundary for collection of agricultural information. This has removed the limitations in integrating data from other sources for use in development planning, particularly at the local level that resulted from the dissemination workshops at DAE.
- BCA is being used as an analytical tool of spatial data in assignments given to postgraduate students at Bangladesh Agricultural University (BAU), Chittagong University and BSMRAU.
- BAU has developed a GIS course where BCA is the major course component.

c) Whole family training (WFT) in maize

As demand for maize grain increases from the poultry industry in Bangladesh, farmers are interested to grow more maize. We have continued to train farmers on modern maize practices. Additionally, several research and other capacity development activities were initiated to intensify and diversify maize cultivation. Brief activities and achievements during 2005-06 are given below:

Whole family training

- About 2000 farm families (four members in each family) were trained at 29 locations in Bangladesh.
- An updated training manual was distributed to the 2000 WFT families, to 250 trainers of the trainees, and to other stakeholders.
- Poster and video on modern maize cultivation demonstrated in each training session.

- One hundred eighty two farmers were interviewed twice, once before training and again after harvesting maize to assess the improvement of farmers with maize cultivation knowledge after the maize whole family training. Survey results showed that maize area increased by 48.4% and yield increased by 18.1% after whole family training.

Research and demonstration

- Several hybrid variety demonstrations of BHM-2, BHM-3 and BHM-5 were set up in farmers' fields in different locations by the OFRD of BARI, DAE and Winrock International. Different yields were found over environments for different varieties.
- On-farm experiments showed that a significant yield reduction of BARI hybrid maize varieties occurred when late planted. Also, BHM-3 yielded better than BHM-2, BHM-5 and Pacific-11 hybrids.
- Research on the synchronization of N application to maize growth stage showed that urea application of 50% as basal + 50% at 8 leaf stage or 30% as basal + 70% at 8 leaf stage gave better yield than the current recommended urea use of 33% as basal + 33% at 8 leaf stage + 33% at tasseling stage.
- An experiment on the development of potential maize-based intercropping systems found that intercropped maize with vegetables gave a higher Maize Equivalent Yield than sole maize cultivation.
- An experiment on the development of maize + potato intercropping systems found that yield and net returns of intercropping maize with potato were higher in all planting dates compared to sole maize cultivation.
- A total of 48,869 kg seed of BHM-2, BHM-3 and BHM-5 were produced by the different stakeholders.
- An experiment on the tolerance of BARI hybrid maize to variable plant population densities found that there was no significant yield difference among the different spacings or plant populations, so that 44000 plants per ha was sufficient.
- An experiment on the productivity of recycled seed (F_2) of different varieties compared to F_1 seed showed that recycled seeds yielded less than F_1 seed.
- Maize scientists and experts from Mexico and India visited work on-station, in farmers' fields and seed production fields to share ideas on maize research.
- A high profile team from different government agencies visited seed production, farmer crops and training initiatives and have agreed to provide more support to maize research and promotion in Bangladesh.

d) Development of ring spot virus resistant transgenic papaya for Bangladesh

Cornell University and USDA international partners and national partners BARI, BSMRAU and BARC have been working with this program since 2002. Key activities with this project in 2005-06 were:

- The application for the receipt by Bangladesh of transgenic papaya was submitted to BARI who passed it onto the National Biosafety Committee who scrutinized it and requested that additional information be added. The application was resubmitted to BARI in May 2006.
- PRSV isolates were collected and sent to Hawaii for analysis of their coat protein sequences. These analyses were done and were part of the submission of the application for importation and testing of potential transgenic lines.
- During the period April – July 2005, fresh samples of papaya leaves were sent to Cornell for viral isolation and inoculation on the transgenic lines of papaya at Cornell that will ultimately be sent to Bangladesh.
- PRSV strains are being maintained (based on symptoms) in Bangladesh through inoculation at BSMRAU. Screening of papaya varieties is in progress against PRSV under natural conditions as well as artificial inoculation. Development and testing of mild and virulent strains of PRSV are also in progress.
- A PhD student from Cornell University, USA, has been conducting research on papaya management and production under this program. She completed her research work in Bangladesh in 2006.

1. Facilitation and Promotion for Adoption of Mechanization by Growers

Initially, USAID granted funds for the period July 2002 through June 2005 to the CIMMYT Office in Bangladesh for our 'Facilitation and Promotion for Adoption of Mechanization by Growers' pilot program. The project was extended from July 2005 to June 2006 with minimum funding. Due to the limited funding, the activities of the program were reduced in the year 2005-06. The program concentrated on the supply of power tiller operated seeders (PTOS) and training in their use in Rajbari and Dinajpur districts and in research to broaden the range of crops that can be planted by PTOS. Locations where hand tractor accessories have been sold or demonstrated are shown in Figure 1.1.

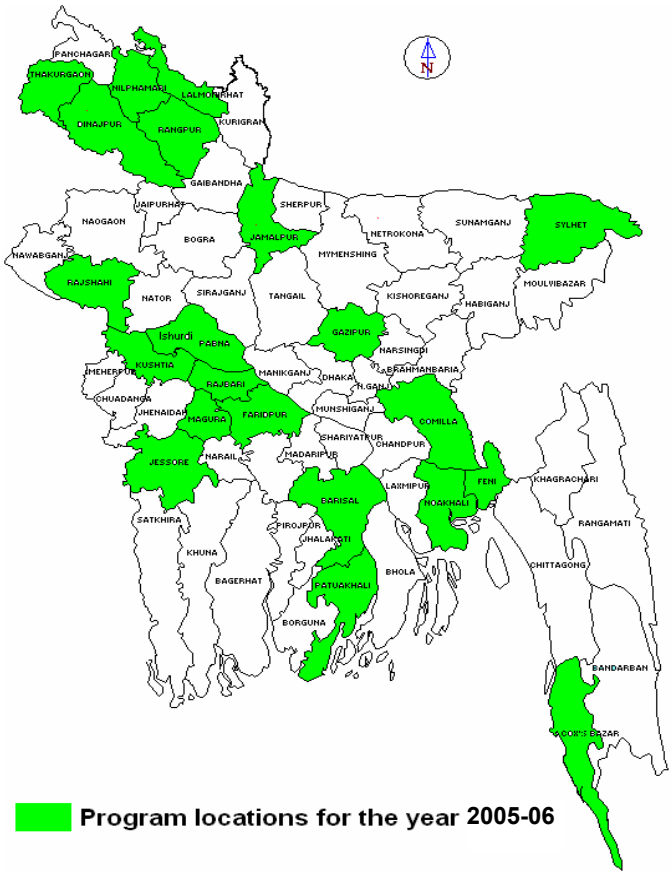


Figure 1.1: Map of Bangladesh showing the mechanization program sites

Achievements made with program activities during 2005-06 are highlighted in the following sections.

1.1 Equipment Procurement and Distribution

For the intensification and diversification of the existing cropping systems and to conserve agricultural resources for sustainable productivity and livelihood improvement, the CIMMYT Office in Bangladesh and its partners have developed

Figure 1.2: Machinery handover at Baliakandi, Rajbari district in October 2005

new diesel-engine-operated Bangladesh Hand Tractor (BHT) agricultural equipment. These include a reaper, bed planter, zero tillage equipment, high speed rotovator, thresher and maize sheller. During this report year, CIMMYT Bangladesh procured 50 power tiller operated seeders and distributed them to different stakeholders. Out of these, 44 were sold to farmers in Rajbari, Rangpur and Dinajpur districts. Each farmer was given training on the repair, operation and maintenance of the power tiller and seeder. The program handed over the machines to farmers in October 2005. High officials of various organizations (especially BARI and DAE), local politicians and farmers, were present in the machinery handover program. Figure 1.2 depicts scenes at the machinery hand over program at Rajbari in October 2005.

1.2 Equipment Usage and Area Coverage

During 2005-06, a total of 8,394 hectares of land were brought under this mechanization program. Farmers used the equipment for land preparation, seed sowing, harvesting, and threshing/shelling of several major crops including wheat, maize, mustard, mungbean, chickpea, lentil, jute, onion, garlic, and some minor crops like soybean, sesame and okra. The area coverage for a range of crops is in Figure 1.3. Farmers used power tillers to prepare more than 5,000 ha of land for various crops. During 2005-06, more than 15,000 farmers used the various Bangladesh Hand Tractor (BHT) accessories for different crop production activities. A highlight this year was the successful planting and growing of about 0.8 ha of direct seeded *boro* rice by a modified PTOS seeder in an on-farm experiment near to WRC Dinajpur. The yield of direct seeded boro rice was very good. Yields were similar to those with transplanted rice but there were savings in irrigation water and labour. Additionally, this year there has been a lot more interest to plant jute with the PTOS, mixing seed with sawdust. Because the seeder puts seed in furrows under the soil, about 50% seed can be saved. Also 30% weeding cost is saved by using upland weeders in the jute field.

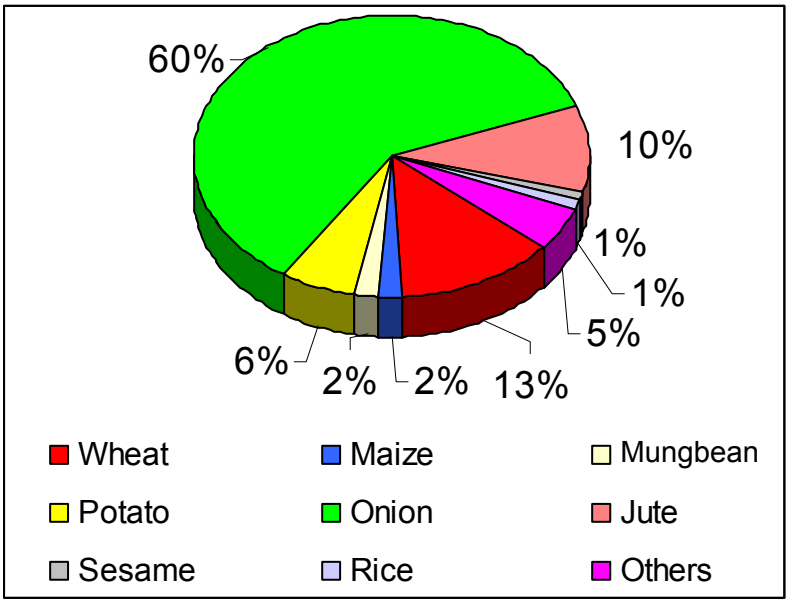


Figure 1.3: Percent of land area covered by different crops under the mechanization program in 2006

1.3 Research on Bangladesh Hand Tractor (BHT) Equipment

Based on farmer needs for seeding different crops, for inter-cultivation, bed making, re-forming of soil beds, seeding on beds, residue management, and simplicity in management, maintenance and operation in the existing diversified farming systems, CIMMYT (in collaboration with the GOB, NGOs and private sector) developed, modified and demonstrated a range of power tiller operated agricultural equipment. Two programs were undertaken in collaboration with the Wheat Research Center and the Farm Power and Post-harvest Engineering Division of BARI during 2005-06. Brief reports of the experiments are given in the following sections.

Experiment 1: Modification and improvement of power tiller operated bed planter

A power tiller operated bed planter was modified and improved with locally available materials at the Wheat Research Centre, Dinajpur, with financial and technical assistance of CIMMYT. The implement simultaneously creates a trapezoidal raised bed and performs seeding operations on the top of the bed in one operation behind the Chinese Hand Tractor. These are readily available in Bangladesh with reports of up to 300,000 now within the country. The bed shaper has been improved to handle flexible bed size and soil clumps. The implement comprises four major components: a toolbar frame, furrow opener, seeding unit and bed shaper. Performance of the implement was tested for wheat, maize, mungbean and rice cultivation. After initially forming the bed, an additional advantage is that a reshaped bed can be used for crop cultivation without any further tillage operation. There were also provisions for fertilizer application along with seed sowing. Bed formation and seeding was done by introducing a modified shaper; replacing the regular press roller of the PTOS behind the seeder.

With this equipment, bed making and seeding were performed in one operation in pre-tilled soil. Cost comparisons of bed planting and conventional methods are shown in Table 1.1. Furrow opener angle and shaper position play an important role in the success of the planter. To maintain equal shape, size and a straight bed, the furrow opener angle and wing radius of curvature need to be accurate for both furrow openers. Radius of curvature of the furrow opener wing was 58 cm. An operational view of the bed planter is shown in Figure 1.4. The modified PTOS bed planter was tested for wheat and maize cultivation. Bed size was reduced to 58x23 cm compared with 70x30 cm when the toolbar-type bed former is used.

Figure 1.4: Bed planter in operation

Table 1.1: Comparative cost of wheat and maize cultivation with a bed planting system in Bangladesh

Cost parameter	**Bed planting system (Tk./ha)**				**Conventional flat plant system (Tk./ha)**	
	New bed		Permanent bed			
	Wheat	Maize	wheat	Maize	Wheat	Maize
Land preparation with planking/reshape	1778	1778	815	815	1706	2600
Sowing cost	1222	1047	1222	1047	60	960
Total seeding cost Tk./ha	**3000**	**2825**	**2037**	**1862**	**1766**	**3560**

Cost calculations (Table 1.1) showed advantages with the soil bed planting system over the conventional system. Real benefits of the bed planting system were in crop cultivation on a permanent bed where there is no need for land preparation. Only bed reshaping is needed to achieve suitable seeding conditions. To make a new soil bed, four to eight passes are required which ultimately increases wheat production cost. To grow wheat on a new bed required almost double (Tk. 3,000/ha) the cost compared to the conventional method (Tk. 1,766/ha). There was a drastic cost reduction in the bed system for maize cultivation compared to traditional methods where farmers sow maize seed on flat land. An earthing up is done at the eight leaf stage, which is extremely laborious and costly. But in this system, there is no need for earthing up. Maize planting cost in new beds was 21% less than the conventional system, and 48% less on permanent beds.

Experiment 2: Improvement of power tiller operated zero tillage planters

A power tiller operated zero till planter was fabricated in the Wheat Research Centre, BARI with financial assistance from the CIMMYT project. The major components of the planter were a toolbar frame, seed and fertilizer box, Inverted "T" furrow opener and depth control wheel. The Persian wheel type seed metering mechanism was introduced for better planting performance. The planter was able to apply seed and fertilizer in a narrow opening slit in one operation. The planting depth and seed rate can be regulated during operation. Power tiller wheel slippage increased with increased soil moisture content. Below 35% soil moisture it was suitable to operate the planter without excess slippage. Immediate T. aman-harvested land and land with fewer weeds were suitable for this system. Fertilizer management and weed control were key issues for adopting this new technology.

The yield of wheat, mungbean and rice in zero tillage systems and with conventional methods are in Table 1.2. The yield of wheat with zero till varied from place to place due to land type, soil moisture and weed management. The average wheat yield was 1.5 t/ha, which was less than the conventional method. Immediately after the harvest of T. aman rice, the less weedy land was suitable for zero till wheat cultivation. Mungbean was planted immediately after wheat harvest (April 1st week). The planting date should be in March for better crop yield and management.

Generally, farmers in this area did not grow mungbean conventionally, but plenty of land harvested from wheat remained fallow up to the planting of T. aman rice in June–July. Mungbean should be suitable for planting in April. There was great potential to fit mungbean in the rice-wheat cropping system, not only for increased crop production but for soil health improvement.

Table 1.2: Comparison of yield between zero tillage and conventional method

Planting system	**Yield (t/ha) (CV%)**		
	Wheat	**Mungbean**	**Rice**
Zero tillage system	1.5 (28)	0.7	3.2 (8)
Conventional method	1.9 (22.6)	Not available	3.5 (14)

Planting costs of wheat, mungbean and rice by zero till and conventional methods are presented in Table 1.3. Planting cost of wheat and mungbean in the zero till system and conventional method were Tk. 1620 and Tk.1766 respectively. Similarly, rice planting costs were Tk. 1620 for zero till and Tk. 5800 with the conventional. The planting cost of wheat and rice with the zero tillage planter were 8% and 72% less than that of the conventional planting method.

Table 1.3: Comparison of cost of planting by zero tillage and conventional system

Planting system	**Cost of planting (Tk./ha)**		
	Wheat	**Mungbean**	**Rice**
Zero tillage system	1620	1620	1620
Conventional method	1766	1766	5800

Experiment 3: Accelerate and popularize use of RCT machinery by small land holders of Bangladesh

The demand for food production is increasing day by day along with the increasing human population. But the cultivable land is being lost to development work such as road construction, housing, active river damage, etc. To meet food needs, pressures are increasing to grow more food per unit of crop land.

Farmers are producing large volumes of crops continuously throughout the year. They are always busy doing many agricultural activities. Most of these operations are accomplished by human labor which is slow, time consuming and costly. Farmers face trouble completing agricultural operations due to labor shortage, especially during the planting season, and during harvesting and threshing periods. Labor shortage is one of the main constraints to successful crop production.

Small agricultural machinery such as the power tiller, power tiller operated seeder, zero tillage planter, rice-wheat thresher, and reaper are alternative ways to manage labour storage and keep crop production at a high and economic level. Rice-wheat is

the major cropping system in Bangladesh agriculture. It is now important to adopt the Resource Conserving Technology (RCT) machinery for critical operations like planting, harvesting and threshing. This will speed up operations and help fit crops such as potato, maize, and pulses within the existing cropping patterns for crop diversification.

Selected RCT machinery under this programme are listed here:-

- Power tiller operated seeder (PTOS)
- Power tiller operated bed planter
- Bed former and planter by PTOS
- Power tiller operated zero till planter
- Punch planter (Star wheel)
- Power tiller operated potato planter (Cup type)
- Power tiller operated potato planter (Pin type)
- Power tiller operated improved plough
- Cage wheel
- Rice-wheat thresher
- Winnower (Power tiller, belt mounted)
- Bi-cycle type winnower.

Based on RCT machinery demonstrations in farmers' fields in 2005-06, the following observations and results were described. During the project period 2005-06, PTOS, bed planter, zero till planter, potato planter, and improved plough were demonstrated to popularize them and to motivate farmers. Some advanced wheat growers purchased PTOS, wheat threshers and maize shellers from WRC, Dinajpur. Area coverage by selected RCT machinery is shown in Table 1.4. The PTOS is becoming popular due to its versatile use and robust performance in rough field conditions.

Table 1.4: Area under RCT machinery in Dinajpur, Thakurgaon and Rangpur, 2005-06

Planting system	**Area planted (ha) in the project locations**
Minimum tillage with PTOS	156.7
Bed planting system	25.1
Zero tillage	1.2
Potato planter	2.8
Total =	185.8

Maize, aman rice, boro rice, jute and mungbean were successfully planted directly in one pass during 2005-06. Field performance of crop cultivation by the PTOS is shown in Table 1.5. Boro rice was directly planting with 20 hr-primed seed by PTOS. Boro rice yielded 5.3 t/ha while in the conventional system the yield was 5.0 t/ha. The total number of irrigations in PTOS was seven while in the conventional system

17 irrigations were applied. It was found that in dry conditions, PTOS plots did not crack but conventional plots did crack.

Table 1.5: Field performance of PTOS for direct seeding along with Boro rice

Particulars	Wheat	Maize	Mungbean	Aman rice	Boro rice
Variety	**Shatabdi**	**NK-46/ Pioneer**	**BARI Mug-6**	**BR-11**	**BR-28**
Seed rate, kg/ha	120	20	25	37	37
Line spacing, cm	20	60x20	40	20	20
No. of irrigations	2	3	0	1	7
Plant population/m^2	237	7-8	27	286	326
Field capacity, ha/hr	0.14	0.14	0.14	0.14	0.14
Crops yield, t/ha	2.9	6.5	0.9 – 1.0	3.7	5.3
Conventional yield, t/ha	1.9	5.8	0.5- 0.7	3.5	5.0

Experiment 4: Adaptation of high speed rotary tiller for dry land cultivation

Observing the benefits of conservation tillage or reduced tillage, 65 units of the power tiller operated minimum tillage seeders were purchased by the farmers of Rajbari, Magura and Jhenaidah districts. Many used the seeder as a high speed rotary tiller (HSRT) after modification. The HSRT was mainly used for onion and garlic cultivation. The average area covered by each tiller was 27 ha. Total area covered by the tillers was about 1,764 ha in the 2005-06 Rabi season. Minimum and maximum net benefits earned by the tillers were Tk 15,000/ha and Tk 85,000/ha, respectively. Field performance of HSRT on onion cultivation was compared with the traditional power tiller. The time saved for preparing land by HSRT was 56% compared to the traditional tiller. The cost of land preparation by HSRT was Tk 3,400/ha compared with Tk 4,500/ha for the traditional tiller. Due to better tilth, the time required for planting onion or garlic in HSRT fields was 23% less compared to a traditionally tilled field. Time and money required for planting onion in HSRT fields were 114 man-day/ha and Tk 7,980/ha and those planted using traditional tillers needed 148 man-day/ha and Tk 10,360/ha. Due to better tilth and higher plant population, the yield of onion was increased by 18% over the traditional method. Net benefit earned by the farmer for onion cultivation using HSRT was Tk 34,450/ha. The new tiller was also used for potato cultivation. A comparative study of HSRT with the traditional tiller for potato cultivation was also conducted. Time saved for preparing land by HSRT was 63% compared to a traditional tiller. Cost of land preparation by HSRT and traditional tiller were Tk 3,700/ha and Tk 4,450/ha, respectively. Yield of potato was 15.83 t/ha in the HSRT field and that in the traditional tiller field was 14.16 t/ha. Yield of potato was 11.7% higher in the HSRT field than a traditional tiller field.

1.4 Training

During 2005-06, 114 participants, including farmers, NGO workers, private sector staff, and research organizations received in-service training on i) Power tiller operation and maintenance; ii) Multiple seed drill operation and maintenance; iii) Multi-crop reaper operation and maintenance; iv) Bed planting/formation; and v) other agricultural accessories such as dry and wet land weeder, cage-wheel, high speed rotovator, etc. The training was jointly organized by CIMMYT, BARI, BRRI and BAU at Wheat Research Center-Dinajpur, the Regional Agricultural Research Station-Jessore, and On-farm Research Division-Faridpur, and conducted during September and October 2005.

1.5 Field Days

To create awareness among farmers, extension staff, workshop owners, operators, and scientists of different crop research institutes about the benefits of using the BHT accessories for resource saving (labour, time, seed) and income generation in agriculture, we organized five field days on the establishment of wheat, jute, onion, sesame and potato in Jamalpur, Thakurgaon, Faridpur, Pabna and Rajbari districts. More than 600 people representing the farmer community, school teachers, agricultural accessory manufacturers, agricultural extension, NGOs and research organizations participated in the field days in the 2005-06 Rabi and Kharif seasons.

1.6 Sustainability of PTOS

Significant interest was generated in the PTOS by farmers, researchers and machinery suppliers during 2005-06. Hundreds of farmers are interested to buy a PTOS for the 2006-07 farming year. Farm equipment suppliers have agreed to support farmers to access the PTOS.

A total of 32 farmers have been listed to buy PTOS and power tillers (20 for seeders plus power tillers and 12 only the seeders) at the cost of Tk. 42,000 per PTOS and Tk. 64,000 per power tiller. Farmers requested to have credit support at Tk. 20,000 per seeder and Tk. 40,000 for both the seeder and power-tiller. Farmers will pay a down payment before they take over the machinery. Credit will be paid back with 15% interest in 10 equal monthly installments. Green Machinery Stores (PTOS and power tiller importer) has agreed to import and sell the equipment to farmers through BARI and CIMMYT. Green Machinery Store also agreed to provide loans to farmers as they requested. The FMPE Division of BARI has arranged partial funding for continuation of the PTOS training program during 2006-07. All of these developments are helping to put the support given by USAID through CIMMYT onto a more sustainable basis and clearly demonstrates that the impact our work on farm machinery development and promotion for Rabi season crops is now deepening.

2. GIS-Bangladesh Country Almanac (BCA): A User Friendly GIS Tool for Agricultural and Natural Resource Management

The Bangladesh Country Almanac (BCA) is a user-friendly spatial database for Bangladesh based within licensed mapping software AWhere-ACT from a US-based software firm, Mud Springs Geographers, Inc. The BCA project started in July 2002 with partnership of the Bangladesh Agricultural Research Council (BARC), Soil Development Resource Institute (SDRI), Bangladesh Rice Research Institute (BRRI) from the Bangladesh national agricultural research system and International Maize and Wheat Improvement Center (CIMMYT), with USAID funding. These organizations worked together to accumulate data and have developed a feature-rich geo-spatial BCA database at the national and Upazila levels. The latest version of Bangladesh Country Almanac was released on 09 April 2006 as version 3.0 (**BCA 3.0 in Figure 2.1**) with the software version AWhere-ACT 3.7.52. BCA 3.0 is the largest CD-based database in Bangladesh consisting of both spatial and attribute data on climate, land and soils, crops, demography, hydrography, infrastructure, health, marketing, livestock, forestry and poverty. BCA facilitates the availability, proliferation and utilization of spatial data by persons who might not otherwise get access to such databases.

Figure 2.1: CD of the new version of BCA software

In dissemination and training workshops conducted throughout the country, researchers, scientists, academicians, students, and developmental GOs and NGOs have been sensitized to use the BCA in their own programs. The BCA has attracted many government agencies like the Bangladesh Bureau of Statistics (BBS), Department of Agricultural Extension (DAE), Bangladesh National Nutrition Council (BNNC), Department of Agricultural Marketing (DAM), Bangladesh Meteorological Department (BMD) and NGOs to use BCA as a platform in the sharing of their information.

2.1 Technical Implementation Committee (TIC)

A BCA Technical Implementation Committee (TIC) represented by BARC, SRDI, BRR) and CIMMYT met once a month for program planning and implementation of BCA. The meetings were held at the CIMMYT Office in Bangladesh and at partner institutes. The TIC assessed the need for training of BCA users, and decided on data collection and updating. TIC also reviewed feedback received from stakeholders (both from end users and partners) on data requirements as well as on the problems faced during operation of the software, and tried to solve those problems.

2.2 Release of BCA V3.0

Bangladesh Country Almanac version 3.0 (BCA V3.0) with the database driving software called AWhere-ACT 3.7.52 was released in a workshop held at the Jahangir Nagar University, Savar, chaired by its Vice Chancellor Professor Khandaker Mustahidur Rahman on 09 April 2006. A total of 112 participants including teachers, postgraduate students, researchers, extension and NGO personnel attended the day-long workshop. BCA V3.0 is the largest off-line CD-based database in Bangladesh. It has updated spatial and attribute data on climate, land and soils, crops and crop suitability, forestry, demography, hydrography, infrastructure, health and nutrition, marketing, fisheries and livestock, and poverty. The new verson includes a huge amount of non-spatial time series data on agriculture.

2.3 AWhere-ACT Software version 3.7.52

AWhere-ACT 3.7.52 was received from Mud Springs in August 2005. The software was tested during the report period with each of the old, modified and the newly created data sets to identify problems and bugs. During the exercise, the partners identified some problems with the database that slowed down some of the operations; sometimes spatial interpolation and characterization even hanged the computer. The problems were removed and the database was uploaded onto AWhere-ACT. BCA V3.0 has now been made almost bug free in terms of its software interface with the database.

2.4 Database Development and Upgrading

BCA v3.0 comes with an upgraded, updated and new spatial and non-spatial database. BARC digitized 330 Upazilas to generate a spatial and text attribute database. Realizing user demand to make the BCA database useful for solving real world problems, the remaining 129 Upazilas were digitized under the BCA project and added to the initial 330 Upazilas. This completed the Upazila database for Bangladesh on land, soils and other features of Thana/Upazila Nirdeshika prepared by SRDI. The Upazila database was combined to make the database at district and national levels through edge-matching and joining (merging) processes. Additionally, a Union base map (Figure 2.2) has been added to the political element of the BCA database to facilitate development planning at the Union level. In the

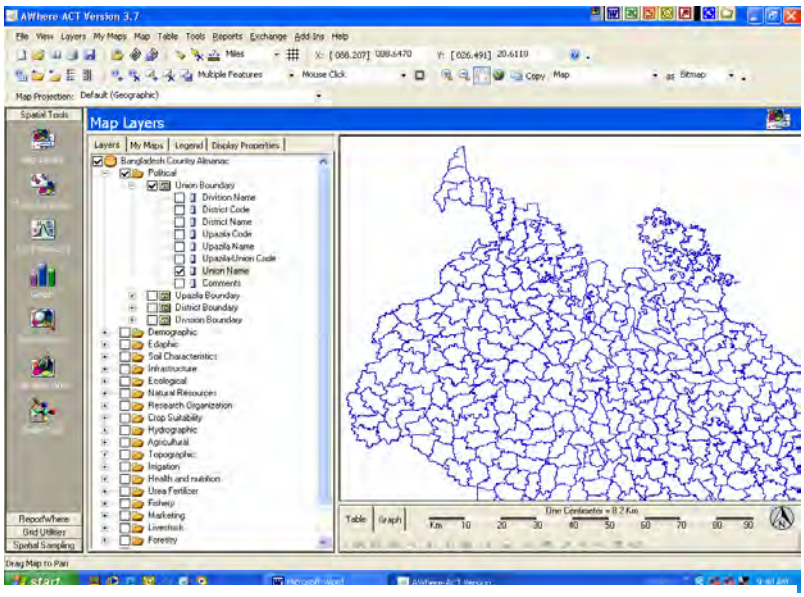


Figure 2.2: BCA database with Union boundary

new versions of BCA, the national database on land and soils is at the 1:100,000 scale instead of 1:250,000 in earlier versions. Under the BCA project, the national and district level database on land and soils has been created using semi-detailed information at the Upazila level at a 1:50,000 scale.

One major change in the new version of the BCA database is that soil physical properties have been grouped depending on the similarity of edaphic criteria in relation to agricultural use instead of by soil series (Figure 2.3). Suitability maps for major field crops and fruits in Bangladesh and a huge amount of time series data on crops, livestock, fisheries, forests, marketing, infrastructure, demography, education, health and nutrition have been added in the new version of the BCA database. Climate and some other elements have been updated. All corrected spatial data were uploaded as shape files.

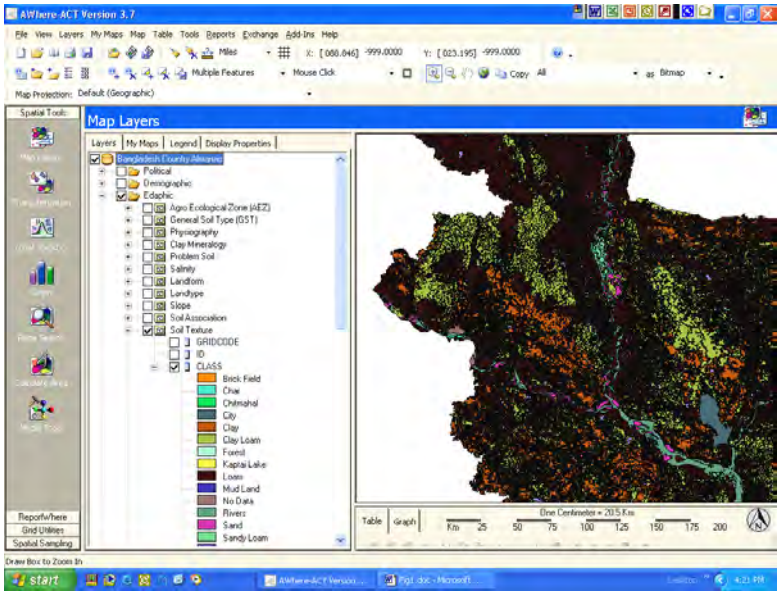


Figure 2.3: New top soil texture data set created from Upazila Nirdeshika

Besides spatial data, many new non-spatial data sets were added to the database in the new version of BCA. These include time series and other attribute data on agriculture, marketing, livestock, fisheries, forests, nutrition and health, demography and education at the national and district levels (Figure 2.4). A non-spatial database is also available for some selected Upazila. All these data are added under the non-spatial database in a data folder "Agril Stat", which can be queried running the file "Agril Stat.exe".

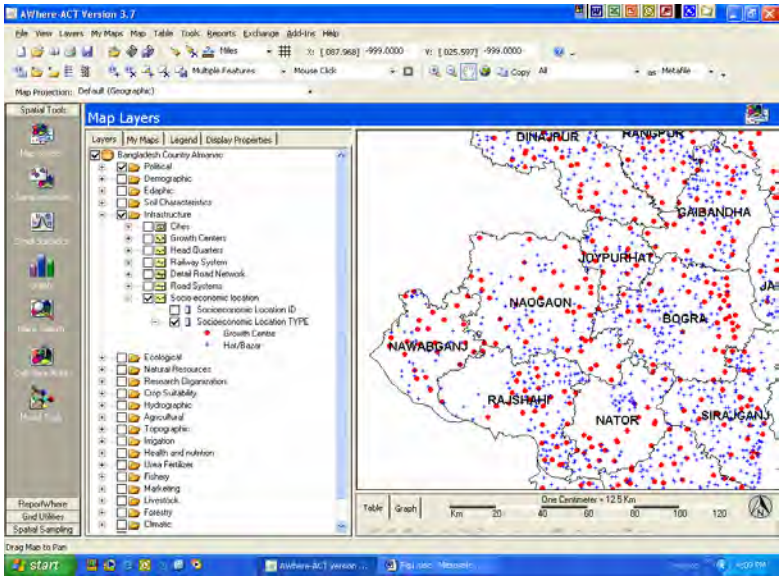
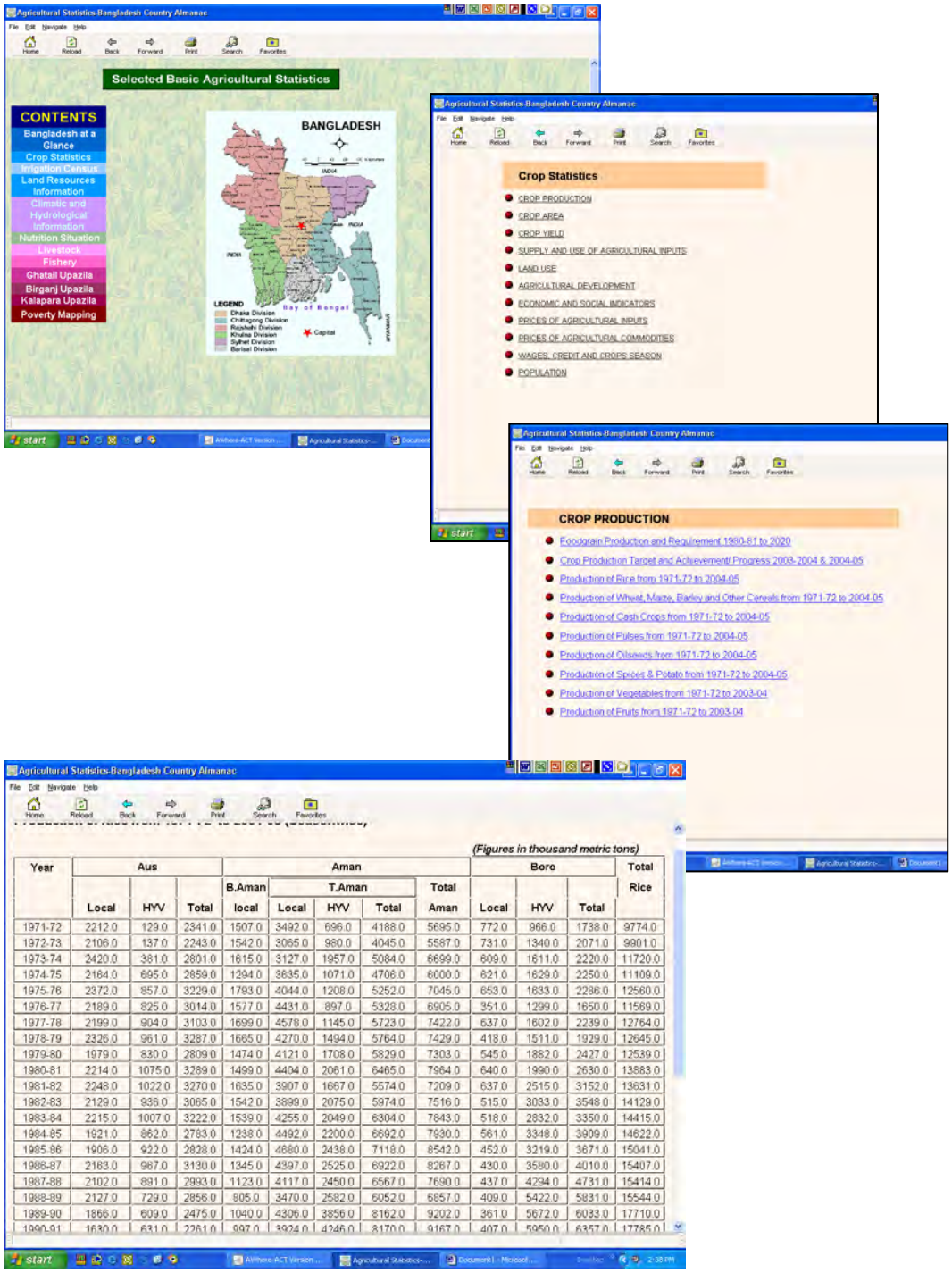


Figure 2.4: Socioeconomic growth centers

The data structure of the non-spatial database is shown in Figure 2.5:



Year	Aus			Aman					Boro			Total Rice
				B.Aman	T.Aman			Total				
	Local	HYV	Total	local	Local	HYV	Total	Aman	Local	HYV	Total	
1971-72	2212.0	129.0	2341.0	1507.0	3492.0	696.0	4188.0	5695.0	772.0	966.0	1738.0	9774.0
1972-73	2106.0	137.0	2243.0	1542.0	3065.0	980.0	4045.0	5587.0	731.0	1340.0	2071.0	9901.0
1973-74	2420.0	381.0	2801.0	1615.0	3127.0	1957.0	5084.0	6699.0	609.0	1611.0	2220.0	11720.0
1974-75	2164.0	695.0	2859.0	1294.0	3635.0	1071.0	4706.0	6000.0	621.0	1629.0	2250.0	11109.0
1975-76	2372.0	857.0	3229.0	1793.0	4044.0	1208.0	5252.0	7045.0	653.0	1633.0	2286.0	12560.0
1976-77	2189.0	825.0	3014.0	1577.0	4431.0	897.0	5328.0	6905.0	351.0	1299.0	1650.0	11569.0
1977-78	2199.0	904.0	3103.0	1699.0	4578.0	1145.0	5723.0	7422.0	637.0	1602.0	2239.0	12764.0
1978-79	2326.0	961.0	3287.0	1665.0	4270.0	1494.0	5764.0	7429.0	418.0	1511.0	1929.0	12645.0
1979-80	1979.0	830.0	2809.0	1474.0	4121.0	1708.0	5829.0	7303.0	545.0	1882.0	2427.0	12539.0
1980-81	2214.0	1075.0	3289.0	1499.0	4404.0	2061.0	6465.0	7964.0	640.0	1990.0	2630.0	13883.0
1981-82	2248.0	1022.0	3270.0	1635.0	3907.0	1667.0	5574.0	7209.0	637.0	2515.0	3152.0	13631.0
1982-83	2129.0	936.0	3065.0	1542.0	3899.0	2075.0	5974.0	7516.0	515.0	3033.0	3548.0	14129.0
1983-84	2215.0	1007.0	3222.0	1539.0	4255.0	2049.0	6304.0	7843.0	518.0	2832.0	3350.0	14415.0
1984-85	1921.0	862.0	2783.0	1238.0	4492.0	2200.0	6692.0	7930.0	561.0	3348.0	3909.0	14622.0
1985-86	1906.0	922.0	2828.0	1424.0	4680.0	2438.0	7118.0	8542.0	452.0	3219.0	3671.0	15041.0
1986-87	2163.0	967.0	3130.0	1345.0	4397.0	2525.0	6922.0	8267.0	430.0	3580.0	4010.0	15407.0
1987-88	2102.0	891.0	2993.0	1123.0	4117.0	2450.0	6567.0	7690.0	437.0	4294.0	4731.0	15414.0
1988-89	2127.0	729.0	2856.0	805.0	3470.0	2582.0	6052.0	6857.0	409.0	5422.0	5831.0	15544.0
1989-90	1866.0	609.0	2475.0	1040.0	4306.0	3856.0	8162.0	9202.0	361.0	5672.0	6033.0	17710.0
1990-91	1630.0	631.0	2261.0	997.0	3924.0	4246.0	8170.0	9167.0	407.0	5950.0	6357.0	17785.0

Figure 2.5: Non-spatial database structure

The following data were obtained from different sources and shape files were created to fit with the BCA format:

- Forest area by Upazilla
- Flood damage and GOB relief allocation by district
- Updated landuse map
- Zone mapping for selected Upazilla
- Nutrient status map updated
- Digital Elevation Model (DEM) 90m x 90m downloaded and prepared to create shape files
- Mouza names collected from different sources and Mouza boundaries updated
- Marketing price and commodity data on crops, fruits, vegetables, spices
- Child risk measure in rural area
- Rights of children and adolescents
- Water and sanitation
- Maternal health
- Diarrhoea prevalence last 15_days_<5 years (%)
- Treatment given during diarrhoea_both sex_<5 years
- Diarrhoea treated by_both sex_<5 years (%)
- Fast/difficult breathing last 2 weeks_<5 yrs child
- Knowledge to seek help acute respiratory infection
- Household using iodized salt (%)
- Vitamin A received on last NID_12-59 months (%)
- Malnutrition MUAC <12.5cm_12-59 months (%)
- Colostrum given_both sex (%)
- Child given honey/sugar/water imm. after birth(%)
- Exclusive breastfeeding rate children_<4months (%)
- Period of exclusive breastfeeding_b_sex_5_23months
- Duration of continued breastfeeding_13-59months(%)
- Type of injury <18 years_per 1000 (%)
- Current condition after injury <18 yrs_per 1000(%)
- Children with disability_both sex (%)
- Infant immunization

A huge amount of crop, fisheries, socioeconomic, demographic and educational data from recent years was gathered from the Department of Agricultural Extension (DAE) and Bangladesh Bureau of Statistics (BBS). Most of the data were at the District level (new 64 districts) and some were at the Upazila level. Data collected had some problems to feed directly into BCA. These included:

1. Most of the data were messy and unorganized, i.e. not consistent with the BCA data format.
2. In the BCA database, the number of Upazilas in the Upazila base map is 464 where all Upazilas in a metropolitan area are placed under one metropolitan

Upazila. Upazila data collected from DAE had the same number of Thana as in BCA, whereas BBS used 507 Thana in recording Thana-wise crop data.

3. All data files did not have the same spelling of District and Thana names and also the Districts and Thanas were not placed in the same order.
4. None of the data files contained geo codes of the Districts or of Thanas. These are necessary to join with BCA base maps.
5. Units of measurement were not the same throughout.
6. All data files were in Excel but in most cases there was cell merging for reporting regional and divisional totals in case of district level data and district, regional and divisional totals in case of thana level data. This created a problem in sorting data and merging files.
7. A few files contained inconsistent/erroneous data.

In order to remove these problems and make the data files acceptable to BCA, all the data files were thoroughly and carefully examined, edited, corrected for errors and geo coded. In cases where the number of Thanas was larger than in the BCA database, the relevant Thanas were merged. Before geo coding and merging, the spellings of district or Thana names were converted to the spelling used in the BCA database. To facilitate sorting and file merging, data in a file was labeled only by District or Thana wherever applicable. The process was tedious and took a long time to complete.

2.5 Software License

Like the previous versions, the AWhere 3.7.52 has a runtime license which allows users to use the software for a period of 60 days commencing on the date of installation. When the license expires, it will automatically prompt to enter a new license code. Upon expiration of the runtime license, users must register with CIMMYT in Bangladesh/BARC to renew the license. There is an agreement with Mud Springs to provide 300 user licenses. That license will expire after every one year period, after which users can request for a free license code renewal. CIMMYT/BARC will supply Mud Springs with full names and addresses of up to 300 registered users of the AWhere-ACT Software. In case of winding up of trade by Mud Springs, time un-limited registration codes covering the purchased 300 user licenses will be ensured by Mud Springs to CIMMYT/BARC.

2.6 Dissemination and Training Workshops organized in different locations from July 2005-June 2006

This year, a major training program was undertaken, especially from April-June 2006, to promote BCA version 3 (Table 2.1). A common request at these workshops is to get more or more specialized training on the use of BCA.

Table 2.1: BCA training workshops conducted between July 2005 and June 2006.

Types of workshop	Location	Number of participants
Dissemination workshop	Bangladesh Livestock Research Institute (BLRI), Savar, September 26, 2005	70
	Bangladesh Agricultural University (BAU), Mymensingh, September 29, 2005	100
	Jahangir Nagar University, Savar, March 9, 2006	112
	Department of Livestock (DLS) on May 27, 2006	103
Training workshop	Bangladesh Agricultural Research Council from March 28-29, 2006	25
	Bangladesh Rice Research Institute, May 8-9, 2006	22
	Bangladesh Agricultural Research Institute, May 29-30, 2006	27
	Chittagong University, May 21-22, 2006	36
	Bangabandhu Sheikh Mujibur Rahman Agricultural University, June 12-13, 2006	26
	Soil Resource Development Institute (3 workshops), May 24-25, June 4-5 and June 18-19, 2006	89
	Bangladesh Bureau of Statistics on May 28-29, 2006	44
	Khulna University on June 18-19, 2006	39
Total participants		**693**

2.6.a One-day Dissemination Workshops

- **Dissemination workshop at BLRI:** The workshop was held at the Bangladesh Livestock Research Institute (BLRI), Savar on September 26, 2005. Seventy participants from various organizations, including GOs, NGOs and extensionists attended the workshop. The Director General of BLRI inaugurated the workshop.

Dissemination workshop organized at BLRI, Savar on September 26, 2005

- **Dissemination workshop at BAU:** The workshop was held at Bangladesh Agricultural University (BAU), Mymensingh on September 29, 2005 presided over by its Vice Chancellor. One hundred university teachers from different disciplines attended the day-long workshop.

Dissemination workshop organized at BAU, Mymensingh on September 29, 2005

- **Dissemination workshop at Jahangir Nagar University, Savar:** The workshop was held on March 9, 2006 where 112 university teachers from different disciplines attended. Professor Khandaker Mustahidur Rahman, Vice Chancellor of Jahangir Nagar University inaugurated the workshop. In this workshop, BCA V3.0 was formally released. No problem was encountered during the presentation of this new version of BCA unlike those faced with the previous versions. The participants were impressed with the software and the database and expressed their opinion that BCA partners should provide adequate training for the users so that the BCA tools and the database can be effectively utilized.

Vice Chancellor, Jahangirnagar University giving his speech in the BCA dissemination workshop

- **Dissemination workshop at Department of Livestock Services (DLS), Dhaka:** The workshop was held on May 27, 2006 with 103 scientists in attendance. Dr. Salehuddin Mahmud, Director General, DLS inaugurated the workshop. Dr. Sunil Chandra Ghosh, Director (Extension) along with several renowned scientists expressed sorrow that they have still to develop a standard format for DLS data which means it is not publically available, unlike data from other sectors. They are optimistic and urged the BCA team to form a committee with representatives of Bangladesh Livestock Research Institute (BLRI) and DLS so that they can accumulate information from different sectors.

Dissemination workshop organized at DLS, Dhaka

2.6.b Two-day Training Workshops

- **Training-workshop at BARC:** The first 2-day hands-on training workshop was held on May 18-19, 2006 at Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka organized for the Bangladesh Agricultural University, Mymensingh. Twenty five university teachers attended the training workshop. The participants, having no previous knowledge in operating GIS software, were greatly impressed with the software AWhere-ACT because it was easy to handle when manipulating the huge BCA database. They expressed gratitude to BCA partners for the accumulation of invaluable information within the reach of users free of cost. However, most of the participants requested more time to learn the software as well as time to travel through the BCA Database.

BCA training workshop organized at BARC on May 18 and 19, 2006

Certificate distribution to a trainee at a BCA training workshop

- **Training-workshop at BRRI:** This training workshop was held at the Bangladesh Rice Research Institute (BRRI) on 8-9 May 2006. The Training workshop was inaugurated by Dr. M. A. Baqui, the Director of Research of BRRI. Twenty scientists participated in the training workshop and eight attended a similar program earlier. The participants, particularly those who attended the initial program, expressed their satisfaction with the new version of AWhere-ACT and the database because there was no software bugs and hanging of computers during operations. Early on the second day of training, there was a group discussion among the participants on the software interface and on the database, followed by a presentation by the group leader.

BCA training workshop at BRRI on May 8 and 9, 2006

During the presentation, speakers raised a concern that BCA 3.0 can take too much time to perform some operations such as characterization with multiple features. Participants spoke about insufficient time for the training and suggested to schedule further training for at least one week and include some case studies in the training module.

- **Training-workshop at Chittagong University:** The training workshop was held on 20-21 May 2006 at Chittagong University and was inaugurated by its Vice Chancellor Prof. Dr. M. Badiul Alam. Forty participants drawn from academicians of different disciplines at the university and researchers from Bangladesh Forest Research Institute attended the training workshop. Some of the participants had also attended the dissemination workshop held at the university in 2004. All the participants had good knowledge on computer applications and some of the senior professors showed their keen interest in the software and the database. They said that the BCA could be a useful tool for thesis work by their students if they could have adequate training on the software. They requested an operational manual as an aid to learn the software and utilization of the BCA database through self-teaching. They were assured that the training manual with video instruction will be sent to them. At the conclusion of the training workshop, the Dean of the Science Faculty, a senior-most professor in the Statistics Department (who was also a participant) awarded certificates among the participants. In his concluding remarks, the Dean said, "I heard of GIS during my Ph.D. program but did not know about its power in analyzing and presentation of data before this training". He also proposed that BCA be used by Chittagong University teachers in their class curriculum for effective analysis of spatial information instead of traditional analysis considering the information as point data.

BCA training workshop at Chittagong University on May 20 and 21, 2006

- **Training-Workshop at BARI:** This training workshop was held at Bangladesh Agricultural Research Institute (BARI) on 29-30 May 2006. The participation by 27 scientists from different disciplines was inaugurated by Director (Support Service) as chief guest, with Director Training and Communication Dr. Haurn-ur-Rashid in the chair. Some of the participants also attended a similar program held at BRRI in 2005. Younger participants showed their enthusiasm more than the older ones. Some participants reported on the second day of training that they had successfully installed the software and the database in their home computers and practiced the lessons learnt in the previous day. While recapitulating the day one lessons, two participants described how they had learned to use the BCA database and incorporate their own data within the BCA database to produce maps. They felt strongly that the BCA database would be useful in designing their research plan. They said two days of training was not enough to learn the software and data mining.

A training workshop session at BARI

Trainees at BARI training workshop on BCA software

- **Training workshop at BSMRAU:** Twenty six participants attended the training-workshop held on 11-12 June 2006 at Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). The participants were teachers of different disciplines and some PhD students at the university. Five participants had attended a similar program held in 2005 at BRRI. Most of the participants had adequate computer literacy and had previously attended a dissemination workshop held at the university a year ago. They expressed their satisfaction with the software and remarked very positively about the usefulness of the database. Some senior professors have already been using BCA in their academic research. Besides, BCA is being used for student assignments in course work. At the end of the workshop, a common request from the participants was to arrange some in depth training for a longer period with a small group from the university who can later train or help others

BCA training session at BSMRAU

to use BCA. Some senior participants said that project preparation and problem solving issues should be included in future training on BCA. They also urged the BCA partners to continue updating the database, particularly the agriculture, livestock, fisheries and marketing components that change with time. Participants also stressed the need to add information on agroforestry, insect pests and diseases to our BCA database. That will help plan optimum farm resource management, forecasting of crop pest and disease outbreaks and the design of crop protection management practices.

- **Training workshop at Khulna University:** The training workshop at Khulna University was held on 18-19 June 2006 in the computer laboratory with opening remarks from the Dean of the Life Science School, Prof. Dr. Sanjay Kumar Adhikary. Thirty nine university teachers from various disciplines attended the training workshop. Most participants had also attended the dissemination workshop on an earlier version of BCA held at the university in 2005. Some of them complained about the earlier version of BCA because of software bugs that caused computers to crash during operations and lack of some useful data management options. However, they had used the database with other GIS software like ARCVIEW and performed GIS-based analysis as a part of their project activities. On the second day of training, two participants recapped what they learned during day 1. They expressed their satisfaction with the new version of AWhere-ACT because of its bug free operations in day 1 and that the software was now upgraded with new interface options and data management facilities. They thanked the BCA partners for making such a huge database readily available for end users, to which a single user or even institutions would normally have limited access. During discussion on the database, some participants said that the Bay of Bengal is a big resource for Bangladesh for fish, but there are no such data in BCA. They suggested to include the data in a future version. At the conclusion of the program, Prof. Dr. Nazmul Ahsan, Director, Research Cell and the coordinator of the training workshop said that they all had passed two very hard days. They were amazed with the techniques followed in the training and the humorous way the resource

BCA software training session at Khulna University

Participants of BCA training workshop at Khulna University

persons answered the questions from participants, with real life but simple examples. It was real hands-on training he commented because the resource persons worked with each and every participant until the last person completed the exercise.

- **Training Workshop at Soil Resource Development Institute:** Three two-day training workshops were conducted at the Soil Resource Development Institute (SRDI) where scientists from various regional stations attended. The training workshops were inaugurated by Md. Monirul Huq, Director of SRDI. Altogether eighty nine scientists participated in the workshops.

The Director mentioned that the software and the database are very relevant to SRDI professionals. SRDI mainly deals with land and soil data and often advises stakeholders on proper utilization of land-soil resources. BCA provides all these data/information together with excellent software with which many GIS based analyses could be done to generate spatial information on soil nutrient status, crop suitability, landuse zoning, etc.

A training session at SRDI

Ms. Dilara Hasan said that the software is compatible with MS Word and Excel. Any type of map, table or graph could easily be handled by using an MS Word file. Images can be inserted using the MS Word option and then printed for reports. It is PC based and very user-friendly. Climate data are very detailed. The tool for finding climate information in graphical form seems very useful for SRDI officers as they deal with agro-ecological zones.

Further training at SRDI

After training on BCA, the researchers realized that data generated by SRDI should be stored in Excel format with which they can generate geo-reference based data and have diverse graphical output by extrapolating and interpolating existing data. SRDI field officers also felt that data generated by them needs to be well structured as it is in BCA to feed and update the BCA database. As a result, the GIS unit under the Data Processing and Statistical Section (DPSS) of SRDI could provide technical support to field offices involved in disseminating local

level data/information required for development planning. Moreover, SRDI field officers with a computer can use this software and database on-station.

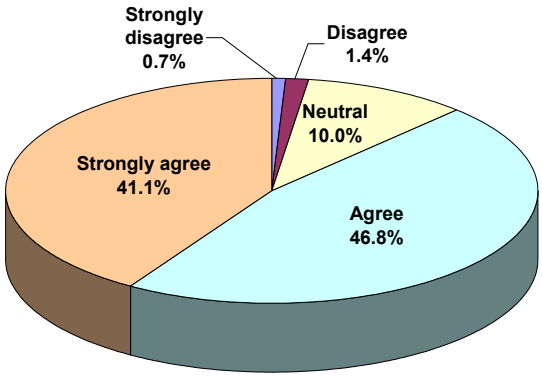
Finally Mr. Jalal Uddin Md. Shoaib said there should be random field verification of the data. Human resource development in SRDI will be required to impart training on the use of BCA to SRDI field officers. A forum should be effective and viable for regular monitoring, evaluating and updating of the BCA.

A training session at SRDI

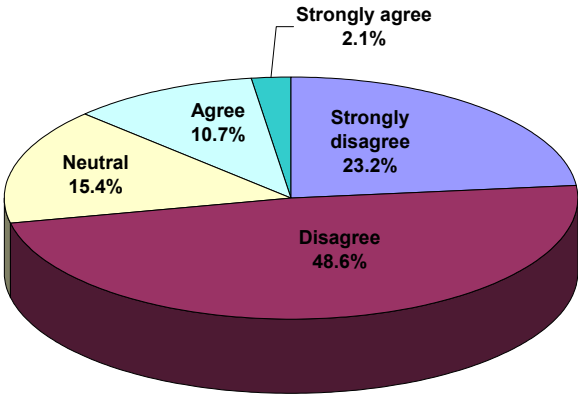
Usually, at the end of a training workshop, evaluation sheets are distributed among the participants to get their reaction and feedback on software and the BCA database. These elicited extremely positive responses. Some valuable comments from participants included: 1) Software made it easy to display maps in a meaningful manner, 2) Data were less useful than I had expected, 3) Country-level data are more useful than Upazila level data, 4) The graphing and data table tools are very useful, 5) The BCA workshop helped make me aware of potential uses of GIS, 6) I would recommend this BCA to my colleagues, 7) GIS has little relevance to my work, and 8) I would expect to load my own data into BCA. Summary results of the participants' evaluation are presented in charts given in Figure 2.6. In all workshops, the nature of participants' responses on the BCA database and software were similar.

Figure 2.6: BCA trainees' opinions on the software and database

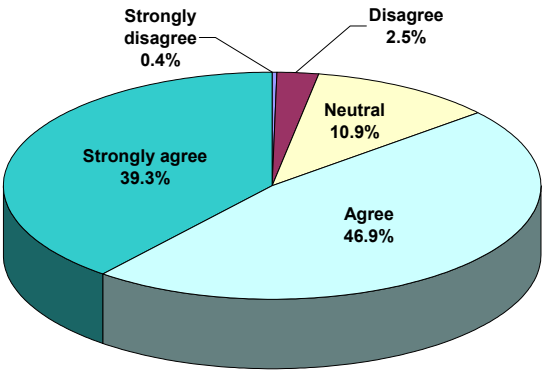
The software made it easy to display maps in a meaningful manner



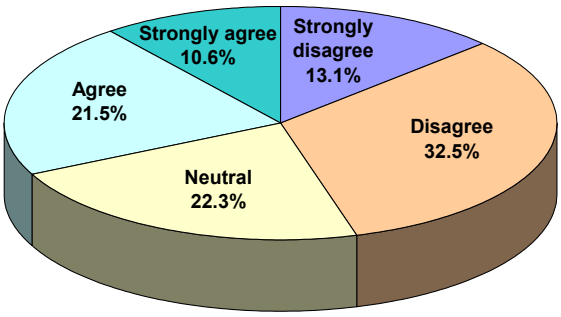
The data were less useful than I had expected



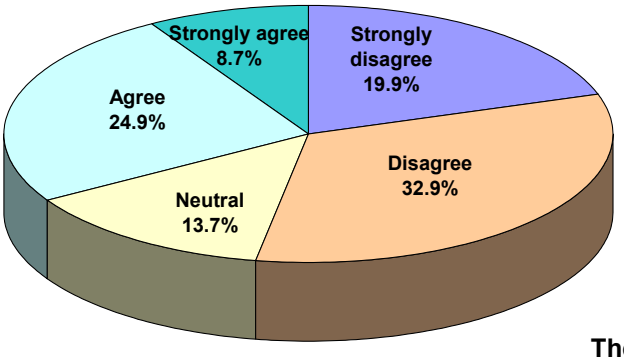
The graphing and data table tools are very useful



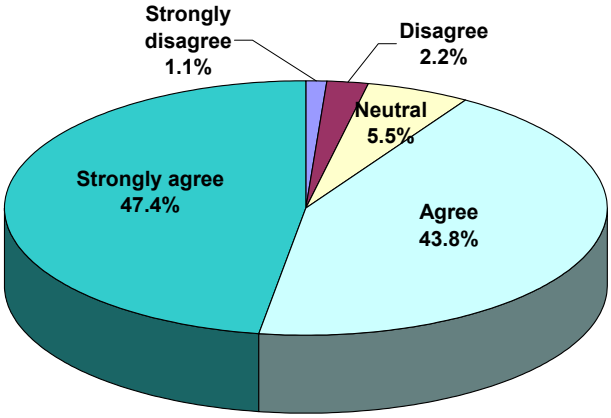
Country-level data are more useful than upazila level data



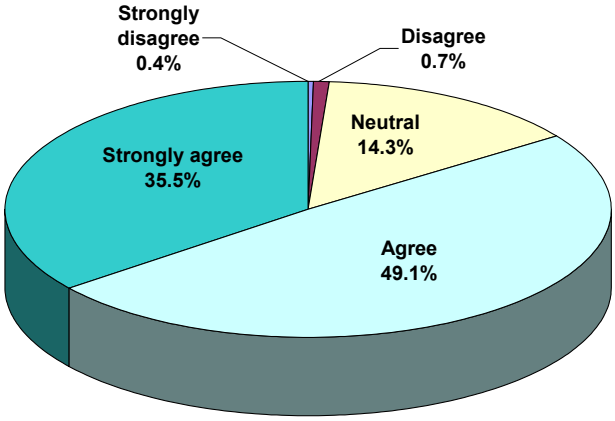
GIS has little relevance to my work



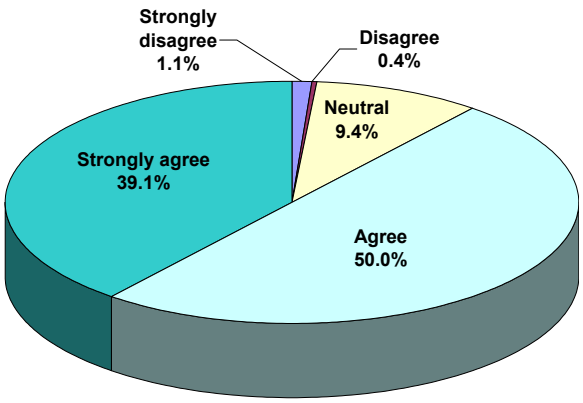
The BCA workshop helped make me aware of potential uses of GIS



I would expect to load my own data into BCA



I would recommended this BCA to my colleagues



2.7 Some Achievements and Applications of BCA during 2005-06

- BCA is being applied for a range of problem solving analyses such as identification of research priorities and research locations, determination of extrapolation domains of potential technologies, assignments to university students by academicians for utilization of the available resource base and designing development programs by extension and NGOs.
- One of the minigrant outputs "*Identification of Potential Extrapolation Domain for Photosensitive MV T. Aman*" has been used to prepare the national action plan designed to increase agricultural production of Bangladesh by 20% by the year 2009.
- Soil Resource Development Institute (SRDI) officially decided to use BCA as a platform to deliver data from field locations to its HQ.
- BCA was able to convince BBS, BNNC, DAM, DAE to publish agricultural data by Upazila. This is a big achievement of BCA.
- DAE agreed to change its block concept to match the administrative boundary for collection of agricultural information. This has removed the limitations in integrating data from other sources like BBS, LGED, Public Health, etc., in development planning, particularly at the local level. This resulted from the dissemination workshops at DAE.
- BCA is being used as a tool to analyze spatial data in assignments given to post graduate students at Bangladesh Agricultural University, Chittagong University and BSMRAU.
- BAU has developed a GIS course where BCA is the major course component.

3. Whole Family Training in Maize

3.1 Introduction

A technology transfer method that is gender biased and non-participatory will be of limited effectiveness. Considering this, the CIMMYT Office in Bangladesh adopted a Whole Family Training (WFT) approach to transfer modern maize cultivation technologies and practices among the farming community. This approach is gender unbiased, participatory and simple in practice. It has been found effective during the life of the project. It helps the farmer to learn at all stages from planting to marketing. The CIMMYT Office in Bangladesh continued to implement this program during the 2005-06 report period jointly with BARI, DAE, NGOs and private entrepreneurs. Figure 3.1 shows the whole family training sites in 29 districts of Bangladesh for 2005-06. Every training session consisted of eight families with four members from each family (head of the family, spouse, son/daughter or in-law). With this approach, males and females can share their knowledge and teenagers can supplement this in the absence of an adult. Additionally, an agronomic research program to develop new recommendations on modern maize production for Bangladesh was continued. Details of the activities conducted and results obtained are described in the following sections.

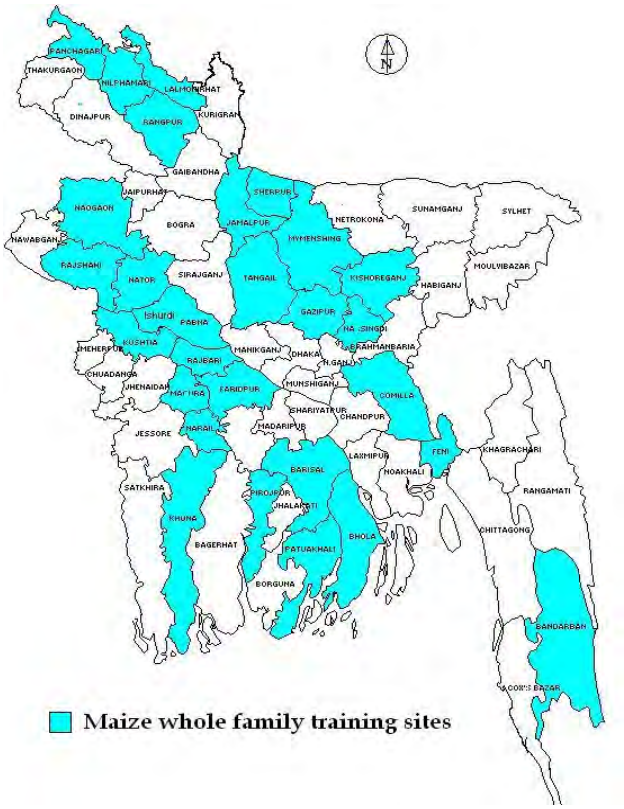


Figure 3.1: The Bangladesh maize whole family training sites for 2005-06

3.2 Whole Family Training (WFT)

Because of a reduction in resources, the whole family training on maize cultivation and practices was reduced to 2000 families for 2005-06. The CIMMYT Office in Bangladesh and its partners (including BARI, DAE, NGOs and private entrepreneurs) jointly conducted the WFT training sessions in different parts of Bangladesh. Figure 3.2 gives the distribution of families trained in the five Divisions of the country.

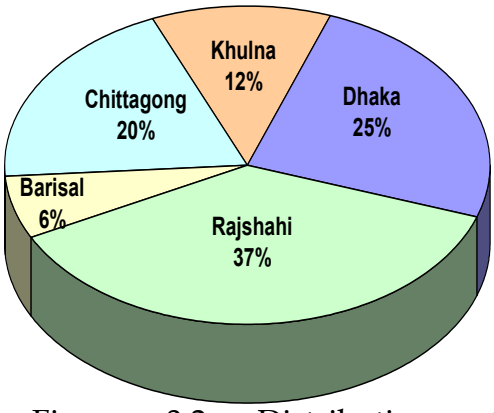


Figure 3.2: Distribution of families given maize whole family training, by Division for 2005-06

CIMMYT worked with different partners, including the Plant Breeding Division of BARI, Regional Agricultural Research Stations of BARI, Wheat Research Center of BARI, Doyel Agro Industries, Integrated Development Organization and Comilla Chashi Kallyan Samity (BCKS), to conduct the training sessions at various locations in Bangladesh. The distribution of 2000 farm families trained in maize production during 2005-06 is shown in Figure 3.3.

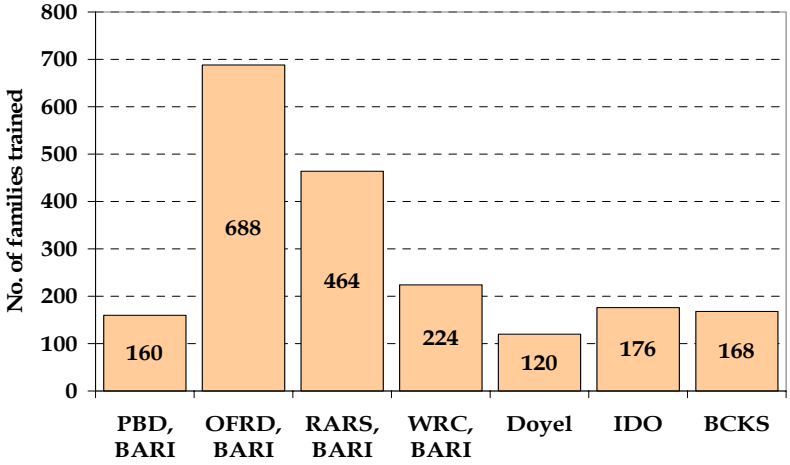


Figure 3.3: Number of families trained in maize production by different organizations during 2005-06

Figure 3.4 gives the number of farm families and number of trainers that received maize WFT from 2001-02 to 2005-06. The families and the trainers who were trained have not only carried out modern maize cultivation themselves but also extended their knowledge among the community.

Based on our improved training knowledge and changes in maize practices during the last four years, we updated the content of our training manual in 2005 to help farmers access the latest knowledge on maize production in Bangladesh.

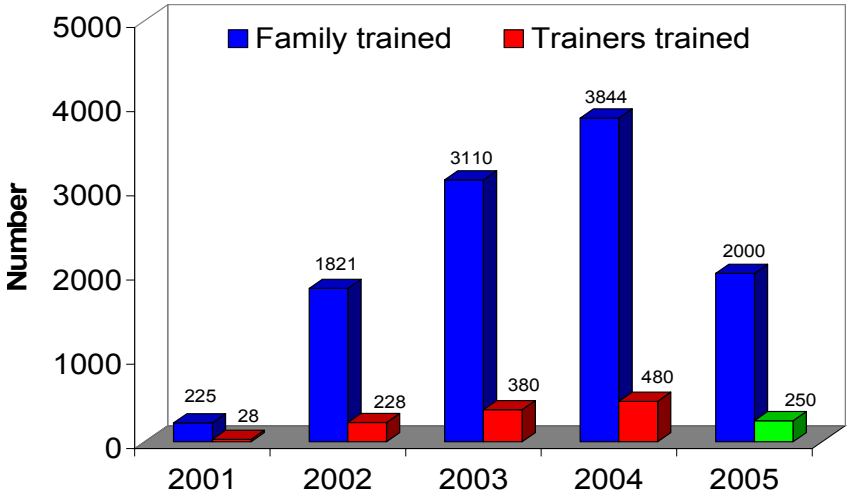


Figure 3.4: Number of trained families and trainers involved with maize whole family training in Bangladesh from 2001 to 2005

3.3 Distribution of Training Materials and Seeds

To accomplish the WFT program more effectively, the following training materials and seeds were distributed during 2005-06 to the trainees and other interested persons to help them learn about modern maize cultivation:

- 2,500 sets of the new 2005 version of the modern maize production manual in Bengali, including multicolored diagrams, pictures and text. The cover page of the manual is illustrated in Figure 3.5.
- 27 sets of large-sized multicolored pictorial posters.
- 2 kg of BARI Hybrid Maize-3 seed was distributed to each of the 2000 families trained.
- Video demonstrations on modern maize cultivation and practices at the training sessions of WFT and trainer training.

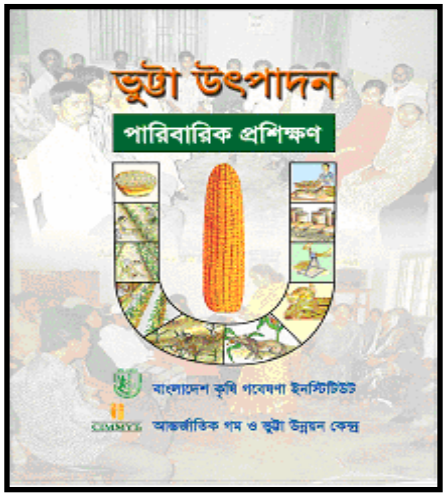


Figure 3.5: The cover page of the maize whole family training manual for 2005-06

3.4 Training Assessment on Maize Cultivation Knowledge

Two separate surveys were conducted in 2005-06 to assess changes in maize cultivation knowledge and current practices as a result of the maize WFT. One survey was conducted before the training session and another was conducted with the same trained families after they had harvested their maize. One hundred eighty two maize farm families were surveyed before and after training in 2005-06. The data collected were analyzed according to a set of parameters selected to assess the adoption of training knowledge.

3.4.a Area under maize cultivation

Among the farmers surveyed prior to training, 44.8% of the farmers reported they had never cultivated maize. Table 3.1 shows a 6.81 ha (48.4%) area and 0.93 t/ha (18.1%) grain yield increase as a result of farmers practicing the modern maize cultivation practices received through WFT. A field of maize from a farmer that had received WFT is illustrated in Figure 3.6.

Figure 3.6: A maize field cultivated by a farmer that had received maize whole family training

Table 3.1: Maize area and grain yield before and after training in 2005

	Pre-training (N= 182)	**Post-training (N=182)**	**Amount of increase**	**% increase**
Area (ha)	14.06	20.87	6.81 ha	48.4
Grain yield (t/ha)	5.12	6.05	0.93 t/ha	18.1

3.4.b *Planting time*

During the whole family training session, family members were trained to plant maize between November 1 and December 15, which is considered the optimum planting period for higher maize yield. Survey data revealed that 76.4% of the trained farmers planted maize during the optimum planting period, which was higher than before training (Figure 3.7). Again crops planted at the optimum planting date yielded higher than those planted at any other period with both pre- and post-trained farmers. With the optimum planning date, maize crops grown by trained farmers gave 6.48 t/ha of grain yield compared with 5.23 t/ha before training (Figure 3.8).

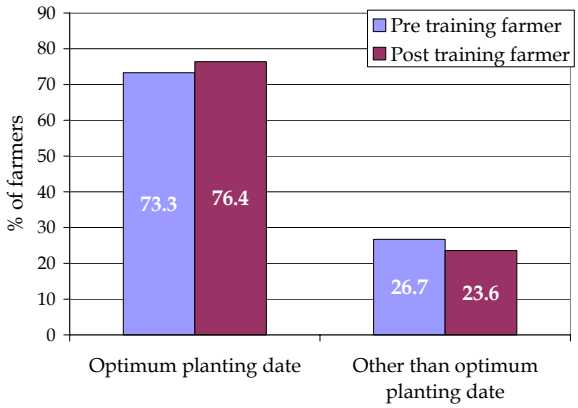


Figure 3.7: Percent of farmers that planted maize at optimum time and during other periods

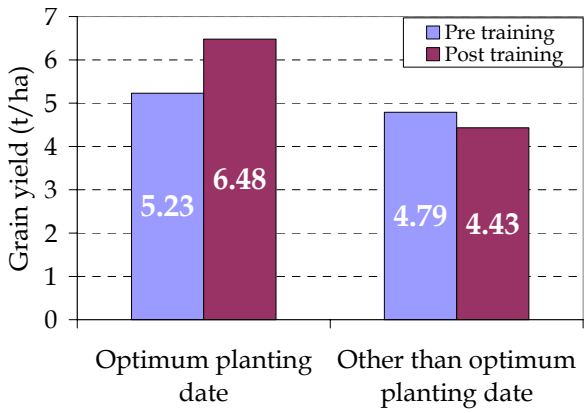


Figure 3.8: Grain yield of maize at optimum and other planting dates for pre- and post-training farmers

3.4.c *Irrigation of maize*

Irrigations are important for good plant growth to help ensure high grain yield. The yield of maize increased gradually as the number of irrigations increased for farmers both before and after training (Figure 3.9). However, for every irrigation, maize crops from trained farmers yielded higher than those grown by farmers without training. In particular, four irrigations resulted in the highest yield of 6.98 t/ha after training.

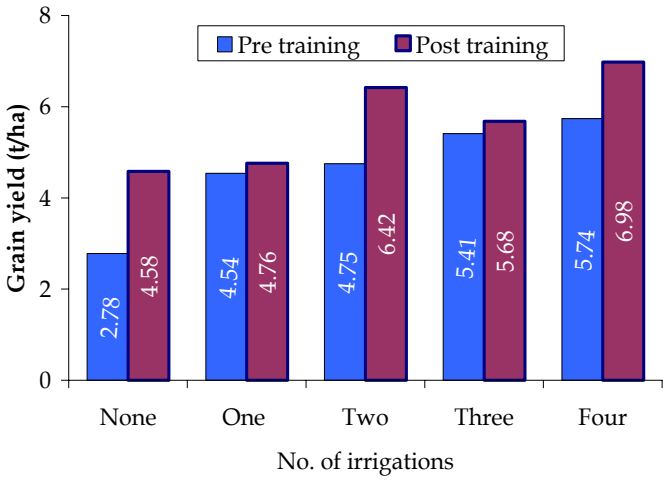


Figure 3.9: Grain yield (t/ha) by number of splits in the irrigation for farmers before and after training

3.4.d *Fertilizer in maize*

In the post training survey, farmers reported using a higher rate of urea, triple superphosphate, muriate of potash and gypsum than they used before receiving training. But this rate was still lower than we recommended to the farmers during the training sessions (Figure 3.10). However, the zinc use rate in the post training survey was higher than in pre training and surprisingly higher than that recommended.

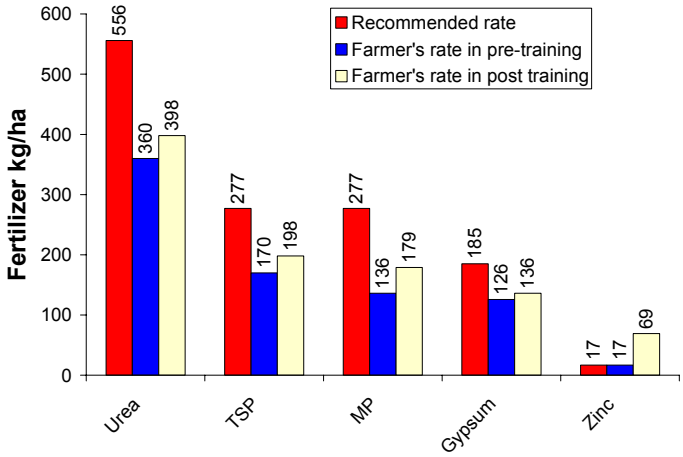


Figure 3.10: Comparative fertilizer use on maize by farmers, before and after training

3.4.e *Maize based cropping patterns*

Several cropping patterns involving maize are being practiced by farmers in the areas that received WFT. Figure 3.11 shows that 48% of farmers practiced a Maize-Fallow-T.Aman Rice based crop sequence. Several minor cropping patterns were practiced by a total of 24% of farmers.

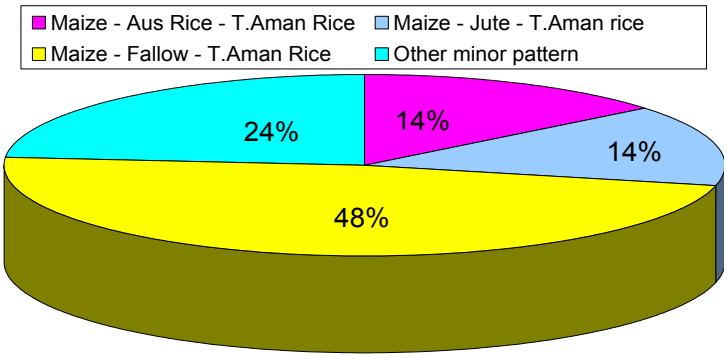


Figure 3.11: Percent of farmers practicing common maize-based cropping patterns after training

3.5 Research and Demonstration Results for 2005 - 06

We continued with several research and demonstration trials on station and on farmers' fields in different locations in collaboration with Bangladesh Agricultural Research Institute, Bangladesh Agricultural Development Corporation, NGOs and seed companies. These experiments were designed to develop new insights on maize technologies and practices to be incorporated into future maize WFT initiatives.

3.5.a *Hybrid variety demonstrations*

i) Variety demonstrations by OFRD of BARI

To evaluate the field performance of BARI-developed hybrid maize, BHM-2, BHM-3 and BHM-5 were demonstrated at 11 locations around Bangladesh.

Pacific 11 was also compared at three locations. At most of the locations there were no significant grain yield differences among the tested hybrids. Yield variation among the hybrids across locations was large (6.33 to 12.5 t/ha). Figure 3.12 illustrates the mean yield performance of the hybrids in 2005-06.

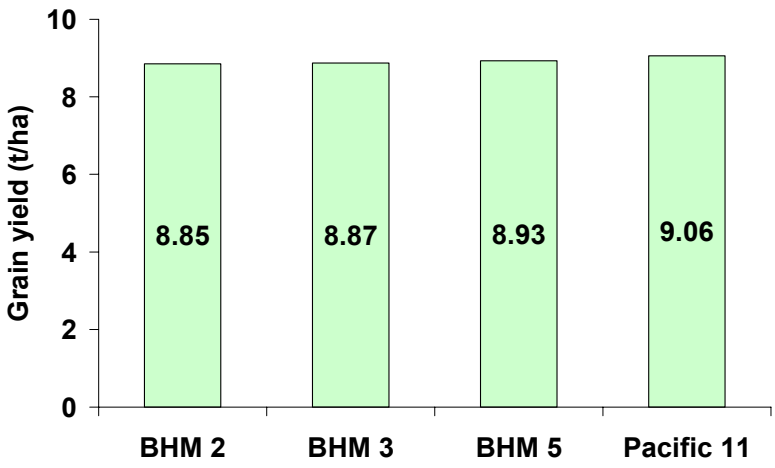


Figure 3.12: Mean grain yield of three BARI-developed maize hybrids compared with Pacific-11 at 11 locations in 2005-06

ii) Variety demonstrations by DAE

Hybrid maize variety demonstrations were conducted on 12 farmers' fields in Dhaka, Narayanganj, Munshiganj, Narsinghdi, Manikganj and Tangail during 2005-06. Each farmer planted BHM-2, BHM-3 and BHM-5 hybrids in three consecutive plots. Figure 3.13 shows that very similar yields were produced by the three hybrids but BHM-5 produced a slightly higher yield than the other two hybrids. Besides this, another 15 demonstration plots were set up for BHM-2 and BHM-3 in Shariatpur district to show the performance of the hybrids. Among the plots, 10 plots were planted with BHM-3 and the remaining five plots were planted with BHM-2. Figure 3.14 shows that BHM-3 performed much better (grain yield of 7.2 t/ha) compared to BHM-2 with 5.73 t/ha.

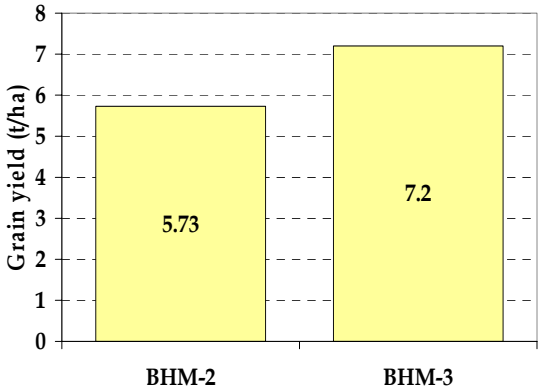


Figure 3.13: Average grain yield of BHM-2 and BHM-3 in Shariatpur during 2005-06

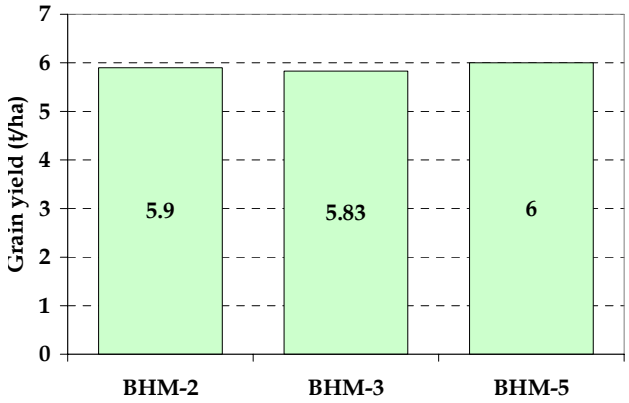


Figure 3.14: Average grain yield of different BARI maize hybrids on farmers' fields in six locations during 2005-06

iii) Variety demonstrations by Winrock International

Twelve trial plots of BARI hybrids BHM-2, BHM-3 and BHM-5 were set up in 12 districts by Winrock International during the Rabi season of 2005-06. Seed, fertilizer, irrigation and other inputs were used in the trial plots according to guidance given in the maize WFT manual. BHM-5 yielded higher (7.2 t/ha) than the other two hybrids (Figure 3.15).

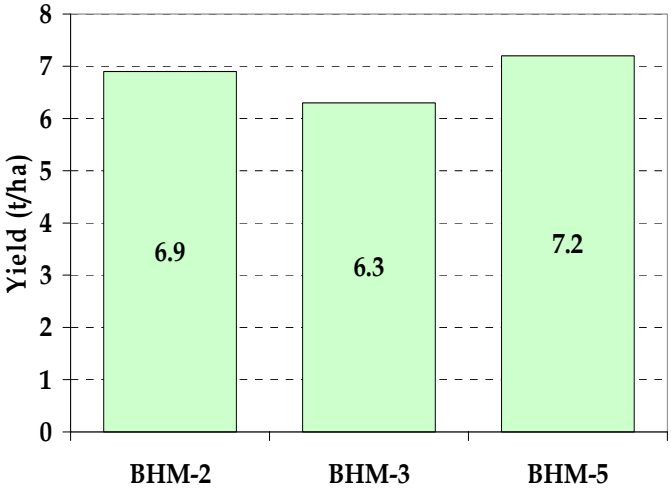


Figure 3.15: Average grain yield of three maize hybrids in 12 Winrock trials during Rabi 2005-06

iv) Variety demonstrations by BRAC

During 2005-06, three distinct hybrid varietal demonstrations were conducted at BRAC seed farm in Bogra. Average yield of common varieties were calculated for the three trials and are shown in Figure 3.16. All the varieties except Pacific-747 gave higher yield than the double cross hybrid Pacific-11.

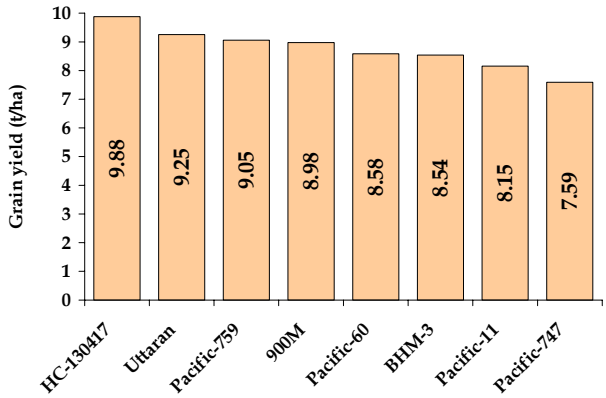


Figure 3.16: Average maize variety grain yield of three experiments at the BRAC seed farm, Bogra

3.5.b Planting time effect on the yield of hybrid maize

Our previous research found that the grain yield of maize in Bangladesh varies with planting time. To further assess this, an on-farm experiment was conducted in Rangpur and Bandarban districts during the Rabi season 2005-06 to evaluate the performance of BARI released hybrid maize BHM-2, BHM-3 and BHM-5 along with the check hybrid Pacific-11 at three dates of sowing; November 30, December 15 and December 30. Figure 3.17 shows that BHM-3

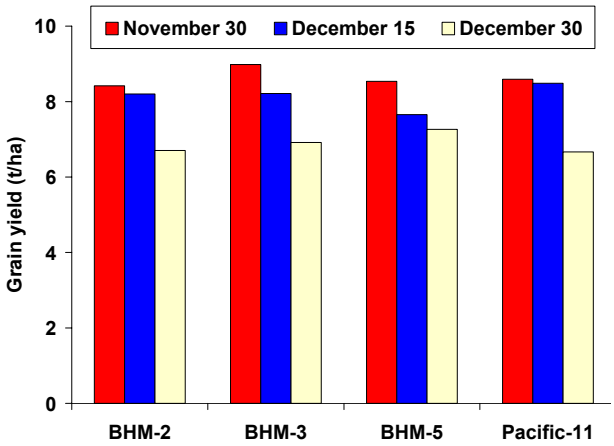


Figure 3.17: Grain yield of different maize hybrids under three planting dates at Rangpur 2005-06

produced the highest grain yield at all three dates of sowing but a yield reduction occurred with late sowing for all the hybrids.

3.5.c Synchronization of N application to maize growth stage

An experiment was undertaken by the On Farm Research Division of BARI to verify the effect of N application at different growth stages of maize at Comilla, Bogra, Jhenaidaha, Rangpur, Kishorganj, Pabna and Kushtia during 2005-06. Three urea application treatments were made; T1=1/3 as basal +1/3 at 8 leaf stage + 1/3 at tasseling stage (present recommendation), T2=1/2 as basal + 1/2 at 8 leaf stage and T3=30% as basal + 70% at 8 leaf stage. The experimental results found no significance difference for grain yields among the treatments in all locations except in Kushtia. In most of the locations either T3 or T2 gave higher yields compared to T1 (Figure 3.18). These findings could save farmers some labor costs and relieve farmers from the health hazard associated with applying urea at tasseling.

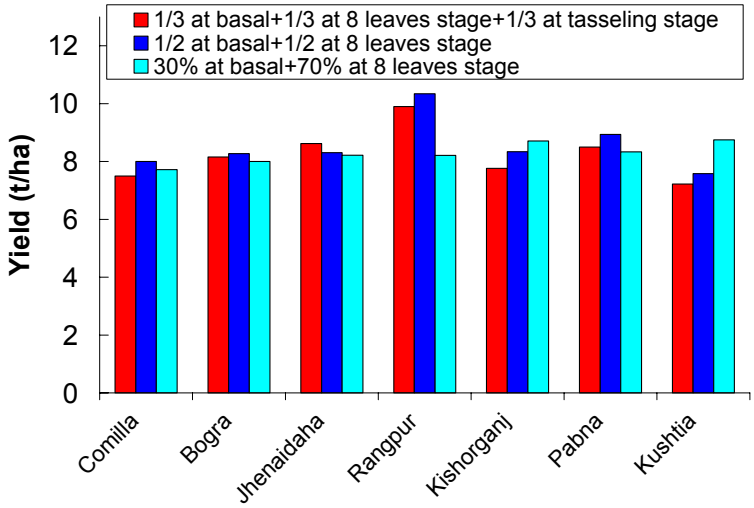


Figure 3.18: Grain yield of maize by different N application times in different locations

3.5.d Development of potential maize based intercropping systems

To determine the most productive and economically viable maize + vegetable intercropping system, a field experiment was conducted in eight different districts. The productivity of maize + vegetable intercropping was compared with sole maize cropping in terms of maize equivalent yield (MEY) and benefit cost ratio (BCR). Figure 3.19 shows that all maize + vegetable intercropping combinations produced higher MEY than the sole maize grown. Considering the MEY and BCR, Maize + Spinach and Maize + Bushbean were found promising.

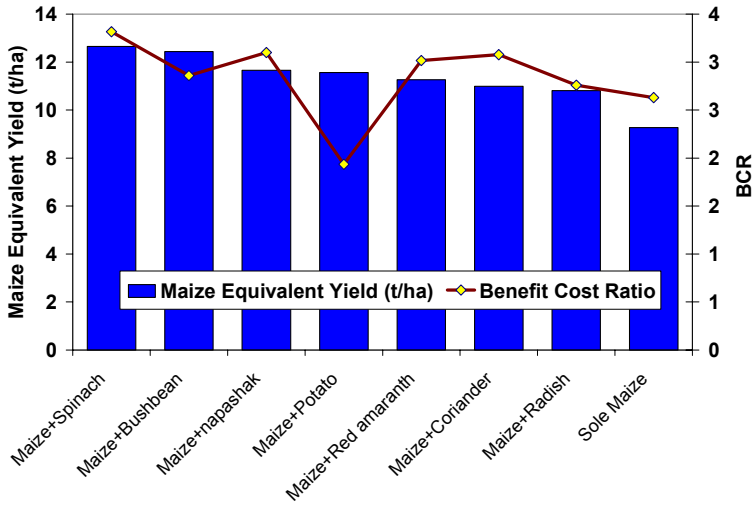


Figure 3.19: Agronomic and economic productivity of maize + vegetable intercropping in Bangladesh

3.5.e Development of maize + potato intercropping system

Maize is a long duration crop. The intercropping of a short duration potato cultivar with maize could help the farmer to earn a quick return. To get maximum benefit, an experiment was undertaken to observe the intercropping and relay time of maize along with potato plant population, assess returns from potato and also the intercropping effect of potato on maize yield. The treatments were; T1=Same-day planting of maize and potato; T2=Maize sowing at 20 days after planting (DAP) of potato; T3=Maize sowing at 35 DAP of potato, T4= Sole maize. The experiment was laid out in an RCB design with four replicates; in two locations, Pabna and Rangpur. Figure 3.20 shows the comparative yield and net return of sole maize with the three maize + potato intercropping combinations. Maize yield and net returns were both higher for intercropping with potato in all planting dates compared to sole maize cultivation. In particular, T3 (maize sowing at 35 days after planting of potato) showed the highest net return among the treatments.

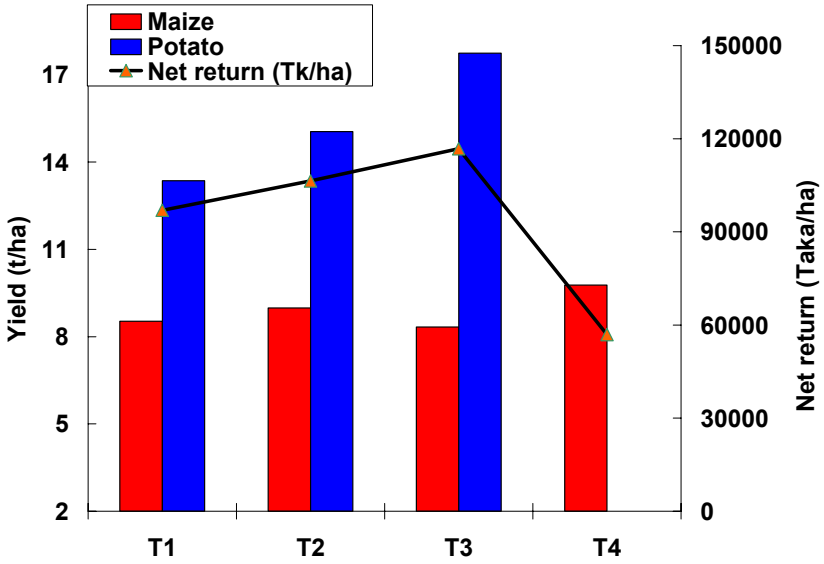


Figure 3.20: Agro-economic productivity of maize + potato intercropping systems, 2005

3.5.f Seed production of BARI hybrid maize

To help promote BARI hybrid maize throughout the country, CIMMYT took the initiative to produce BARI hybrid maize seed in our 2005-06 winter season through support to the following stakeholders; BADC, Supreme Seeds Company Ltd., IDO and Unnayan Sangha. CIMMYT provided financial and technical assistance, training and the inbreds to these stakeholders. As a result, a total of 48.9 t of seed was produced on 30 ha of land. It is expected that about 2,500 ha of land could be sown with these hybrids in 2006-07. Table 3.2 gives the area and amount of seed produced by different organizations in 2005-06. BADC has taken the responsibility to produce 500 t of BARI-developed hybrid maize seed during 2006-07.

Table 3.2: Seeds of Maize Hybrids Produced by Different Agencies in Bangladesh during 2005-06.

Organizations	Maize hybrid							
	BHM 2		BHM 3		BHM 5		Total	
	Area (dec)	Prod. (kg)	Area (dec)	Prod. (kg)	Area (dec)	Prod. (kg)	Area (dec)	Prod. (kg)
BADC	3,400	24,834	3,700	22,205	-	-	7,100	47,039
Supreme Seeds	-	-	-	-	164	623	164	623
IDO	-	-	66	837	-	-	66	837
Unnayan Sangha	-	-	43	370	-	-	43	370
Total	**3,400**	**24,834**	**3,809**	**23,412**	**164**	**623**	**7373**	**48,869**

3.5.g Tolerance of BARI hybrid maize varieties to variable population densities

An on-station experiment was undertaken during 2005-06 in Rajshahi on the tolerance of BARI hybrid maize to different plant population densities and spatial arrangements. BHM-2 and BHM-5 were tested. Research results found there was no significant yield difference among the different spacings or plant populations. Thus, this study suggests that farmers could use a minimum 44,444 plants/ha with 75 cm x 30 cm spacing per plant without reducing the grain yield of maize. This will save seeds and money (Figure 3.21). Further studies should be conducted over environments for a robust conclusion.

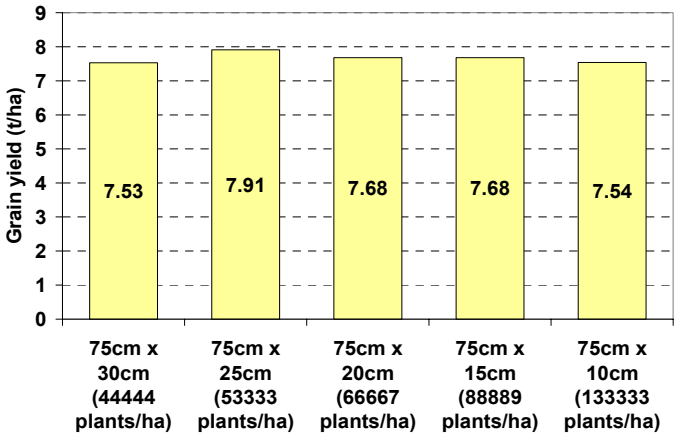


Figure 3.21: Yield of BARI hybrid varieties under different plant spacing

3.5.h Productivity of recycled seed (F_2) of different hybrids compared to F_1 seed

To evaluate the effect of using recycled seed on the productivity of different maize hybrids, an on-farm experiment was undertaken at the Regional Wheat Research Center in Rajshahi. Five treatments were given :- a) Pacific-11 and their Rabi and Kharif recycles, b) Pacific-60 and their Rabi and Kharif recycles, c) BHM-2 and their Rabi and Kharif recycles, d) Uttaron-1 and their Rabi and

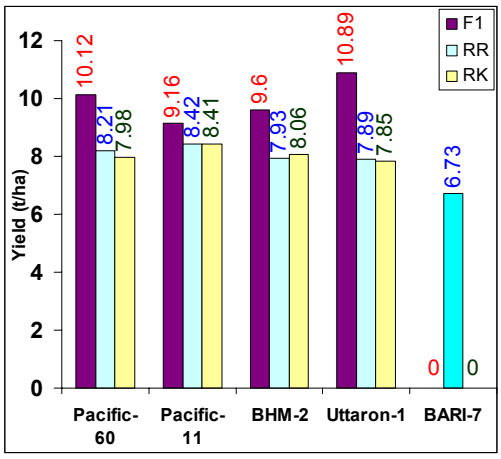


Figure 3.22: Yield of F_1 hybrid maize and their Rabi and Kharif recycles

Kharif recycles, and e) new seed of BARI Maize-7 (an OPV). Average grain yields of F1 and recycled seed of different hybrids in the Rabi and Kharif seasons are shown in Figure 3.22.

3.5i Evaluation of imported maize hybrids

An on-station trial was conducted to evaluate the performance of different maize hybrids imported into Bangladesh. Twenty hybrids including three checks (BHM-2, BHM-3 and BHM-5) were laid out in the experiment. The imported varieties Mukti, Ester, Konok, C-1837 and Emperor gave similar yield to the check hybrids BHM-2 and BHM-3 (Figure 3.23).

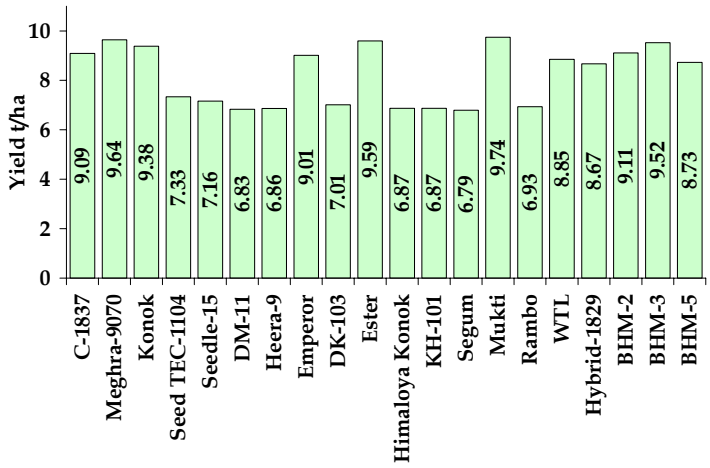


Figure 3.23: Grain yields of imported and locally developed maize hybrids, 2005-06

3.6 Maize Germplasm Importation and Distribution

The CIMMYT Office in Bangladesh received 37 hybrid materials in two trials from CIMMYT Mexico. We distributed these to BARI and BRAC partners for evaluation and selection of the best entries from each trial for the development of new hybrids. Table 3.3 shows potential entries selected through the experimental trials for further evaluation in hybrid development. Requests for the inbreds of the selected entries were made to CIMMYT HQ during the report period.

Table 3.3: Maize Trials Received from CIMMYT Mexico and Entries Selected in 2005

Name of Trials	No. of locations	No. of entries evaluated	Name of potential entries selected (Hybrid code)	Remarks
CHTTY-A (Tropical yellow normal and QPM hybrid)	3	24	CMS033002, CMS983002, CMS033010, CMS033016, CMSQ033022 CMSQ033028	Overall performance of the selected entries found to be very good under different environmental conditions and was selected for further evaluation.
TTWSCYL-A (Tropical three way and single cross yellow late normal and QPM trial)	3	13	CMTQ033068	Overall performance of the selected entry found very good under different environmental conditions and was selected for further evaluation.

3.7 Expansion of Whole Family Training Concept

Different organizations like Winrock International received technical assistance from CIMMYT on whole family training. During 2005-06, Winrock adopted the whole family training concept and are practicing the technology in their BREAD II project. Winrock published CIMMYT training materials on their own and also continue to get assistance from CIMMYT as and when necessary.

3.8 Scientist Exchange and Visit Program

Kevin Pixley, Director, Tropical Ecosystems Program and Head of CIMMYT Maize for Latin America and Asia (located in Mexico) and two CIMMYT maize breeders/seed production specialists from India visited Bangladesh from 6 to 11 February 2006. They visited on station work (Figure 3.24) and farmer fields near to different NARS stations. They interacted with Bangladeshi scientists, farmers and seed companies to exchange their ideas on maize research and current practices among the participating countries. In particular they were able to help BARI develop a more coordinated maize breeding program for the future. Such visits help to improve the research capability of the scientists as well as the institutions through the exchange of information and materials.

Figure 3.24: CIMMYT maize breeders from Mexico and India visited CIMMYT maize germplasm evaluation trial at BARI HQ Gazipur

3.9 Field Days

Ten field days in ten locations were organized during 2005-06 to transfer useful agricultural information and technology to larger numbers of farmers. Maize production and practices were discussed and demonstrated to the trained and non-trained farmers, private sector and extension personnel during the field days. Figure 3.25 shows a field day where farmers are interacting with each other and sharing ideas for greater economic benefit from maize cultivation.

Figure 3.25: Field day in Feni on maize whole family training

3.10 High Officials Visit Maize Fields

A very high profile maize field tour was organized on April 15 and 16 by Nur-E-Elahi, CIMMYT Affiliate Scientist, Maize, with the Executive Chairman (EC) of Bangladesh Agricultural Research Council (BARC), Director General (DG) of Bangladesh Agricultural Research Institute (BARI), Chairman of Bangladesh Agricultural Development Corporation (BADC) -- a government seed producing agency; Director, Department of Agricultural Extension (DAE); Additional General Manager, seed production at BADC and Stephen Waddington, CIMMYT Agronomist. The purpose of this trip was to show them how BADC, with technical support from CIMMYT, is producing seed of the CIMMYT-derived hybrids released as BHM-3 and BHM-5 (QPM) by BARI. We also looked at the field performance of the hybrids cultivated by farmers that had been trained in the maize whole family training program in different locations. After visiting the seed production and grain production fields, the group participated in a well attended farmer's rally where BHM-3 and BHM-5 growers, seed producers from the public and private sectors, seed dealers, local level extension officers, NGOs and researchers participated and exchanged views. The policy outcome of this tour is that the CIMMYT whole family training approach for maize promotion will continue with national as well as CIMMYT support. BADC will produce BHM-3 and BHM-5 seed on 500 ha of land in 2006 through growers and DAE will do country-wide demonstrations with these hybrids to ensure farmer awareness and adoption in 2006-07.

Figure 3.26: EC of BARC, DG of BARI, Chairman of BADC and other senior scientists visiting the BHM-3 seed production field of BADC

Figure 3.26 shows the team members (EC of BARC, DG of BARI, Chairman of BADC) visiting the BHM-3 seed production field of BADC and interacting with the CIMMYT scientist Nur-E-Elahi about hybrid maize seed production technology. Figure 3.27 shows the DG of BARI, EC of BARC and others viewing the excellent field performance of BHM-5 (QPM) hybrid cultivated by whole family trained maize farmers. Figure 3.28 shows the team at a farmer rally exchanging their views on the promotion of BHM-3 hybrid maize with the whole-family-trained and non-trained maize growers and others.

Figure 3.27: Visit to an excellent crop of BHM-5 maize cultivated by a whole-family-trained farmer

Figure 3.28: Farmer's rally in Natore where BHM-3 growers, local people and experts exchanged their views

This visit helped DAE to decide to demonstrate BARI hybrid maize in farmers' fields throughout the country and BADC to produce seed of BARI hybrids. It is reported that DAE will set up 988 demonstrations throughout the country during 2006-07 with their own network and financial support. BADC plan to produce 500 t of seeds on 120 hectares of land, 80 ha with BHM-3 and 40 ha with BHM-5 (QPM hybrid) during 2006-07. These developments demonstrate the impacts of our support to maize development and training in Bangladesh.

4. Development of Ring Spot Virus Resistant Transgenic Papaya for Bangladesh

This year was the fourth year of the 5-year USAID-funded program whereby the application for the receipt by Bangladesh of transgenic papaya was prepared for BARI, submitted, scrutinized, resubmitted and is now under consideration by BARI, BARC, the national biosafety committee, and ultimately then the Ministries of Agriculture and the Environment. We heard that the last year of the USAID budget to this program had to be severely cut, hampering our ability to conclude the program as we had originally intended. Activities for the final year will be reflected in our annual plan of action, but unless other funds can be identified, the final conclusion of the 5-year program might result in no transgenic able to be sent and tested as planned.

A group of biotechnology project coordinators working in Bangladesh, 2006

4.1 Activities Performed in 2005-06

According to the plan of action, the following were the activities to be preformed during this past year:

a) Work on regulatory and bio-safety guidelines

b) Transformation of Bangladeshi strains at USDA, Hawaii

c) Engineer CP gene of BD strains to develop transgenic plants at Hawaii

d) Development of transgenic papaya plants and their multiplication through tissue culture and establishment of plantlets at USDA

e) Testing of transgenic lines at USDA/ BARI

All the activities were reported quarterly to USAID and are now summarized in this annual report.

4.1.a Work on regulatory and bio-safety guidelines

Craig Meisner, Adjunct Professor with Cornell University, continued to act as this program's liaison scientist, attending many biotech meetings on behalf of the program to represent transgenic virus-free papaya as one of three USAID-funded biotech components. He was able to conduct a lecture at BAU, hosted by the Vice-Chancellor where he highlighted the potential results of introducing virus-free papaya. Professor Meisner will continue to act as liaison scientist with the program through 2007.

Workshop on transgenic crops held on April 30, 2006 at BINA, Mymensingh

During the report year, the application was submitted to BARI who passed it onto the National Biosafety Committee. They scrutinized it and requested that additional information be added. The application was resubmitted to BARI in May 2006 and is still being scrutinized. Assuming that the GOB accepts the resubmitted application and approves field trials, our goal is now to have the seed ready for the August/September 2006 sowing which is the second season for papaya sowing during the year, i.e. right after the heavy monsoon rains, or by next spring 2007.

Deregulation of 'SunUp' and 'Rainbow' (both commercialized in the U.S.A) transgenic papaya in Japan could set an important precedent for getting approval of the transgenic papaya in Bangladesh, Thailand, and other parts of the world. It is hoped that clearance of the transgenic papaya in Japan will pave the way for a less extensive deregulation process of transgenic papaya in Bangladesh and other countries.

4.1.b Transformation of Bangladeshi strains at USDA, Hawaii

As the Shahi papaya variety germplasm was not available from Bangladesh, transformation of their lines will not begin until the successful introduction of other virus-free lines to Bangladesh.

4.1.c Engineer coat protein (CP) gene of Bangladeshi strains to develop transgenic plants at Hawaii

PRSV isolates were collected and sent to Hawaii for analysis of their coat protein sequences. These analyses were done and were part of the submission of the application for importation and testing of potential transgenic lines. The genes were sequenced and then engineered to have a 'segmented' gene construct that would be tailored for Bangladesh. That is, this gene construct would have segments of coat

protein genes of PRSV isolates from Bangladesh. This technically challenging task was completed and plasmids are now ready for transformation into papaya.

Papaya has also been transformed with 'synthetic' coat protein gene segments. A number of transgenic plantlets have been obtained and are coming out of tissue culture. The transgenic lines will be multiplied and tested against strains of PRSV from Hawaii and Bangladesh.

4.1.d Development of transgenic papaya plants and their multiplication through tissue culture and establishment of plantlets at USDA

A fast track effort was done to speed up the project by using transgenic lines with a gene construct that contained segmented genes from PRSV isolates from Thailand, Taiwan, and Hawaii. These lines were of transgenic cultivars of Hawaiian solo 'Kapoho' and 'Sunrise'. The lines had originally been screened against PRSV isolates from Thailand, Taiwan, and Hawaii. They were subsequently brought from Cornell University to Hawaii where they were evaluated horticulturally and screened against PRSV from Hawaii. The selected cultivars are horticulturally good and resistant to PRSV under field conditions in Hawaii. Since coat protein analysis of PRSV isolates from Bangladesh showed that these coat proteins were very similar to those of PRSV from Hawaii, we expect that these papaya lines would be resistant to Bangladesh isolates. Five different transgenic lines were sent to Cornell University for analysis of their resistance to PRSV isolates. The plants grew slowly (due to winter conditions) but well. PRSV isolates were shipped to Cornell University, the isolates were inoculated to *Cucumis metuliferus*, which is a host that we have routinely used to propagate PRSV isolates. The inoculated *C. metuliferus* gave positive ELISA readings which showed that infection had been established. Concurrently, *C. metuliferus* plants were inoculated with PRSV from Hawaii. As expected, the PRSV from Hawaii incited severe symptoms on *C. metuliferus* but unexpectedly the Bangladesh isolates showed very mild to almost no symptoms, although virus could be detected by ELISA. These inoculated *C. metuliferus* were used to inoculate nontransgenic and transgenic papaya seedlings. However, symptoms of infection did not develop on transgenic or nontransgenic papaya. We need to establish the inocula on papaya by directly inoculating the dried inocula. During the period April – July 2005, fresh samples of papaya leaves were sent to Cornell for viral isolation and inoculation on the transgenic lines of papaya at Cornell that will ultimately be sent to Bangladesh. Results of these tests should be ready by July 2006. A Bangladeshi Scientist, Dr. Akhanda of BSMRAU, collected these fresh samples. He is the national virologist associated with this program.

4.1.e Testing of transgenic lines at USDA/ BARI

As USDA cannot inoculate papaya with 'foreign' viral strains in Hawaii, testing is ongoing at Cornell described above. PRSV strains are also being maintained (based on symptoms) in Bangladesh through inoculation at BSMRAU. Screening of papaya varieties is in progress against PRSV under natural conditions as well as artificial inoculation. Development and testing of mild and virulent strains of PRSV are also in progress.

4.2 Variety

Due to the inability to identify the specific genetic stock of the national papaya variety, "Shahi", other varieties are being tested at Cornell and may be sent to Bangladesh, if approved for testing (Table 4.1).

Table 4.1: Papaya varieties being tested.

Segmented Genes	Seeds (R2)	Cultivar
Kp EETV 95	50 grams	Kapoho
Kp KKTV 111	50 grams	Kapoho
Kp KKTV 118	50 grams	Kapoho
Sr KKTC 463	50 grams	Sunrise
Khaknuan line 319	100 grams	Khaekdum

4.3 Transgenic Variety Development

Once the GOB approves the import of transgenic lines, the whole program will be coordinated in Bangladesh through a team approach with BARI through the leadership of Dr. Dennis Gonsalves. Craig Meisner will remain as the functional national Cornell University program liaison scientist through 2007. Technically, the team has been constituted with divided responsibilities as follows:

A. Identification of virus - Prof. M A Mannan Akhandha will look after virus activities at BSMRAU and also at BARI.
B. Tissue culture – Three scientists, namely Dr. Abdul Hoque, Dr. Kabita Anzu–Man–Ara and Ms. Dilafruza Khanam will be responsible for tissue culture related activities at the laboratory and in the field.
C. Testing transgenic in net house – The transgenic materials will be evaluated and tested in the net house under controlled conditions. Here, three scientists, Dr. M. A. Jalil, Dr. Al-Amin and Mr. Nazrul Islam will take the initiative.
D. Field trial – Also Dr. M. A. Jalil, Dr. Al-Amin and Mr. Nazrul Islam will evaluate the performance of the improved transgenic papaya.
E. Regional trial – Final evaluation of performance will be done on a regional basis in Bangladesh, ensuring adaptability of any new lines.

4.4 Ph.D Research Work in Collaboration with Cornell University

Ms. Jacqueline King, a Ph.D. student from Cornell University had been conducting research on papaya management and production in collaboration with CIMMYT in Bangladesh. She returned to Cornell at the end of May 2006 to write her thesis. The overall objectives of her research have been to:

(1) improve commercial and homestead garden papaya production through optimum inorganic and organic fertilizer management.

(2) evaluate the effect of different agricultural practices on the nutritional quality of papaya.

(3) determine the impact of alternate planting dates on papaya yield and quality.

Beginning in spring 2004, field trials were initiated at the On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI) station in Rangpur and also at the On-Farm Research Division, BARI station in Pabna. In April 2005, additional experiments were initiated in farmers' fields in the Pabna and Ishurdi areas. Ms. King's research activities were completed in spring 2006.