Annual Report

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

July 2004-June 2005

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Executive Summary

I. Background

The Bangladesh Office of CIMMYT (CIMMYT Bangladesh) initiated a five-year project **"Food Security in Bangladesh: Improving Wheat, Maize and Papaya Production and Impacts of Arsenic Contamination"** with USAID funds in July 2002. The goal of the project is: **Enhancement of food production in Bangladesh through improving efficiency and profitability in crop production and sustainable use of natural resources.**

The project is being implemented through eight programs each with specific objectives and pertinent research-development-extension activities targeting the achievement of the project goal. The eight programs are:

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
5. Impacts of arsenic contamination on agricultural sustainability and food quality
6. Agro-food nutrition in Chakaria
7. Monitoring and evaluation
8. Human resource development

For the last three years, CIMMYT Bangladesh has been implementing the above programs in collaboration 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 of Bangladesh, and Cornell University and Texas A&M University of USA. CIMMYT Bangladesh, as the project implementing agency, has been regularly submitting to USAID quarterly and annual technical progress reports on the program activities since the initiation of the project.

In this summary we provide brief notes on the major activities, progress and accomplishments of the different programs during the period July 2004 to June 2005. Details are provided in the chapters that follow.

II. Progress and achievements

1. Facilitation and promotion for adoption of mechanization by growers

In view of the increasing shortage of animal draft power and human labor for farming operations, the need for reducing the turnaround time between wet season rice and the following wheat or any other non-rice crop, we initiated 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 2004-05 with the following progress made:

- Further development of a diesel-engine-operated reaper, bed planter, zero tillage, high speed rotovator, thresher and maize sheller and distribution of 83 Bangladesh Hand Tractor (BHT) accessories to different stakeholders.
- During 2004-05, a total of 4,409 hectares of land were brought under the mechanization program. Wheat and maize accounted for 79% of this area. A total of 5,857 farmers used the BHT accessories for different crop production activities.
- Continued R&D on power tiller (PT) operated equipment like the Sifeng Type Seeder, Seeder Operated Bed Former and Planter, Zero Tillage Planter, Multi-Crop Seeder, Potato Planter and High Speed Rotovator Tiller.
- Studies with this equipment showed a 25-40% advantage over conventional cultivation methods in terms of productivity, resource conservation and profitability for a wide range of crops like wheat, maize, potato and mung bean.
- During 2004-05, 73 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.
- The BHT seeder helped to popularize two new wheat varieties, Protiva and Shatabdi, released by WRC. About 4 t seeds were distributed among farmers owning the seeder who in turn produced 29 t seeds from 33.5 ha land in 2005 for expanded cultivation of these wheats in 2005-06.
- A study on the adoption and impacts of PTs in Bangladesh showed that the use of PT increased total production per unit area of land by increasing productivity by 4.8 % in wheat, 10.0% in T. Aman rice and 5.7% in winter Boro rice.

2. Bangladesh Country Almanac (BCA)

The BCA is a feature-rich series of geo-spatial data at the national and upazilla levels resulting from the collective work of several partner institutions including BARC, SRDI, BRRI and CIMMYT with a contract with the Mud Springs Geographers (MSG). The integrated database includes climatic, soils, crops, demographic, hydrographic and infrastructure information. The BCA is in the process of continuous development and updating of information resources for Bangladeshi scientists, planners, investors and development partners.

- **Release of software and database versions:** In June 2004, Ver 3.6 of the AWhere-ACT software and database Ver. 2.0 of the BCA were released. The AWhere-ACT 3.7 beta version was received from MSG in June 2005 and is being tested with the old and newly created databases to identify the

problems and bugs. A new BCA version will be released as Ver. 2.5 in October 2005. This latest version includes several important new tools and features.

- **Database development and upgrading:** Progress was made on a new national database on land and soils using semi-detailed information at the Upazila level at a 1:50000 scale and at the country level at a 1:100,000 scale. Land suitability maps for major field crops and fruits in Bangladesh have been created and time series data on crops, climate and some other elements have been updated for inclusion in the new version of the BCA.

- **Dissemination/training workshops:** In the report period, five one-day dissemination/training workshops and three two-day hands-on-training events were organized in collaboration with regional networks, NARS, NGOs and the private sector at different locations. A total of 652 participants attended training workshops, with most of them satisfied with the new knowledge gained.

- **Mini-grants:** During 2004-05, eight mini-projects were supported by the BCA program. The outputs of these projects will be integrated with the BCA database as case studies. Such case studies will provide management or problem solving information for the users, e.g., characterization of 'hot spots' of rice hispa – a case study in Sylhet region.

- **Expansion of BCA:** The usefulness of BCA was recognized by BBS, BNNC, DAM and DAE. These Government agencies will work with the CIMMYT BCA program with their data inputs.

3. Whole family training (WFT) in maize

With a steady growth of the poultry industry in Bangladesh, the demand for maize increased to about 1.2 million t per year, but maize production was less than 150,000 t in the year 2000. However, the potential for rapid growth in maize production exists in the country. A program to increase maize production through training, research and extension was initiated and vigorously pursued through the last three years. A brief summary of the activities and accomplishments of the program in 2004-05 is given below:

a. Whole family training

The WFT concept was used to effectively train maize growers on modern maize production technologies at whole family training sites in 28 districts.

- Various CIMMYT Bangladesh partners, including GOB, NGOs, private entrepreneurs and farmer organizations conducted whole family training for 3,844 maize farm families (involving 15,376 maize growers). All targeted families received training.
- Training materials including maize production manuals, posters and video CD's. were distributed to the partners, farmers, NARS institutions,

development agencies, universities, private entrepreneurs and seed companies.

- A post training assessment for 2271 families trained in 2003-04 indicated the effectiveness of the WFT methodology in terms of variety use, time of planting, irrigation and fertilizer application for maize production and maize-based cropping patterns. Maize yields for the trained farmers varied depending on how well they applied the knowledge gained from the training for maize cultivation. For example, 57% of the trained families planted maize at the optimum time (between November 1 and December 15) getting an average yield of 6.1 t/ha compared with 5.4 t/ha obtained by the remaining 43% farmers who failed to plant maize at the optimum time. Due to enhanced knowledge through WFT, 93% of the trained families found maize to be more profitable than wheat or Boro rice.

b. Research and demonstration

For strengthening the maize program in Bangladesh, need-oriented applied research and demonstration programs on different production factors were undertaken in collaboration with BARI, BADC, a few NGOs and seed companies.

- Varietal demonstrations indicated potential for cultivation of locally developed hybrids in the country rather than imported hybrids. The BARI developed hybrids BHM-2, BHM-3 and BHM-5 performed better than Pacific-11. BHM-5 was released as a quality protein maize (QPM) rich in the two essential amino acids, lysine and tryptophan.
- It was found from survey data that planting maize later than the optimum period, i.e., Nov. 1 to Dec. 15, resulted in a significant yield reduction. However, varietal differences were observed in this respect. For example, less yield reduction was observed in Pacific-11 (a double cross hybrid) and BHM-3 (a single cross hybrid) compared with the other hybrids indicating that these two varieties could be broadly adopted for cultivation in the existing rice-based farming systems of Bangladesh.
- In research on the development of potential maze based intercropping systems, maize + potato, maize + spinach and maize + radish were found promising. However, further trials with more locations and farmers were needed for conclusive results.
- Work on maize establishment methods indicated that the soil bed planting method could be better than the conventional method. Bed planting, gave 34% higher maize yield. Better maize growth and higher yield on the soil bed could be the result of better water and fertilizer use by the crop.

c. Expansion of WFT

Through interactions, discussions and meetings with CIMMYT scientists on the WFT concept, Winrock International and the Northwest Crop Diversification Program (NCDP) of DAE found the WFT concept very effective in empowering maize

growers with modern maize production knowledge, and expanded their use of this approach.

Winrock International in its BREAD-II project and DAE in their NCDP project have adopted the WFT concept for maize promotion in their project areas and used the training materials developed by CIMMYT for their farmers and trainers. During 2004-05, a total of 86 Sub-Assistant Agricultural Officer (SAO) of DAE and 54 field organizers of nine different NGOs were trained by CIMMYT maize scientists on the WFT concept and methodology and on modern maize production technologies.

4. Development of ring spot virus resistant transgenic papaya for Bangladesh

The successful use of transgenic papaya in the USA for Papaya Ring Spot Virus (PRSV) resistance opens a new avenue for its adoption in Bangladesh. Papaya is popular in Bangladesh both as a vegetable and as a fruit. However, the PRSV disease greatly damages papaya production and fruit quality. The fruit is rich in nutritive value, especially in vitamin A and vitamin C. A 5-year program on papaya improvement through infusion of PRSV resistance using biotechnology was initiated in 2002 in collaboration with Cornell University and USDA. Some of the activities in 2004-05 were:

- During the period April – July, 2004, a total of 96 PRSV strains (based on symptoms) were collected from 7 regions of the country by BSMRAU (Bangladesh partner university). All the PRSV strains previously collected from different parts of the country were sent to the USDA Lab in Hilo Hawaii. The isolation and characterization of the coat protein gene of PRSV were done in Bangladesh.
- Development and testing of mild and virulent strains of PRSV are in progress.
- Development of facilities for handling transgenic papaya at the Horticulture Research Center of BARI is in progress.
- A Ph.D. student from Cornell University, is currently conducting research on improvement of papaya crop production and management in Bangladesh.

5. Impacts of arsenic contamination on agricultural sustainability and food quality

There is a growing national concern about arsenic contamination of ground water in Bangladesh because many millions of people in Bangladesh face a two-way risk of exposure to arsenic, directly through the water they drink and indirectly through food crops grown on soils contaminated by arsenic through groundwater irrigation. An understanding of the nature and extent of arsenic pollution of the irrigation waters, soils and crops and a start in developing water-soil-crop management practices to mitigate the arsenic problem in agriculture and food are essential. A program was initiated in early 2002 with four national and three international partners to study the impact of arsenic contamination in crop production and attempt to develop arsenic management technology.

a. Arsenic in the water-soil-plant system: Survey and assessment

A nationwide survey (began in 2003-2004) to assess the arsenic situation in 184 unions in 92 *thanas* all over the country was continued through 2004-2005. Important findings are given below:

- **Arsenic in irrigation water**: A very wide range of As in irrigation water was found. Seventy-seven percent of the 355 shallow tubewells (STW) studied had a relatively low As content, <100 µg/L), 15% had a high As level (100-200 µg/L) and the remaining 8% had very high As, >200 µg/L. The northern half of the country had the lowest As content in STWs. The highest values were found in the south western, south central and south eastern districts.
- **Arsenic in soils**: Across the country, soil As ranged from negligible to 64 mg/kg, with an average of 6.5 mg/kg for 394 soil samples. About 55% of the samples had an As content of <5 mg/kg, but at least 25% of the soils had high As levels of 10 to >20 mg/kg. Such high As levels in soils may be undesirable for crop production, especially rice.
- **Arsenic in rice**: Out of the 345 Boro samples, the As content in around 50% of them was greater than 0.2 mg/kg. The corresponding T. Aman rice samples had a lower As content (mean value 0.17 mg/kg). Because rice is the staple food in Bangladesh and because it is consumed in large quantities (450 g /person /day), As contaminated rice could seriously aggravate the human health risk when consumed along with As-charged drinking water in many areas of Bangladesh.
- **Arsenic in non-rice crops**: Arsenic contents in the human edible parts of 70 different non-rice crops, like wheat, maize, leafy vegetables, tomato, chilli, beans, brinjal, etc. were determined. The As content in maize and wheat grains was found to be very low, from almost zero to 0.13 mg/kg for wheat and up to 0.17 mg/kg for maize. On the contrary, in the human edible parts of most of the other crops, particularly the leafy vegetables like amaranthus and spinach, the As content was double or triple that of rice.
- **Database and documentation**: Geo-statistical analyses of the national survey data have been partially completed and maps prepared to document the information with the objective of developing a comprehensive national database on arsenic in agricultural production systems of Bangladesh. This will be useful for arsenic risk assessment and development of arsenic management strategies. The survey work will continue.

These findings may have serious implications for the long-term safety of agriculture and food in an As-contaminated environment such as much of Bangladesh. Follow up is necessary to 1) Determine the safe levels, and 2) Find mitigation options. Arsenic in the water-soil-plant system needs to be closely and conclusively studied and As management technologies be developed.

6 Agro-food nutrition in Chakaria

Information on Ca-deficiency rickets and possible means of preventing the disease were disseminated through mass media campaigns like live theater, movie, video CD, etc. The partnership project between SARPV and CIMMYT ended in June 30, 2005.

- **Follow up project activities**

  1. Drama shows on Ca-deficiency rickets were scheduled as per local government requests, in observance of the National Disability Day, Bangla New Year's Day, National Farmer's Fair, etc.
  2. A show was arranged at ICDDRB health complex where field workers and physicians were present. They reported that they initially did not have any idea about rickets and they could not treat the ailing patients who came to them with other complaints. After the show they started suggesting to their patients, especially the pregnant mothers, to include Ca-rich vegetables in their diets.
  3. Demonstration plots with Ca-rich vegetables were set up at the community sites to attract the neighboring people. The whole family training concept was followed to promote and help adopt the technologies. During the training period, seeds were supplied to the concerned growers for quick dissemination to the people at the site. As a result, seeds of appropriate crops spread out quickly in the project areas. The homesteads were covered not only with Ca-rich vegetables but also with other diversified crops including fruit trees. The growers were trained on how to preserve seeds and increase incomes.

- **Impact assessment study on rickets awareness and prevention**

  From April 2 to 27, 2005, a team consisting of six members from CIMMYT Bangladesh surveyed 16 randomly selected sites and 4 control sites in Chittagong, Banderban and Cox's Bazar districts. These sites were selected from among 76 live drama and video shows viewed by about 42000 people. Randomly selected male and female viewers were interviewed using a questionnaire to assess the impact of the rickets awareness campaign on the local population. The survey results are being analyzed.

7. Human resource development

Human resource development in the agricultural sector is very important in national capacity building for research, technology development and dissemination. This was a major activity of each program of the Food Security Project. The human resource development initiatives included sponsoring graduate degree programs, short-term training, organizing workshops, scientists' participation in national and international conferences, facilitating international scientists' visits to Bangladesh, etc. Some major activities related to human resource development are listed below:

a. Graduate degree programs

Four Bangladeshi scientists continued their PhD degree studies ? one at Cornell University and three at BAU ? financed and facilitated by the Arsenic Program.

b. Short-term overseas training

- One professor from BSMRAU received 6 months of training (July 2004 to January 2005) on papaya Ring Spot Virus isolation, characterization and screening procedures at USDA, Hawaii and Cornell University.

c. Regional scientist exchange programs

- Two BRRI scientists, one private equipment manufacturer and one farmer attended a traveling seminar in India during September 14-24, 2004. The seminar included visits to crop production fields, rice-wheat system research sites and observation of agricultural machinery and equipment in action.
- A team of five Pakistani maize scientists visited maize research and development programs in Bangladesh during March 13-18, 2005. They shared experiences with local scientists and professionals on hybrid maize production.
- The CIMMYT Regional Wheat Breeder based in Nepal attended the Internal Review Workshop of the Wheat Research Center as an expert member during May 28-30, 2005.

List of Acronyms

ABSP II	Agricultural Biotechnology Support Project II
ACIAR	Australian Centre for International Agricultural Research
ADC	Additional Deputy Commissioner
AGBIOS	Agriculture and Biotechnology Strategies Inc.
AVRDC	Asian Vegetable Research and Development Center
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BCA	Bangladesh Country Almanac
BCKS	Bangladesh Chashi Kallyan Samity
BCR	Benefit Cost Ratio
BHT	Bangladesh Hand Tractor
BINA	Bangladesh Institute of Nuclear Agriculture
BMD	Bangladesh Meteorological Department
BNNC	Bangladesh National Nutrition Council
BRAC	Bangladesh Rural Advancement Committee
BREAD II	Bangladesh Rural Enterprise and Agricultural Development Project II
BRRI	Bangladesh Rice Research Institute
BS	Block Supervisor
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
C&RM	Crop and Resource Management
CABI	Centre for Agriculture and Biosciences International
CARE	Cooperative for Assistance and Relief Everywhere
CBR	Community Based Rehabilitation
CfA	Communicating for Advocacy
CGIAR	Consultative Group on International Agricultural Research
CIGR	International Commission of Agricultural Engineering
CIMMYT	International Maize and Wheat Improvement Center
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSO	Chief Scientific Officer
CU	Cornell University
DAE	Department of Agricultural Extension
DAM	Department of Agricultural Marketing

DARE	Department of Agricultural Research and Education
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information System
GOB	Government of Bangladesh
GPS	Global Positioning System
HEED	Health Education and Economic Development
HRC	Horticulture Research Center
HRD	Human Resource Development
HSRT	High Speed Rotovator Tiller
ICDDRB	International Center for Diarrhoeal Disease Research, Bangladesh
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IRRI	International Rice Research Institute
IT	Information Technology
MEY	Maize Equivalent Yield
MP	Member of Parliament
MSG	Mud Springs Geographers
NARC	Nepal Agricultural Research Council
NARC Pakistan	National Agricultural Research Centre, Pakistan
NARS	National Agricultural Research Systems
NCDP	Northwest Crop Diversification Program
NGO	Non Government Organization
NRG	Natural Resource Group
OFRD	On Farm Research Division
PARC	Pakistan Agricultural Research Council
PRISM	Project and Research Information System Module
PROSHIKA	Proshikkhan Shikkha Karmo
PRSV	Papaya Ringspot Virus
PSO	Principal Scientific Officer
PT	Power Tiller
R & D	Research and Development
RCT	Resource Conserving Technology
RSC	Regional Steering Committee
RTCC	Regional Technical Coordination Committee
R-W	Rice-Wheat
RWC	Rice-Wheat Consortium
SAAC	Sub-Assistant Agriculture Officer

SAIP	Smallholder Agriculture Improvement Project
SARPV	Social Assistance and Rehabilitation for the Physically Vulnerable
SCA	Seed Certification Agency
SEHD	Society for Environment and Human Development
SHABGE	Strengthening Household Access to Bari Garden Extension
SMCRSP	Soil Management Collaborative Research Support Program
SO	Scientific Officer
SRDI	Soil Resource Development Institute
SSO	Senior Scientific Officer
TCRC	Tuber Crops Research Center
TIC	Technical Implementation Committee
TNO	Thana Nirbahi Officer
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
USDA	United States Development of Agriculture
WFT	Whole Family Training
WRC	Wheat Research Center

Introduction

During the period July 2004 to June 2005, CIMMYT Bangladesh and an array of local and international partners continued to implement the USAID-funded project entitled "Food Security in Bangladesh: Improving Wheat, Maize and Papaya Production, and Impacts of Arsenic Contamination". The project continued to operate with the following eight components to achieve our objectives:

1. Human Resource Development
2. Facilitation and Promotion for Adoption of Mechanization by Growers
3. GIS-Bangladesh Country Almanac
4. Whole Family Training in Maize
5. Papaya Improvement Through Viral Disease Resistance
6. Impacts of Arsenic Contamination on Agricultural Sustainability and Food Quality
7. Agro-food Nutrition Program in Chakaria
8. Monitoring and Evaluation of the Programs

During the year covered by this annual report, the project undertook a vast array of agricultural research and development and capacity building activities and has made significant advances in many areas of work. These were summarized in the Executive Summary. Details by project component are given in the subsequent seven chapters that form the bulk of our annual report.

The project looks forward to complete most of the project components during 2005-2006, and to develop next steps. CIMMYT Bangladesh and its partners acknowledge the substantial financial support received from USAID during 2004-05 that made the work reported here all possible.

1. Human Resource Development

Human resource development is very important in improving the technical capacity and management skills of the scientists, professionals and farmers. Newly recruited and junior scientists require short and advanced training courses for updating their knowledge. The mid and senior level scientists also require short term training and participation in workshops and seminars at the national, regional and international levels for presentation of their research results, reports and exchange of scientific knowledge. CIMMYT has established a strong linkage in HRD with NARS partners, especially with BARI and BRRI. In addition, the farmers, private and NGO entrepreneurs need to use modern technologies developed in the previously mentioned institutions. The project has provided funding for scientists and professionals to educate farmers on improved research technologies, operation and maintenance of agricultural equipment through various training events for better crop and seed production.

I. Short Term Overseas Training

- One professor from Bangabandhu Seikh Mujibur Rahman Agricultural University received 6 months of training from July 25, 2004 to January 30, 2005 on transgenic papaya virus isolation, characterization and screening procedure in USDA, Hawaii and Cornell University, New York, USA.
- During our last wheat season, arrangements were made for 3 WRC scientists to visit CIMMYT Mexico to see the latest developments in breeding, pathology and resource conservation technologies and also select germplasm for Bangladesh. But the scientists did not get approval from the Ministry of Agriculture for their visit and their program was dropped.

II. Regional Scientist Exchange Program

- Two BRRI scientists, one private equipment manufacturer and one progressive farmer attended a traveling seminar in India during September 14-24, 2004. They visited various crop production fields, rice-wheat system research and saw agricultural machinery and equipment during their tour.
- A team of five Pakistani maize scientists visited maize research and development programs in Bangladesh during March 13-18, 2005. They shared experiences with local scientists and professionals on hybrid maize production.
- The CIMMYT Regional Wheat Breeder in Nepal attended the Internal Review Workshop of Wheat Research Center as an expert member during May 28-30, 2005. He made some suggestions and comments for the improvement of the program and thanked WRC scientists for their excellent presentations on the research results.

III. Participation in International and Regional Wheat and Maize Workshops, Meetings, Seminars, etc.

- CIMMYT Agronomist and Country Liaison Officer for Bangladesh visited Cornell University, USA; NARC Pakistan and later attended a regional CIMMYT meeting in China from August 15-September 12, 2004.
- CIMMYT Affiliate Scientist working on our arsenic program attended a workshop on Chemical Bio Availability in Terrestorial Environment and Contaminated Site Remediation in Australia from September 11-22, 2004.
- A group of 5 scientists from BARI, BRRI and CIMMYT participated in the 4th International Crop Science Congress in Brisbane, Australia from September 23 to October 10, 2004. Poster presentations were made on rice wheat system research, including resource conservation technologies in the Congress.
- Director Training and Director WRC of BARI attended the Golden Jubilee Celebration of Wallington Regional Station, Tamil Nadu, India from September 21 to 27, 2004.
- Two agricultural engineers from BARI, one Program Manager of CIMMYT Bangladesh and one scientist from CIMMYT Nepal working on BHT, visited China from October 6 to November 2, 2004. They attended 2004 CIGR International Conference and presented papers on CIMMYT/BARI resource conservation activities with two wheel tractors. They visited a farm machinery trade fair and also visited farmers fields and observed machinery use and crop production practices.
- The CIMMYT Agronomist and Country Liaison Officer for Bangladesh attended the American Society of Agronomy meeting in USA and World Rice Congress in Japan from October 30 to November 8, 2004.
- Two WRC scientists participated in a Helminthosporium workshop in Nepal from January 30 to February 2, 2005. They presented results of the experiments conducted on the yield loss assessment of wheat with some old and new varieties using the fungicide “Tilt” and without Tilt.

IV. Overseas Scientists, Consultants and Visitors

- Two professors from Cornell University, USA visited Bangladesh arsenic programs from August 24 to September 4, 2004.
- One scientist from CIMMYT Nepal attended a training program on the operation and maintenance of BHT accessories from September 16 to 24, 2004.
- Two professionals from CIMMYT Mexico visited Bangladesh from November 11 to 15, 2005. They presented a seminar on IT management and discussed IT needs with CIMMYT Bangladesh personnel.

- Two professors from Cornell University and one professor from Texas A & M University visited arsenic programs from November 20-27, 2004. They visited project sites again from January 10-15, 2005 and attended a workshop on arsenic mitigation in Dhaka.
- One professor from Aberdeen University, USA and one CIMMYT scientist from Nepal visited Bangladesh arsenic project sites from January 15-22, 2005.
- Seven CIMMYT scientists participated in a traveling workshop from February 9 to 12, 2005 and visited various R-W sites and BHT programs.
- An evaluation of the CIMMYT Bangladesh program was made by a professor from Queensland University, Australia from January 15-22, 2005. He visited NARS institutions and discussed with scientists the role of CIMMYT and activities in Bangladesh.
- Two CIMMYT scientists from Mexico and one professor from Cornell University, USA visited the RCT program on wheat in Bangladesh from January 18-21, 2005.
- A group of seven CIMMYT scientists from Mexico, Zimbabwe and India attended a Crop and Resource Management (C&RM) traveling seminar. They visited various R-W sites, RCT programs in Bangladesh from February 9-12, 2005.
- One scientist from USDA, Hawaii visited NARS partners on the development of transgenic papaya from May 8-15, 2005.
- Two professors from Cornell University visited arsenic and SMCRSP programs from May 16-27, 2005.
- The CIMMYT Country Liaison Officer for Bangladesh met with CIMMYT partners from May 22 to June 2, 2005.
- Two professionals from Nepal visited BHT programs from May 28 to June 7, 2005.

V. Participation in Other Activities

- The annual internal review workshop of WRC was held at BARI seminar room, Joydebpur from May 29 to June 1, 2005. Seventy participants from WRC, BARI, DAE, BARC, SCA and CIMMYT, including several expert members from home and abroad, attended the review workshop. A dinner was hosted by the Director, WRC for the participants to bid farewell and welcome to CIMMYT outgoing and incoming Country Liaison Officers for Bangladesh.
- The WRC scientists and their families participated in a team building exercise in Cox's Bazar from January 11-15, 2005. Mr. Khandker Zakiur

Rahman, Program Officer, Family Health International acted as a Facilitator for the team building.

- CIMMYT Bangladesh staff and their families also participated in a team building event in Cox's Bazar from April 17-22, 2005. Mr. Jason Munshi, a Freelance Consultant acted as a Facilitator and spoke at the events.

VI. Facilitation of Scientists Outside the USAID Project

Besides USAID funding, CIMMYT Bangladesh facilitated the following programs:

- One BARI scientist attended a RWC meeting in India from July 4-7, 2004.
- One WRC scientist participated in a workshop on micronutrients in Nepal from September 8-12, 2004.
- A group of 5 scientists from NARC, Nepal and IRRI, Philippines visited IFAD programs in Bangladesh from October 21-25, 2004.
- Several CABI meetings were arranged from October 5-8, 2004, November 8-19, 2004 and March 8-15, 2005.
- A legume workshop was arranged from ACIAR, Australia from March 16-18, 2004.
- 11th Regional Steering Committee (RSC) and 13th Regional Technical Coordination Committee (RTCC) meetings of the Rice-Wheat Consortium for the Indo Gangetic Plains were held in Dhaka from February 5-8, 2005. About 100 participants including a total of 62 foreign delegates from various institutes, universities and donor agencies participated at the meetings. Several NARS scientists also attended. Some high officials including the DG of CIMMYT and its Director Intensive Agriculture Program; DG of AVRDC; DDG of IRRI; Chairman, PARC, Pakistan; Chairman, BARC, Bangladesh; Secretary, DARE, India attended the meetings.
- A group of 4 scientists from the National Academy of Sciences, USA visited Bangladesh and met with the honorable Minister and Secretary of Agriculture, donor agencies and NGO officials from January 15-22, 2005 to know the latest developments of science and technology in Bangladesh.

VII. List of Scientists that Attended Overseas Training, Workshops and Field Visits during July 2004 to June 2005

Sl	Name & address	Subject	Period	Place	Fund source
I. Short term overseas research training					
1	Dr. A. Mannan Akanda, Professor Bangabandhu Seikh Mujibur Rahman Agricultural University	Transgenic Papaya Development Screening Procedure	July 25, 2004 to January 30, 05	USDA, Hawaii and Cornell University, NY	USAID
II. Regional scientists exchange program					
1	Mr. Akhter Hossain Khan, PSO, BRRI	Traveling Seminar on Rice Research and Development	September 14 to 24, 2004	India	USAID
2	Mrs. Mahfuz Ara Begum, SO, BRRI	Do	Do	Do	USAID
3	Mr. Kader Newaz, Equipment Manufacturer	Do	Do	Do	USAID
4	Mr. Mominur Rahman, Farmer	Do	Do	Do	USAID
5	Mr. Abdul Shakoor Khan, Maize Scientist, Pakistan	Traveling Seminar on Maize Research and Development	March 13 to 18, 2005	Bangladesh	USAID
6	Dr. Sajjad R. Chaghatai, Maize Scientist, Pakistan	Do	Do	Do	USAID
7	Dr. H.N. Malik, Maize Scientist, Pakistan	Do	Do	Do	USAID
8	Dr. Karamat Khan, Maize Scientist, Pakistan	Do	Do	Do	USAID
9	Dr. Monwar Ahmed, Maize Scientist, Pakistan	Do	Do	Do	USAID
10	Dr. Memo Ortiz Ferrera, CIMMYT Nepal	WRC Internal Research Review Workshop	May 28 to 30, 2005	Do	USAID
III Participation to regional/international wheat/maize workshop, meeting, seminar etc.					
1	Dr. M. Matiur Rahman, Director Research, BARI	RWC meeting	July 4 to 7, 2004	Delhi, India	RWC
2	Dr. Craig A. Meisner, CIMMYT Agronomist	Visiting program at CU, NARC Pakistan and attending Regional Meeting for CIMMYT, China	August 15 to September 12, 2004	Cornell University, USA, Pakistan and China	USAID
3	Mr. Badruzzaman, SO, WRC, BARI	Agricultural Strategies to Reduce Micronutrient Problems in Mountainous and Marginal Areas of Nepal	September 8 to 12, 2004	Nepal	SMCRSP

Sl	Name & address	Subject	Period	Place	Fund source
4	Dr. G.M. Panaullah, CIMMYT Affiliate Scientist	Chemical Bio Availability in Terrestrial Environment and Contaminated Site Remediation	September 11 to 22, 2004	Australia	USAID
5	Dr. M. Mazid Miah, CSO, BRRI	4th International Crop Science Congress	September 23 to October 10, 2004	Australia	USAID
6	Mr. Afzal Ali, SO, BARI	Do	Do	Do	USAID
7	Mr. ASMHM Talukder, SO, WRC, BARI	Do	Do	Do	USAID
8	Mr. Ilias Hossain, SO, WRC, BARI	Do	Do	Do	USAID
9	Dr. Craig A. Meisner, CIMMYT Agronomist	Do	September 26 to October 3, 2005	Do	USAID
10	Mr. Harun Ur Rashid, Director Training, BARI	Golden Jubilee Celebration of Wellington Regional Station, India	September 21 to 27, 2004	India	USAID
11	Dr. A. Sufian, Director, WRC, BARI	Do	Do	Do	USAID
12	Mr. Enamul Haque, Program Manager, CIMMYT Bangladesh	CGIAR International Conference and Agril. Farm Machinery Fare	October 6 to November 2, 2004	China	USAID
13	Dr. K..C. Roy, CSO, BARI	Do	Do	Do	USAID
14	Mr. Israil Hossain, SSO, WRC, BARI	Do	Do	Do	USAID
15	Mr. Scott Justice, CIMMYT Nepal	Do	Do	Do	USAID
16	Dr. Craig A. Meisner, CIMMYT Agronomist	American Society of Agronomy Meeting and World Rice Congress	October 30 to November 8, 2004	USA and Japan	USAID
17	Dr. Craig A. Meisner, CIMMYT Agronomist	Meeting in CIMMYT Nepal	November 13 to 15, 2004	Nepal	USAID
18	Dr. A.B. Siddique, CSO, RARS, BARI, Jessore	Helminthosporium Workshop	January 30 to February 2, 2005	Nepal	USAID
19	Mr. Haider Hossain, SO, RARS, BARI, Jessore	Do	Do	Do	USAID
20	Dr. Jahiruddin, Professor, Bangladesh Agricultural University	8th International Conference on Biogeochemistry of Trace Elements	March 31 to April 9, 2005	Australia	USAID
21	Mr. Bakhtear Hossain, SSO, BINA	Do	Do	Do	USAID
22	Dr. A.T.M. Farid, CSO, BARI	Do	Do	Do	USAID
23	Dr. M.A. Saleque, SSO, BRRI	Do	Do	Do	USAID
24	Mr. Shahjahan Kabir, BRRI	Do	Do	Do	USAID

Sl	Name & address	Subject	Period	Place	Fund source
25	Dr. G.K. Mustafizur Rahman, Bangabandhu Sheikh Mujibur Rahman Agricultural University	Do	Do	Do	USAID
26	Dr. A.M. Ghani, National Coordinator, IRRI	Do	Do	Do	USAID
27	Dr. G.M. Panaullah, CIMMYT Affiliate Scientist	Do	Do	Do	USAID
28	Dr. Craig A. Meisner, CIMMYT Agronomist	Do	Do	Do	USAID
29	Md. Asaduzzaman Khan, Sher E Bangla Agricultural University	Do	Do	Do	USAID
30	Dr. Mazid Miah, CSO, BRRI	Do	Do	Do	USAID
30	Prof. John M. Duxbury, Cornell University	Do	Do	Do	USAID
31	Prof. R.H. Loeppart, Texas A & M University	Do	Do	Do	USAID

VIII. List of overseas scientists, consultants and visitors during July 2004-June 2005

Sl	Name & address	Subject	Period	Fund source
1	Mr. Joost Lieshout, InterSard, UK	PRISM Workshop	July 3 to 9, 2004	RWC
2	Mr. R. Bharat, CIMMYT India	Do	Do	RWC
3	Professor John Duxbury, Cornell University, USA	SMCRSP and Arsenic program	August 24 to September 4, 2004	USAID
4	Dr. Julie Lauren, Cornell University, USA	Do	Do	SMCRSP
5	Mr. Scott Justice, CIMMYT Nepal	BHT training	September 16 to 24, 2004	USAID
6	Dr. Etienne Duvieller, CIMMYT Nepal	CABI Meeting	October 5 to 8, 2004	CABI
7	Dr. John Bridge, UK	Do	Do	CABI
8	Dr. K. Poudyal, CIMMYT Nepal	Participatory Research Methodology Workshop	October 6 to 11, 2004	IFAD
9	Dr. Nityanand Khanal, Nepal	Do	Do	IFAD
10	Dr. Krishna Devokota, Nepal	Do	Do	IFAD
11	Dr. K. D. Joshi, Nepal	Do	Do	IFAD
12	Prof. John Witcombe, University of Wales, Bangor, UK	Do	Do	IFAD
13	Dr. Joynal Abedin, IRRI, Philippines	IFAD program	October 21 to 25, 2004	IFAD
14	Dr. Sam Page, CABI, UK	CABI program	November 8 to 19, 2004	CABI

Sl	Name & address	Subject	Period	Fund source
15	Mr. Ed Brandon, CIMMYT Mexico	IT Management	November 11 to 15, 2004	USAID
16	Mr. Enrique Martinez, CIMMYT Mexico	Do	Do	Do
17	Dr. Tony Fischer, ACIAR, Australia	Legume Workshop	November 16 to 18, 2004	ACIAR
18	Dr. Kuhu Mukharjee, ACIAR, Australia	Do	Do	ACIAR
19	Prof. John Duxbury, Cornell University	Arsenic Program	November 19 to 29, 2004	USAID
20	Dr. Julie Lauren, Cornell University	Do	November 20 to 27, 2004	USAID
21	Dr. R. Loeppart, Texas A & M University	Do	Do	USAID
22	Dr. Raj K Gupta, CIMMYT India	RWC Meeting	December 17 to 20, 2004	RWC
23	Miss. Noriko Furyuya, PhD Student, Japan	Papaya research	October 26 to December 17, 2004	JICA/USAID
24	Prof. R. Loeppart, Texas A & M University	Arsenic Mitigation Workshop	January 10 to 15, 2005	USAID
25	Prof. John Duxbury, Cornell University	Do	Do	USAID
26	Dr. Julie Lauren, Cornell University	Do	Do	USAID
27	Prof. Yamily Zavala, Cornell University	Do	Do	USAID
28	Prof. Paul Williams, Aberdeen University	Arsenic program	January 15 to 22, 2005	USAID
29	Ms. Jhuna, CIMMYT Nepal	Do	January 16 to 23, 2005	USAID
30	Prof. Shu Fukai, Queensland University, Australia	Evaluation of CIMMYT Bangladesh Program	January 15 to 22, 2005	USAID
31	Prof. Chartre Hess, National Academy of Science	Science and technology development	January 15 to 22, 2005	National Academy of Science, USA
32	Prof. Glen Schwitzer, National Academy of Science	Do	Do	National Academy of Science
33	Prof. Susan Henry, National Academy of Science	Do	Do	National Academy of Science
34	Prof. Rosalyn S. Hobson, National Academy of Science	Do	Do	National Academy of Science
35	Dr. Tim Williams, Georgia University, USA	Peanut project development	January 16 to 21, 2005	CRSP
36	Dr. Ken Sayre, CIMMYT Mexico	RCT program	January 18 to 23, 2005	USAID
37	Mr. Scott Justice, CIMMYT Nepal	Do	Do	USAID
38	Dr. Peter Hobbs, Cornell University, USA	Do	Do	USAID
39	Liz Humphreys, CSIRO, Australia	RSC/RTCC meeting	February 5 to 8, 2005	RWC and other
40	Christian Roth, ACIAR, Australia	Do	Do	RWC and other
41	Mangala Rai, Secretary DARE & DG ICAR, India	Do	Do	RWC and other
42	Sidhu P.S., World Bank, India	Do	Do	RWC and other

Sl	Name & address	Subject	Period	Fund source
43	Raj K. Gupta, CIMMYT India	Do	Do	RWC and other
44	P. Bhattacharya, World Bank, India	Do	Do	RWC and other
45	Parvesh Chandna, CIMMYT India	Do	Do	RWC and other
46	S.N. Singh Chauhan, India	Do	Do	RWC and other
47	Olaf Erenstein, CIMMYT India	Do	Do	RWC and other
48	Gupta Anmol, CIMMYT India	Do	Do	RWC and other
49	Shoran Jag, Director, DWR, India	Do	Do	RWC and other
50	M.L. Jat, ICAR, India	Do	Do	RWC and other
51	J.D.H. Keatinge, DDG, ICRISAT, India	Do	Do	RWC and other
52	A.R. Khan, ICAR, India	Do	Do	RWC and other
53	Bharath Krishnan, CIMMYT India	Do	Do	RWC and other
54	Ujjawal Kumar, ICAR, India	Do	Do	RWC and other
55	J.K. Ladha, IRRI, India	Do	Do	RWC and other
56	R.K. Malik, HAU, India	Do	Do	RWC and other
57	Aleen Mukherjee, USAID, India	Do	Do	RWC and other
58	D.K. Pal, NBSS, India	Do	Do	RWC and other
59	Suresh Pande, ICRISAT, India	Do	Do	RWC and other
60	R.V. Pandey, NDUAT, India	Do	Do	RWC and other
61	Lawrence Paulson, USAID, India	Do	Do	RWC and other
62	R.K. Sharma, DWR, India	Do	Do	RWC and other
63	S.S. Singh, India	Do	Do	RWC and other
64	Samar Singh, CIMMYT India	Do	Do	RWC and other
65	U.P. Singh, BHU India	Do	Do	RWC and other
66	B. Sivaprasad, IRRI India	Do	Do	RWC and other
67	Ashish Srivastava, CIMMYT India	Do	Do	RWC and other
68	William Thorpe, ILRI, India	Do	Do	RWC and other
69	Masa Iwanaga, DG, CIMMYT	Do	Do	RWC and other
70	Rodomiro Ortiz, Director, IAP, CIMMYT	Do	Do	RWC and other
71	Ivan Ortiz-Monasterio, CIMMYT	Do	Do	RWC and other
72	Etienne Duveiller, CIMMYT Nepal	Do	Do	RWC and other
73	Guillermino Ortiz Ferrara, CIMMYT Nepal	Do	Do	RWC and other
74	J. Tripathi, NWRP, Nepal	Do	Do	RWC and other
75	B.P. Tripathi, IRRI Nepal	Do	Do	RWC and other
76	S.L. Maskey, NARC, Nepal	Do	Do	RWC and other

Sl	Name & address	Subject	Period	Fund source
77	Kamal Paudyal, CIMMYT Nepal	Do	Do	RWC and other
78	Bhawna Shereshta, Nepal	Do	Do	RWC and other
79	Ganesh Sah, AIRC, Nepal	Do	Do	RWC and other
80	Sreshtha Srimat, Nepal	Do	Do	RWC and other
81	Shanti Bhattaria, Nepal	Do	Do	RWC and other
82	B. Soomro, Chairman, PARC, Pakistan	Do	Do	RWC and other
83	Ifthikhar Ahmed, DDG, NARC, Pakistan	Do	Do	RWC and other
84	Mushtaq A. Gill, DG, Water Management, Pakistan	Do	Do	RWC and other
85	Ahmed Hossain Khan, PARC	Do	Do	RWC and other
86	Sajjad Sulaiman Malik, Pakistan	Do	Do	RWC and other
87	Shabbir Ahmad Kalwar, Pakistan	Do	Do	RWC and other
88	Aqil Khan Muhammad, Pakistan	Do	Do	RWC and other
89	Riaz A. Mann, NARC, Pakistan	Do	Do	RWC and other
90	Hafiz Mujeeb-ur-Rehman, Water Management, Pakistan	Do	Do	RWC and other
91	Abdul Rashid, Land Resource Institute, Pakistan	Do	Do	RWC and other
92	William Padoline, DG, IRRI	Do	Do	RWC and other
93	Zainal Abedin, IRRI, Philippines	Do	Do	RWC and other
94	V. Balasubramanian, IRRI, Philippines	Do	Do	RWC and other
95	Mahabub Hossain, IRRI, Philippines	Do	Do	RWC and other
96	Ren Wand, DDG, IRRI, Philippines	Do	Do	RWC and other
97	Bayarsaihan, ADB, Philippines	Do	Do	RWC and other
98	Thomas A Lumpkin, DG, AVRDC, Taiwan	Do	Do	RWC and other
99	L.J. Sam Page	Do	Do	RWC and other
100	Stephen Waddington, CIMMYT Zimbabwe	Do	Do	RWC and other
101	Dr. Mirijam Pulleman, CIMMYT Mexico	C&RM Traveling Seminar	February 9 to 12, 2005	USAID/RWC
102	Dr. Stephen Waddington, CIMMYT Zimbabwe	Do	Do	USAID/RWC
103	Dr. Patrick Wall, CIMMYT, Zimbabwe	Do	Do	USAID/RWC
104	Dr. Bran Govaerts, CIMMYT Mexico	Do	Do	USAID/RWC
105	Dr. Ken Sayre, CIMMYT Mexico	Do	Do	USAID/RWC
106	Dr. Christian Thierfelder, CIMMYT Zimbabwe	Do	Do	USAID/RWC
107	Dr. Ivan Ortiz- Monasterio, CIMMYT Mexico	Do	Do	USAID/RWC
108	Dr. Olaf Erenstein, CIMMYT India	Do	Do	USAID/RWC

Sl	Name & address	Subject	Period	Fund source
109	Dr. Noel Rahman, Ph.D Student, USA	Data collection	March 3 to April 17, 2005	USAID
110	Dr. Sam Page, CABI, UK	CABI Project	March 8 to 15, 2005	CABI
111	Dr. Dennis Gonsalves, USDA, USA	Papaya meeting and workshop	May 8 to 15, 2005	USAID
112	Prof. John Duxbury, Cornell University, USA	Arsenic Program	May 16 to 27, 2005	USAID
113	Dr. Julie Lauren, Cornell University, USA	SMCRSP program	May 19 to 27, 2005	USAID
114	Dr. Stephen Waddington, CIMMYT Zimbabwe	Meeting with CIMMYT partners	May 22 to June 2, 2005	USAID/CIMMYT ALP fund
115	Mrs. Eva Waddington	Visit	May 22 to May 29, 2005	USAID/CIMMYT core fund
116	Dr. Ashok Chawdhury, Nepal	RCT program	May 28 to June 7, 2005	USAID
117	Mr. Scott Justice, Nepal	Do	Do	USAID

2. Facilitation and Promotion for Adoption of Mechanization by Growers

I. Rationale for Introduction of the Bangladesh Hand Tractor (BHT)

Draft power available for farming in Bangladesh has reduced over time due to frequent cyclones and floods reducing the number and increasing the cost of raising cattle. Agricultural labor is also declining due to rural urbanization and migration overseas. Under these socio-economic conditions and fragmented small land holdings, big agricultural machinery is either affordable or practical for Bangladeshi farmers.

Furthermore, cropping intensity now stands at more than 200 percent. Triple cropping is also practiced by an increasing number of growers. Failure to sow wheat on time reduces wheat yields by 1.3 percent per day it is planted after December 1, and more than 50% of growers sow wheat after this date. Late sowing of wheat is a major factor for obtaining reduced yields. To overcome these problems, the widespread introduction of hand tractors and their accessories in the country is urgently needed.

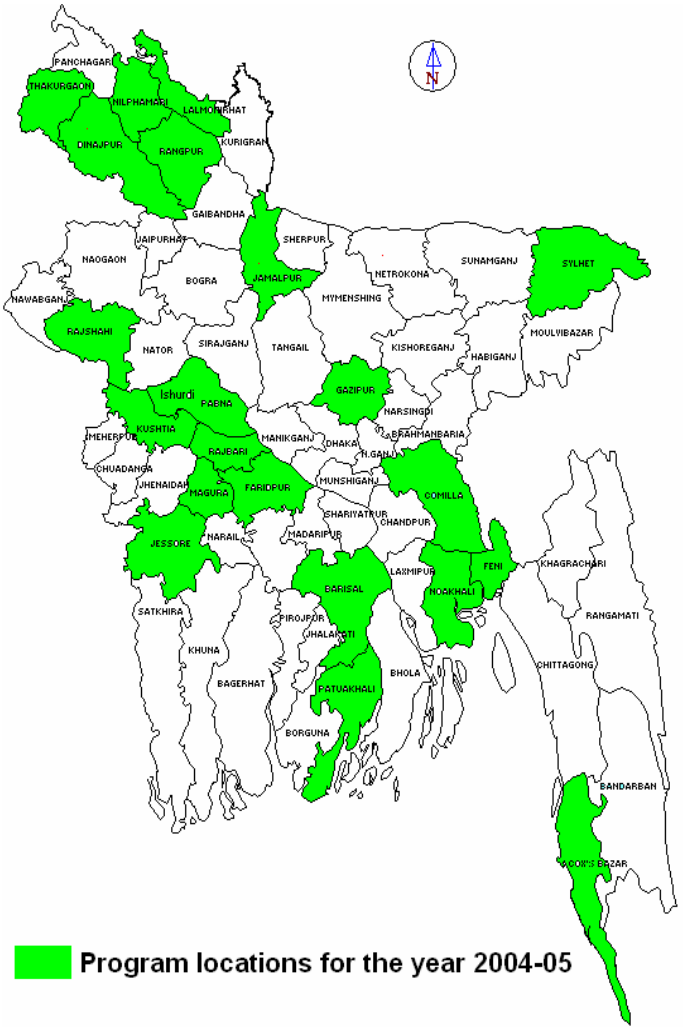

Figure 2.1: Map of Bangladesh showing the program sites

In 1998, 72% of wheat growers reduced the turnaround time between crops by using hand tractors imported from China. Seeders and reapers can further reduce the time between rice harvesting and wheat sowing. Reapers can be used to cut rice and lay the stalks on top of the ground, and reduced tillage wheat seeders can be used to open the soil with a seed drill, place the seed into the soil and then cover the seed in one operation. Reductions in turnaround time through reduced tillage practices can also promote crop diversification as new crops are introduced into rotations, and lead to substantial water savings, particularly where wheat or other crops are substituted for Boro rice.

USAID granted funds for the period from July 2002 through June 2005 to CIMMYT Bangladesh for our 'Facilitation and Promotion for Adoption of Mechanization by Growers' pilot program. Locations where hand tractor accessories have been sold or demonstrated are shown in Figure 2.1.

Achievements made with program activities during 2004-05 are highlighted in the following sections:

II. Equipment Procurement and Distribution

For intensification and diversification of the existing cropping systems and conservation of agricultural resources for sustainable productivity and livelihood improvement, in collaboration with the partners, CIMMYT Bangladesh has developed diesel-engine-operated new agricultural equipment. These include a reaper, bed planter, zero tillage, high speed rotovator, thresher and maize sheller. During this year, CIMMYT Bangladesh procured 81 new accessories and distributed 83 accessories to different stakeholders. Figure 2.2 shows the agriculture accessories and their distribution pattern.

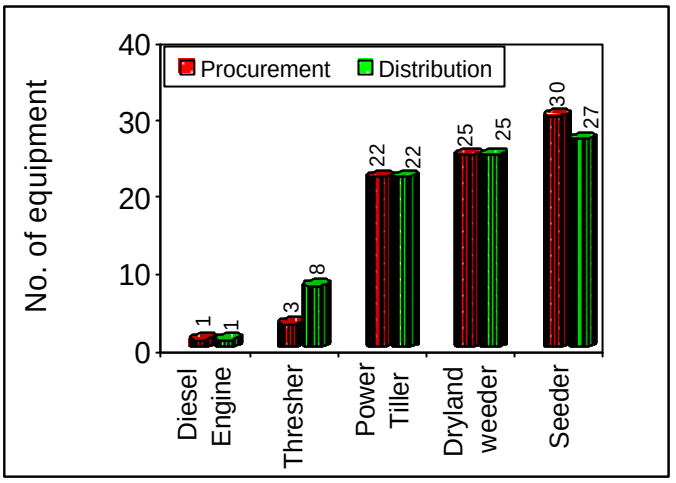

Figure 2.2: Equipment procurement and distribution status 2004-05.

III. Equipment Usage and Area Coverage

During the year 2004-05, a total of 4,409 hectares of land were brought under this mechanization program. Farmers used the equipment on 2,054 ha for land preparation, seed sowing, harvesting, threshing/shelling etc. of several major crops including wheat, maize, mustard, mung-bean, chickpea, lentil, jute, onion, garlic, and other minor crops like soybean, sesame and okra. Crop-wise area coverage is depicted in Figure 2.3. Farmers used power tillers to prepare 2,355 ha of land for various crops.

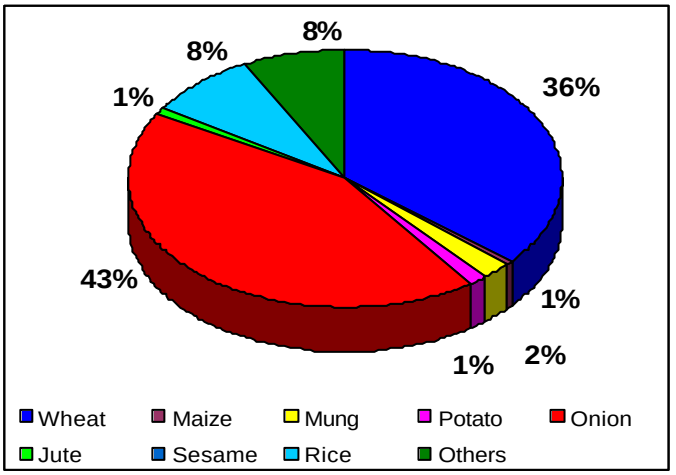

Figure 2.3: Crop-wise area covered by the CIMMYT led agricultural machinery Research and Development program, during the year 2004-05.

During 2004-05, a total of 5,857 farmers used the Bangladesh Hand Tractor (BHT) accessories for different crop production activities (Figure 2.4).

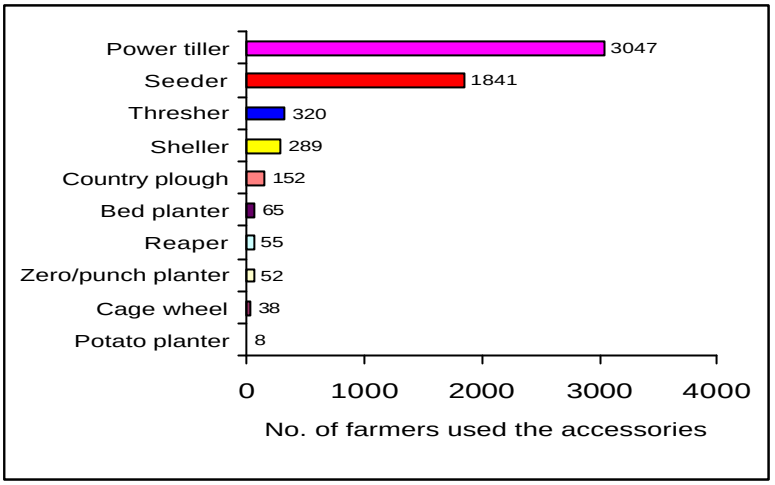

Figure 2.4: Number of farmers using different agricultural accessories for different crop production purposes

IV. Research on Different Bangladesh Hand Tractor (BHT) Equipment

Based on farmers' need for seeding of different crops, inter-cultivation, bed making, re-forming bed and seeding on bed, residue management, and simplicity in management, maintenance and operation in the existing diversified farming systems, CIMMYT in collaboration with the GOB, NGOs and private sectors modified, developed and demonstrated a range of power tiller operated agricultural equipment. Major R&D activities are highlighted below:

a) Sifeng Type Seeder:

Extensive field visits and survey data reveal that of the total available power tillers in Bangladesh, Sifeng power tillers have been used by 50% farmers and Dongfeng power tillers by another 50% farmers. Since 1995, CIMMYT and partners have been promoting only the Dongfeng seeder because of the non availability of the Sifeng seeder. During 2004-05, in a Learning and Changing Workshop, it was decided that partners should explore different ways to obtain the Sifeng type seeder in order to bring more crop area under seeder cultivation. Accordingly, CIMMYT identified the Sifeng type seeder and started its promotion. As a result, a total of 12 Sifeng type seeders will be procured, sold and demonstrated in the 2005-06 program year.

b) Seeder Operated Bed Former and Planter:

Planting crops like vegetables, potato, tomato, maize and taro on soil beds is a traditional practice of Bangladeshi farmers. Beds are made manually, a time consuming and labor expensive activity for crop production. Intensive field visits and interaction with the farmers growing crops on beds shows that these farmers are looking for alternative resource-conserving and cost-effective options for crop production and diversification. Keeping this in mind, a collaborative program is underway with the Wheat Research Center for the development of agricultural equipment that can address the issue of resource conservation, crop diversification

and diversify use of existing seeders. As a result, CIMMYT and WRC successfully developed a seeder-operated bed former/planter during the year 2004-05. Figure 2.5 illustrates bed preparation by a seeder-operated planter. The major changes such as tine arrangement and replacement of roller by shaper have been made at a cost of Taka 1,000. The machine can prepare 0.12 ha of land per hour (both seeding and bed forming).

Figure 2.5: Bed preparation by the seeder operated bed former

c) Zero Tillage Planter:

A two-wheel-tractor operated zero tillage planter is fabricated with the Wheat Research Center, BARI under the technical and financial assistance of CIMMYT Bangladesh. The major components of the planter are toolbar frame, seed and fertilizer box, inverted "T" type furrow opener and depth control wheel. This planter is able to apply seed and fertilizer in a narrow opening slit in a single operation. Planting depth and seed rate can be regulated by this machine during operation.

Harvested crop fields with few weeds and moisture around field capacity are suitable for using the zero till machine. Considering the farmers' needs and field conditions, three different models of zero till machines have been developed. All three models have been tested to plant wheat, rice, maize and mungbean both on and off station in Dinajpur, Jessore and Noakhali districts.

Figure 2.6: Zero tillage planter being used for mungbean planting (left) and zero tillage mungbean field (right)

Diammonium phosphate (DAP) and Muriate of Potash (MP) fertilizers were applied during the planting operation in the same slit as wheat and maize seed. Roundup herbicide was sprayed @ 36 ml per 10 litre of water for weed control seven days before wheat seeding. No herbicide was used on maize and mungbean fields as the weed intensity of these fields was very low.

The machine performance parameters were recorded as described in the Regional Network of Agricultural Machinery (RNAM) test code. Field data were also collected to determine the labour requirement and cost saving over the conventional method. The planting cost comparison is in Figure 2.7.

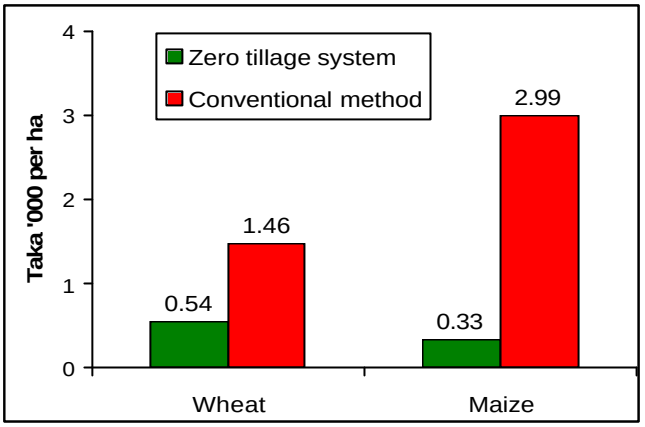

Figure 2.7: Zero tillage vs. conventional system cost comparison for planting wheat and maize

Performance of zero tillage planters for wheat, maize and mungbean are shown in Table 2.1.

Table 2.1: Performance of two-wheel-tractor operated zero tillage in wheat seeding

Parameters	Wheat	Maize	Mungbean
Fuel consumption, lit./hr	1.40	1.4	1.4
Speed of operation, km/hr	2.20	2.25	2.3
Soil moisture content, %	31	29	32
Wheel slippage,%	9	8	9
Effective field capacity, ha/hr	0.14	0.23	0.14
Field efficiency, %	83	75	80

Soil moisture content is the key factor for utilization of the zero till machine. It is very difficult to operate one zero till drill with soil moistures above 35% due to excessive tiller wheel slippage. During the trial, it was found that wheel slippage linearly increased with increasing soil moisture (Figure 2.8). Effective field capacity of the drill for wheat and maize planting was 0.14 ha/hr and 0.23 ha/hr, respectively. The effective field capacity for maize planting was higher than wheat planting due to the sowing width during maize planting 1.40 m (2 lines spacing 70 cm) but in wheat seeding it was 80 cm. Fuel consumption during wheat, maize and mungbean sowing

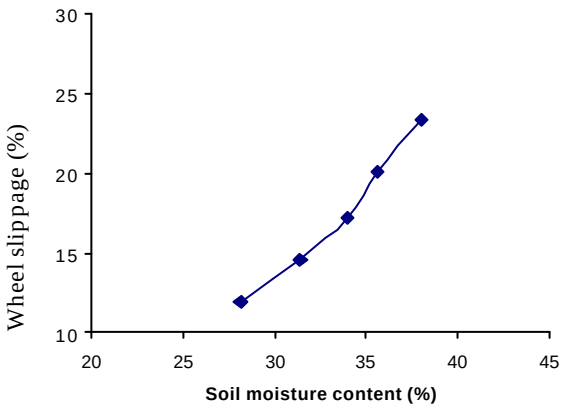

Figure 2.8: Relationship between soil moisture content and wheel slippage

was 1.4 litre/hr. The field efficiency for maize planting was 75%, which was comparatively lower than wheat and mungbean planting due to more time lost with drill adjustment.

Crop performance of the zero tillage planters is shown in Table 2.2. Applied seed rates for wheat, maize and mungbean were 120 kg/ha, 20 kg/ha and 35 kg/ha, respectively. Flute type gravity flow seed metering devices were used for both wheat and mungbean sowing. Inclined plate metering mechanism was used for maize planting. The average width of opening slits for wheat was 2-3 cm and depth of planting 3-4 cm. It was observed through field monitoring that 7-8% thinning and about 5% gap filling were needed for maize planting due to the doubling and missing seed placement resulting from uneven seed size. It was also found that a slower speed was comparatively better for seed placement into the opening slit. The adjustment of row spacing between two successive passes was maintained by operator skill and experience. The width of slit during maize sowing was bigger due to the slightly dipper position of the "T" opener.

Table 2.2: Crop performance of two-wheel-tractor operated zero tillage planters

Parameter	Wheat	Maize	Mungbean
Seed rate, kg/ha	120	20	35
Row to row spacing, cm	20	70	30
Depth of planting, cm	3-4	4-5	4-5
Width of opening slit, cm	1-2	1.2-2.4	<2
Number of plant/m2	215	7	31

The yield of wheat and maize in the zero tillage system and conventional method were compared (Table 2.3). The yield of wheat in zero till method varied from place to place due to land type, soil moisture, lack of fertilizer application and weed management. The average wheat yield was 3.9 t/ha, which was competitive with the conventional method at 3.1 t/ha. The yield of maize in zero till and conventional methods were almost similar.

Table 2.3: Comparison of yield between zero tillage and conventional method

Planting system	Yield (t/ha)		
	Wheat	Maize	Mungbean
Zero tillage system	3.9	9.1	0.7
Conventional method	3.1	9.3	Not available

d) Multi-crop Seeder:

The three operations, land preparation, seeding and planking, could be done in one pass by the multi-crop seeder (Figure 2.9). This accessory is operated by power tiller and the field performance is perfectly alright if operator is well trained. With a well trained operator, the field capacity of this accessory is about 0.16 ha per hour and could save about 50-60% seeding cost including for land preparation and planking.

Figure 2.9: Wheat field planted by the multi-crop seeder (left) and multi-crop seeder (right)

Compared to the conventional method, these accessories could save 20-25% wheat seed. After harvesting T.Aman rice, the turn around time for the next crop could be reduced to 10-15 days. If the moisture of the soil is at field capacity this would result in higher crop productivity.

Since this accessory sows the seed in a line, weeding is very efficient and thus weeding cost could be reduced to one third that of weeding in broadcast wheat fields.

e) Potato Planter:

In the rice-wheat rotation, potato has been identified as a high yielding and income generating crop. For minimizing potato establishment and seed costs, WRC in collaboration with CIMMYT initiated work to develop a potato planter in 2003-04. The work is being continued to develop two types of power tiller operated potato planter, a conveyer belt system and a pin type. The conveyer system could be used for plating whole potato seed and the pin type for cut piece potato seed. Both potato planters were tested and demonstrated on-farm at Monshigonj, Dinajpur and Debigonj-Ponchagaor districts in collaboration with WRC and Tuber Crop Research Center (TCRC). On-station demonstrations were done at Dinajpur, Debibonj-Ponchagaor and Monshigonj in collaboration with WRC, OFRD and TCRC. Figure 2.10 shows the conveyer belt type potato planter along with a matured potato field planted by the machine at Monshigonj. Farmers felt that though the conveyer type potato planter could plant potato within the shortest time and save planting cost, since this method requires use of a whole tuber as seed, it

Figure 2.10: Potato field planted by the potato planter (photo inset of the planter)

makes it a costly input for the farmers. Growers suggested an alternative planter by which cut potato could be planted, saving seed cost. With this suggestion, WRC with CIMMYT's assistance jointly developed the pin type potato planter, tested and demonstrated with the potato growers at Dinajpur. However, CIMMYT and WRC recommends both types of planter as some potato growing areas use whole tuber and some areas use cut tuber for reducing the seed cost .

At the optimum speed of operation, the cost of planting potatoes with the planter was Taka 393 with 9 man-days/ha but the conventional method costed Taka 3,801 with 54.3 man-days/ha. Therefore, the labour saving by the potato planter was 45.3 man-days/ha or 83%. Furthermore, the planting uniformity of both the planters were very similar at 91% and 89%.

f) High Speed Rotovator Tiller (HSRT):

Existing land preparation by traditional power tiller requires 8 - 10 passes to bring the soil to a suitable tilth for planting onion and garlic seedlings, which is labour and time intensive. Therefore, alternative tillage equipment that could address the issues needed to be developed. CIMMYT and the Farm Power and Post Harvest Engineering Division of BARI initiated research and developed the High Speed Rotovator Tiller (HSRT) in 2003-04 (Figure 2.11). The HSRT can make the soil tilth suitable for planting onion and garlic seedling in two passes, and result in time and cost saving for land preparation of 71% and 27%, respectively, compared to the traditional land preparation system by power tiller. Moreover, for transplanting onion and garlic seedlings, a total saving of time and money by HSRT over the traditional methods were respectively 26% and 25%. HSRT made soil tilth so much favorable that farmers could transplant 20% - 25% more seedlings per unit area, resulting in increased yield of about 20% over the traditional method.

Figure 2.11: High Speed Rotovator Tiller (left) and the benefit of the HSRT being harvesting by the farmers of Rajbari district

g) Training:

During 2004-05, 73 participants, 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. The training was jointly organized by CIMMYT, BARI, BRRI and BAU at Wheat Research

Figure 2.12: Training session of self-propelled reaper operation and maintenance at Jessore

Center, Dinajpur, Regional Agricultural Research Station Jessore, On-farm Research Division, Faridpur, and Bangladesh Chashi Kollan Samity, Comilla. Figure 2.12 depicts one training session at Jessore.

V. Seeder Helps Popularize and Promote New Wheat Varieties in the BHT Program Areas

In the year 2004-05, a total of four t of the new wheat varieties (Protiva and Satabdi) was received from the Wheat Research Center, Dinajpur for promotion of these varieties in the BHT areas. The seeds were distributed to the seeder owners with idea of popularizing seeder use for seeding wheat among the farmers as well as popularizing the new wheat varieties. A total of 33.5 ha of land were sown by the seeder with the supplied seed. The results of this initiative indicated that thousands of farmers in the demonstrated areas became familiar with the newly released wheat varieties and modern wheat establishment techniques by the seeder (Figure 2.13). The impact of the demonstration is that about 29 t seed of Satabdi and Protiva was produced and kept among the farmers in 2005 for cultivation of these varieties in expanded areas. We have also promoted seeder use in the same expanded areas for wheat cultivation.

Figure 2.13: Farmer in a field of the newly developed wheat variety Satabdi in Rajbari district. The crop was planted with the mechanical seeder.

VI. Thresher Demonstration

At present farmers are reluctant to grow wheat because of the threshing problem, as was reported by many wheat growers. To help farmers stay in wheat cultivation, there is a need for suitable wheat threshing technology. The technology is available in Bangladesh but wheat growers are not familiar with the use of the thresher technology. To address that issue, a demonstration program was undertaken in Rajbari and Dinajpur districts. Only one thresher demonstration in Rajbari during 2004 motivated 13 other wheat growers to purchase the same type of thresher for their own threshing as well as threshing wheat from other growers on a grain sharing basis (4 kg for every 40 kg threshed wheat). This way an owner of a thresher earned about

Figure 2.14: Wheat is being threshed in Rajbari district using a power operated thresher

4 t of wheat grain (equivalent to Taka 50,400) within 20 days, an excellent way of generating income by the unemployed young generation. Figure 2.14 depicts a thresher owner threshing wheat of other farmers on a sharing cropping basis at Rajbari district.

VII. Field Day

To create awareness among the farmers, extension staff, workshop owners, operators, and scientists of different crop research institutes about the benefit of using the accessories for resource saving (labour, time, seed, etc.) and income generating in agriculture, two field days were organized on the establishment of wheat, jute, onion, sesame and potato in Faridpur and Rajbari districts. More than 400 people representing farmer's community, school teachers, agricultural accessory manufacturers, agricultural extension, NGOs and research organizations participated in the field day. Photographs in Figure 2.15 illustrate meeting farmers after the field visit and a good jute field of about one ha land sown by a Dongfeng seeder.

Figure 2.15: A big jute field (left) planted by the multi-crop seed drill, and scientists are answering the questions of the participants during the field day (right) at Rajbari district

VIII. Technology Expansion

CIMMYT and BARI have together developed potential agricultural accessories, i.e., seeder, zero tiller, bed planter, strip tiller, weeder, etc. All these were further scaled up among the farmers through a demonstration program of Cornell University's Bed Planting Program at Rajshahi, WRC funded by FAO—an additive project of CIMMYT's on-going BHT program. During the year 2004-05, the accessories were demonstrated in 11 locations of 6 districts, Dinajpur, Thakurgaon, Noyakhali, Jessore, Jamalpur and Barisal. Figure 2.16 depicts a dry land bed weeder in use by the farmer at Rajshahi.

Figure 2.16: Dry land weeder being used in bed planted wheat at Rajshahi

IX. Loan and Reimbursement Status

Since 2002-03, Taka 2.49 million (US$ 38,246) has been provided to 42 farmers without charging interest. Out of the total disbursed amount, Taka 2.14 million (US$ 32,849) was refunded by the farmers. The outstanding amount is being paid by the farmers on an installment basis. The loan refunding and loan outstanding ratios are 86% and 14%, Figure 2.17 shows the status of loan disbursement and reimbursement status. All farmers are refunding loan money on time as scheduled except for 2 or 3 cases in Dinajpur district.

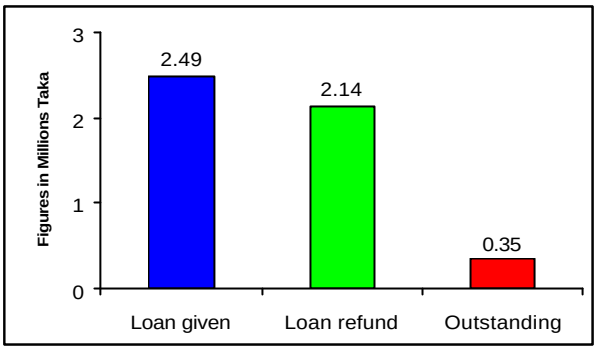

Figure 2.17: Loan disbursement and reimbursement status

X. Scientists Exchange and Visit Program

To exchange and share ideas about agricultural mechanization and resource conserving technologies in agriculture developed by different parts of the world, a group of 4 scientists from different partners institutions of Bangladesh Agricultural Research Institute, Wheat Research Center, CIMMYT Bangladesh and CIMMYT Nepal attended the 2004 International Commission of Agricultural Engineering (CIGR) International Conference in Beijing, China. Five papers from the CIMMYT - BARI collaborative research program were presented in Session IV of the conference. All full papers have been published in the proceedings. A follow-up field visit of different types of conservation agriculture was organized by the conference organizing committee. Photographs of the participants are marked in the Figure 2.18 by ⬆ point.

Figure 2.18: Participants of Session IV of the 2004 CIGR International Conference held in Beijing, China

During the program year, a CIMMYT Crop and Natural Resources Group Traveling Workshop was organized by CIMMYT Headquarters consisting of scientists from CIMMYT regional offices. The team visited Bangladesh CIMMYT led agricultural mechanization program in different parts of the country from February 9 - 12, 2005 (Figure 2.19).

Figure 2.19: C&RM Group are discussing with wheat farmers in Rajbari district. The crop was established by the multi-crop seeder.

XI. Study on Adoption and Impacts of Power Tillers in Bangladesh

A study on the adoption and impacts of power tillers in Bangladesh was conducted to document extent of diffusion of power tillers; characterize Power Tiller (PT) adopting farmers; quantify input use changes, especially labor; quantify productivity changes at a farm-level; estimate input use efficiency [production function analysis]; estimate impact on profitability of rice-wheat production; discuss implications for livelihoods of rice-wheat farmers; and elicit views on future prospects of the technology. The study was conducted by BARI, BRRI and CIMMYT. The study methodology and a summary of the findings are described below.

Data on existing number of working power tillers were collected covering all districts in Bangladesh except for 6. Village level primary data were collected with the help of Block Supervisors (BS) of the Directorate of Agriculture Extension (DAE). An adoption and impact survey was confined to 8 districts; namely Brahmanbaria, Faridpur, Jessore, Chuadanga, Dinajpur, Rangpur, Rajshahi, and Jamalpur. Adoption survey data were collected from 320 adopted farmers. Those were randomly selected from 64 villages of 16 upazilas under the above mentioned districts. Among the 320 selected samples, 96 farmers were selected consisting of 6 from each upazila for the impact study. To estimate the profitability of owning a PT, data were collected from 20 PT owners covering at least one from each upazila. Both descriptive and appropriate inferential statistical tools were used to analyze the data and are presented in tabular form. Stochastic frontier production function analysis was carried out to examine the technical efficiency of farms. By applying the straight line method, the depreciation cost of a PT was calculated considering a salvage value of Tk. 10,000 after 6 years life.

In 2002, our survey data showed there are 123,867 working PTs available in the country. Undoubtedly there were more PT imported up to 2002 (Quasem mentioned 220,000). The working life of a PT is 5-6 years, after that it is not economic to use, as

mentioned by the farmers. During 1993, there were 32,469 PTs. This increased to 68,871 and 123,867 by 1998 and 2002, respectively.

Among the sample farmers, about 98% used PT for tillage operations. Farmers used PT irrespective of farm size, education level, farming experience, physical assets of the farmers and village infrastructure availability. Of the PT adopted farmers, none was found to stop using PT after beginning to use it. Among all the categories, larger farmers (medium and large) are the early adopters compared to smaller farmers.

PT adoption had a multidimensional impact on the crop sector. It increased total production per unit area of land by increasing productivity (4.82 % in wheat, 10.03% in monsoon T. Aman rice and 5.67% in winter Boro rice), increasing cropping area under optimum planting time (16% increased in wheat, 21% in winter Boro rice and 28% in monsoon T. Aman rice planting) and cropping intensity. Adoption of PT also increased profitability of crop production by reducing the cost of land preparation and by increasing yield. After PT adoption, the undiscounted benefit cost ratio of winter Boro rice and wheat were 1.37 and 1.68 instead of 1.04 and 1.34 before. PT adoption increased the technical efficiency (TE) level of the farmers. TE level above 76% increased tremendously after PT adoption in wheat but in case of winter Boro rice the TE level remain more or less similar as in before.

Among the 320 samples, 17% had their own PT, of which 33%, 22% and 9% owned by large, medium and small farmers, respectively. After meeting their own demand, the PT owners usually rented it to others and earned cash. On average, 85 ha of land was ploughed by each PT over the year with more coverage in Rabi (winter) and late Kharif (monsoon) season. Considering the 6 years working life (1891.44 working hours) of a PT, depreciation cost as well as other operational costs and returns were calculated. It was found that 52 percent of total income remained as net benefit and 48% covered other costs. As a result, an owner of the PT earned about Tk 327.44 per ha and Tk 27,824 ($ 463.7 USD) per year. They can easily recover their purchased value within 2 years of operation. Farmers used their extra income from a PT for their crop production and livelihood improvement.

There were some constraints faced by the PT owners. These included insufficient knowledge about PT maintenance, low quality spare parts and oil in the market and lack of institutional intervention to control the input quality and technical support to improve / properly use of the PT technology.

Faster operation by power tiller permits an increase in yields through more thorough cultivation, timely planting and increase in cropping intensities and a faster turnaround time between crops. PT also increased the profitability of crops by reducing the cost of labor for land preparation and by increasing productivity. The PT also increased the cropping intensity and technical efficiency of the farmers. It gives cash returns to the owner of the machine. For further development of this technology the following issues are suggested which need to be taken into account.

Training should be given to upgrade the operators' knowledge about repair and maintenance which will help to increase the lifetime of PT as well as minimize the cost of its maintenance. Extension personnel (they have one Ag. Engineer in each DD, DAE office) can arrange a trainers training program with the help of BARI/BRRI by using the CIMMYT/WRC model. Availability of quality parts and oil should be ensured. A national mechanization policy is needed to manufacture PTs locally through a partnership business with China. Institutional guidance is needed to control the quality of PT as well as spare parts.

XII. Data Integration with the Bangladesh Country Almanac and Map Preparation

To have a clear picture of the power tiller numbers in different districts, it was essential to produce a map. The collected data on power tiller numbers have been entered into the Bangladesh Country Almanac and produced a map showing district-wise power tiller distribution over time (Figure 2.20). This figure was prepared by using the Bangladesh Country Almanac.

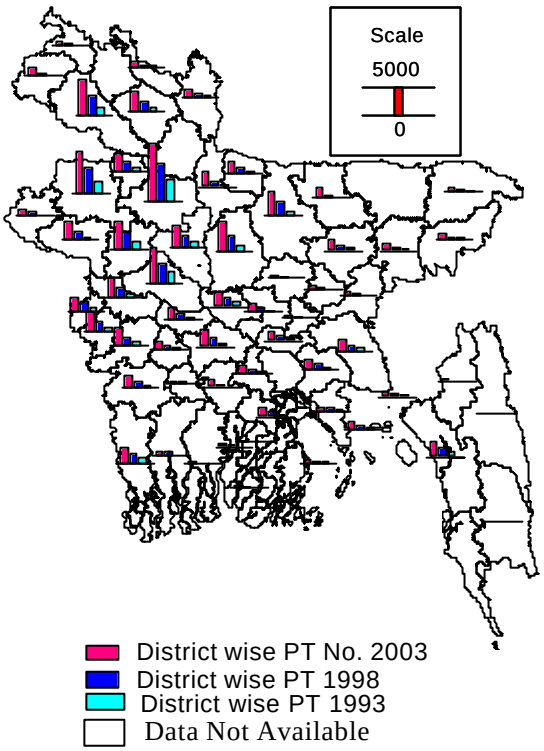

Figure 2.20: Map of Bangladesh showing district-wise power tiller uses over the years 1993 to 2003

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

Bangladesh Country Almanac (BCA) is a package of GIS based database and user friendly software with querying tools which is targeted for use in agriculture and natural resource management activities. The ***BCA database*** is the core component of the package and ***AWhere Act*** is driving software for query and extraction of data from and adding new data to the database, analysis and reporting. The project started in July 2002 with the vision to increase stakeholder access to and effective use of integrated geo-spatial information on agricultural research and development and natural resource management in Bangladesh. Several components were needed including suitable software tools, relevant database and effective diffusion and capacity building mechanisms for end users. After successful completion of two years of activities, USAID extended the fund to prolong the project period for an additional nine months to June 2005. To complete the design activity another 'no-cost extension' proposal was submitted to USAID to continue until June 2006. It is expected that the new version of BCA with additional and updated data and updated software will be released in October 2005.

The BCA database is primarily a feature-rich series of geo-spatial data at the national and Upazila level resulting from the collective work of the partner institutions-BARC, SRDI, BRRI and CIMMYT-involved in the project. Such an integrated database that includes climatic, soils, crops, demographic, hydrographic and infrastructure information is a major advance in terms of an information resource for Bangladeshi scientists, planners, investors and development partners. The BCA has attracted many government agencies and NGOs to share their information. Such organizations are Bangladesh Bureau of Statistics (BBS), Department of Agricultural Extension (DAE), Bangladesh National Nutrition Council (BNNC), Department of Agricultural Marketing (DAM), Bangladesh Meteorological Department (BMD), etc. New information will be included in the new version of BCA as it becomes available.

I. Technical Implementation Committee (TIC)

A BCA Technical Implementation Committee (TIC) represented by Bangladesh Agricultural Research Council (BARC), Soil Development Resource Institute (SDRI), Bangladesh Rice Research Institute (BRRI) and International Maize and Wheat Improvement Center (CIMMYT) met once a month for program planning and implementation of BCA. The meeting was held at the CIMMYT Bangladesh office and at partners' institutes. The TIC assessed the need for training of BCA users, and decided on the software upgrading, data collection and modifications. TIC also reviewed the feedbacks received from stakeholders (both from end users and partners) on the requirement as well as on the problems faced during operation of the software and passed those on to the Mud Springs Geographers (MSG) through

CIMMYT, Mexico for their action. CIMMYT, Mexico made arrangements with MSG for updating the software.

II. Release of Software and Database Versions

During July 2001-June 2004, three versions of the AWhere-ACT software (Ver. 3.0, Ver. 3.5a, and Ver. 3.6) and database versions of the BCA (Ver. 0.5, Ver, 1.0 and Ver. 2.0) were released. Mud Springs delivered the latest AWhere-ACT 3.7 beta version in June 2005 to test and report back to them on bugs, errors etc. The software is being tested by partner organizations to see if there is any problem and bugs in the updated version and whether the problems identified in the earlier version have been addressed properly. The test results will be sent to MSG for necessary corrections. After getting the corrected version, the BCA will be released as Ver. 2.5 in October 2005.

III. AWhere-ACT Software Development (3.7 Beta version)

AWhere-ACT 3.7 beta version (Figure 3.1) was received in early June 2005. The software is being tested with old and newly created databases to identify the problems and bugs. In the beta version of the software, a raster module has been incorporated to facilitate the analysis of raster database and a grid module to perform grid algebra. Some other enhancements (menus tools, etc) have been done, along with all of the original spatial analysis functions and utilities available in AWhere Version 3.6. An additional module has been incorporated with the beta version for querying attribute data both at national and *upazila* level, which, in the previous version of BCA could be done only by using separate customized software.

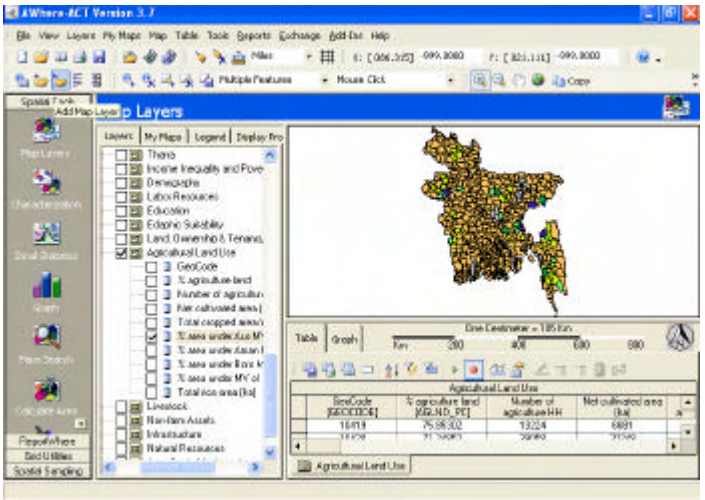

Figure 3.1: Layout of AWhere-ACT 3.7 software

Along with all of the original spatial analysis functions and utilities available in previous versions, AWhere version 3.7 has numerous new features that take AWhere further toward being an all-in-one, well rounded Spatial Information System. Some of these are truly new features, and some are modifications and improvements to previously existing features. Along with the new and improved tools, there is a new look to the various icons and buttons throughout the interface.

The new tools and features contained in AWhere 3.7 are listed and briefly described here, using information provided by Mud Springs:

1) Display Zonal Statistics in Legend - Displaying Zonal Statistics in the Legend allows calculations to be made on certain values and associated with categories of the same or different values. For any class breaks or unique value classification we can calculate statistics for any other variable based on that grouping. The maximum, mean, minimum, standard deviation, and sum of any numeric Variable may be calculated, categorized by any other Variable in the same Datalayer (numeric or string data). The calculated values for that Variable will be displayed in the legend in brackets beside the District.

2) Data Link Feature in Treeview - The Data Link tool, which has been an Add-In before 3.7, is now imbedded directly into the main application, via the Treeview. Using this feature, we can link external data to individual data layer variables whereby we can map that external data in AWhere. It is designed to establish links between the attribute table of data layers (shapefiles) existing in an AWhere database and external data tables or databases. With a link established between a data layer and an external data source, when any edits or additions are made to the external data source, the data layer's attribute table can easily be updated with that newly edited data.

3) Raster files (Grids) Supported - We can now add grids (raster data) to an AWhere database. Previously, it was required that a grid be converted to a "gridpoly" shapefile before it could be viewed in AWhere. This is no longer the case as a grid can be read directly into an AWhere database, viewed and color rendered just like any layer, and can have calculations performed on it using the new Grid Algebra Add-In. We can display Grids in the AWhere map window with any other data layers in the database; we can perform most color rendering operations on grids, site selection operations, and load site information extracted from a grid into the Table panel.

4) Multiple Projections Supported - The map now can be projected to many different coordinate systems. Layers in different coordinate systems may be viewed together in a new projection. The layer Properties has an added tab that allows defining the geographic coordinates (datum) and projection for any layer. It is possible to apply a single coordinate definition to all visible layers or all layers in the database. Once the projection is defined for all layers then those layers can be viewed in any other projection. The projections are not supported for grids or images.

5) More Data Rendering and Display options - a) Loading saved Classes (a saved .xml file) will provide a preview of how the loaded class setting will display the target data and will allow for immediate adjustments to the color rendering, b) Additional Class Breaks methods, c) More flexibility in feature symbol options for Class Breaks and Unique Value rendering.

6) Several Table Tool Enhancements - a) The order of the fields as they are listed across the table heading is the same as the order they are listed in the Treeview, b) we can choose to view, in a data layer's attribute table, only those records that are

associated with map features selected on the map, c) we can choose to perform calculations only on selected records/features rather than being forced to perform calculations on every record in the table.

7) Additional Feature Selection Methods - Additional methods of selecting map features including drawing a box around multiple features, selecting everything within "x" radius of a point, and entering coordinates of desired features.

8) Creation of New AWhere Databases more automated - Upon starting AWhere now, a default AWhere database is automatically created, and it asks to add data to it. You no longer have to actively create a new database before working with AWhere. Upon closing that database, it will prompt to save and name the database; and if we lose that database before saving it, there is a recovery feature where we can retrieve the lost work.

9) Add-Ins Manager - Add-Ins are additional utilities and tools that may be incorporated into the foundation AWhere application after AWhere has already been installed. Typically, most Add-Ins that are installed on top of an installation of AWhere will be made available to select via the "Add-Ins" menu at the top of the AWhere interface. The Add-In Manager is installed with the main AWhere application. By clicking on the "Add-Ins Manager" option under the "Add-Ins" drop-down menu, we will see the Add-Ins Manager window. This window allows checking on (turn on) or check off (turn off) any currently installed AWhere Add-Ins.

In the Add-In there is an option for 'Agriculture Statistics' to call the external 'Agril Stat' program. There is some information which is not geo-referenced but are very useful were kept in separate database. To call up this information, we developed an external program. Earlier, this program was separate. Now the user can call up that information remaining within the platform. Like the 'Agril Stat' application, it is possible to incorporate the third party or placed elsewhere on the computer as an Add-In.

10) Some AWhere features now Add-Ins - Some features of AWhere that were previously inherent parts of the interface are now AWhere Add-Ins that can be installed separately from the main application and can be managed (turned on or off) via the Add-In Manager. These features include the Model Tools, Spatial Sampling tools, Grid Utilities, and Climate Chart tool.

11) Graticules in Map View Window - There is a tool in the toolbar that allows to turn on/off map graticules. A grid of X and Y values may be drawn on the map at any desired interval. The graticule will always represent the current coordinate system (grid lines will always be horizontal and vertical).

12) Back-end Performance Improvements - The software company has made some backend improvements in memory and processing speed of the application.

13) BCA About - In the Help menu there is an 'About' option for support information for the BCA so that users can communicate with the relevant persons for further assistance.

IV. Database Development and Upgrading

BARC had taken the initiative to build a complete GIS database on agro-ecological zones, Soil and Landform from Thana/Upazila Nirdeshika of Bangladesh. Initially 330 Upazilas were digitized to generate a spatial and textual attribute database. Further under the BCA project, the remaining 129 Upazilas were digitized to complete the set. Also, edge-matching and joining (merging) processes are being developed to make the database at district and national levels using the Upazila datasets.

In the previous versions of BCA, our national database on land and soils was in the scale of 1:250000 (reconnaissance survey), which was too general, limiting its real world applications. A new national database on land and soils is being created using semi-detailed information at the Upazila level at a 1:50000 scale and at country level at 1:100,000 scale. In the old database, information on soil physical properties was based on soil series and in the new database, soils are grouped depending on the similarity of edaphic criteria in relation to agricultural applications. In the coming version of BCA, the new database on land and soil will be added which is the major change in the new version of BCA to be released in October 2005. Suitability maps (Figure 3.2) for major field crops and fruits in Bangladesh have been created and time series data on crops,

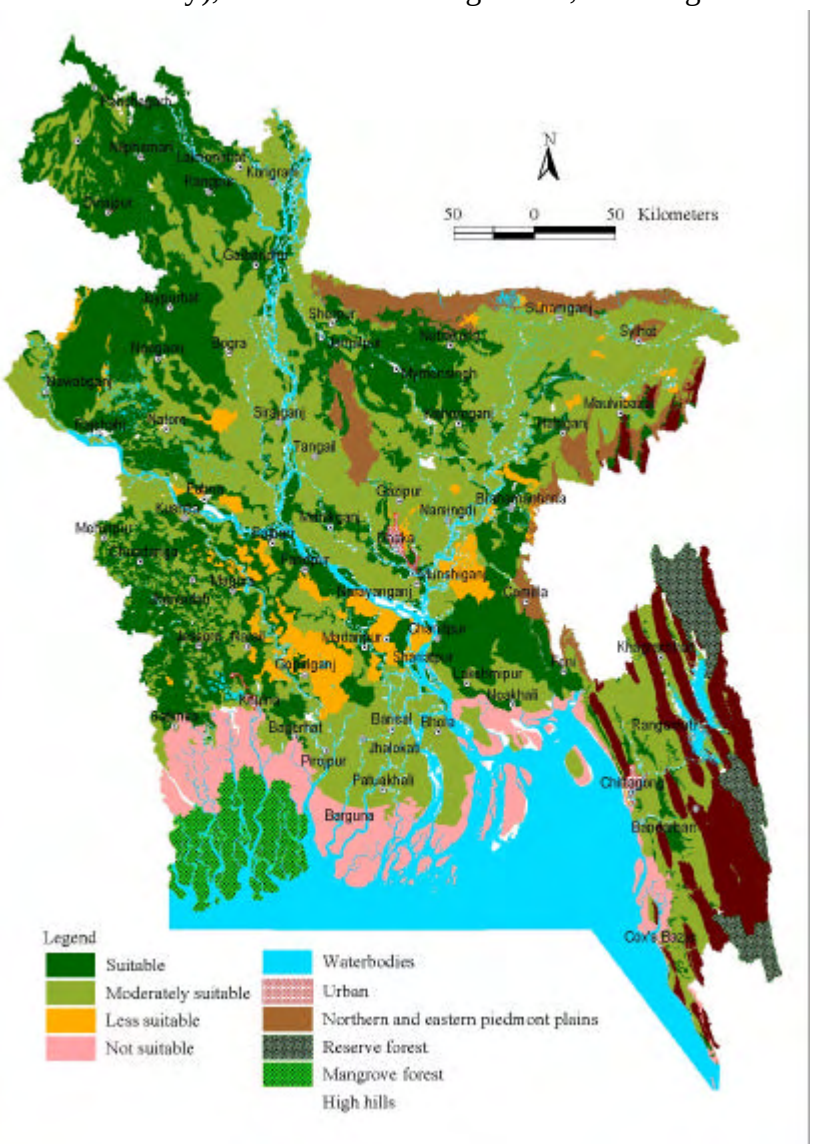

Figure 3.2: Maize suitability map

climate and some other elements have been updated for inclusion in the new version of BCA. As usual, all spatial data will be uploaded as shape files.

The dataset is listed below:

Political boundary

1. Union
2. Mouza

Birth Rate (by district)

1. Crude Birth Rate
2. Total Fertility Rate
3. Crude Death Rate
4. Child Death Rate
5. Infant Mortality Rate

Educational Statistics (by district)

1. No. of High School, Student and Teacher (both private and public)
2. No. of College, Student and Teacher (both private and public)
3. No. of Dakhil madrasha, Student and Teacher
4. No. of Fazil madrasha, Student and Teacher
5. No. of Kamil madrasha, student and Teacher
6. No. of Ebtadayee madrasha, Student and Teacher
7. Primary School Enrolment Rate 6-10 years
8. Primary Education Statics –School, Teacher and Enrolment

Area, production and yield of Crops (by District/Upazila)

Aus Aman Boro by Variety	Garikalai
Wheat	Gram
Maize	Arhar
Potato and Sweet Potato	Kheseri
Sugarcane	Mashkalai
Oilseeds	Masur
Jute	Motor
Betalnut	Mung
Betel leaves	Other drugs

AEZ, Soil and Landform database from Upazila Nirdeshika

1. Physiography
2. Cropping pattern
3. Land Use
4. Moisture
5. Soil Consistency
6. Drainage
7. Soil Reaction
8. Soil Texture
9. Salinity

10. Organic matter
11. Soil fertility (Ca, Mg, K, N, P, S, B, Cu, Fe, Mn, Zn)
12. Water recession
13. Land Classes
14. Harbazar / Road / Growth Centre / Embankment / Railway
15. Settlement / District HQ / Thana HQ / Union HQ

Fisheries

1. Selected Agricultural Statistics
2. Annual Total Catch in Flood Land
3. Annual Total Area and Total Catch of Pond
4. Annual Total Catch of Shrimps Farm
5. Annual Catch in Other Rivers by District by Species

Suitability mapping

1. Kharif vegetable, Rabi vegetable, Sugarcane, Gram / Black gram, Lentil, Oilseed, Mango, Jackfruit
2. Sugarcane, Jute, Potato, Spices (Onion, Turmeric, Garlic, Chilly and Ginger
3. Suitability Maize, Aman

Climate

1. Rainfall surfacing maps

Health and nutrition sector's information

Human Resource in Health Sector

1. Total numbers of doctors under Ministry of Health and Family Welfare
2. Total number of nurses under Directorate of Health Service
3. Total number of nurses under DGHS and DGFP
4. Total number of dentists
5. Total number of medical assistants, technicians, radiographers, pharmacists, health inspectors, union family planning inspector
6. Upazila health complex and union sub-centers

Human Resource Development Institutions

Medical Universities, medical colleges, medical assistant institutes, college of nursing, dental colleges, regional training centres, homeopathic college and other

1. Providers - Population radio in the health and population sector
2. HRD - institutions population ratio in the public sector
3. Teaching staffs for HRD
4. Number of Teachers, students, students sex ratio etc.
5. Name of diseases pattern in last few years

Human Resource in nutrition sector

1. Name of disease pattern
2. Vital statistics on Health and Nutrition

Providing morbidity pattern

Most common diseases
Fever, malaria, dengue, typhoid, scabies, malnutrition/anemia, diarrhoea, ARl, pneumonia, dysentery, dyspepsia/gastritis/peptic ulcer, influenza, common cold1URI, acute cough/bronchitis, asthma, waist pain, high blood pressure, gout, diabetes and others diseases.

Immitieable diseases
Measles, poliomyelitis, tetanus, whopping cough, tuberculosis and diphtheria.

Marketing and commodities

1. Monthly average wholesale price of fertilizers
2. Monthly Grower level prices of all crops, pulses, fruits, vegetables, spices
3. Monthly average wholesale prices of Paddy, Rice, Wheat, Ata, Sugar and Sugarcane
4. National Wholesale Price of Pulses, Dal, Oil seed and Oil
5. Monthly average wholesale price of Spices
6. Monthly average wholesale price of vegetables
7. Retail prices of some commodities
8. Import of some agricultural commodities.

Adoption and Impacts of Power Tillers in Bangladesh

1. Status of Power Tiller Uses (by Upazila)

Upazila/Thana level spatial data

To facilitate the use of data on larger scale (1:50,0000) for local level planning, the information on various features of two new *upazilas*, Kapasia in Dhaka district and Chakaria (Figure 3.3) in Cox's Bazar district, will be added to BCA 2.5. As with country level data, upazila attribute data can be queried using the Add Ins menu.

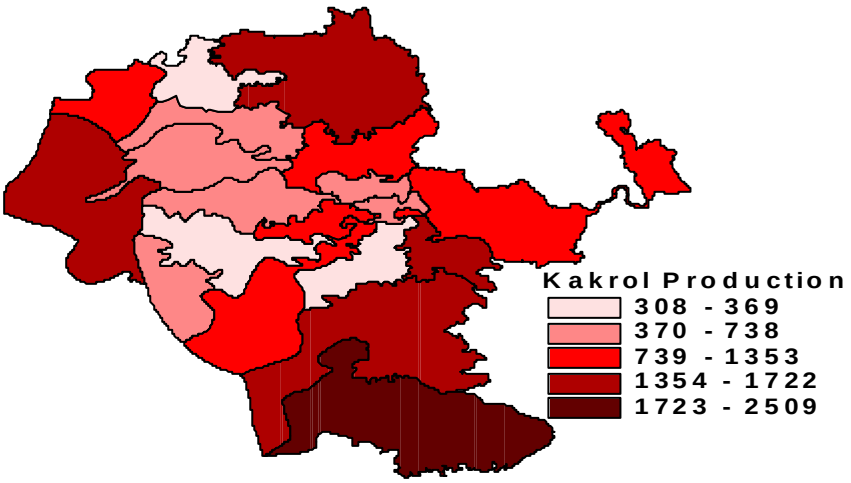

Figure 3.3: Kakrol production of Chakaria upazila for 2004

In Bangladesh, agricultural extension services have been following a territorial division which is defined as a "Block". In the agricultural planning system, Block is the basic unit of extension and development efforts. Within a block there exists a range of variability for crops grown, land type, land use, resource availability, farm categories, risks factors and infrastructural setup.

The upazila territory has been split into Block where Block supervisors (BS are now called Sub-Assistant Agriculture Officer) are assigned to implement the extension activities. The BSs are the prime extension workers who maintain a close touch with the farmers in a Block. BS works at the block assisting the farmers towards implementing extension events within the block based on local needs. They also collect information about the natural resources, population, areas under different crops, input requirements, numbers and extent of farmers adapting, testing and adopting technologies. They also maintain a BS diary to record day-to-day progress and plan for future activities. DAE targeting involves developing programs which meet the needs of the different types of farmers.

The main thrust of this study is to formulate a block map along with the attribute data to help bottom up agricultural extension planning at the upazila level using our BCA tool. The present study attempts to design and build the geographical shapes (jurisdiction) of all the extension blocks under Chandina upazila and to integrate essential socio-economic attributes. A digital block shape of the upazila would be available defining block names, areas, human population, crop statistics (Figure 3.4), farm families, and categories of farmers of the blocks in the study upazila. This mapping will help save time with easy and action-oriented extension interventions. All the block supervisors (now SAAC) could be in a position to keep a standard block map with the BS diary delineating the important block

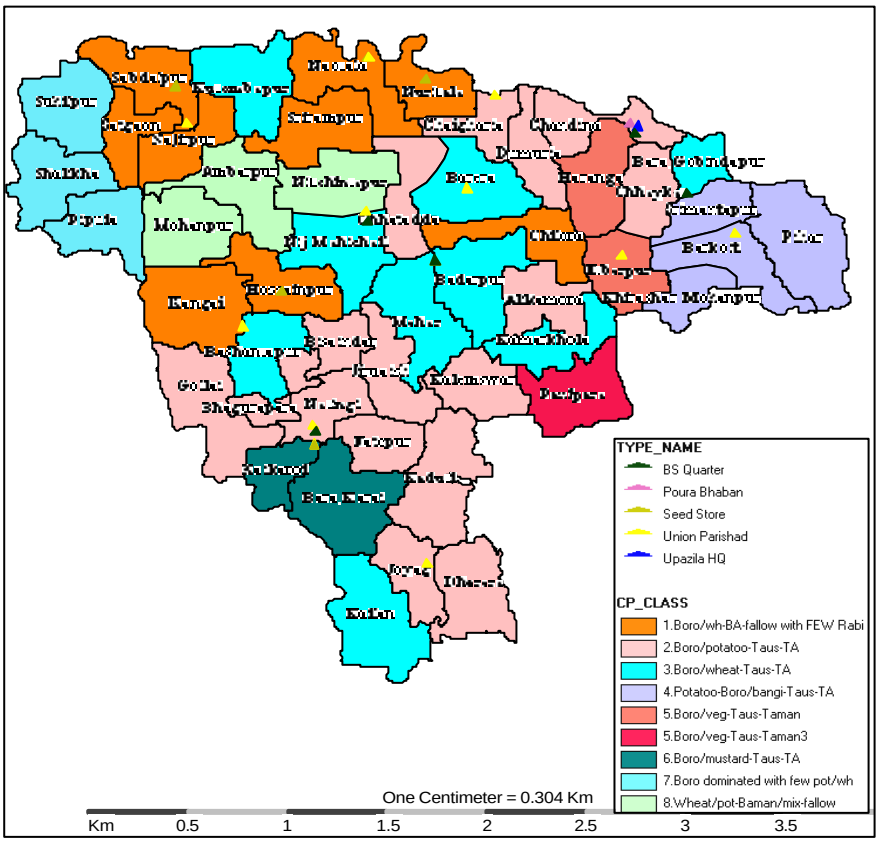

Figure 3.4: Cropping pattern of Chandina Upazila under Comilla District- A case study done by DAE

parameters. It would ensure the extensionist has information of the blocks for forward planning. This block map preparation effort will be of great importance for the DAE in updating national data and to ensure computerized local level planning.

After completion of the study, a workshop (Figure 3.5) was organized to look at analytical block maps prepared based on information of farm families, irrigation coverage, major land uses, cropping patterns, population and crop statistics. In the session, the PD of SAIP showed his interest and urged the project to cover the block mapping and database for all the districts of Mymensingh, Jamalpur and Sherpur and all districts under the SAIP project where computers are available at the Upazila level. He urged the BCA team to provide technical assistance.

Figure 3.5: Local level planning workshop at DAE on Chandina Upazila of Comilla District

V. BCA on the WEB

The workshop participants suggested to the BCA team to maintain a webpage uploading essential information and GIS maps so that interested people can ascertain the information through a search engine. Therefore, some useful information was uploaded to the web over the last three years (http://www.cimmytbd.org/bca). Besides, a web server has been prepared using ESRI ARCIMS technology to distribute mapping and GIS data and services on the web. Users can have the geographic data and analysis as well as the map. There is also a search/query option to get the particular point data. A sample site has been hosted temporarily at http://www.cimmyt.org/gis/bangladesh/bca to test this feature.

Suggestions and constructive criticism on the web site are welcome.

VI. Software License

Like the previous version, the AWhere 3.7 will be accompanied by a runtime license, which allows users to test it for a period of 60 days commencing on date of installation. If there is no license for the application, or if the license expires, it will automatically prompt to enter a new license code. Upon expiration of the runtime license, users must register with the CIMMYT Bangladesh/BARC for further renewal of license. There was an agreement with Mud Springs to provide 300 user

licenses (previous 200+new 100). The BCA license renewals will revolve on an annual basis. The license expires after every one year, after which users can request for a free license code renewal. CIMMYT will supply Mud Springs with full names and addresses of 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.

VII. Dissemination/Training Workshop

Five one-day dissemination/training workshops (Figure 3.6) and three two-day hands-on-training events were organized in collaboration with regional networks,

Figure 3.6: Scientists/agriculturalists from various district offices attended a one day dissemination workshop held at conference room of SRDI, Dhaka

NARS, NGOs and private sectors in different locations. The workshop participants took part in the discussion, and raised several issues pertinent to their field of application that helped TIC in decision making for the improvement of the software tools and database. An evaluation sheet distributed among the participants to get their reaction and feedback on software and BCA database, elicited extremely positive responses.

Some of the valuable comments the participants had to make on that evaluation sheet 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 in Figure 3.7. In all workshops, the nature of participants' responses on database and software were similar.

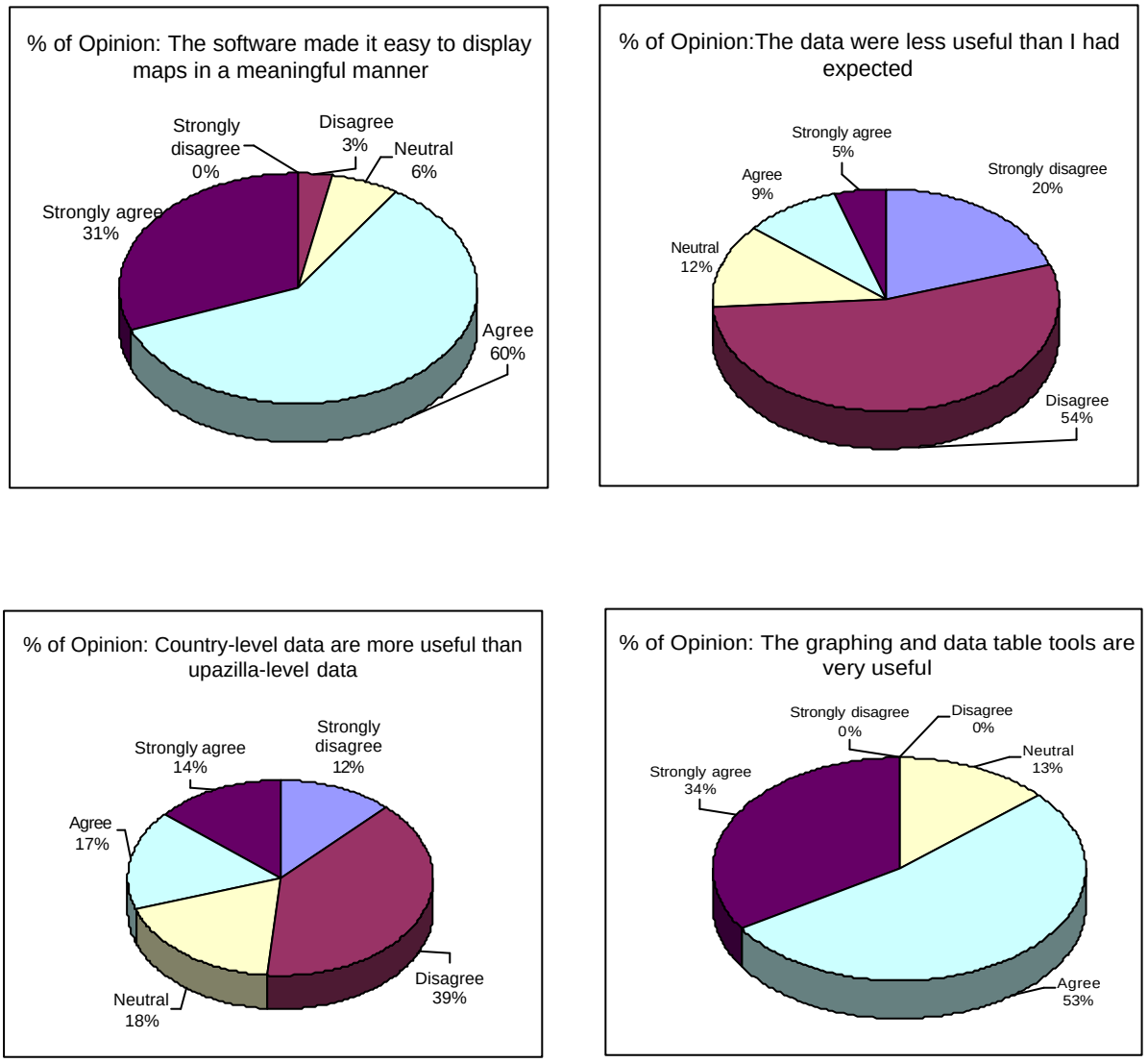

Figure 3.7: Workshop/training participants' opinion on BCA 2.0

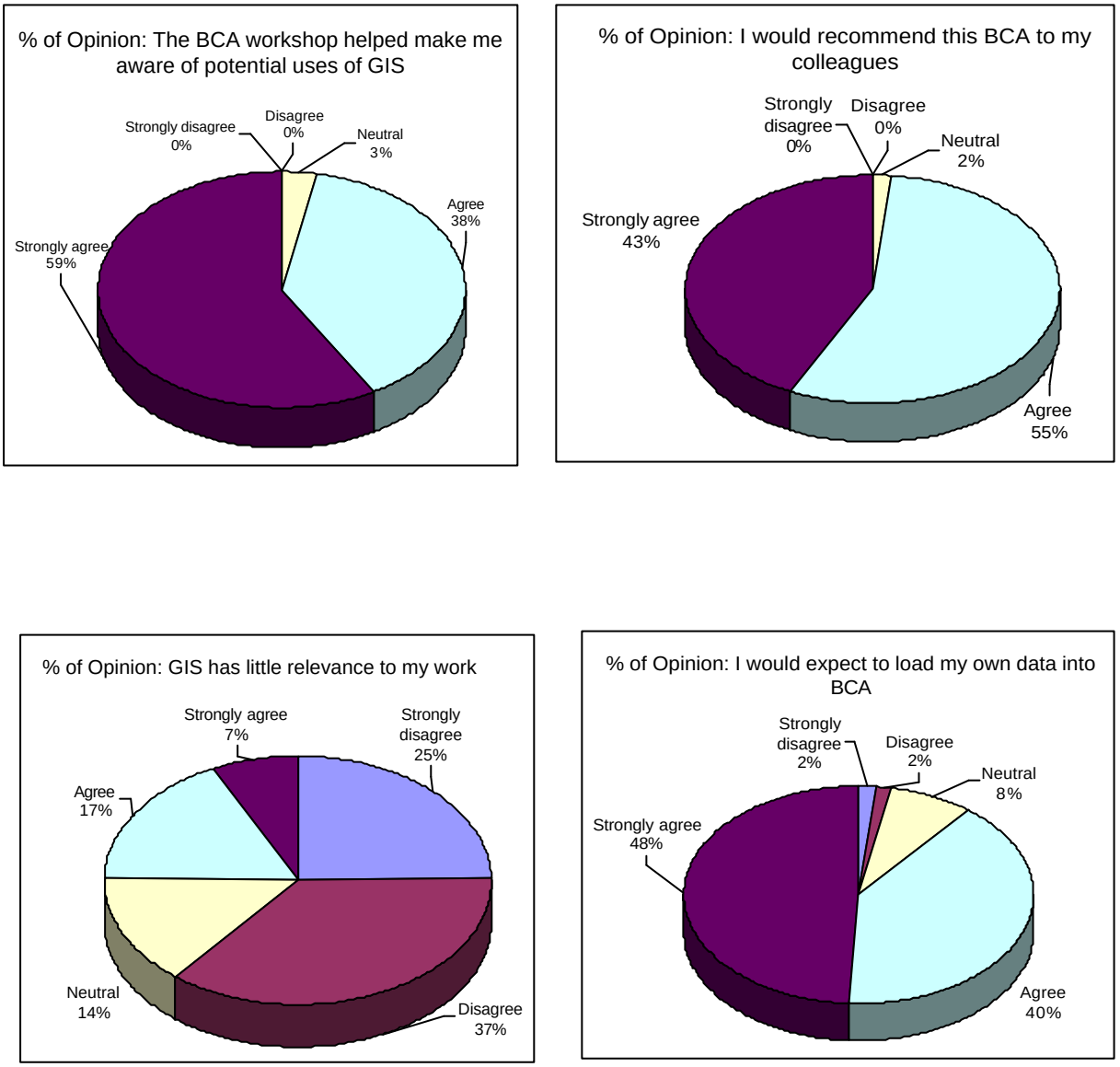

Figure 3.7 Continued: Workshop/training participants' opinion on BCA 2.0

Hands-on-training highlighted the problems and expectations in more detail. During the training, the participants encountered several bugs in executing some of the modules and tools of the software and expressed their concern on the incompleteness and or inadequacy of some of the data layers which they thought are important, particularly for local level planning. With these limitations, the participants showed great enthusiasm while working themselves with BCA and made some very useful products out of the database. Some participants recognized that failure of some of their research activities may be because of the wrong selection of study sites, as revealed from the output of the characterization tool. Some were able to produce new maps incorporating their own data with BCA database and were happy to see the extrapolation domain of their research results. However, they all expressed their dissatisfaction on the short duration of the training (Figure 3.8) as

they could not touch all the options available. They got too little time for adequate practice to develop full confidence in operating the software. One anonymous

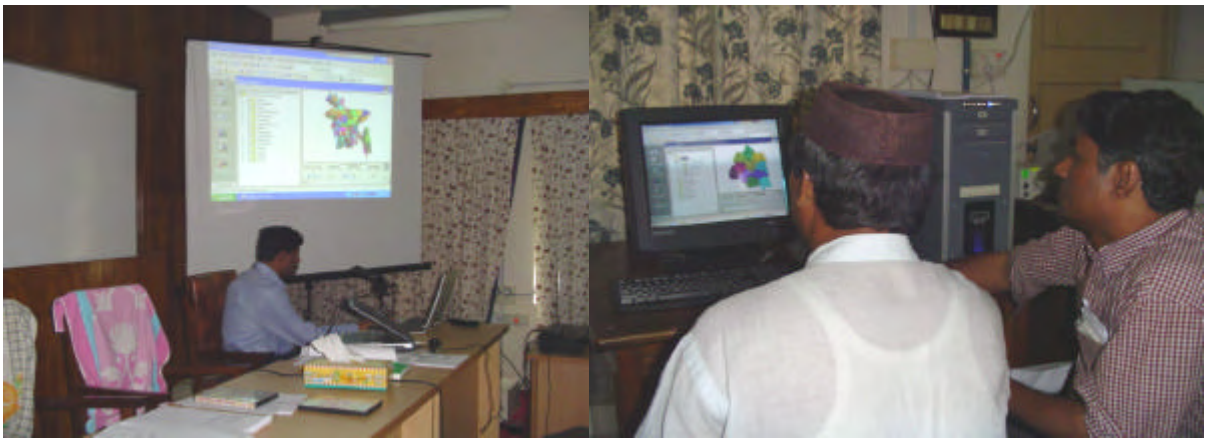

Figure 3.8: WRC scientists attending a two-day BCA training workshop at WRC, Dinajpur

remark passed by the trainees is to form a BCA user group with representatives from all user organizations. Mechanisms should be developed to keep the group members updated who in turn will disseminate the updated knowledge to users in their respective organizations'.

Dissemination/Training workshops were organized in different locations from October 2004-June 2005.

Types of workshops	Location	Number of participants
Dissemination workshop	Sher-E-Bangla Agricultural University (SAU), Dhaka	134
	Regional Agricultural Research Station, Jessore	74
	Khulna University of Engineering and Technology, Khulna	103
	Soil Resource Development Institute, Dhaka	100
	Bangladesh Bureau of Statistics, Dhaka	60
Training workshop	Bangladesh Rice Research Institute, Gazipur	25
	Bangladesh Agricultural Research Council, Dhaka	28
	Wheat Research Centre, Dinajpur	30
Block Level Planning/ Awareness Workshop	Department of Agricultural Extension, Comilla and Dhaka (3 nos.)	98
Total participants		**652**

VIII. Mini Grants

Mini-grants are provided to interested users to support very small projects to facilitate use of BCA as a resource base of geospatial data as well as an incentive to the mini-project investigator for self training. Project proposals were invited from

interested users during BCA workshops organized in different regions and organizations in Bangladesh. The submitted proposals are then discussed in TIC and those found viable in terms of their importance in Bangladesh and opportunity to use the BCA database were considered for support. During 2004-05, 8 mini-projects were supported from our BCA fund. The outputs of these projects will be integrated with the BCA database as case studies. Such case studies will act as ready-made references and promotional material to display the power and utility of BCA in constructing useful maps and for data mining. The case study reports will encourage other users to apply BCA tools and use their own database to prepare maps and extract information useful in their fields of application. That in turn is expected to improve decision support in research and development planning where spatial data is an important input in decision making. A list of the 8 mini grants executed is given below:

1. Characterization of 'hot spots' of rice hispa – a case study in Sylhet region by Entomology Division, Bangladesh Rice Research Institute
2. Identification of Potential Extrapolation Domain for Photosensitive MV T.Aman varieties under Boro-Fallow-T.Aman cropping pattern by Rice Farming Systems
3. Mapping of Used Pesticide on Different Crops in Selected Area of Bangladesh by Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University
4. The Application of the AWhere-Almanac Characterization Tool with Special Emphasis on the Selection of Benchmark Research Sites of Bangabandhu Sheikh Mujibur Rahman Agricultural University
5. Physical Evaluation of Land Suitability for Boro Rice in Bangladesh: A Study Using BCA by Department of Geography and Environmental Studies, University of Rajshahi
6. Soil Fertility under Diverse Agro-ecosystems by Bangladesh Agricultural Research Council
7. Application of GIS to identify the prevalence of white spot disease in shrimp (Peneaus monodon) farms in relation with water salinity and pH in greater Khulna region, Bangladesh
8. A spatial assessment of urea briquette supply using the Bangladesh Country Almanac (BCA).

IX. BCA in Addressing Problem Areas

With the much awaited information and the tools provided in the BCA CD, a user can apply it for many different problem solving activities. While the researchers are using BCA in the identification of areas of research, academics are using it to assign tasks to their students for higher degree work and the extension and NGO workers are using it for development programming purposes. It was felt necessary to document some of those as an example. The BCA's mini grant findings could be used to show how BCA helped in addressing agricultural constraints and assessing their importance. Three examples follow.

a. Identify the Prevalence of White Spot Disease in Shrimp Farms:

The BCA tool was able to identify the prevalence of the most devastating white spot disease in the shrimp farms in greater Khulna region (Figure 3.9) where shrimp culture is practiced more widely than elsewhere in Bangladesh. There were serious outbreaks of white spot disease in this region which results in severe damage to the shrimps and the farmers suffer large economic losses. The diseased shrimp displayed the classic signs - red or bluish coloration and white spots under the shell. This virus affected 80% of farms in all the polders. Dead shrimps were sometimes found on the bottom. In two to three days, mortalities reached 50-70%, and the remaining shrimp did not grow well. The prevalence in this region is severe in winter. The sudden change of temperature also increases the destructive nature of this disease. Water pollution is greatly responsible for the prevalence of white spot disease. As a consequence, farmers harvested small-sized shrimp.

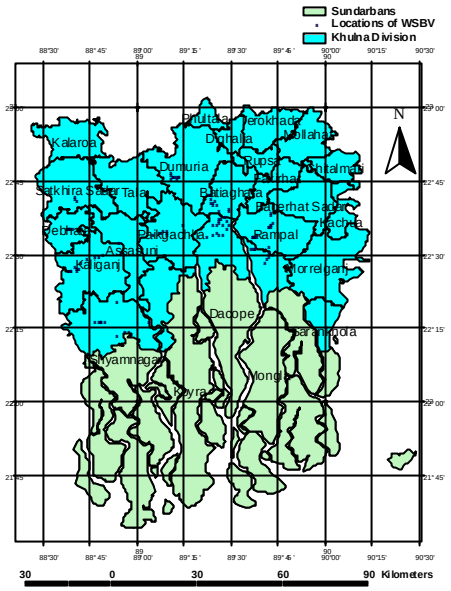

Figure 3.9: Prevalence of white spot disease of shrimp in greater Khulna

b. *Factors Influencing Rice Hispa Outbreaks in Sylhet Regions*

Factors associated with the outbreak of rice hispa, one of the most serious rice pests in Bangladesh were identified using BCA database (Figure 3.10). Minimum temperature, relative humidity, land type are found to influence hispa population build-up and Kharif drought is a major limiting factor for hispa incidence thereafter. The risk zone belongs to the area where the minimum temperature does not go below 10-15^{0}C in January. Minimum temperature in other months of the year remains above 15^{0}C which helps the pest to spread from the risk zone to all over greater Sylhet area. In winter months, hispa requires a low humidity level. The pest requires a low temperature-low humidity period for maintaining reproductive diapause in winter. Hispa ´risk-zone` was also

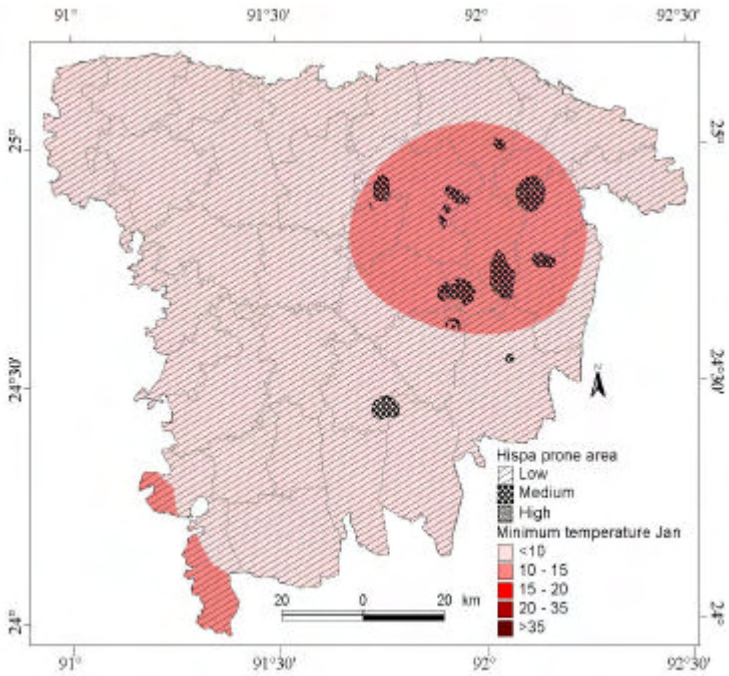

Figure 3.10: Minimum temp(January) and Hispa prone areas of Sylhet region

found to be associated with the land type as well as Kharif drought. Medium low land was found to be related with the hispa outbreak risk. The micro-environment in rice fields of this land type seems to be favourable for hispa growth. Moreover, some semi-aquatic weeds which supports hispa life cycle, particularly in winter months, grows very well in such land-type. Rice hispa cannot withstand a drought situation after the termination of reproductive diapause. Kharif drought is important in relation to population build up after the reproductive diapause termination. A drought situation prevailing in kharif season can inhibit hispa development. As expected, the risk-zone of hispa belongs to the no-drought zone of greater Sylhet area in kharif season.

c. *Identification of Potential Extrapolation Domain for Photosensitive MV T. Aman*

Using BCA Database, the potential extrapolation domain of photosensitive modern T. Aman varieties, BR22, BR23, BRRI dhan40, BRRI dhan41 and BRRI dhan44 has been delineated. Total area under medium high land phase 2 (MHL-2) estimated from the BCA database is about 3.825 Mha. Total T. Aman area under MHL-2 is about 1.659 Mha, which is less than half of the total area of MHL-2 estimated based on BCA database, and this is due to the inclusion of lands that belong to non-agricultural sectors like settlement, urban areas, roads and highways. MHL-2 in the inundation range of 50-90 cm deep is potential for late planting with an estimated area of about 0.74 million ha where farmers normally grow low yielding traditional photosensitive varieties. The potential for expanding BRRI dhan44 in southern districts of Barisal division and some northern parts of Khulna division (excluding a saline area along the coastal belt) is quite high. BRRI dhan40 and BRRI dhan41 bred were for saline soils and can be suitably grown in the saline prone areas of Khulna and Barisal divisions, Feni, Noakhali and

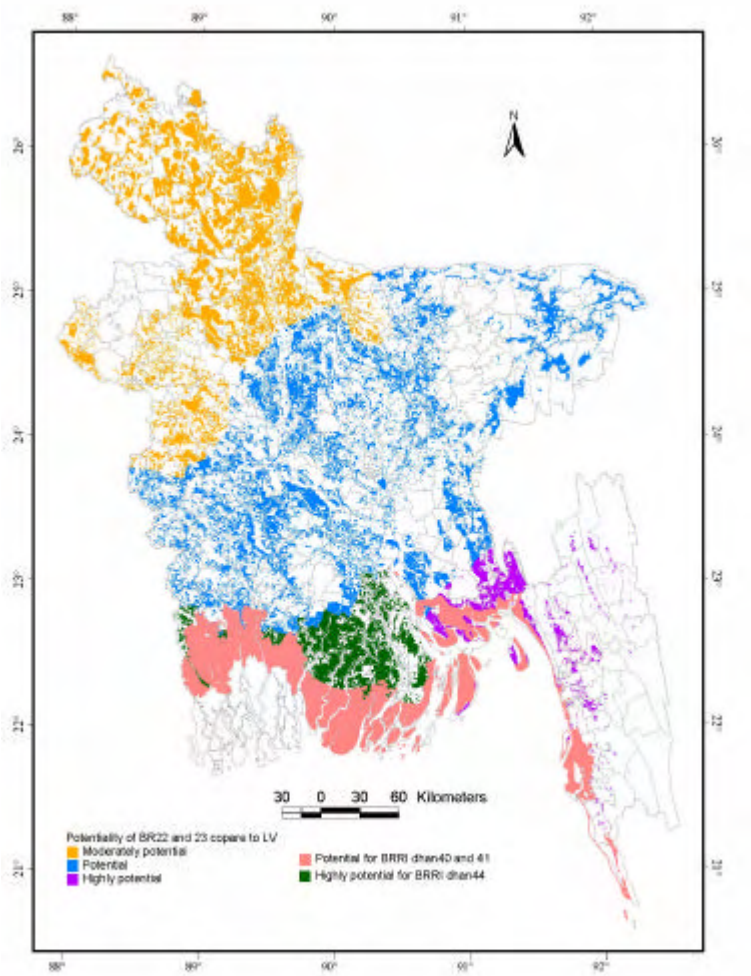

Figure 3.11: Potential areas for photosensitive MV T. Aman varieties and BRRI dhan44

Laxmipur, Chittagong and Coxes Bazar districts. Rest of the MHL-2 area is high to moderate potential for growing BR22 and BR23 depending on the amount of November rainfall. An additional production of 1.1 million t of paddy could be achieved due to this transformation of LV area to MVs. Figure 3.11 shows the potential areas for the selected varieties.

X. Highlights of BCA Achievements

1. Different organizations like BARC, SRDI, BRRI, WARPO, BWDB, BMD, LGED, BBS, DAE generated a huge spatial database and attribute data with spatial reference. Because of limited availability of GIS software and trained manpower, most of the organizations (both Go and NGO) could not utilize these valued resources built using huge money. Even for the organization having GIS facilities it was difficult to access such a database due to bureaucratic process. BCA database is an accumulation of spatial databases generated by different organizations through a participatory approach resulting from strong commitment of the data owning organizations for widening application and exchange of information.
2. DAE is the largest source of agricultural data at grass root level but uses the block concept for collection of agricultural information which is inconsistent with the administrative boundary at the local level. This causes a limitation in integrating data from other sources like BBS, LGED, Public Health, etc., in developing level planning particularly, at the local level. DAE now realizes the usefulness of changing its old block boundary to match with the administrative boundary as a result of demonstration of BCA and its power to DAE management and, interaction of BCA users both from DAE (through case studies) and other organizations and individual users. The issue is now receiving active consideration by DAE.
3. Some limitations of using national AEZ database on land and soils have discovered by BCA users. The old soil database was based on soil series too general limiting practical utility. The modification of soil database using semi-detailed information of Thana Nirdeshika is under process for inclusion in BCA. The new soil database will be based on soil class from the point of land use for agricultural production.
4. BCA was able to convince BBS, BNNC, DAM, DAE, the official agency of the Bangladesh Government to publish agricultural data Upazila-wise. This is probably, a big achievement of BCA.

4. Whole Family Training in Maize

I. Introduction

'Whole Family Training' is a gender unbiased participatory agricultural technology transfer system which has proved to be effective in disseminating wheat production technologies. It has also been proposed and tested for modern maize production technology transfer. The concept is designed to be comprehensible to and appropriate for the more marginalized maize growing families, providing agronomic options for the growers, obtaining feedback, and incorporating options developed by the growers into the curriculum of the course. Field workers from non-governmental and governmental organizations, who routinely worked with maize growing families in other capacities, are instructed on modern maize production technologies using the 'Whole Family Approach and Methodologies', so that they, in turn, could train their clientele. Figure 4.1 shows the whole family training sites in 28 districts. Details of the activities conducted and results obtained are described in the following sections.

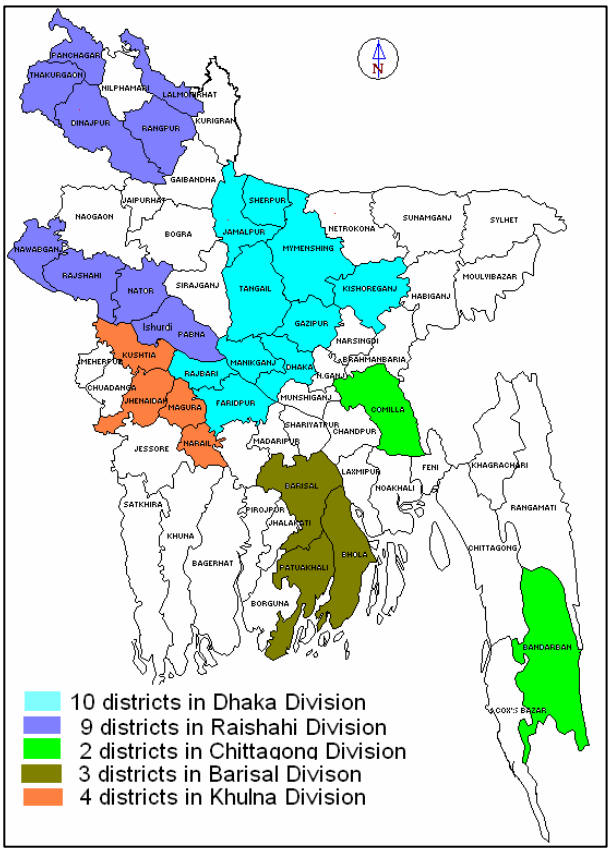

Figure 4.1: The whole family training sites

II. Whole Family Training (WFT)

Through planning meetings, various CIMMYT Bangladesh partners, including GOB, NGOs, private entrepreneurs and farmer organizations decided to conduct whole family training among 3,844 maize farm families (involving 15,376 maize growers) on modern maize cultivation. One hundred percent of the targeted families were trained throughout the country. Figure 4.2 depicts the distribution of families trained under the maize whole family training program in five divisions in Bangladesh.

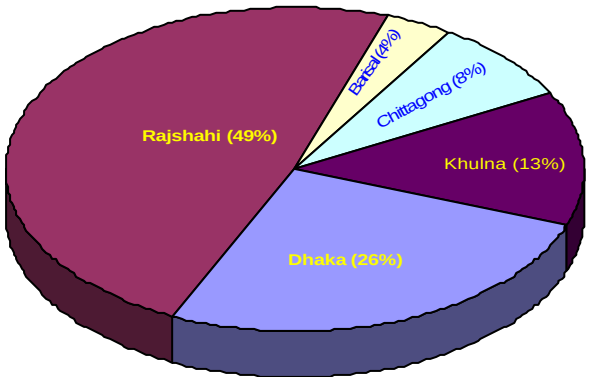

Figure 4.2: Division-wise distribution of maize whole family trained families

Figure 4.3 shows year-wise achievement of family numbers and trainers trained on modern maize cultivation practices from 2001 to 2004 and the proposed number of families and trainers to be trained during 2005. The reduced number of families and trainers trained in 2005 is due to funding constraints with the project.

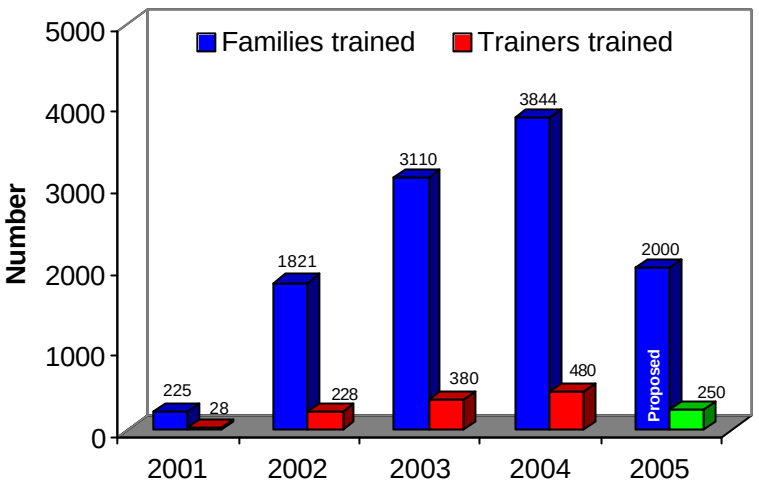

Figure 4.3: Number of trained families and trainers involved with maize whole family training from 2001 to 2005

In the proposed plan of activities, each year 1,000 families were targeted for training. Since 2001 was the beginning year of the program, CIMMYT in consultation with partners decided to train only 225 families. Knowing the usefulness of the training and the effectiveness of the approach in empowering farm families on modern maize cultivation practices, GO and NGO partners expanded the training to more families. Therefore, CIMMYT- Bangladesh and partners agreed to increase the numbers in 2002 and continued conducting training with increased numbers of families up to 2004. To train more families, partners and CIMMYT-Bangladesh decided to share the budget allocated for demonstration purposes. In this case, a private entrepreneur, Doyel Agro Industrial Complex Ltd. shared the partial cost for the training of their 500 families and a few demonstrations. To train the whole families, a total of 480 trainers from the Department of Agricultural Extension (DAE), NGOs and private entrepreneurs were trained on the whole family concept and on modern maize cultivation practices by CIMMYT and NARS scientists. Figure 4.4 shows a typical trainers training session and Figure 4.5 shows a whole family training session.

Figure 4.4: A session of trainers training

Figure 4.5: A session of whole family training

III. Training Material Preparation and Distribution

For training purposes, the following materials were prepared and distributed to the partners, farmers, NARS institutions, development agencies, universities, private entrepreneurs and seed companies:

- 8,147 sets of our modern maize production manual in Bengali, including multicolored pictures and text. The cover page of the manual is illustrated in Figure 4.6.
- 22 sets of large-sized multicolored pictorial posters.
- 500 modern maize cultivation video CDs.
- 50 wheat whole family training concept video CDs.

Figure 4.6: Cover page of maize whole family training manual

IV. Post-training Assessment for 2003-04

Through a survey with structured questionnaires, CIMMYT in 2003-04 assessed farmers' pre- and post-training maize cultivation knowledge and reported our findings of pre-training knowledge in the 2003-04 annual report. Data on maize cultivation knowledge by 2,271 families surveyed after they had been trained have been analyzed and are reported in the 2004-05 annual report. The information generated is described below:

a) Variety Use:

The 2,271 trained families planted a total of 587 ha of land with different maize hybrids. Figure 4.7 gives the percent area covered by the different hybrid maize varieties. Sixty six % of the total area was planted to Pacific-11. CIMMYT-distributed Pacific-11 seed covered 57% of the Pacific-11 area and farmer-bought Pacific-11 seed covered 43% of the Pacific-11 area. Other CIMMYT-recommended hybrid maize varieties, such as Pacific-60, Mukta, 900M and Pioneer, were also cultivated by the trained families indicating the effectiveness of the whole family training in cultivating hybrid maize in Bangladesh.

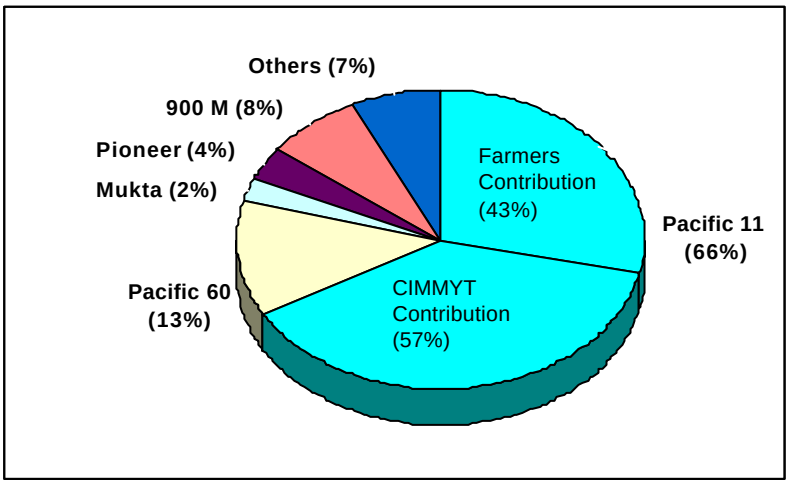

Figure 4.7: Percent area covered by the different hybrid maize varieties

b) Planting Time:

During the whole family training session, family members were trained to plant maize between November 1 and December 15; considered the optimum planting period for higher maize yield. Survey data revealed that 57% of the surveyed

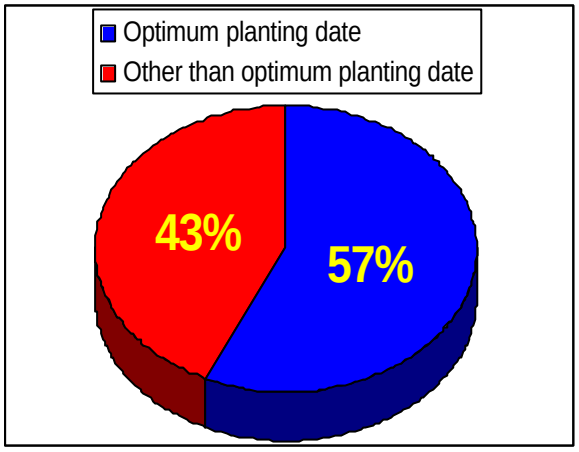

Figure 4.8: Percent of farmers planted maize at optimum and other than optimum dates

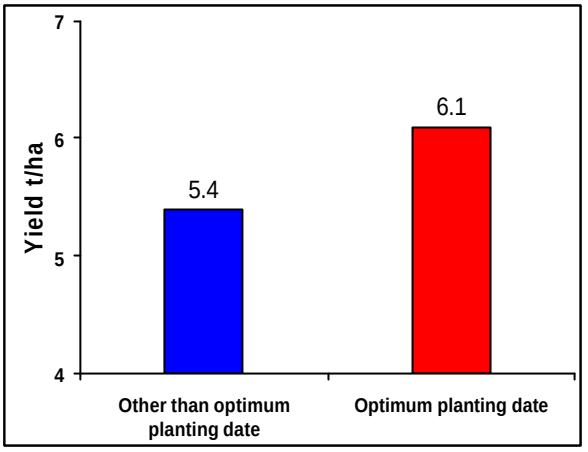

Figure 4.9: Yield of maize at optimum and other than optimum planting dates

families planted maize in the ways learnt from the whole family training, while 43% planted maize at other dates than optimum planting period, as illustrated in Figure 4.8. It was also found from the survey data that those families who planted maize within the optimum planting date (Nov. 1 to Dec, 15) obtained maize crops that yielded an additional 0.7 t/ha grain yield compared with those that planted maize outside the optimum planting period (Figure 4.9).

c) Irrigation in Maize:

Irrigation and its application time in relation to key maize growth stages is very important for proper growth, development and respectable grain yield. This was emphasized during the training session. Survey data revealed that 35% of the farmers applied three irrigations at the recommended time, i.e. at the 8 leaf stage, tasseling and seed development stages (Figure 4.10). This irrigation schedule also produced the highest yield (6.1 t/ha). Four-time irrigation had no extra advantage on maize yield.

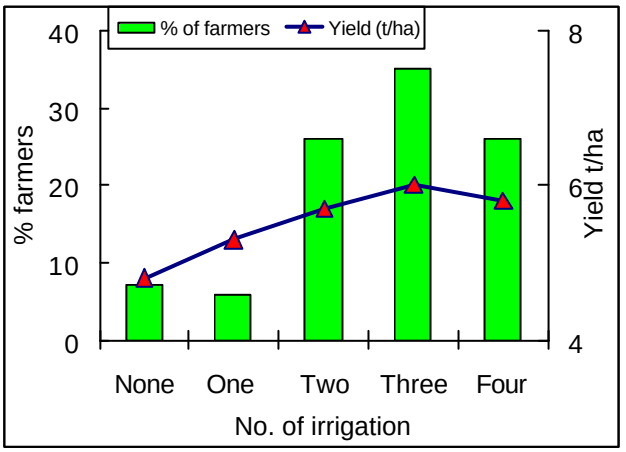

Figure 4.10: Percent of farmer that practiced irrigations and yield obtained by the number of irrigation used

d) Fertilizer in Maize:

Surveyed farmers used less fertilizer than the recommended rate. Figure 4.11 illustrates the amount of different fertilizers used by farmers for maize cultivation.

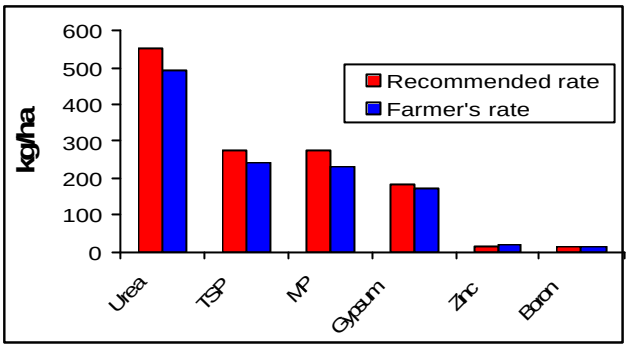

Figure 4.11: Farmers and recommended fertilizer rates for maize in Bangladesh

e) Maize Varieties and Maize Grain Yield:

CIMMYT recommended several hybrid maize varieties to be cultivated by the trained families. Five single cross hybrids (NK-46, Pacific-984, Pacific-983, Pacific-988 and Mukta), one modified single cross (900M), one Quality Protein Maize hybrid (HQ2000), one three way cross (Pacific-60) and one double cross hybrid (Pacific-11) were cultivated. It was found that under farmers' current management practices, NK-46 yielded the highest (7.4 t/ha) followed by Pacific-984 (6.9 t/ha) and HQ2000 (6.8 t/ha). The lowest yield (5.2 t/ha) was obtained from Pacific-988, as shown in Figure 4.12.

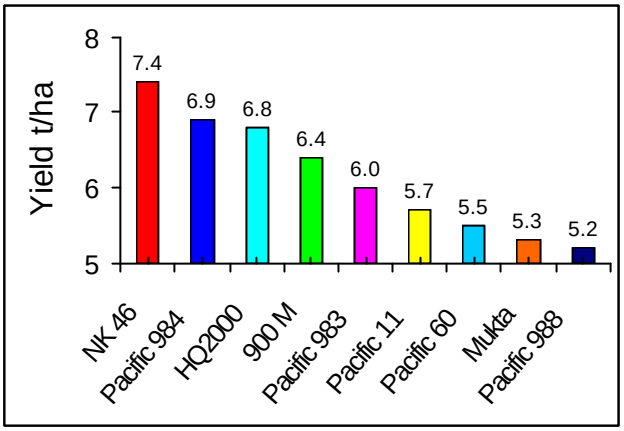

Figure 4.12: Grain yield of recommended maize varieties in 2003-04

f) Weeding in Maize:

Keeping maize fields free from weed competition for 30-35 days from crop emergence is a pre-condition for successful maize cultivation. This requirement was discussed during the whole family training session. A total of 83% of families weeded their maize fields within the recommended period. 15% of families weeded their maize fields, but did not follow our training recommendation (Figure 4.13). Only 2% of families did not weed.

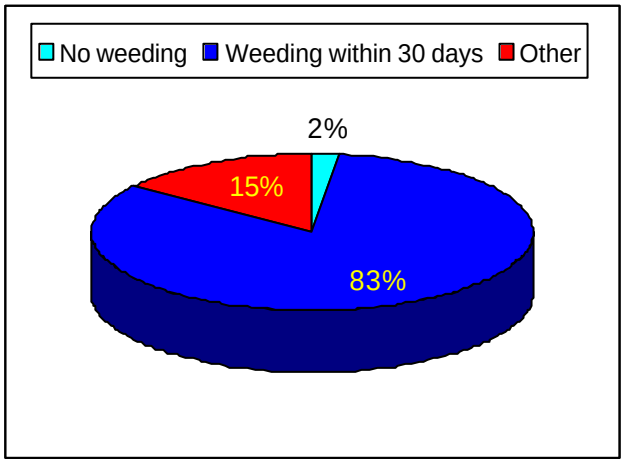

Figure 4.13: Weeding practices by the farmers

g) Maize Based Cropping Patterns:

Several cropping patterns were found to be practiced by the whole-family-trained families in their farming systems. Maize - Fallow - T. Aman Rice was the dominant cropping pattern practiced by 31% of the surveyed families. This was followed by a Maize - Aus Rice - T. Aman Rice cropping pattern as reported by 25% of the surveyed families. Other patterns were practiced by the trained farmers as depicted in Figure 4.14. It was clear about the position of maize in the cropping pattern. Maize growers cultivate maize in the winter time, a sub-tropical environment which accounts for 95% of the total cultivated maize area. Rainfed summer maize is currently confined to parts of the Chittagong Hill Tracts.

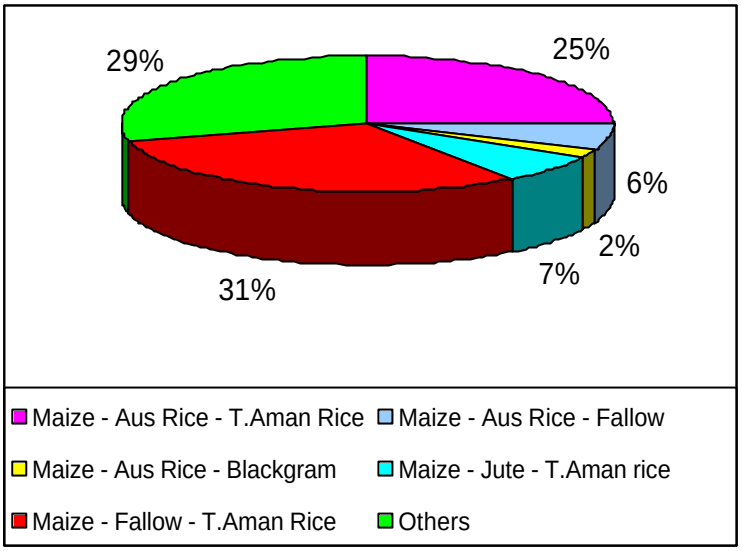

Figure 4.14: Cropping patterns used by maize farmers in Bangladesh

h) Maize Profitability:

Questions on the profitability of maize cultivation compared with boro rice and wheat have been raised by different stakeholders, including maize growers. In the survey of 2,271 trained families, 93% of the respondents reported maize cultivation to be more profitable than wheat and boro rice. Reasons include that maize grain yields are 2-3 times higher than wheat and double those from boro rice, less water is required than boro rice and the good market price of maize which is in heavy demand for poultry and fish feed. This perception of maize profitability was confirmed by Wheat Research Center (WRC) scientists. In a study of the comparative economic performance of wheat, maize and boro rice, WRC found a higher benefit cost ratio (BCR) of maize (1.9) than wheat (1.7) and boro rice (1.4).

V. Pre-training Assessment of Maize Cultivation Knowledge in 2004-05

Three thousand eight hundred and forty four maize farm families were surveyed through a structured questionnaire for assessing pre-training maize cultivation knowledge in 2004-05. Of these, data from 1,481 families were analyzed on the selected parameters for understanding pre-training knowledge. The information generated is highlighted below. A post-training survey of maize cultivation knowledge was conducted in 2004-05. Results from that survey are being analyzed and will be in the next report.

a) Variety Use:

Forty-nine percent of the respondents reported growing Pacific-11, a well adapted double cross hybrid maize. The rest reported cultivating Pacific-984 (10%), 900 M (11%), Mukta (12%) and other varieties as illustrated in Figure 4.15.

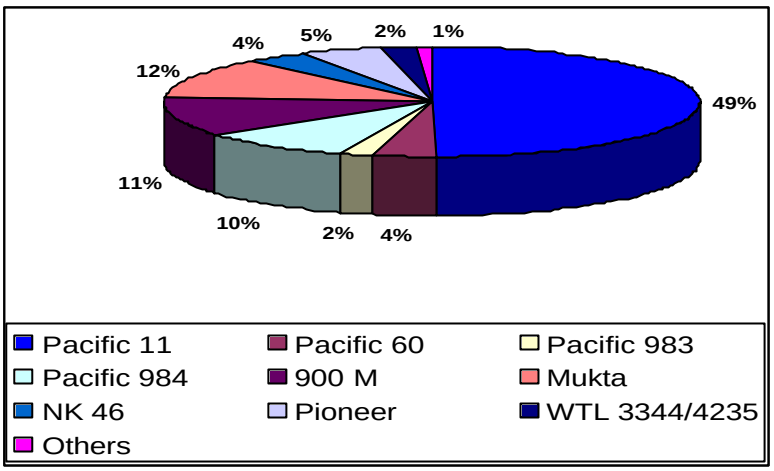

Figure 4.15: Percent of maize variety used in 2004-05

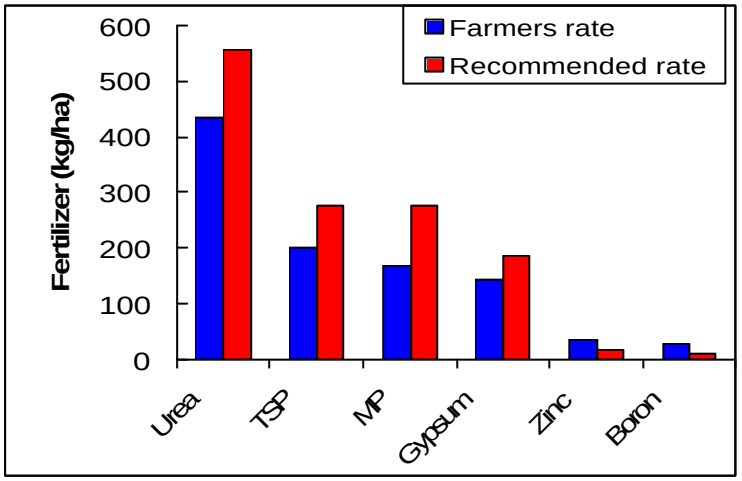

Figure 4.16: Farmers and recommended fertilizer rates in 2004-05

b) Fertilizer in maize:

Surveyed farmers used less than the recommended amounts of Urea, TSP, MP, Gypsum, Zinc and Boron in maize cultivation. Figure 4.16 illustrates the fertilizer rates used and the recommended fertilizer rates for maize cultivation.

c) Maize Based Cropping Patterns:

Several maize based cropping patterns are being practiced by the surveyed farmers and illustrated in Figure 4.17. Highest percent of farmers (34%) practiced Maize - Fallow - T.Aman Rice followed by Maize - Aus Rice – T.Aman Rice (22%). Several minor patterns were grouped together and considered as "other minor patterns" and were practiced by 41% of the farmers.

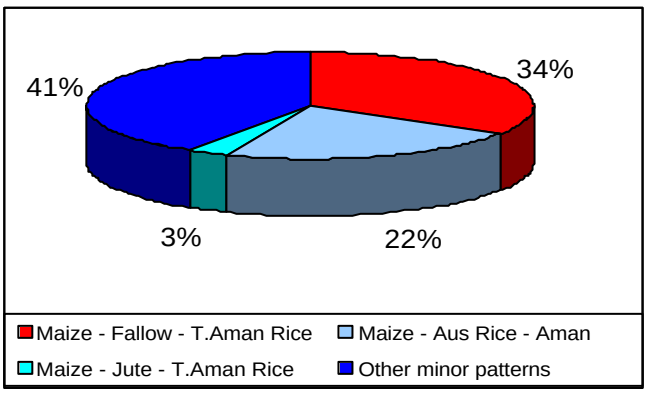

Figure 4.17: Percent of farmer used maize-based cropping pattern in 2004-05

d) Maize Cultivation Problems:

Since maize is a new cereal crop, its cultivation and other production, processing and marketing practices are not familiar to most maize farmers. Survey data reveals that maize cultivation and its promotion are constrained by several factors as illustrated in Figure 4.18. 26% of farmers reported that higher seed costs limit maize cultivation expansion. 21% of the respondents reported that high fertilizer and labor requirements are the problems of maize cultivation. Bird or rat damage and difficulties with the shelling of corn were also reported by 18% and 17% of the respondents, respectively.

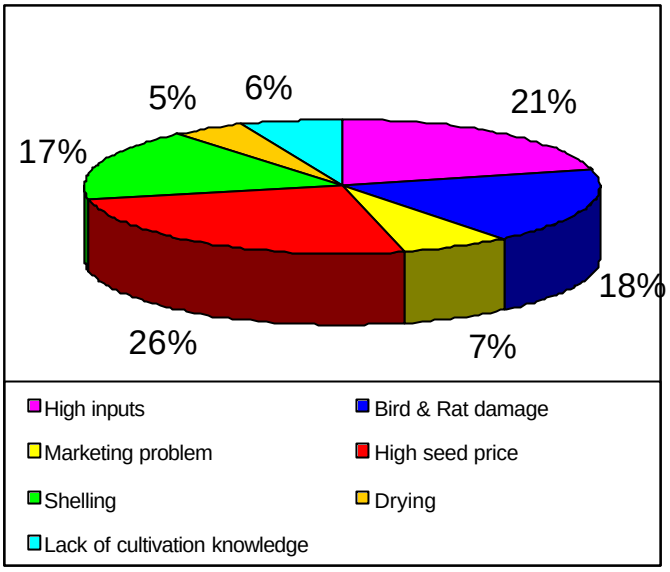

Figure 4.18: Problems of maize cultivation in 2004-05

VI. Research and Demonstration Results 2004 - 05

For strengthening the maize program in Bangladesh, needs-oriented applied research and demonstration programs on different production factors were undertaken in collaboration with the Bangladesh Agricultural Research Institute, Bangladesh Agricultural Development Corporation (BADC), a few NGOs and seed companies. The results are highlighted below.

a) Varietal Demonstrations:

BARI-developed hybrid maize varieties were demonstrated in five locations under on-station and on-farm conditions. The trial was set up to evaluate the varietal performance of the BARI hybrids. Single cross hybrids were compared to the most adopted double cross popular hybrid, Pacific-11. Figure 4.19 illustrates the mean productivity performance of different BARI developed hybrid maize varieties, BHM-2 (CML287XCML298), BHM-3 (CML285XCML287) and BHM-5 (CML161XCML165). BHM-5 is released as a quality protein maize (QPM) rich in two essential amino acids i.e. lysine and tryptophan. Results show that BHM-2 and BHM-5 hybrid maize varieties out yielded Pacific-11 hybrid both in on-station and farm trials. This suggests the greater potential for cultivation of locally developed hybrids in the country than the imported hybrids.

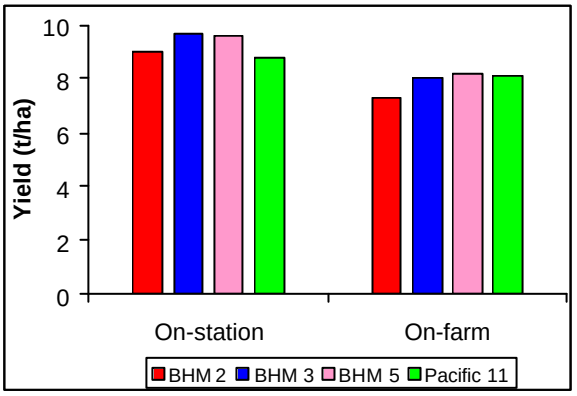

Figure 4.19: Yield of three BARI developed Hybrid maize varieties compared with Pacific-11

b) Evaluation of BARI and BRAC Hybrids through the Private Sector:

Field evaluation of BARI developed and BRAC promising hybrid maize varieties was done at Patgram, Lalmonirhat district in the farmers field under the direct supervision and management of the CIMMYT partner, Doyel Agro Industrial Complex Ltd. (Doyel). Doyel has been promoting maize in the North Western region of the country (Lalmonirhat). All BARI hybrids out-yielded BRAC hybrid maize varieties by 1.5-2.0 t/ha as shown in Figure 4.20. Doyel is convinced with the seed colour and seed type of these two BARI maize hybrids, BHM-3 and BHM-5 and showed great interest in its promotion in that region in coming years.

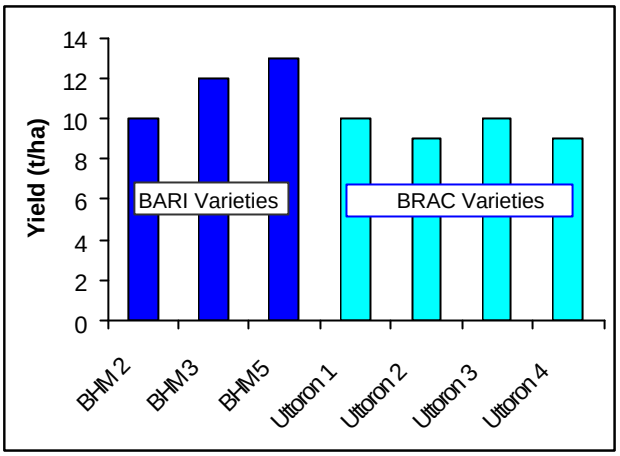

Figure 4.20: Yield performance of BARI and BRAC developed hybrid maize

c) Performance Evaluation of Hybrid Maize from Different Sources:

Various seed marketing companies have been importing maize hybrids and marketing those throughout the country. For understanding the yield performances and adaptability of the imported hybrids, seed companies provided seeds to CIMMYT for evaluation under Bangladesh conditions. CIMMYT Bangladesh through BARI collaboration evaluated the hybrids at BARI Gazipur experimental farm under recommended management practices. The trial was planted on December 12, 2004. Figure 4.21 shows yield levels of the different hybrids. Pacific-747 yielded the highest followed by 900M, LVN-4, LVN-10 and BHM-3. The lowest yield (7.0 t/ha) was recorded from NT-6621, a variety from Syngenta followed by Uttaron-3 variety from BRAC. The results of the trial will help our maize breeders to understand the yield level of the imported seed compared to the yield level of their developed hybrids.

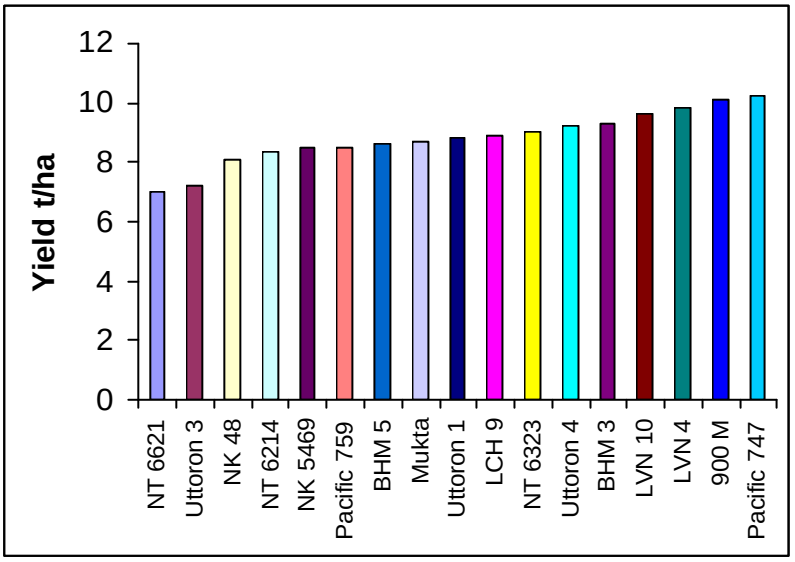

Figure 4.21: Yield Performance of different hybrid maize from different sources

d) Planting Time Effect on the Yield of Hybrid Maize:

Intensive field visits and survey data across the country revealed that maize growers plant different types of maize hybrids over a wide range of planting dates. Moreover, farmers are not familiar with the performance of the different hybrid types, single, double and three-way cross under different planting environments. It was found from the survey data that planting maize beyond the optimum date (Nov. 1 – Dec. 15) results in significant yield reduction.

To better understand the extent of yield reduction of different hybrid types (including single cross, double cross and three-way cross hybrids) under different planting environments, a trial consisting of 3 single cross hybrids (Pacific-983, Pacific-984 and BHM-3), one three-way cross hybrid (Pacific-60) and one double cross hybrid (Pacific-11) was set up in Rangpur location, North Western region of the country under two planting dates, November 20 and December 20. These two planting dates differ mostly in temperature regime. Results indicated that the November 20 planting produced significantly higher yield from all hybrid types than the December 20 planting date (Figure 4.22). Less yield reduction was observed in Pacific-11 (double cross hybrid) and BHM-3 (single cross hybrid) compared to the other hybrid types indicating that these two varieties are less sensitive to environment and could be broadly adapted maize hybrids for cultivation in the existing rice based farming systems.

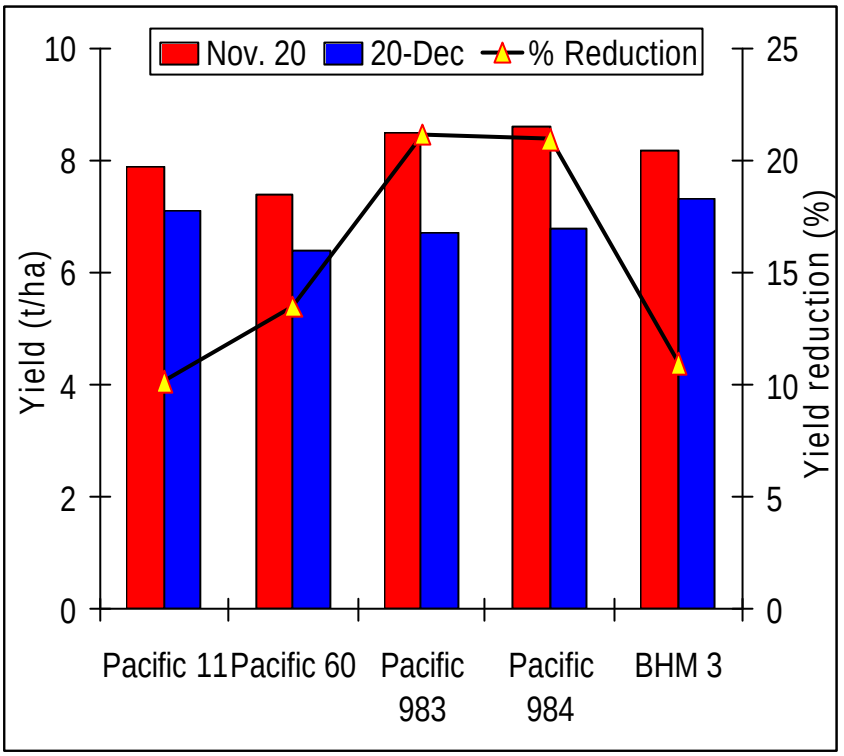

Figure 4.22: Yield of different hybrids under two planting dates in Rangpur

Another similar trial was conducted in Rajshahi, a cold prone environment to see the yield level and extent of yield reduction of the different hybrid types. The single crosses, (BHM-2, Uttaran-1), double cross (Pacific-11), three-way cross (Pacific-60) and a composite (BARI maize 7) were planted on November 20, December 10 and December 30 and managed under recommended cultural practices. It was found that planting time significantly affected the yield of all hybrid types and the composite variety. All the hybrids and the composite yielded the highest with the November 20 planting but the yield level varied among the hybrids. Uttaran-1 yielded the highest (11.6 t/ha) and BARI maize 7 (a composite maize) yielded the lowest (8.3 t/ha) as shown in Figure 4.23. Yield reduction of different hybrids beyond November 20 planting (Figure 4.24) showed that the single cross hybrid Uttaran-1 reduced yield the most (by 17.23%) from the December 10 planting compared to November 20 planting. However, BHM-2, Uttaran-1, BARI maize-7

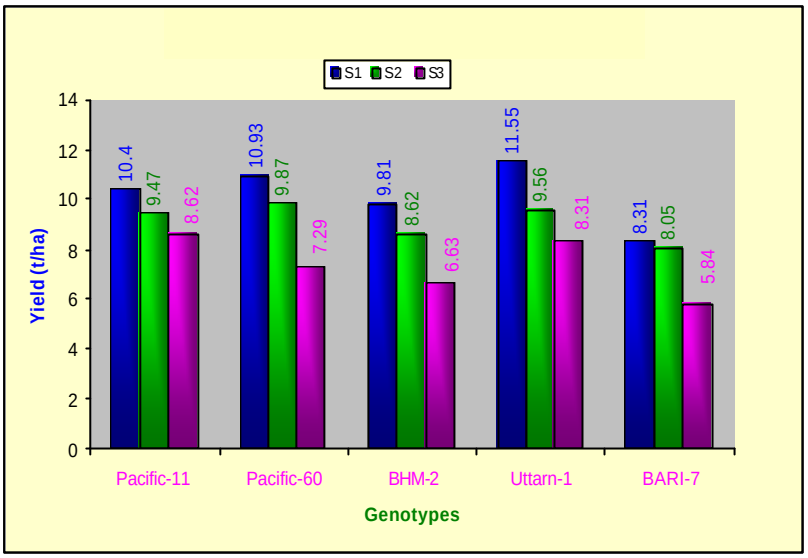

Figure 4.23: Yield performance of different hybrid types at different planting dates in Rajshahi

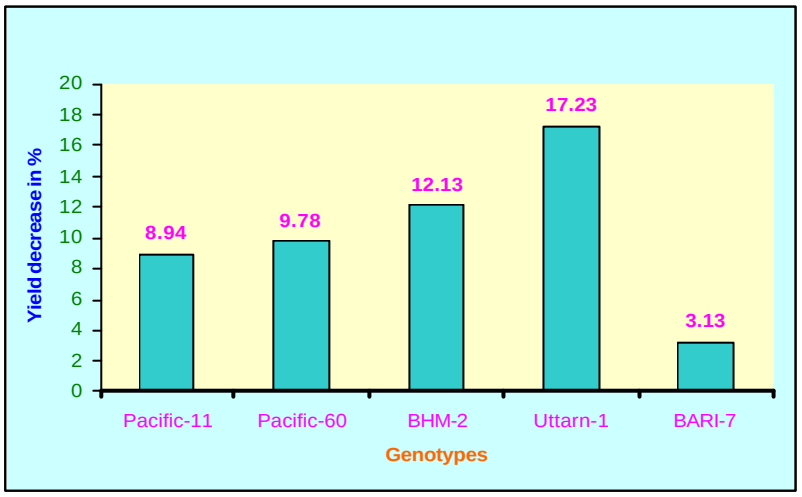

Figure 4.24: Yield reduction in S2 (Dec, 10) compare to S1 (Nov. 20)

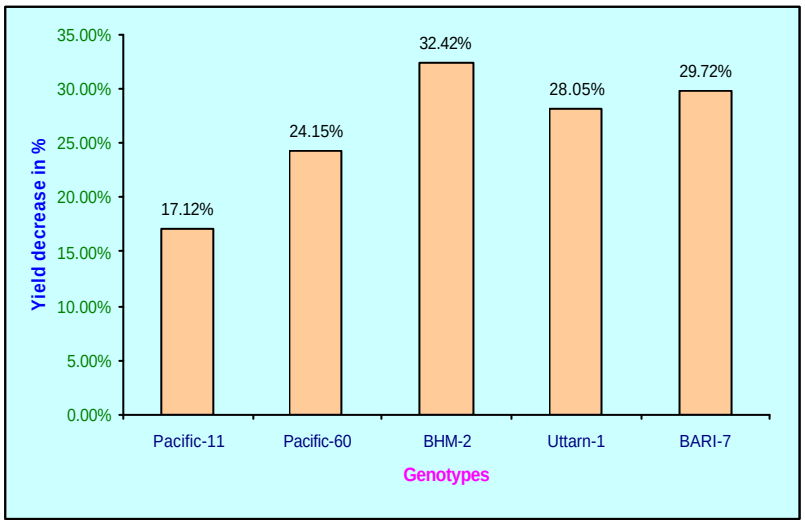

Figure 4.25: Yield decrease in S3 (Dec. 30) compared to S1 (Nov. 20)

and Pacific-60, resulted in the highest yield reduction respectively, about 32.4, 28.1, 29.7 and 24.2 percent when planted in December 30 compared to November 20 and least yield reduction (17.12%) was found with Pacific-11 in our December 30 planting (Figure 4.25). This result suggests that BHM 2 could be planted up to December 10 with minimum yield reduction while Pacific 11 could be the better variety for late planting.

e) Synchronization of N Application to Maize Growth Stages:

Because of the difficulties and other health hazard problems in applying N at tasselling stage (the present recommendation) families that had whole family training suggested modifying the timing of N application in relation to key maize growth stages for higher yield. Keeping this in mind, the present recommended N application time (1/3 N at basal + 1/3 N at 8 leaf stage + 1/3 N at tasselling stage) was modified as ½ N at basal + ½ N at 8 leaf stage). The present recommendation of 3 N splits, modified N application of 2 N splits and farmers practices were evaluated in the farmers fields in Kushtia, Kishorgonj, Jessore and Rangpur and replicated in four farmers fields at each location. Results of the study as shown in Figure 4.26 indicated that the modified N application produced higher or similar maize grain yield than the existing recommended and farmers practices. N rates remained the same for all treatments. For making valid conclusions and recommendations for N application timing to farmers, this trial will be continued for one more year with more farmers and locations.

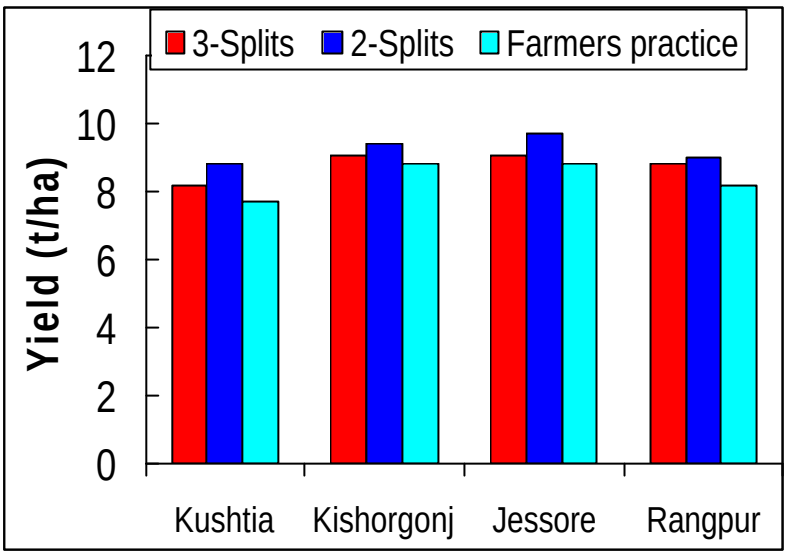

Figure 4.26: Yield of maize as affected by nitrogen application time in different locations

f) Development of Potential Maize Based Intercropping Systems:

For intensifying and diversifying the maize production system as well as to maximize the farmers profit, several short growing (45-50 days), high market

Figure 4.27: Maize + vegetable intercropping practices in farmers field

demand and consumer preferred vegetable crops (potato, lalshak, spinach, radish, coriander and French bean) were intercropped in between the rows of a maize crop simultaneously and managed under recommended maize management practices. Figure 4.27 depicts some of the maize + vegetable intercropping systems planted in the farmers fields.

The productivity of maize + vegetable intercropping was compared with sole maize cropping. Figure 4.28 depicts the productivity of maize, vegetables, maize equivalent yield (MEY) and benefit cost ratio (BCR) of the different maize + vegetable intercropping systems. It was seen from the figure that maize yield was less affected when coriander and potato was intercropped with

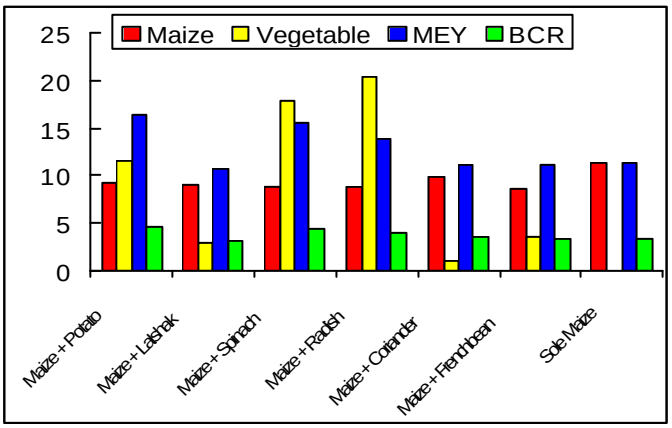

Figure 4.28: Agronomic and economic productivity of maize + vegetable intercropping

maize compared to other vegetable crops. Considering the MEY and BCR, Maize + Potato, Maize + Spinach and Maize + Radish were found promising and need further investigation with more locations and farmers for making valid conclusions and recommendations for different stakeholders.

g) Development of Maize + Potato Intercropping Systems:

To maximize the productivity of maize and potato as well as economic return from the maize + potato intercropping systems, an experiment consisting of seven maize + potato intercropping systems was conducted. The treatments were, T1=One row of potato intercropped in between the two maize rows planted on the same day; T2=Two rows of potato intercropped in between the 2 maize rows planted on the same day; T3= One row of potato planted in between 2 maize rows ten days before maize planting, T4= Two rows of potato in between 2 maize rows planted 10 days before maize planting; T5 = One row of potato in between 2 maize rows planted 20 days before the maize planting; T6= Two rows of potato in between 2 maize rows planted 20 days before maize planting; T7 = Sole maize. The trial was conducted in three locations, Comilla, Noakhali and Pabna replicated on three farmers fields at each location. Figure 4.29 shows one of the seven treatments (T2) in one farmers field at Pabna.

Figure 4.29: A view of maize + 2 row of potato planted on the same day

Figure 4.30 shows the productivity and net return of the seven potato + maize intercropping systems. Maize yield was little affected by potato in all potato planting dates and practices compared to sole maize. All the potato + maize intercropping systems earned higher net returns than the sole maize crop but returns varied among the intercropping systems. Treatments T4 and T6 earned higher net returns compared with

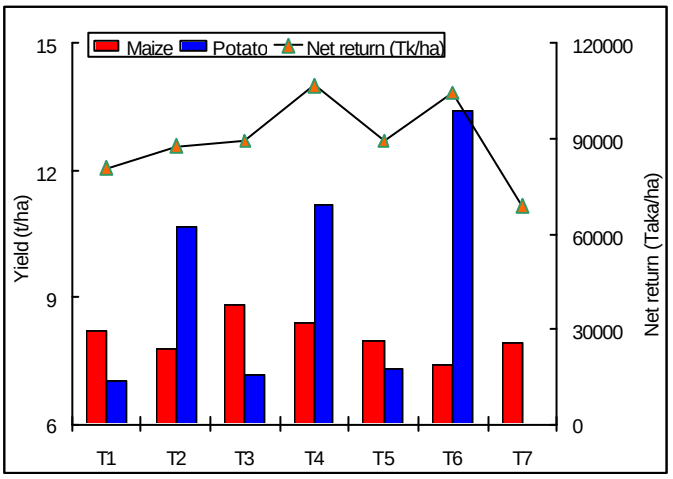

Figure 4.30: Agro-economic productivity of maize + potato intercropping systems

the other systems. Considering the overall productivity (including maize yield, potato yield and net return of the system), maize + potato intercropping systems could be promising for both the potato and maize farmers by earning higher income through better land utilization. This shows the potential for further maize and potato area expansion in the country. Further research is needed for fine tuning of this result.

h) Maize Establishment Methods:

For maximizing the maize yield through efficient utilization of natural resources, a trial with three maize establishment methods was conducted in Rajshahi, north western Bangladesh. The three maize establishment methods were T1=prepared land by power tiller operated seeder (PTOS) in a single pass and sow maize seed manually, T2=prepared land by power tiller, soil bed made by bed planter and seed sown manually on the bed (Bed Planting); and T3=conventional method (Prepared land by power tiller). Results indicated that bed planting method (T2) produced about 34% higher maize yield over the conventional method (T3) and about 11% higher over the PTOS method (Figure 4.31). Better crop growth and higher maize yield on the soil bed could be the result of better water and fertilizer use by the maize crop. Figure 4.32 shows a good maize stand on the soil bed (left) compared to poor maize stand established by PTOS in the right photo.

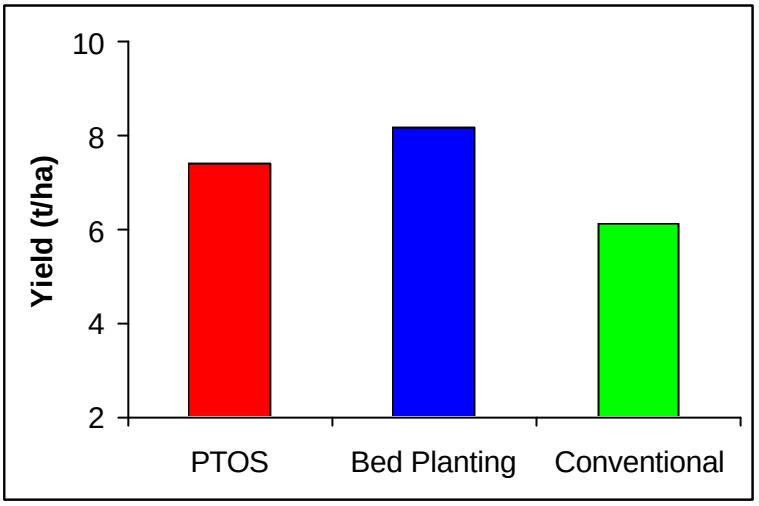

Figure 4.31: Maize yield under different establishment methods

Figure 4.32: A good maize stand on a soil bed (left) compared to poor maize stand (right) on the flat

i) Hybrid Seed Production Method:

Several female : male row ratio combinations are being used for producing hybrid maize seed of different types. In Bangladesh, several seed companies currently engaged in maize seed marketing have started producing hybrid maize seed. These companies are looking for the best female : male row ratio combination for maximizing seed yield of a single cross hybrid. To identify the best female : male row ratio combination, a trial consisting of 4:2, 4:1 (interplant), 4:1 and 6:2 (female : male) row ratio combinations for F_1 seed production of BHM-3 was undertaken. The

Figure 4.33: A view of the 6:2 female: male row ratio BHM-3 seed production field at Modhupur

experiment was set up in different locations and maintained proper time and distance isolation to control contamination problems. Figure 4.33 depicts a 6:2 row ratio seed production field of the single cross hybrid maize, BHM-3, at our Modhupur site.

Figure 4.34 shows seed yield of BMH-3 produced under different row ratio combinations. 6:2 female : male row ratio combination produced the highest seed yield (2.1 t/ha) followed by 4:1 (1.8 t/ha) row ratio. The seed production companies interested in producing seeds for single cross hybrids could share this information for producing higher seed yield of single cross hybrids. However, for making valid recommendations we need to conduct more trials in more locations and seasons.

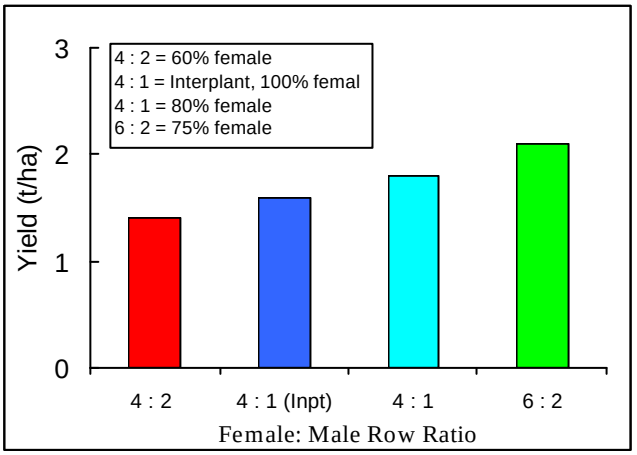

Figure 4.34: Seed yield of BHM-3 under different row ratio combinations

j) Seed Production of BARI Hybrid Maize Varieties:

For promoting BARI developed hybrid maize throughout the country, CIMMYT took an initiative to produce BARI hybrid maize seeds in our 2004-05 winter season through different stakeholders, BARI, East-West Seed Ltd., BADC, BRAC, Doyel, BCKS and Supreme Seed Company. Accordingly, CIMMYT provided financial and technical assistance, training and inbreds to these stakeholders. As a result, a total of 16.3 t of seeds have been produced. Table 4.1 shows the amount of seed produced by different organizations. About 25% of the produced seed will be used by 2000 CIMMYT-led whole family trained maize growers across the country. Some 64 demonstrations in 64 districts will be set up by the Department of Agricultural Extension (DAE) and nine demonstrations will be set up in nine different locations by Winrock Int'l, an NGO engaged in maize promotion in the country. BADC, East-West and Supreme Seed will produce 35, 50 & 15 t of seed of BHM-2, BHM-3 and BHM-5 during 2005-06.

Table 4.1: Seeds of Different Hybrids Produced by Different Agencies in 2004

Varieties	Organization (seed production in kg)						
	BARI	East-West	BADC	BRAC	Doyel	BCKS	Supreme Seed
BHM 2	945		2673				190
BHM 3	1387	7500	3200	36	58	160	
BHM 5	130						
Total:	**2462**	**7500**	**5873**	**36**	**58**	**160**	**190**

VII. Maize Germplasm Importation and Distribution

CIMMYT Bangladesh received 12 exotic inbreds and 49 hybrid materials from CIMMYT Mexico and distributed to BARI and BRAC partners for evaluation and

Figure 4.35: A View of the CIMMYT hybrid trial at Regional Agricultural Research Station, Jamalpur

selection of the best entries from each trial for the development of the new hybrids. Table 4.2 shows number of entries imported for each trial and number of potential entries selected through experimental trials for further advancement of hybrid development. Request for the inbreds of the selected entries will be made to CIMMYT HQ for the development of hybrids and its promotion in Bangladesh. Figure 4.35 shows one of the CIMMYT hybrid trial fields at the regional station experimental farm of BARI, Jamalpur.

Table 4.2: Maize Trials Received from CIMMYT Mexico and Entries Selected in 2004

Name of Trials	No. of entries evaluated	Name of potential entries selected (Hybrid code)	Remarks
EVT 13Q (Tropical late yellow QPM synthetic)	11	• SO3TLYQ-A01 • SO3TLYQ-AB03 • SO3TLYQ-AB05	Selected entries out yielded the local check BARI Maize 7, a synthetic variety
CHTTWQ (Tropical white QPM)	23	• CMSQ023005 • CMSQ023007 • CMSQ023009	Selected entries out yielded the local check BHM 3 (single cross) and Pacific 11 (double cross)
CHTSY (Sub tropical yellow)	14	• TLO3B-6117-19X20 • TLO3B-6117-5X8 • TLO3B-6117-7X8 • TLO3B-6117-41X42	Selected entries out yielded the local checks, BHM-3 and Pacific-11

VIII. Expansion of Whole Family Training Concept

Through interactions, discussions and meetings with CIMMYT scientists on the Whole Family Training (WFT) concept, Winrock International and Northwest Crop Diversification Program (NCDP) of DAE found the WFT concept very effective in empowering maize growers with modern maize production knowledge.

Winrock International in its BREAD-II project and DAE in their NCDP project have adopted the WFT concept for maize promotion in their project areas and used the training materials developed by CIMMYT for their farmers and trainers. During 2004-05, a total of 86 Sub-Assistant Agricultural Officers (SAO) of DAE and 54 field organizers of nine different NGOs were trained by CIMMYT maize scientists on the WFT concept, methodology and modern maize production technologies. Figure 4.36 illustrates a training session attended by 86 trainees of the NCDP, DAE maize promotion project in Natore district.

Figure 4.36: A trainers training session for DAE NCDP maize promotion project

IX. Monitoring Whole Family Trained Farmers' Field, Demonstration and Experimental Plots:

During 2004-05, CIMMYT and NARS scientists frequently visited trained farmers' fields, demonstration and experimental plots of different partners. During field visits, scientists observed cob fingering in some hybrid maize seed production fields. Figure 4.37 illustrates the cob fingering and seedless cob problem in the female parent (CML285) of BHM-3 maize seed production plot at the Regional Agricultural Research Station (RARS) Ishurdi, Pabna experimental farm. Possible reasons for such problems were explained to the scientists of BARI engaged in seed production. CIMMYT HQ maize breeders were also notified about the cob fingering problem and we sought reasons for such cob fingering problems and suggestions to resolve the problem.

Figure 4.37: Cob Fingering with no seeds formation in CML 285 line, a female parent

During field visits, CIMMYT scientists also found maize growers intercropping maize + mustard(a), maize + cabbage(b), maize + potato(c) and maize planted in the furrows in between the two rows of potatoes planted on the soil bed (d) as illustrated in Figure 4.38. Farmers' practices with such maize based intercropping systems demanded research on agronomic feasibility and economic profitability.

Figure 4.38: Farmers innovative maize-based intercropping systems

During a field visit at Bandarbon district, a CIMMYT whole family training location in the South Eastern hilly region, it was found that the head of the trained tribal family successfully utilized his maize training knowledge in cultivating maize in the valleys. Figure 4.39 illustrates a good maize stand as an impact of WFT in maize cultivation. Furthermore, hill farmers were found growing maize in the hill slope as a mixed crop with other crops (Figure 4.40 left) as well as on the top of the hill as a sole maize crop (Figure 4.40 right). This indicates the possibility to expand maize production with good germplasm in this region of the country.

Figure 4.39: A good maize field of whole family trained farmer at Bandarban

Figure 4.40: Maize as mixed crop in the hill slope and as sole crop on the top of the hill

While visiting our Whole Family Training site at Patgram, Lalmonirhat, North Western region of the country, trained families were found to store their dehusked cobs for a short time in their indigenous storage system. Additionally, the CIMMYT supported private entrepreneur, Doyel, established a modern maize drying and storage system for short and medium term storage as illustrated in Figure 4.41.

Figure 4.41: Maize drying and storage systems in Patgram

Furthermore, the direct benefit of whole family training in harvesting good maize was observed in the farmers field at Manikgonj location. Figure 4.42 illustrates a good maize field of trained families compared to the adjacent poor maize field of the non-trained family.

Figure 4.42: A view of maize crop of whole family trained and non trained farmer

X. Scientist Exchange and Visit Program

Five maize scientists from Pakistan visited our CIMMYT Bangladesh Maize Program from March 12 - 18, 2005. During this time, they visited CIMMYT and Bangladesh Agricultural Research Institute (BARI) maize program at Gazipur, a CIMMYT-led hybrid maize seed production trial with Bangladesh Agricultural Development Corporation (BADC) at Modhupur location and CIMMYT-BRAC collaborative maize R & D program at Bogra location. They also visited maize whole family training at Jamalpur, Rangpur and Lalmonirhat sites and shared ideas and experiences on our WFT approach and methodology from the farmers and scientists. Their field visit and interactions with the families are illustrated in Figure 4.43. Furthermore, during the year, Dr. S.R. Bhuiyan, Senior Program Management Specialist of USAID, Dhaka also visited hybrid maize seed production farm, Modhupur and Whole Family Maize field at Jamalpur. Figure 4.44 illustrates his visit at Jamalpur WFT maize field.

Figure 4.43: Pakistani maize scientists visiting WFT maize field in Rangpur

Figure 4.44: Dr. Bhuiyan of USAID, Dhaka is in a WFT maize field at Jamalpur

XI. Field Day:

A field day is one of the best ways to transfer useful agricultural information and technology to larger numbers of beneficiaries or users. Keeping this in mind, seven field days on whole family trained maize fields at Dhamrai, Mainkgonj, Kapasia, Ishurdi, Pabna, Rajshahi and Kushtia were organized during 2004-05. We

Figure 4.45: A view of the Farmers Field Day on WFT maize field in Manikganj location

demonstrated maize production practices and maize productivity to the non trained maize farmers that attended, and to extension personnel and private sector people engaged in maize promotion. Figure 4.45 depicts a field day where farmers are interacting with each other and sharing ideas for greater economic benefit from maize cultivation.

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

The successful use of transgenic papaya in the USA for Papaya Ring Spot Virus (PRSV) resistance opens a new avenue for its adoption in Bangladesh. The papaya crop is a commercially viable one in the USA (85 million pounds are produced and consumed by North Americans each year). However, it grows well in Bangladesh as a vegetable and fruit in homesteads and commercial farms year round. The fruit is rich in nutritive value, especially in vitamin A and vitamin C. The devastating PRSV disease deteriorates the current productivity as well as quality of fruits.

Papaya can bear about 21 kg/plant/year but the yield is affected by high incidence of PRSV. Based on improvement of papaya through PRSV tolerant varieties the yield increases by 600% (based on data from field trials from Khon Kaen Thailand). Because of its importance in the country, immediate attention is needed to address this problem aiming at development of PRSV tolerant varieties in Bangladesh. The program began in 2002 and will continue until 2007.

I. Activities Performed in 2004-05

During the period April – July, 2004, a total of 96 PRSV strains based on symptoms were collected from 7 regions of the country. The regions are central region of 5 districts; southern region comprising of 5 districts; northern region comprising of 4 districts; southeastern region comprising of 5 districts; and southwestern region comprising of 7 districts. The strains were collected based on 6 symptoms; mosaic, severe mosaic, chlorosis, fern leaf, leaf distortion and vein clearing. A group of another 12 fresh samples was also collected.

All the PRSV strains previously collected from different parts of the country were preserved in silica gel in vials kept in the refrigerator at Bangabandhu Sheikh Mujebur Rahman Ag University (BSMRAU) as well as sent to the USDA Lab in Hilo Hawaii (i.e. DNA only due to Hawaii quarantine restrictions). A Bangladeshi Scientist, Dr. Akhanda of BSMRAU, participated in activities with the samples at Hilo for 5 months. Isolation and characterization of coat protein gene of PRSV in Bangladesh were done during the period.

PRSV strains are being maintained (based on symptoms) 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 in progress.

II. Variety

In Bangladesh, there is only one released improved variety of papaya, called Shahi (BARI Papaya –1). It was recommended and released in 1992 from Horticultural

Research Center of Bangladesh Agricultural Research Institute. The breeders' seeds are being produced at HRC for its large-scale adoption in the country. This variety will be transformed as a transgenic in the near future. In addition to this work, other transgenic materials will be made available for testing in Bangladesh. Also these materials may be properly utilized through breeding to develop new varieties.

III. Shahi Variety Characteristics

Both female and male flowers occur on the variety. The plant is light green in color, but the leaves are deep green. Flowers bloom after 3 – 4 months of planting. Fruits occur even from the lower parts of the stem (Figure 5.1). The other characteristics are:

Plant height	: 160-200 cm
Leaf number	: 17 – 20
Fruit size	: Round
Fruit weight	: 850 – 1000 gm
Flesh thickness	: 2 cm
Flesh color	: Deep orange
Seed number / fruit	: 500 – 530
Fruit sweetness	: 12% TSS
Fruit number / tree	: 40 – 60
Yield	: 40 – 50 t / ha

Figure 5.1: Recommended Shahi variety

IV. Transgenic Variety Development

In Bangladesh the whole program is a coordinated through a team approach through the leadership of Dr. Dennis Gonsalves. Technically, the team has 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 the field.

C. Testing transgenic in net house – The transgenic materials will be evaluated and tested in the net house under controlled conditions. Here, two 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.

V. Facility for Testing Transgenics at BARI

To develop facilities for handling transgenic papaya, discussions were held with BARI deciding among BARI, USDA and CIMMYT a plan for testing/ handling of transgenic papaya. Initially BARI will provide all support for technical manpower, infrastructure development for tissue culture, controlled net house and field trials at the Horticulture Research Center at BARI HQ. The net house and trial fields are set up at HRC's enclosed field campus and tissue culture materials will be handled in the newly built tissue culture laboratory adjacent to the HRC HQ buildings (see Figures 5.2 and 5.3).

Figure 5.2: Newly built tissue culture lab at BARI

Figure 5.3: Newly built net house at BARI

Figure 5.4 shows the exact location for the field trials for transgenic papaya, assuring isolation from any other papaya plants to ensure zero pollen flow and gene contamination until approved for release.

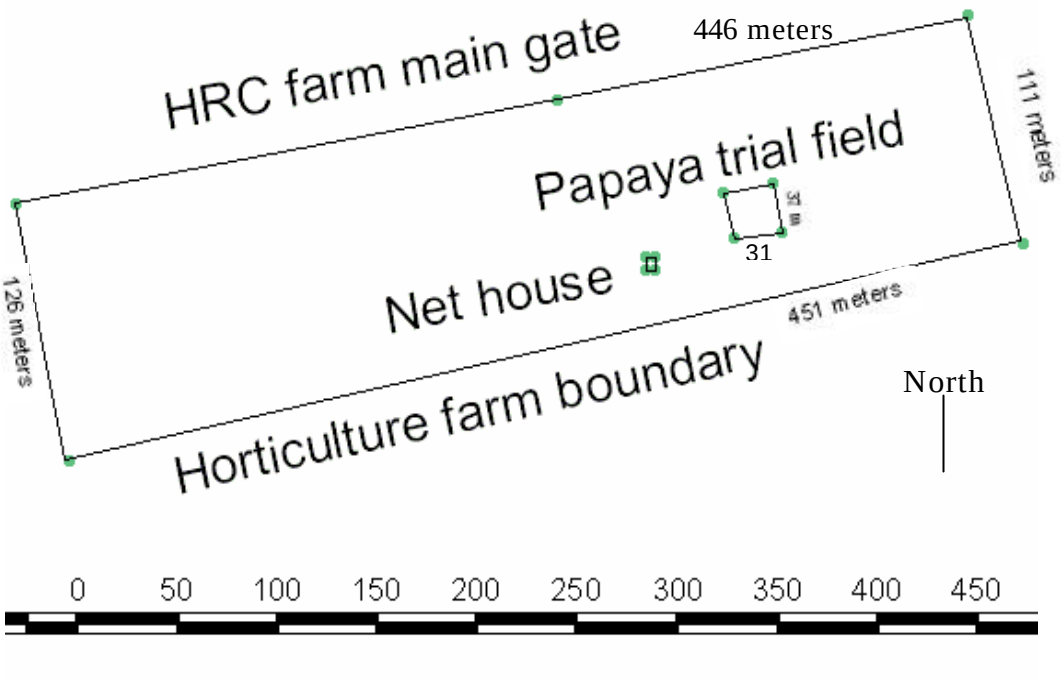

Figure 5.4: HRC farm showing the location of net house and trial field for transgenic papaya

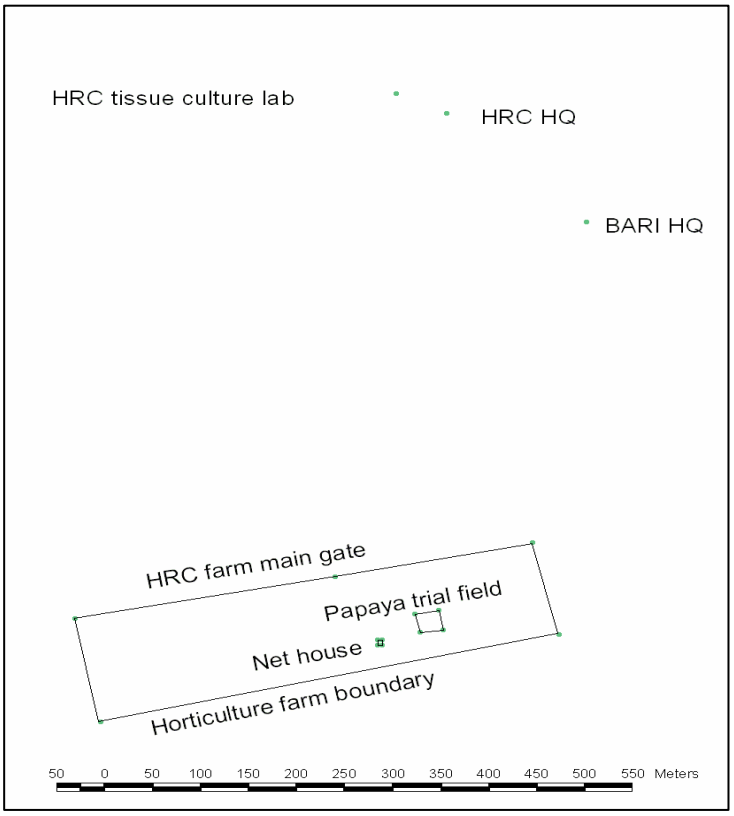

Figure 5.5: Location of BARI HQ, HRC HQ, tissue culture lab and trial field for transgenic papaya

VI. CIMMYT as Facilitator of Other Activities in Biotechnology

Donald MacKenzie of AGBIOS based in Canada and Mariechel Navarrow, Manager, Knowledge Management Service for the Acquisition of Agri-biotech Applications based in IRRI both opened their offices February, 2005 in Bangladesh within the CIMMYT office complex in Dhaka, having signed a contract and began renting office space. Agricultural Biotechnology Support Project II (ABSP II) opened their office in the same complex in 2004. As such, this helps anyone interested in biotech within or visiting Bangladesh with a 'one-stop shop' on biotechnology by visiting one office building. ISAAA will work with information management of biotech, AGBIOS with Government policy, bio safety guidelines and regulation, ABSP II and USDA will be working with the NARS partners in applying for and bringing in potential transgenic material which will be tested in Bangladesh for release if approved by the Bangladesh Government.

The donor, USAID, is equally pleased that all are not only linked and networked as we should be, but we agreed to work together under one roof to promote good agriculture science for development of Bangladesh.

Likewise in relation to the facility development for transgenic papaya in BARI, CIMMYT was closely associated in dialogue and discussion with the authority in developing and creating facilities for the biotechnology division itself. Currently the net house/contained house is in operation.

CIMMYT also provided support for improvement of the net house in the pathology department at Bangabandhu Sheik Mojibur Rahman Agricultural University, Gazipur.

VII. Ph.D Research Work in Collaboration with Cornell University

Ms. Jacqueline King, a Ph.D. student from Cornell University, U.S.A., is currently conducting research on papaya management and production in collaboration with CIMMYT Bangladesh. The overall objectives of her research are 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.

Figure 5.6: A papaya plant on the experimental plot

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 should be completed by spring 2006.

6. Impact of Arsenic Contamination on Agricultural Sustainability and Food Quality

I. The Arsenic Hazard in Bangladesh

Groundwater from shallow aquifers is extensively used for drinking and irrigation in many countries of the world, especially in Bangladesh. The installation of hundreds of thousands of shallow tube wells (STW) in Bangladesh over the last three decades may very justifiably be considered a "groundwater revolution" because it supplied "safe" drinking water for tens of millions of people and was a large contributor to the tripling of the annual production of rice, the staple food crop. This paved the way for the long cherished goal of achieving self-sufficiency in food. However, in the early nineties, i.e, two decades since the first STWs were commissioned, it became clear that a "counter revolution" had begun — the water which was once thought to be safe for drinking, the water that came as a blessing for millions of farmers, especially the rice farmers had, in many places, become contaminated with arsenic, a poison which could affect food and human health (Figure 6.1).

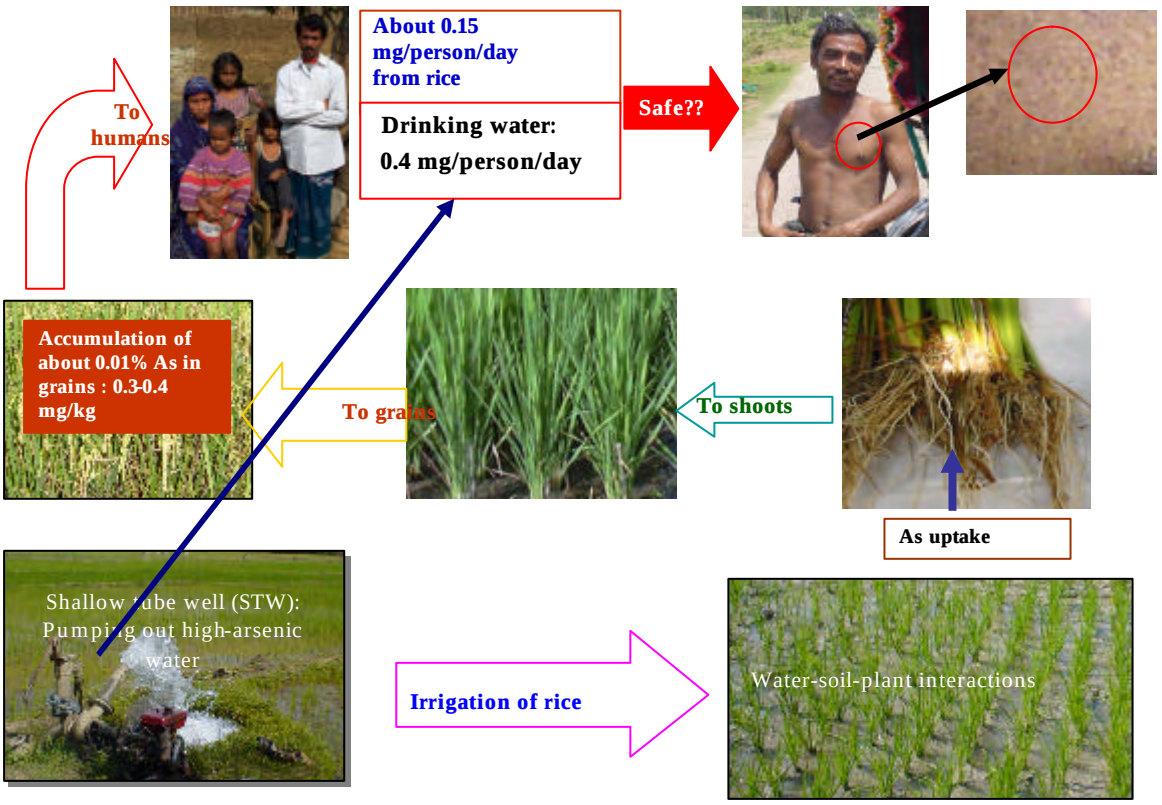

Figure 6.1: Arsenic contamination in Bangladesh agriculture

There is a growing national concern about arsenic contamination of ground water in Bangladesh. This is because many millions of people in Bangladesh face a two-way risk of exposure to arsenic, directly through the water they drink and indirectly through food crops grown on soils contaminated by arsenic through groundwater irrigation. Arsenic is not only a problem in Bangladesh but is also a global problem increasingly evident in many other countries in different parts of the world from Vietnam to the USA. While the consequences of arsenic pollution of water, soils and crops to the environment, and its effects on human and animal health appear increasingly grave in Bangladesh, the behavior of arsenic, especially in agricultural production systems and the food chain is not well understood by the international scientific community, and much less so in Bangladesh. There is an urgent need in Bangladesh for a deeper understanding of the nature and extent of arsenic pollution of the irrigation waters, soils and crops and a start is needed in developing water-soil-crop management practices to mitigate the arsenic problem in agriculture and food.

II. The Arsenic Research Program: Objectives and Partners

An R&D program was initiated in early 2002 with four national and three international partners with the following major objectives:

- National capacity building to enable Bangladeshi agricultural research institutions and scientists to conduct R&D work on As in agriculture.
- Evaluation of the impact of As contamination in water and soils on crop productivity and quality.
- Understanding the chemistry and mineralogy of As in soils as they relate to the uptake and accumulation of the element in crops.
- Development of water-soil-crop management practices to manage the As problem in crop production systems and reduce the As load on the food chain.

a) National Partners

- Bangladesh Agricultural Research Institute (BARI)
- Bangladesh Rice Research Institute (BRRI):
- Bangladesh Institute of Nuclear Agriculture (BINA)
- Bangladesh Agricultural University (BAU)

b) International Partners

- Cornell University (CU), USA
- Texas A&M University (TAMU), USA
- International Maize and Wheat Improvement Center (CIMMYT)

Scientists from national partner institutions in Bangladesh have conducted field surveys and experiments and carried out laboratory analyses for As, Fe, Mn, P in shallow tubewell (STW) irrigation waters, soils and rice plants. Limited analyses have been done for other cereals, pulses, and vegetables. The international partners,

CU and TAMU, helped install and optimize hydride generation (HG) units for the atomic absorption spectrophotometers (AAS) in the laboratories of national partner institutions. They also trained Bangladeshi scientists and laboratory technicians on the use of the HG-AAS set-up for the analysis of As in water, soil and plant samples. In addition, CU and TAMU did the advanced chemical and mineralogical analyses and cross-checked analytical results for quality control. CIMMYT Bangladesh 1) facilitated and coordinated program activities by the national partners 2) provided technical assistance, 3) liaised with the two other international partners, CU and TAMU, and 4) facilitated exchange of information and material between the national and international partners.

III. Arsenic in the Water-Soil-Plant System: Survey and Assessment

In year 1 of the project (2002-2003), five *thanas* (shown in the map below): Brahmanbaria, Senbag, Faridpur, Paba and Tala, representing diverse physiographic and hydrological situations in the eastern, central and western districts of Bangladesh (Figure 6.2) were selected for an As survey-assessment study. The results were reported in the annual reports for 2002-03 and 2003-04.

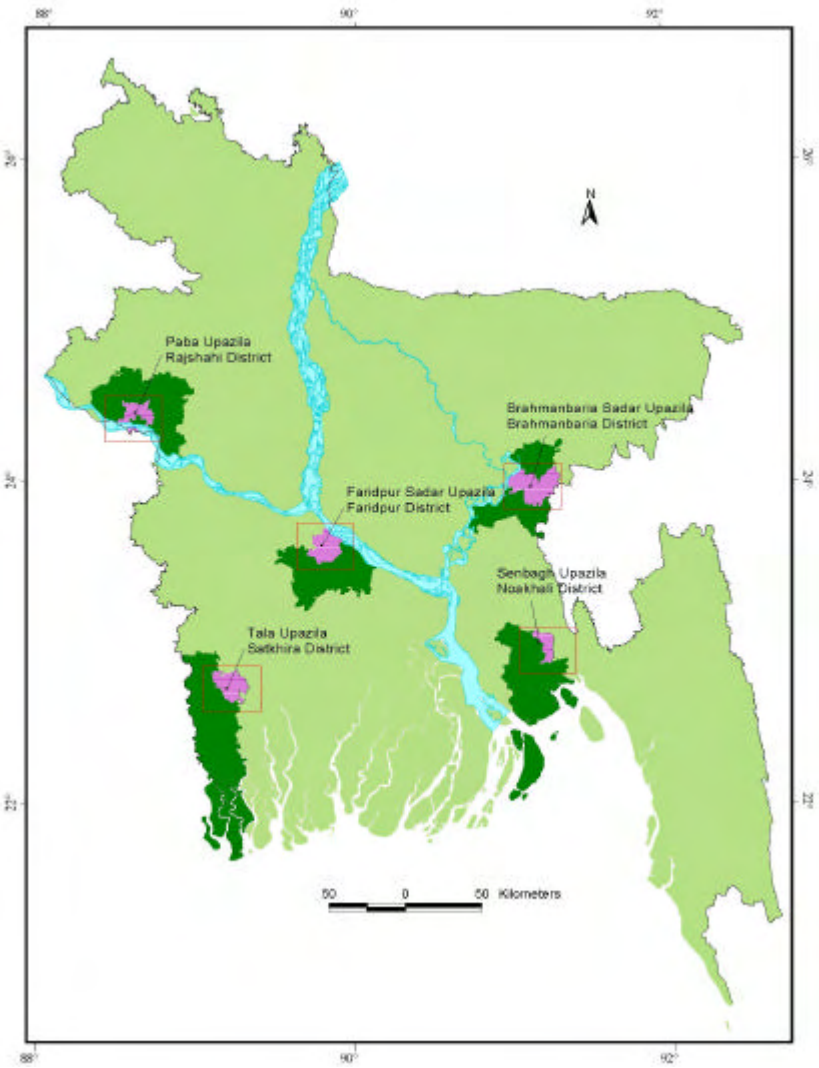

Figure 6.2: The five thanas where an As survey-assessment study was conducted in 2002-03

Evidence of elevated arsenic concentrations in irrigation water, soils and rice were obtained. Complex soil mineralogical compositions, which could variously affect adsorption-desorption and mobility were found. All the soils contained poorly crystalline and well-crystalline Fe-oxides but the amounts and ratios were highly variable. Additionally, the soil As contents correlated poorly with the soil Fe-oxides. Other natural factors like flooding and siltation, and anthropogenic factors like cropping systems and sequences, water management, tillage, etc. may individually and interactively influence As in the environment.

In the second year (2003-04), we began a nationwide survey to assess the arsenic situation in 184 unions in 92 *thanas* all over the country and the work was continued through 2004-2005.

The major activities in 2004-05 were:

- Continuation of the national survey on As in waters, soils and crops
- Study of the behavior of As in STW command areas in relation to chemistry and mineralogy
- Continuation of four graduate (PhD) fellows' work
- Establishment and development of the BARI-CIMMYT Arsenic Laboratory
- Organizing and participating in arsenic workshops in Bangladesh and abroad.

IV. National Survey on Arsenic

A national survey was initiated in the dry (Boro rice) season of 2004 with the objective of assessing the As contamination levels in irrigation waters, soils and crops in different regions of the country, and developing a GIS documented national database on soil As, which was lacking in Bangladesh.

<u>Selection of sampling locations</u>

1. The country was hypothetically divided into seven Hydrological Regions (HR) on the basis of our river network. To develop a database on soil, water (ground water) and plants, only those thanas having ground water irrigation tube wells and particularly STWs, were selected. Thanas in the south-eastern hill areas, the metropolitan thanas and thanas representing non-agricultural land in the coastal region of Bangladesh were excluded.

2. Each HR was divided into 15 km grids. Starting from the thana located in the central grid, thanas located in the alternate grids were selected as the "site" thanas. After locating the thanas in all HRs, thanas located at the border of the HRs were reselected (if necessary) such that no two thanas would have a common border.

3. Two unions were selected at random from each thana using a spatial sampling tool of AWhereACT, the GIS tool of Bangladesh Country Almanac (Figure 6.3).

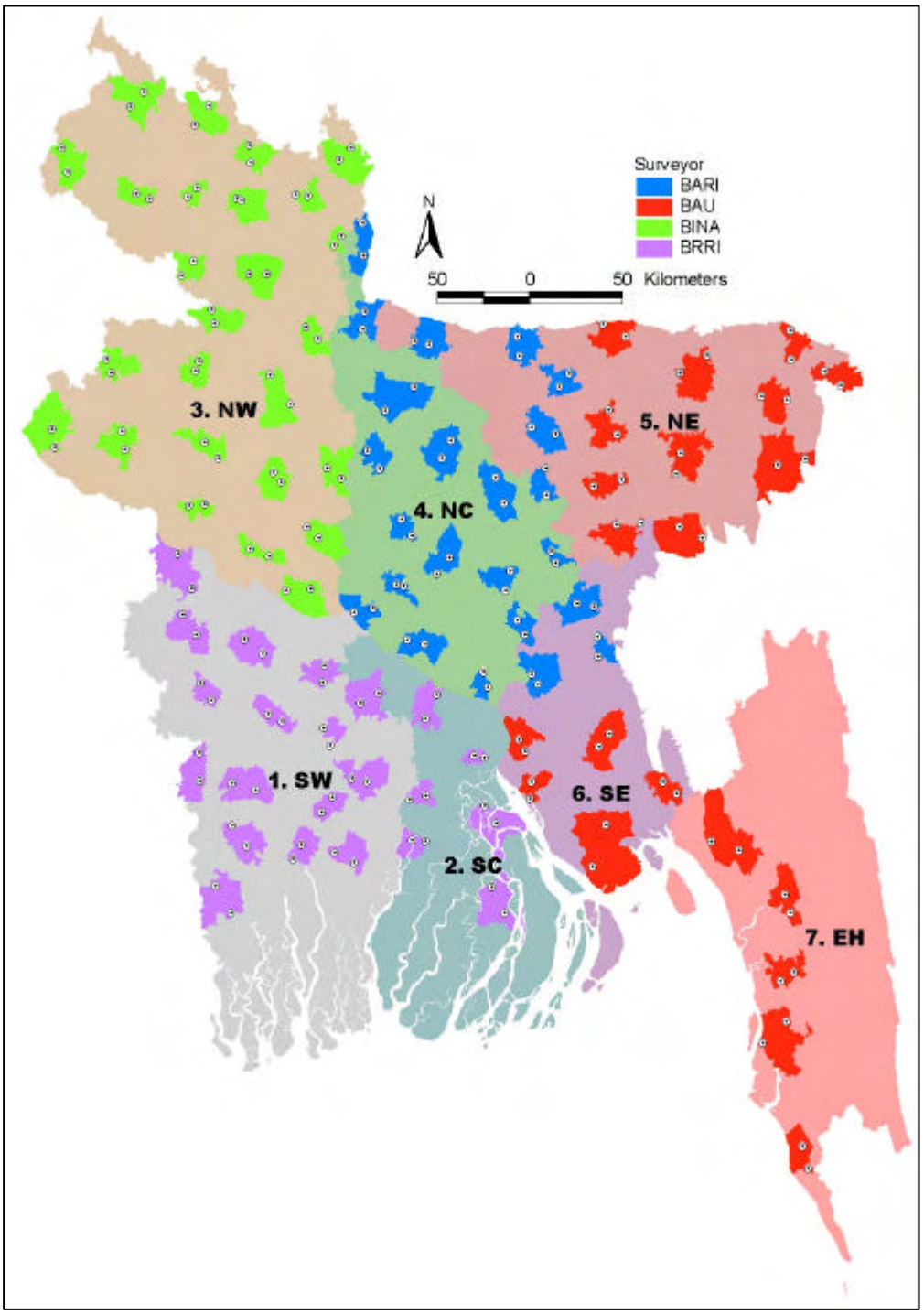

Figure 6.3: Map of Bangladesh showing sampling sites for national survey on arsenic

Sampling strategy

1. The samplings were done in the Boro and T. Aman (wet season rice) of 2004-2005.

2. The sampler took water, soil and plant samples from the rice fields from within the command area of selected STWs and from fields outside the STW command area where non-rice crops were grown. Water samples were also taken from nearby drinking water tubewells and surface water bodies (ponds, rivers, canals, etc.) for comparison with STW groundwater As.

3. From the command area of each selected STW, soil and water samples were collected from one spot in the middle of the rice field nearest the STW. Soil samples were collected from 3 layers: 0-15cm, 15-30cm and 30-60cm. A soil sample of approximately 500 g was collected from each layer.

4. Separate samples (depth-soil) and plant samples were collected from a field outside the STW command area to represent non-irrigated soils and non-rice crops.

5. For rice, both grain and straw samples were collected for each variety grown in the command area. For non-rice crops, samples of edible plant parts from each crop grown were collected.

6. Information on the depth and age of the STW, size of its command area, cropping pattern and land type of the sampling fields was also recorded.

7. All sampling points were geo-referenced using GPS meters.

8. All samples were analyzed for As, Fe, Mn and P.

During the Boro season and T. Aman seasons of 2004-2005, the Bangladesh partners completed sampling of STW water and surface water samples, and crop samples from rice and non-rice crops. As of July 2005, most of the analytical work has been completed and some work is in progress.

The national survey showed very wide ranges of As contamination in waters, soils and crops across Bangladesh. The causes for these differences, that appear to include variations in sediment and land types, flooding and siltation patterns, and agricultural practices, are being evaluated. The findings so far are summarized in the following sections.

a) *Arsenic in Waters*

It was reported in the annual report for 2002-03 and in technical papers presented at the 7th International Conference for the Biogeochemistry of Trace Elements held in Uppsala, Sweden in June 2003 that about two-thirds of the 456 shallow tube wells (STW) studied in five south-western, central and south-eastern “hot spot” districts of

Bangladesh were found to be moderately to severely contaminated. The As content exceeded 0.1 mg/L in about a half of the tube wells studied whereas 0.05 mg/L is considered "safe" for drinking water in Bangladesh.

From the national survey, a very wide range of As was found in water. The 355 STWs (irrigation tubewells) sampled ranged in value of As from below our detection limit (<5 µg/L in the AAS) to 726 µg/L (Figure 6.4). Seventy-seven percent of the STWs had a relatively low As content, <100 µg/L (Figure 6.4), 15% had a high As level (100-200 µg/L) and the remaining 8% had very high As, >200 µg/L. The mean As values for these three categories were 24, 146 and 306 µg/L, respectively.

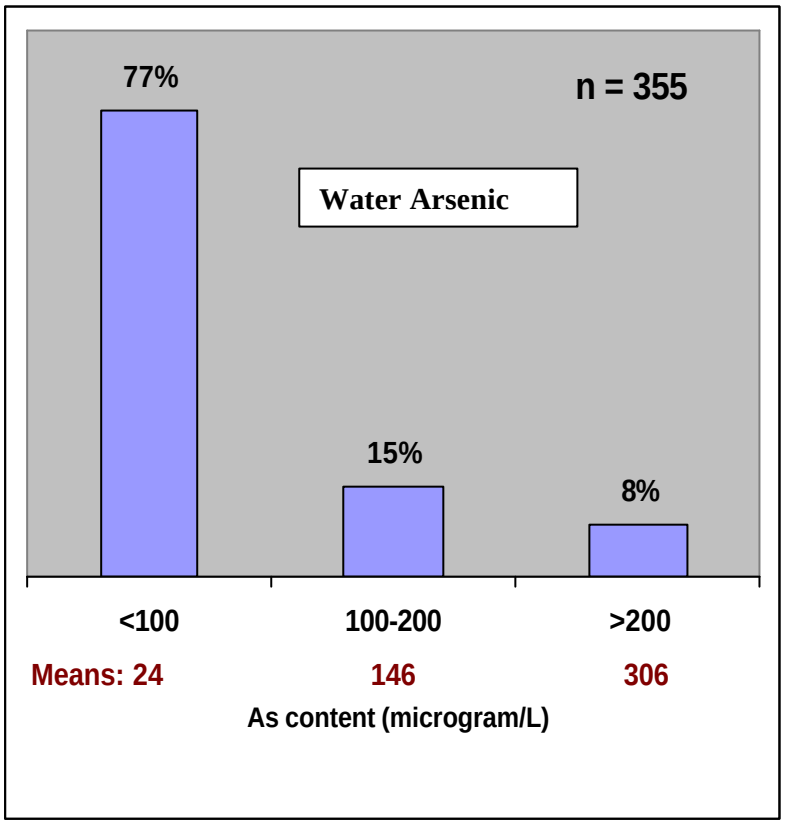

Figure 6.4: As content in 355 shallow tube wells in Bangladesh

The STW As levels varied regionally (map in Figure 6.5). The northern half of the country had the lowest As content in STWs. The highest values were found in the south western, south central and south eastern districts. These findings fit well with the earlier surveys made for drinking water tubewells by the British Geological Survey (BGS) and also corroborate the results for our thana level study in 2002-2003.

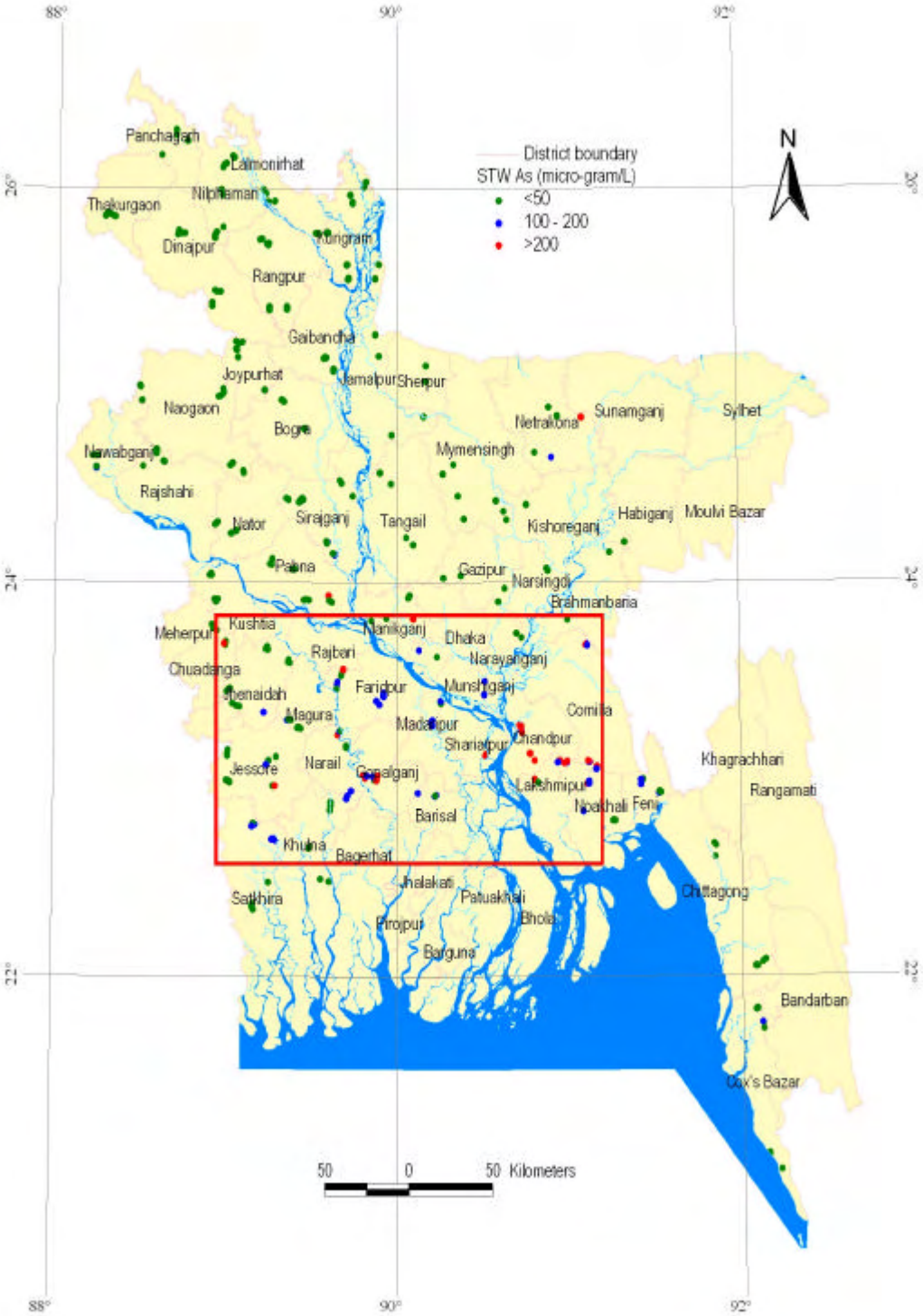

Figure 6.5: Map showing the As levels in water from STWs in different regions of Bangladesh The rectangle marks the area of major As contamination in the central south west of Bangladesh

The As content in the 387 hand tubewells (HTW, for drinking water) near the STWs surveyed varied widely from 0.2 to 552 µg/L. The average value across the country was 56 µg/L, slightly higher than the national safe level of 50 µg/L, meaning probably that the drinking water As situation was worsening. In the BGS surveys during 1993-1997, the As levels in tubewell water in the northern parts of Bangladesh were found to be lower, but our survey showed a little more As in water than that found 10 years ago. In contrast, the average value for surface water was much lower at 8.0µg/L. However, high values, exceeding 50µg/L, were found in some ponds. The reason for this was not ascertained, but this could indicate that surface water, too, might not be very safe for drinking so far as contamination with As was concerned.

b) Soil Pollution

We found earlier that in the command areas of a large number of contaminated STWs, the soil As content was high - exceptionally high in many cases. This indicates that As from irrigation water was accumulating in soils, which could lead to increased plant uptake and accumulation of arsenic in crops and may detrimentally impact land and agricultural sustainability. However, results from the national

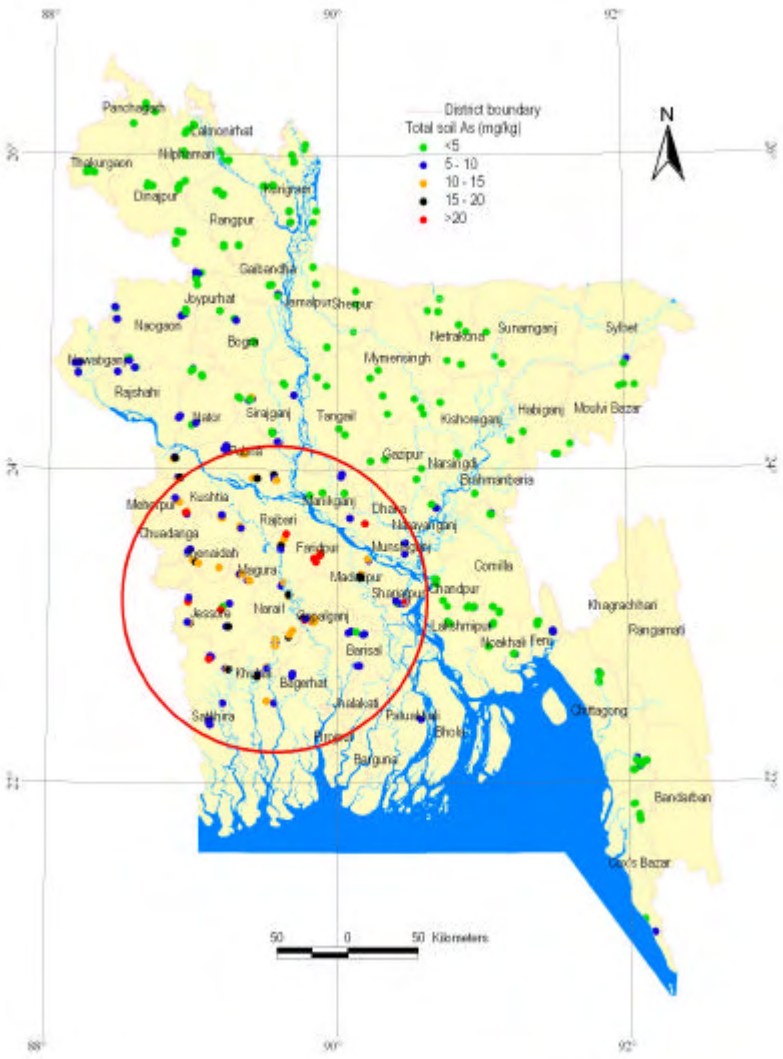

Figure 6.6: As content in soils of Bangladesh

survey did not clearly indicate that the As build-up in the soils was always related to the use of high-As irrigation water. At the same sampling point, irrigated and non-irrigated soils did not differ much in As content, and at the national level, the high-As soil points did not always match the high-As water points, although in parts of the high-As water belt, soils tended to contain high As.

The As content in the soils ranged from negligible to 64 mg/kg, with an average of 6.5 mg/kg for 394 soil samples. About 55% of the samples had an As content of <5 mg/kg, but at least 25% of the soils had high As levels of 10 to >20 mg/kg (Figure 6.7). Such high As levels in soils may be undesirable for crop production, especially rice, because chemical and biochemical conditions in the traditional wetland rice production systems favor the mobilization of As from the soil. Individual and interactive impacts of irrigation water As, "background" soil As, land type and land form, cropping sequences, etc. need to be studied in detail to provide information contributing to local and regional delineation of the potential As hazard. This information will be of practical significance in the design of agricultural management systems to minimize the As hazard.

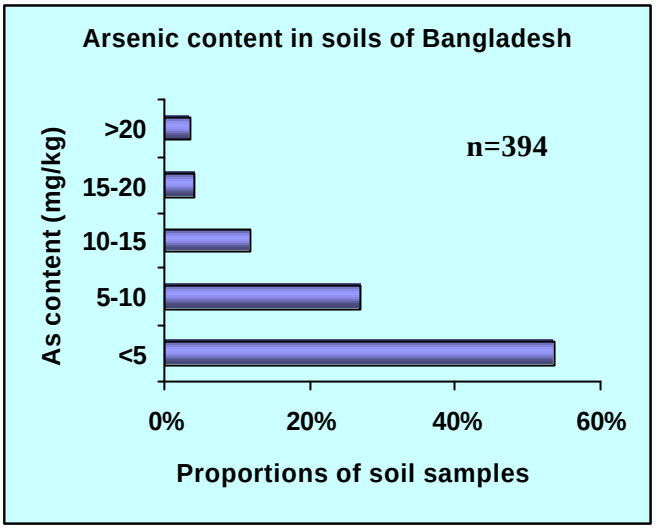

Figure 6.7: Proportions of soil samples with different ranges of As

c) Arsenic in Crops

In our first year's work we observed relatively high As concentrations in the grains and straw of rice in areas where a high As water-soil environment existed. The As content of irrigated Boro rice grain in five As contaminated *thanas* was on average around 0.3-0.4 mg/kg. In contrast, in five other *thanas*, where rice was irrigated with low-As STWs or with surface water, the rice grain As content rarely exceeded 0.2 mg/kg.

In the national survey, out of the 345 Boro samples, the As content in around 50% of samples was greater than 0.2 mg/kg, with a range of 0.04 to 1.10 mg/kg and average value of 0.31 mg/kg (Figure 6.8).

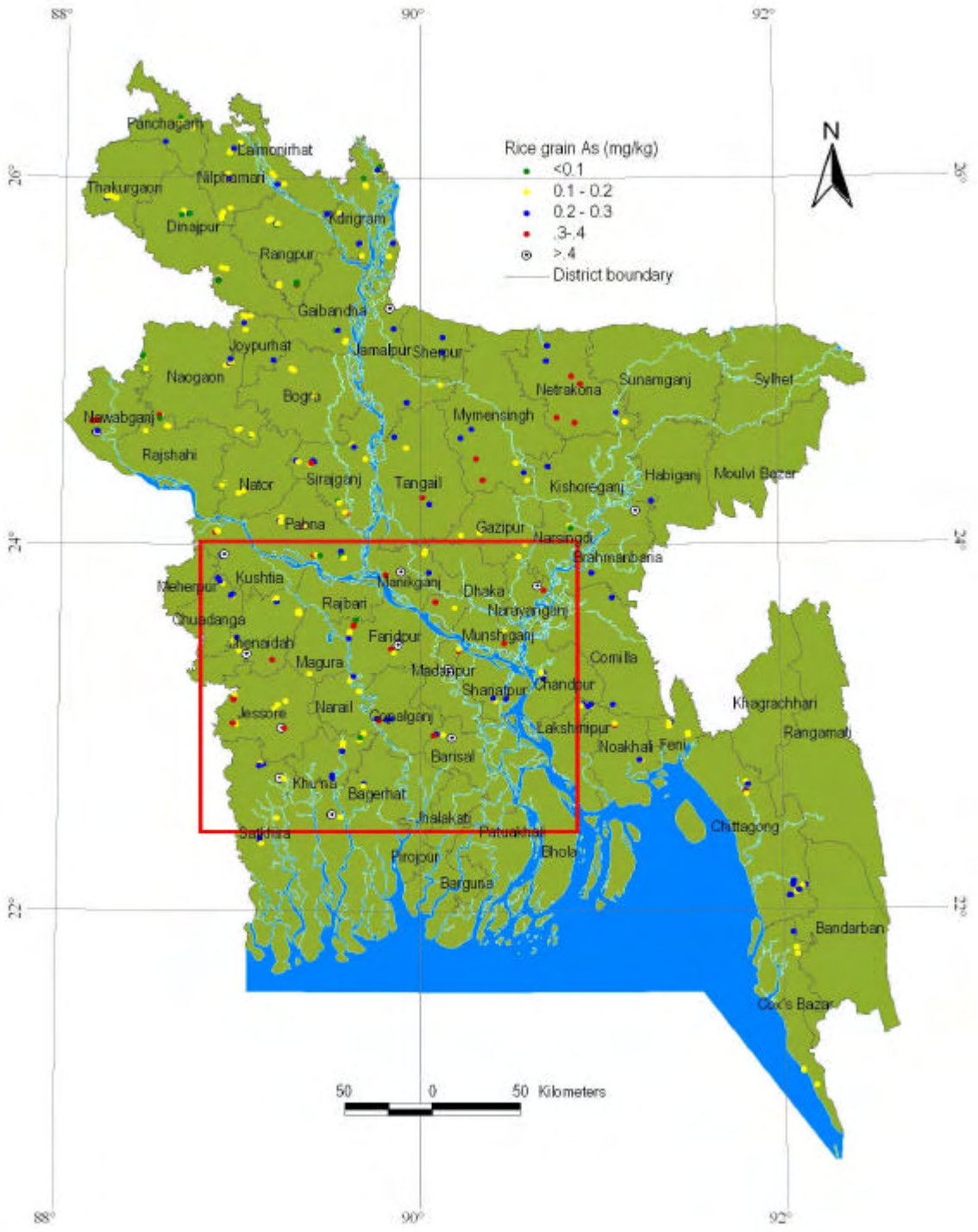

Figure 6.8: Arsenic content in Boro rice grains in different parts of Bangladesh

The corresponding T. Aman rice samples had the highest As content averaging 0.42 mg/kg, with a mean value of 0.17 mg/kg. The As content in Boro rice matched fairly well with the high and low As water and soil areas, but quite high As levels were also found in some northern and northwestern areas where the irrigation water As and soil As were low. This needs further detailed studies.

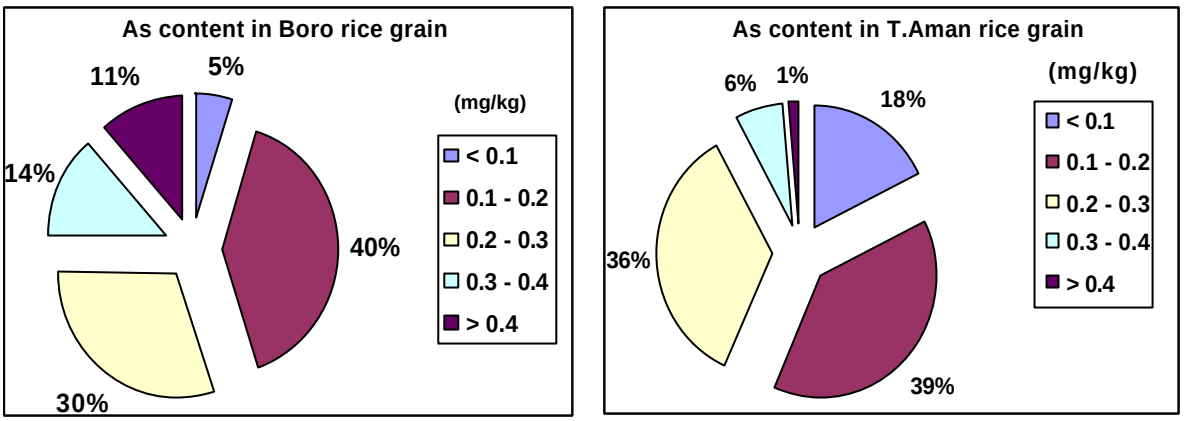

Figure 6.9: Proportions of Boro and T. Aman rice samples with different ranges of As

Because rice is the staple food in Bangladesh and because it is consumed in large quantities (around 450 g /person /day), As contaminated rice could clearly aggravate the human health risk when consumed along with As-charged drinking water in many areas of Bangladesh. The first set of results from the national survey point to the possibility of high As accumulation in rice.

In addition to work on rice, the As contents in the human edible parts of 70 different non-rice crops, like wheat, maize, leafy vegetables, tomato, chilli, beans, brinjal, etc. were determined (Table 6.1). The As content in maize and wheat grains was found to be very low, from almost zero to 0.13 mg/kg for wheat and 0.17 mg/kg for maize. However, to date we have analyzed only a few samples of wheat and maize. More detailed studies on wheat and maize are required. On the contrary, in the human edible parts of most of the other crops, particularly leafy vegetables like amaranthus and spinach the As content was double or triple that of rice. The As values varied widely from region to region, but incidentally, in the greater Jessore region where soil and water As concentrations were high, the As content in these crops was also high.

Table 6.1: As levels in edible parts of some non-rice crops in Bangladesh

	As content in edible part (mg/kg)		
Crop	**Max**	**Min**	**Mean**
Aram	2.31	0.52	1.42
Bean	1.38	BDL*	0.43
Betel Leaf	0.70	0.56	0.63
Bottle gourd	0.60	BDL*	0.39
Brinjal	3.47	BDL*	0.47
Cabbage	0.63	BDL*	0.30
Carrot	0.50	0.40	0.45
Cauliflower	0.63	BDL*	0.43
Garlic	1.33	0.20	0.52
Green chilli	0.83	BDL*	0.27
India spinach (pui shak)	4.18	4.18	4.18
Lentil	0.22	BDL*	0.11
Okra	1.00	BDL*	0.54
Onion	1.11	0.22	0.56
Papaya	0.50	0.24	0.41
Potato	0.83	0.11	0.48
Red amaranthus	3.36	0.60	1.34
Spinach	2.75	0.08	0.97
Sponge gourd	0.70	0.20	0.46
Sweet gourd	3.00	0.13	0.82
Tomato	1.75	0.23	0.51
Wheat	0.13	BDL*	0.05
Maize	0.17	BDL*	0.06

BDL* = below detection limit, < 0.005 mg/kg by AAS-HG method.

d) The "Uncertainty" Factor

Large spatial variability in the As contamination level in water, soil and rice within the STW command areas and among the command areas in a relatively small area of a thana has been noticed. This spatial variability makes a generalization about the As hazard on a nation-wide basis more problematic, and calls for detailed and extensive surveys and mapping for reliable information that would be representative of different regions of the country. This variability also has important implications for the development of an arsenic risk assessment document for researchers, extension agencies, government planners and farmers. The information about spatial variability also points to the need for location-specific water-soil-crop management strategies. Even though the high local spatial variability makes risk assessment more problematic, it has provided the experimental possibility to more fully assess the variables that contribute to As buildup in soil and accelerated absorption by plants. These studies have important implications to the design of optimized crop, soil, and water management systems.

Figure 6.10 for the Tala thana and one STW command area of that thana shows examples of spatial variability of As in soils. The causes of such spatial variability are being studied.

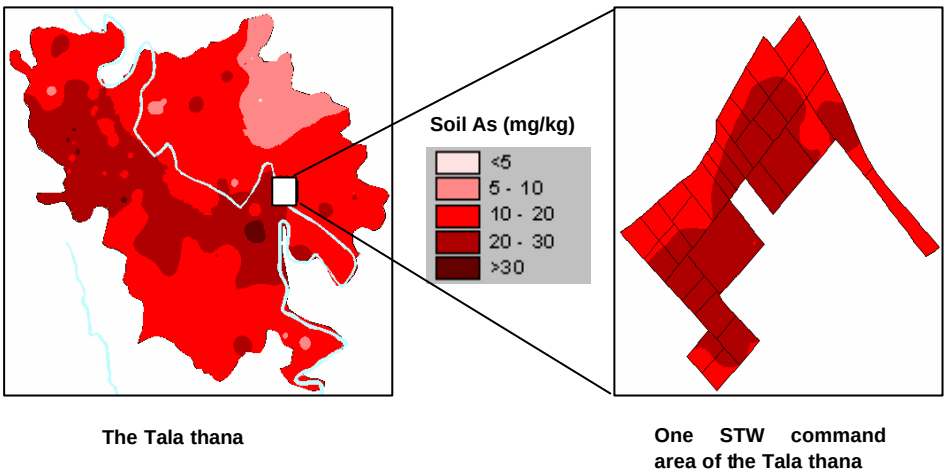

Figure 6.10: Spatial variability of As in soils

e) The Implications

A big volume of data on the As content of irrigation water, soils and rice has been gathered. The data were assessed and interpreted. The ultimate question, however, still remains: How safe are agriculture and food in an As-contaminated environment such as much of Bangladesh.

It is necessary to 1) determine the safe levels, and 2) find mitigation options. Arsenic in the water-soil-plant system needs to be closely and conclusively studied and As management technologies be developed.

V. National Capacity Building

Over the report year, the project invested substantially in analytical facilities and development of human resources to enable Bangladeshi scientists to assess the intensity and magnitude of the As problem in agriculture and then find solutions.

a) Facilities Development

A BARI-CIMMYT Arsenic lab has been established and is being developed with the signing of an LOA with BARI. The Lab is operating now. It has a capacity of approx. 50 samples per day.

The development of this new laboratory has greatly enhanced the capability of the national partner laboratories for precision analysis. This was confirmed through crosschecking of analytical results with our international partners (CU and TAMU).

b) Human Resource Development

We provided hands-on training on water, soil and plant sampling techniques and As analytical methodologies to scientists of Bangladesh partner institutions as a continuing activity.

We provided funds and facilities for one scientist to conduct a PhD degree program at Cornell University, and three scientists for PhD degree programs at BAU.

VI. The Future Outlook

The USAID sponsored project on As has generated a large volume of data on the As status of irrigation water-soil-plant environment in some As hot spots of the country. These data definitely suggest the possibility of As contamination in Bangladesh agriculture and a consequent threat to public health. Therefore, the rapid development of mitigation technologies is a high priority issue. Critical knowledge gaps with conditions and parameters expected to regulate the behavior of As in crop production emerged while scientists worked in the fields and laboratories. The science and applied science of As in agriculture must be clear to the scientists before they recommend anything decisively to stakeholders, policy makers and farmers. The short- and long-term future R&D plans of the project are focused, accordingly, to:

- Continue national capacity building through facilities and human resource development.
- Expand the study of As in the water-soil-system to improve the understanding of the chemistry and mineralogy of As that regulate its uptake and accumulation in wetland rice and upland crops.
- Intensify research on As mitigation and management strategies in cropping systems.

The need for extended R&D

During the last three years of the program, scientists gathered information that greatly improved our understanding of the nature and extent of the arsenic contamination problem in Bangladesh waters, soils and crops. However, there are still critical questions that need to be answered. While continuing the present activities, new research, education and technology development initiatives need to be taken. Some of these issues are pointed out below:

- Continue to develop a nationwide database on “background arsenic” in soils and the contribution of this arsenic (in addition to irrigation water arsenic) to contamination of agriculture and food.
- Continue to understand bioavailability of arsenic: Which arsenic species in water and soil control the plant uptake of arsenic? Which species are the most toxic for humans?
- What should be the safe levels of arsenic in irrigation water, soils and crops under the prevailing cropping systems of Bangladesh in terms of crop yield and quality?
- How do crops and cultivars vary in their susceptibility / resistance to arsenic? If there is significant variation, can this be used as a mitigation tool?

- Develop human capacity to address As issues. Help develop undergraduate and graduate level courses at Bangladeshi universities on the behavior of arsenic in agricultural systems and management options.

The project will also explore a wider program of management options and funding opportunities to support it.

7. Agro-food Nutrition Program in Chakaria

The partnership project between SARPV and CIMMYT finished in June 30, 2005 after the current three-year collaboration. During the period under review, significant progress and impact was created. An ever-increasing number of calcium-deficiency rickets patients were observed to visit the SARPV office not only from nearby areas but also from different parts of Chittagong, Cox's Bazaar and beyond. Even in last three months, 427 rickets patients reported to SARPV center at Chakaria. This was made possible due to the major messages in relation to rickets and its prevention through a mass campaign based on the current achievements of this project.

I. Follow up Project Activities

Drama shows were scheduled in relation to local government requests, in observance of National Disability Day, Bangla New Year's Day, National Farmer's Fair, etc. These are given to special audiences in presence of local government officials for attracting the media and local administration.

The calcium gardens in the Farmer's Fair and National Disability Day were set up and simultaneously discussion meetings were organized at the sites about rickets and its prevention.

Display boards were prepared for placing at public places after approval from the Pourashava authority.

A show was arranged at ICDDRB health complex where field workers and physicians were present. They reported that they did not have any prior idea about rickets and they could not treat the ailing patients who came to them with other complaints. Subsequently they started suggesting to their patients, especially the pregnant mothers, to take calcium rich vegetables in their diets.

Once a live drama was played at the Malumghat Memorial Christian Hospital where about 1500 local people, mostly women, and seven doctors from local hospitals watched the show. One of the viewers came on the dais and expressed that it was good to know about rickets and its prevention through this campaign for calcium-rich vegetables and lime for use in rice cooking pots.

Physiotherapists and French physicians attended the dramas/ shows and participated in discussions after the shows.

Impact assessment was made for the agro-food nutrition program in Chakaria with special importance on awareness of rickets and its prevention.

The collaboration with local development partners as a strategic step was geared up through a rickets prevalence study involving key-respondents by the nine

development partners across Chittagong and Cox's Bazar regions. By the end of 2005, it is expected to have Helen Keller International's nationwide nutrition survey.

Collaborations among local partners of SARPV, regional partners of Abilis and Communicating for Advocacy (CfA) networks have been proposed to join together in a rickets prevention campaign. Rickets convergence group and rickets consortiums are being organized. Both CARE and UNICEF are approaching to join the campaign.

Public campaigns with video and live drama continued to cause an increased number of rickets patients to report from different parts of the country to SARPV centers for treatment. This was a direct outcome of the CIMMYT- SARPV joint campaign.

Strengthening Household Access to Bari Garden Extension (SHABGE) and CBR team members as well as students of Prodipaloy, an exclusive education center of SARPV, continued to support local organization of dramas with different complementary roles. A team of five project leaders shared the overall management responsibilities. Increased collaboration also with other projects and the media was progressing.

II. Kumary Agricultural Farm

The farm set up at Lama in Bandarban helps produce seed important crops or saplings of fruit trees and their distribution for quick benefit of the people in the community sites of the project. The newly released crop varieties from research institutes as well as recommended varieties were raised mostly in the farm. Station development was steadily progressing. Now all crop species and varieties grow very well in this hill station. The most appropriate materials for this agro-ecological condition were multiplied and proved effective. Calcium rich vegetables including Snack gourd, Okra, Country bean, Long yard bean, Taro, Yam potato, Papaya, etc. and fruit trees like Mango, Guava, Olive, Litchi, Pineapple, etc. were grown. A nursery consisting of diversified fruit trees, fire wood, timber trees, etc, was built up here.

III. Demonstration Plots

These were set up at the community sites with calcium rich vegetables to attract the neighboring people. The whole family training concept was followed to promote and help adopt the technologies (Figure 7.1). During the training period, seeds were supplied to the concerned growers for quick dissemination to the people

Figure 7.1: Whole family training organized in the community

in the site. As a result, crop seeds spread out quickly in the project areas. The homesteads were not only covered with calcium rich vegetables but also with diversified crops including fruit trees. The growers knew how to preserve seeds and earn income for their livelihoods.

IV. List of Training Events on Rickets Awareness, July 2004-June 2005.

A. First Quarter, July–September, 2004

Live drama

Date	Area	Address	Total attendance	# of female	# of male
7-9-04	Upazila auditorium	Zillonza, Cox's Bazar	1500	About 600	About 900
23-7-04	Malum ghat Model School	Malum ghat, Chakaria	More than 2000	About 200	About 1800
22-9-04	Junior High School field	Ring Vong, Chakaria	2000	About 600	About 1400
25-9-04	Fashiakhali field	Fashiakhali, Chakaria	680	About 56	About 624

Video show

Date	Area	Address	Total attendance	# of female	# of male
11-7-04	Darbas katara	Chakaria	200	120	80
11-8-04	Batakhali	Chakaria	450	180	270
12-8-04	Mizeghona	Chakaria	375	150	225
21-8-04	Haseridigi Bazar	Fashia khali, Chakaria	560	45	515
11-9-04	Khurskul High School	Cox's Bazar	750	360	390
19-9-04	Mamun para	Khuruskul, Cox's Bazar	350	150	200
20-9-04	Dumkhali	Malum ghat, Chakaria	400	360	40
25-9-04	Shahapura, Rampure	Sharbill, Chakaria	350	300	50

B. Second Quarter, October – December 2004

Live drama

Date	Name of area	Address	Total attendance	Female (%)	Male (%)
10.10.04	Primary school field	Harbang, Chakaria	1400 +	80	20
13.10.04	Zamila Begum high school	West Boro Bheola	1500	85	15

Date	Name of area	Address	Total attendance	Female (%)	Male (%)
08.12.04	High school field	Dulahazara Union Parisad	1500+	92 %	08 %
29.12.04	Malumghat Hospital field	-same-			

Video show

Date	Name of area	Address	Total attendance	Female (%)	Male (%)
12.10.04	Primary school field	Surajpore Kakara	700	10	90
27.10.04	Baruapara Buddist Temple	Purashova Chakaria	600	50	50
24.11.04	Mazerparti Bazar	Kakara Union Parisad Chakaria	600	05	95
04.12.04	North sirakhali	Fasiakhali	200-220	94	06
05.12.04	Midle sirakhali	Fasiakhali	200 +	92	08
06.12.04	South Palakata	Purashova Chakaria	180-220	92	08
07.12.04	Islamnagar	Khaiyerbil Union Parisad	160-200	96	04
08.12.04	High school field	Hidernashi, Lama	1200-1400	15	85
09.12.04	West fasiakhali	Fasiakhali Union Parisad	180-220	94	06
13.12.04	Rasulabad	Boroitholy U.P	200-240	98	02
14.12.04	West lotony	Kakara U.P	230-250	94	06

C. Third Quarter, January – March 2005

Live drama

Date	Name of area	Address	Total attendance	Female (%)	Male (%)
15.01.05	Badarkhali high school field	Badarkhali Chakaria	3500-3800	85	15
18.01.05	Kudakhali high school	Kudakhali Chakaria	3000-3500	80	20
03.02.05	B.M. char High school	B.M.char Chakaria	1500 +	80	20
04.03.05	Kalamarchara high school	Kalamarchara Moheshkhali	3000-3500	60	40
08.03.05	Kayerbil high school	Kayerbil Chakaria	2000-2500	80	20
17.03.05	Rashid Ahmed Chy High school	Fashiakhali Chakaria	3000-3500	85	15

Video show

Date	Name of area	Address	Attendance	Female	Male
09.01.05	Baramohury	Banghermuk Chakaria	150-200	90	10
10.01.05	Kahariagona	Purashova Chakaria	180 -200	85	15
11.01.05	BRAC school	Zidda Bazar Chakaria.	250 -280	80	20
12.01.05	Banierchara	Aziznagar Lama	180 -200	90	10
13.01.05	Gonisikderpara Digerpankhali	Fashiakhali Chakaria	180 -200	85	15
13.01.05	Hatkhula mura	Chunoty Lohagara	450-500	60	40
14.01.05	Rashidergona	Adunagar Lohagara	500-550	65	35
15.01.05	BRAC school Lokita para	Charamva Lohagara	450 -500	75	25
16.01.05	Napartilla Charamva	Lohagara Chittagong	450-500	60	40
17.01.05	Adarsha para Putibila	Lohagara Chittagong	400-450	65	35
06.02.05	Hamidullah para	Fasiakhali	200-220	94	06
09.02.05	Biman Bander field	Chakaria	450-500	08	92
16.02.05	Baruapara	Chakaria	180-220	92	08
27.02.05	Sirakhali Jaladash para	Fasiakhali	180-200	96	04
07.03.05	Gavtholy Rudra para	Khundkarpara Fashiakhali	250-300	85	15
12.03.05	Sikalghata	Laksarchar Chakaria	400-450	25	75
17.03.05	Budipukur	Chiringa Chakaria	400-450	35	65
19.03.05	Jaladashpara Gaiterchar	P.B.Veola Chakaria	400-450	60	40

D. Fourth Quarter, April – June 2005

Live drama

Date	Name of area	Address	Total attendance	Female %	Male %
24.03.05	Palakata High School Field	Cheringa U.P.	700	20	80
06.04.05	Public Library Hall	Cox's Bazaar	500	10	90
04.05.05	High School Field Digerpankhali	Fashiakhali	750	30	70
05.05.05	Gatierchar High School Field	East Baraveola, Chakaria	500	20	80

Date	Name of area	Address	Total attendance	Female %	Male %
08.05.05	Eidgaon High School Field	Cox's Bazaar	750	05	95
09.05.05	Chambal Primary School, Aziznagar	Lama	350	10	90

Video show

Date	Name of area	Address	Attendance	Female (%)	Male (%)
09.04.05	Shorujpur Primary school field	Shorujpur	150-180	90	10
12.04.05	Mugbazar Bermiz primary school	Chakaria pourashava	180-200	30	70
13.04.05	Dacbangla para	Gorak ghata Moheshkhali	150-180	40	60
14.04.05	Hindopara Cyclone shelter	Gorak ghata Moheshkhali	180-200	40	60
15.04.05	Purbo shikder para cyclone shelter	Gorak ghata Moheshkhali	150-180	40	60
16.04.05	Dhakkhin Rakhain para cyclone shelter	Gorak ghata, Moheshkhali	200-220	20	80
17.04.05	Manik para Darbeshkata.	west Boro veowla	150-180	50	50
18.04.05	Union parished field	west Boro Veowla	180-200	70	30
27.05.05	Ringbong Field	Fashiakhali	150-180	90	10
28.05.05	Halkakara Chakaria Puwrasova	Chakaria	180-200	30	70
29.05.05	BRAC School Field East	Lakswarchar	150-180	40	60
31.05.05	Sikalghata Lakswarchar	Chakaria	150-180	60	40
02.06.05	Haserdhigy	Fashiakhali	180-200	05	95
04.06.05	Budipukur Cheringa UP		200-250	35	65
05.06.05	Charandip Cheringa UP		150-180	05	95
06.06.05	Gonapara, Ilishia	West Boro veola	180-200	70	30
08.06.05	Pashim Kashpara Demoshia		150-180	80	20
19.06.05	High School Field Aziznagar	Lama	200-250	65	35
20.06.05	Lotony Kakara	Chakaria	180-200	35	65

V. Live Drama and Video Show

Altogether 76 live dramas and video shows were organized in the period July 2004 – June 2005 (Table 7.2). Among these events, 20 live dramas were arranged and the rest were video shows. Twelve, 15, 24 and 25 events were performed in the first, second, third and fourth quarters respectively in the said period. Both approaches were equally effective to create awareness among the community people in Chakaria. The outcome of impact was noticed that significantly greater numbers of patients visited SARPV center for treatment. Also SARPV were requested to demonstrate their live drama/ video show in observance of important occasions. In this context, impact studies have been initiated to better assess the benefits and results will be given in a separate document.

Figure 7.2: Video drama organized in a school premises

VI. Visit by Delegates

The CARE partners and CARE team members visited the field activities in October, 2004 and appreciated the impact of work in the community areas.

Dr. Craig Meisner, CIMMYT Agronomist and Country Liaison Officer for Bangladesh and Ms. Noriko Furuya, a Japanese Fellow of Tokyo Agricultural University visited CIMMYT – SARPV joint project and disability complex of SARPV, Kumary farm, and a few village demo plots in December, 2004. They watched both live drama and video shows in public places.

In February, 2005, the Upazila Agriculture Officer and Upazila Education Officer for Chakaria visited the Kumary Agriculture farm and later on advised Agriculture Block Supervisors to refer possible rickets patients to SARPV Physiotherapy and Assistive Device Production Centre on seeing primary symptoms.

On March, 2005, the International Women Day, SARPV Bangladesh and Chakaria TNO office jointly organized the rally and discussion meeting with the object to raise the public awareness of women rights and care for pregnant mothers. The rickets issue was raised and extensively discussed.

On 6 April, SARPV-Bangladesh launched a rickets awareness campaign jointly with National Federation of Organizations working with the disabled and the local district disability committee. This time they arranged a show in observance of the

day followed by the discussion completely dedicated to rickets. Local government officials including the ADC (general), Social welfare officer, Shishu Academy Officer, Upazila Nirbahi Officer, and others participated in the sessions.

In late June at Farmers' Fair, the local Minister and the MP visited the Calcium Garden organized by SARPV and learned about joint campaigns. Chakaria TNO office jointly organized rally followed by a discussion meeting in the Fair at the local level.

VII. Impact Assessment Study on Rickets Awareness and Its Prevention

In April 2–27 2005, a Survey Team consisting of six members from CIMMYT Bangladesh made a survey independently in 16 randomly selected sites and four more control sites in Chittagong, Banderban and Cox's Bazaar districts. At the initial stage the SARPV workers from different projects worked closely with the team to help them know the locations and with a clear understanding of the local language.

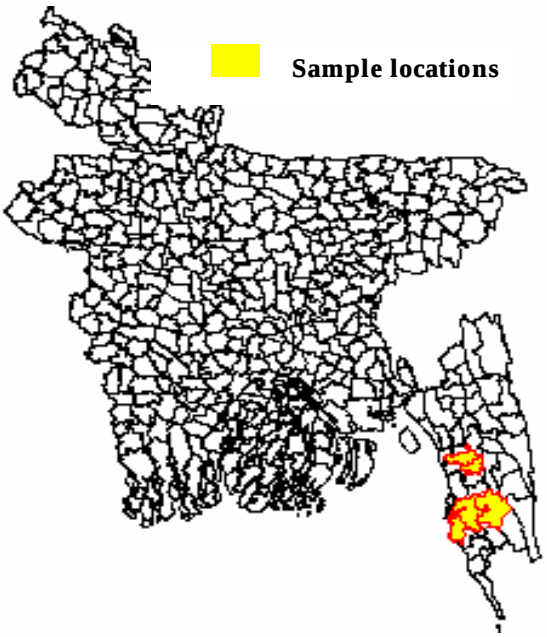

Figure 7.3: Bangladesh map showing sample locations

During the period under review, 76 live and video shows were demonstrated in six upazilas. Of these, 20 live dramas were organized and 56 videos showings were displayed until March 30. The survey was in April during which period altogether 64 shows were arranged. Based on these shows, the survey was made and its impact was assessed. About 42,000 male and female viewers have been reached. 25% of the drama showing spots, i.e. 16, was selected at random. In this case, 13 videos and 3 live dramas' performances were studied. At each selected spot, a sample of 15% males (1124) and 15% females (532) among the viewers were considered for interview. Four control villages were purposively selected in four upazilas. Fifty samples were selected in each control village. Among the fifty samples, 65% were determined from males and 35% were determined from females. Only one person was selected from each household. Here, members aged 15 or above were interviewed. A pre-tested questionnaire was used for the purpose. The targeted numbers of respondents were identified from the village or adjacent village where the live drama or videos were demonstrated. Since the name and address of the viewer was not available, the respondents were selected from those who observed the performance. During the survey, most of the drama/ video attending households were covered by sample respondents. In preparing the study

report, a separate document will be made available. However, a site specific map is shown (Figure 7.3) based on GPS readings.

VIII. Useful Collaboration

Visitors from CIMMYT and Head offices of SARPV visited the project site at regular intervals. Also CARE partners and CARE team visited SARPV fields and praised the collaboration. Representative of GO / NGOs like SEHD, HEED, PROSHIKA, BASTOB and the Upazila Agriculture officer of Chakaria visited and learnt about the collaboration. Other than these, community people visited Kumary farm at regular intervals. They also referred rickets patients to SARPV. Rickets patients are being referred regularly to the SARPV physiotherapy center from their working areas like Banshkhali, Patya, Chandanaish, Ramu, Teknaf and Ukhia.

List of Main Persons of CIMMYT, Cornell University, TAMU and USDA Involved in the Project

Name and address of main person	**Project component**
Dr. Stephen R. Waddington Regional Agronomist for South and East Asia and Country Liaison Officer for CIMMYT Bangladesh Email: s.waddington@cgiar.org	Overall project
Dr. GM Panaullah Affiliate Scientist CIMMYT Bangladesh Email: g.panaullah@cgiar.org	Impact of Arsenic Contamination on Agricultural Sustainability and Food Quality
Dr. Nur E Elahi Affiliate Scientist CIMMYT Bangladesh Email: n.elahi@cgiar.org	Whole Family Training in Maize
Prof. John M. Duxbury Department of Crop and Soil Sciences Cornell University, USA Email: jmd17@cornell.edu	Impact of Arsenic Contamination on Agricultural Sustainability and Food Quality
Prof. Richard H. Loeppert Department of Soil and Crop Sciences Texas A & M University, USA Email: r-loeppert@tamu.edu	Impact of Arsenic Contamination on Agricultural Sustainability and Food Quality
Dr. Dennis Gonsalves Director, USDA-ARS Pacific Basin Agricultural Research Center, Hilo Hawaii, USA Email: dgonsalves@pbarc.ars.usda.gov	Development of Ring Spot Virus Resistant Transgenic Papaya for Bangladesh
Dr. Craig A Meisner Ex. Agronomist and Country Liaison Officer for CIMMYT Bangladesh Email: Email: cmeisner@ifdc.org	Overall project
Dr. MA Razzaque Ex. Affiliate Liaison Scientist CIMMYT Bangladesh	Agro-food Nutrition Program in Chakaria and Development of Ring Spot Virus Resistant Transgenic Papaya for Bangladesh
Dr. Shakhawat Hossain Ex. Affiliate Scientist CIMMYT Bangladesh	Human Resource Development
Mr. Enamul Haque Program Manager CIMMYT Bangladesh Email: e.haque@cgiar.org	Facilitation and Promotion for Adoption of Mechanization by Growers

Name and address of main person	**Project component**
Mr. Donbox Sarker Program Manager CIMMYT Bangladesh Email: d.sarker@cgiar.org	GIS-Bangladesh Country Almanac (BCA): A User Friendly GIS Tool for Agricultural, Forestry and Natural Resource Management