

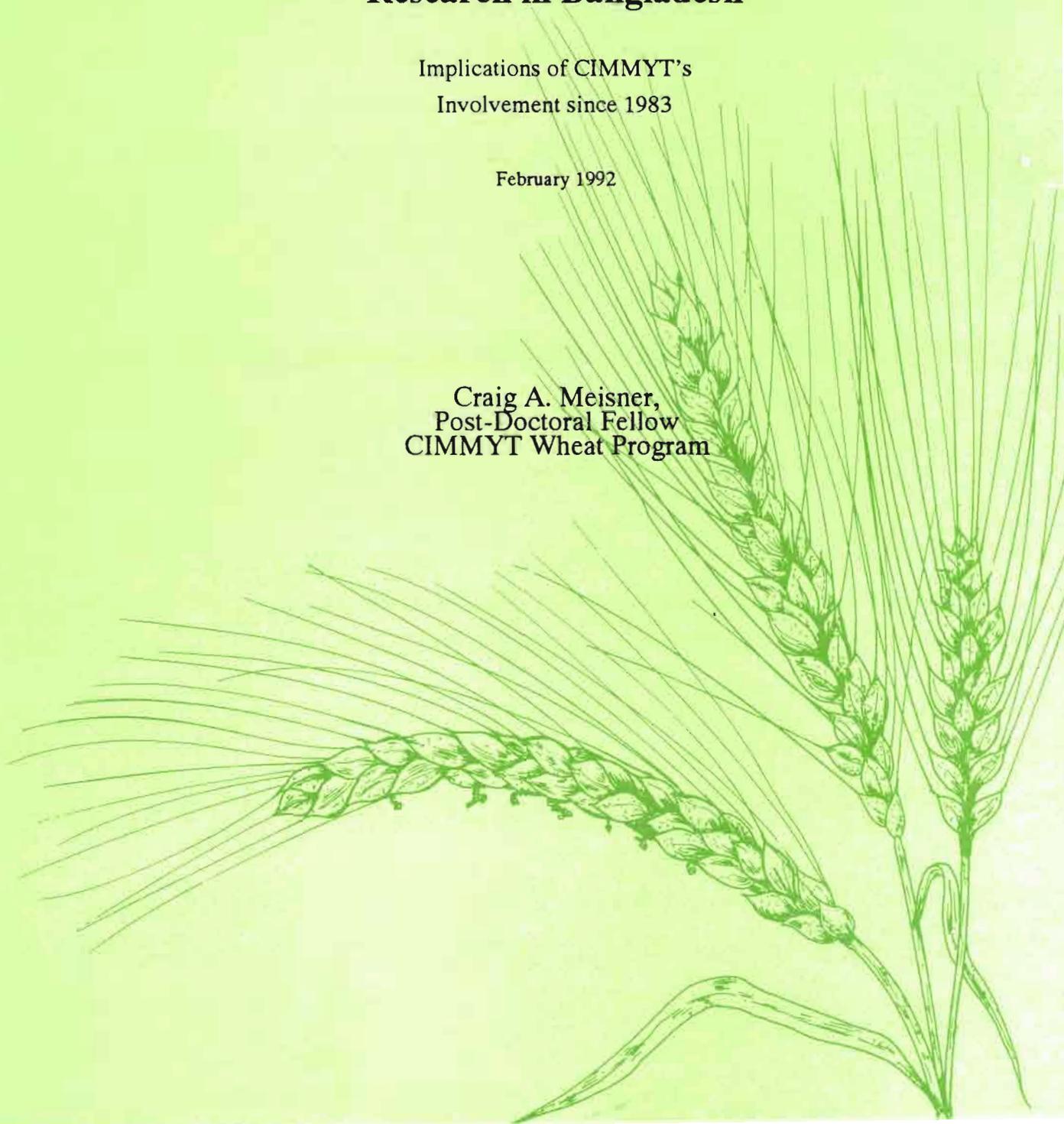
Wheat Special Report No. 3

# Impact of Crop Management Research in Bangladesh

Implications of CIMMYT's  
Involvement since 1983

February 1992

Craig A. Meisner,  
Post-Doctoral Fellow  
CIMMYT Wheat Program



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### **Note on Citing this Wheat Special Report**

By sharing research information in this Wheat Special Report on the Impact of Crop Management Research in Bangladesh, we hope to contribute to the advancement of wheat crop management in this country and elsewhere and to the importance of shared knowledge. However, the information in this report is shared with the understanding that it is not published in the sense of a refereed journal. Therefore, this report should not be cited in other publications without the specific consent of the author.

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## PREFACE

The Bangladesh Wheat Project, presently financed by the Canadian International Development Agency (CIDA), is one of CIMMYT's adaptive crop management research activities. These projects are intended to conduct research to adapt relatively well understood technologies to new situations or countries.

Wheat is the second most important cereal crop of Bangladesh and is usually grown in rotation with rice. About 50% of the country's wheat consumption is presently produced domestically. The challenge ahead is to increase wheat yields on a sustained basis. Optimum on-farm management demonstrations have shown that, with current varieties, wheat yields can be increased significantly at a national level.

This Wheat Special Report gives a brief summary of the diagnostics and research achievements of the project. The technological and institutional impact attained so far appears to be important. Some of the research results will undoubtedly have wider applicability within areas where the rice-wheat system predominates.

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## INTRODUCTION

This document attempts to quantify the impact of crop management research in Bangladesh since 1983, when CIMMYT scientists have been in bilateral positions. No attempt has been made to separate NARS and CIMMYT accomplishments in this paper. The governmental body for wheat research in Bangladesh is the Wheat Research Centre (WRC), under the Bangladesh Agricultural Research Institute, all of which is under the Ministry of Agriculture, Irrigation, Flood Control and Water Resources. While wheat breeding has been on-going actively since 1970 by the WRC, wheat agronomic research was not a priority of the Centre until the arrival of CIMMYT Agronomist, Dr. Mengu Guler in 1983. He was succeeded by Dr. David Saunders (1988 to 1991). This report is based on the published data written by all the scientists doing wheat research in Bangladesh.

In reality, to make a good case for agronomic impact, one would require knowledge of the production recommendations made by the WRC since its inception, percentage of growers adapting such recommendations, and compare these with current recommended practices and adaptations. Unfortunately, such information has only been actively collected during the past two years.

### HISTORICAL PERSPECTIVE OF WHEAT PRODUCTION IN BANGLADESH

Pakistani scientists introduced wheat in the late 1940's in the region then called East Pakistan. Average wheat yields at that time were less than 1 ton ha<sup>-1</sup>. After independence from Pakistan in 1972, the government of the new country of Bangladesh continued its commitment to expanding wheat production as well as continuing to recognize CIMMYT as a potential source of information and germplasm to increase wheat yield potential and production. CIMMYT had begun informal consultation work before independence in 1968 when a CIMMYT scientist first visited East Pakistan. CIMMYT arranged for three key Bangladesh scientists to come to Mexico for training. Dr. Sufi Ahmed, after his training and under his leadership, developed the Bangladesh Wheat Research Centre into what external reviewers have claimed is one of the two strong agricultural research institutions in Bangladesh (Riley, 1986). The other institution is the Bangladesh Rice Research Institute which has had collaboration with IRRI for many years. Dr. Sufi Ahmed's successor, Dr. M.A. Razzaque, also received training at CIMMYT and is presently in a key leadership position. Over the 23 years of relations with Bangladesh, CIMMYT has received over 60 scientists to Mexico for various short courses or training experiences. In addition, the CIMMYT-CIDA project has sponsored 11 Bangladesh wheat scientists to complete their M.S. and/or Ph. D. degrees both in Bangladesh

and abroad. Perhaps the strongest indication of how Bangladesh scientists have felt about CIMMYT's input into their wheat program is the honor given to Dr. Norman Borlaug, breeder and former director of the wheat program at CIMMYT. He was recognized in 1975 by the Bangladesh Academy of Science as a foreign fellow (Heider, 1989) and currently remains one of two non-Bangladesh scientists to have received such an honor, further illustrating CIMMYT's close ties with Bangladesh. A joint Bangladesh-FAO soil survey interpretation project in 1975 determined that 2.3 million hectares of land were physically suitable for wheat production under rainfed conditions (Brammer, et al., 1988). An additional 0.8 million hectares were suitable for wheat production under irrigation. However, wheat cultivation in 1991 was approximately 600,000 hectares, representing only 20% of the total suitable land for wheat cultivation in Bangladesh. Although there is no good data to determine exactly how much of the above is rainfed and irrigated, recent surveys of wheat producing areas would provide an estimate of roughly 2/3 of the 600,000 hectares is probably under irrigation. Wheat production areas ranged over the years from 120,000 to 700,000 hectares (Fig. 1). Thus, expansion of wheat area remains a possibility in Bangladesh. However, even with only 20% of potential area being cultivated, wheat continues to be the second most important cereal crop in

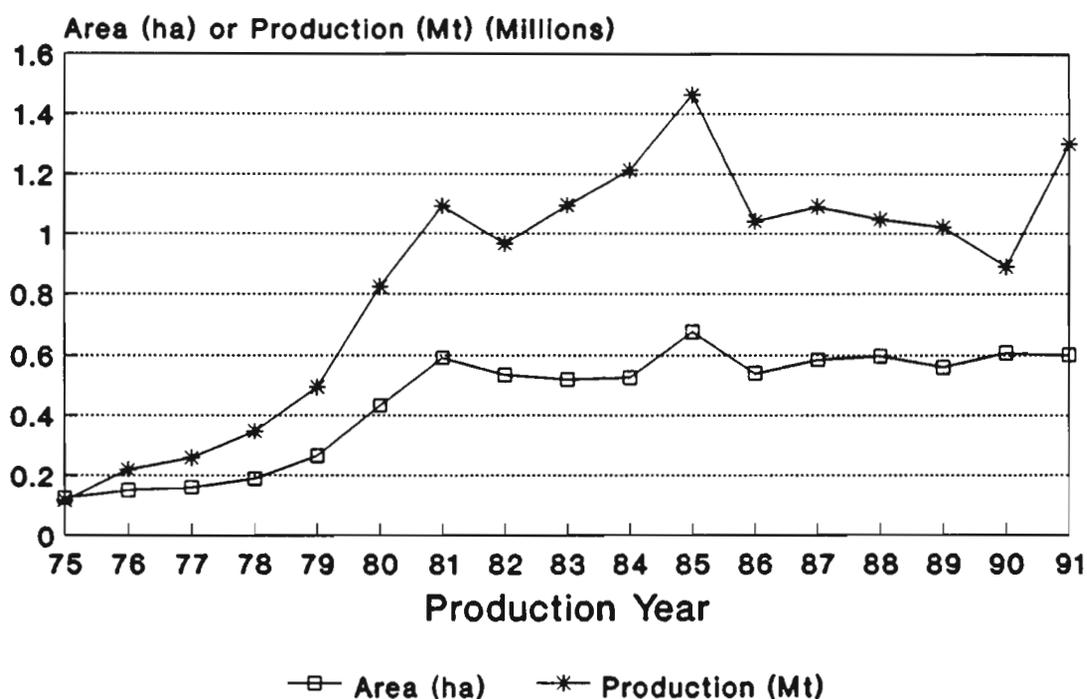


Figure 1. National production and area in Bangladesh (from FAO except 1991 data which are estimates).

Bangladesh's rice-based cropping system. In 1982, CIMMYT assigned the first two bilateral CIMMYT scientists to Bangladesh. Dr. Larry Butler, a breeder/pathologist and Dr. Mengu Guler, an agronomist, served during Phase I from 1982-88. The project was supported by the Canadian International Development Agency (CIDA), executed by CIMMYT and implemented by the Bangladesh Agricultural Research Institute (BARI).

The purpose of the project was to improve applied research and institutional capabilities of the WRC and to promote increases in national wheat production. The project supported overseas training for Bangladesh scientists, local research, demonstration activities, and equipment acquisition. Phase I emphasized wheat breeding and made much progress in developing appropriately adapted, higher yielding varieties. Subsequently, the project was extended to March 31, 1992. The 4-year extended phase placed greater emphasis on crop management research (agronomy). Dr. David Saunders, an agronomist, was the only CIMMYT bilateral scientist during this 4-year extension.

The project was reviewed favorably by external reviewers in 1985 (Dr. L. Sebeski, Univ. Manitoba; Mr. D. Clements, Ag. Sector Team CIDA; and Dr. A. Latif, Bangladesh Ag. Univ.) and in 1988 (Prof. J. Tanner, Univ. Guelph). Progress was made in producing and promoting five new varieties, developing and showing improved agronomic management, and training a multi-disciplinary team of 29 wheat research scientists. During Phase I the newly built facilities of the Wheat Research Centre (WRC) in Dinajpur received substantial equipment to fulfill its goals. Unfortunately, due to uncontrollable factors, wheat area and yields did not increase as planned and actually decreased (Fig. 1). For example, unfavorable input and product pricing coupled with increased availability of relatively cheap shallow tubewell pumps produced a shift in growers sowing wheat to winter (boro) rice. Yields reflected this trend reaching a plateau in the mid-80's and decreasing until 1991 (Fig. 2). A task force was created by the Bangladesh government in 1987 consisting of four distinguished Bangladesh scientists to study the expansion of wheat (Ahmed, et al., 1988). In their published results, they addressed the area, production, and yield decline, concluding "that wheat yield declines are occurring because:

- Wheat is grown mainly by small growers (<2 ha).
- Delayed release of land after transplanted aman rice causes late planting.
- Delayed land availability for wheat due to mixed broadcast aman and aus cultivation in deep water areas.
- Problem of wheat seed availability.
- Higher cost of inputs.

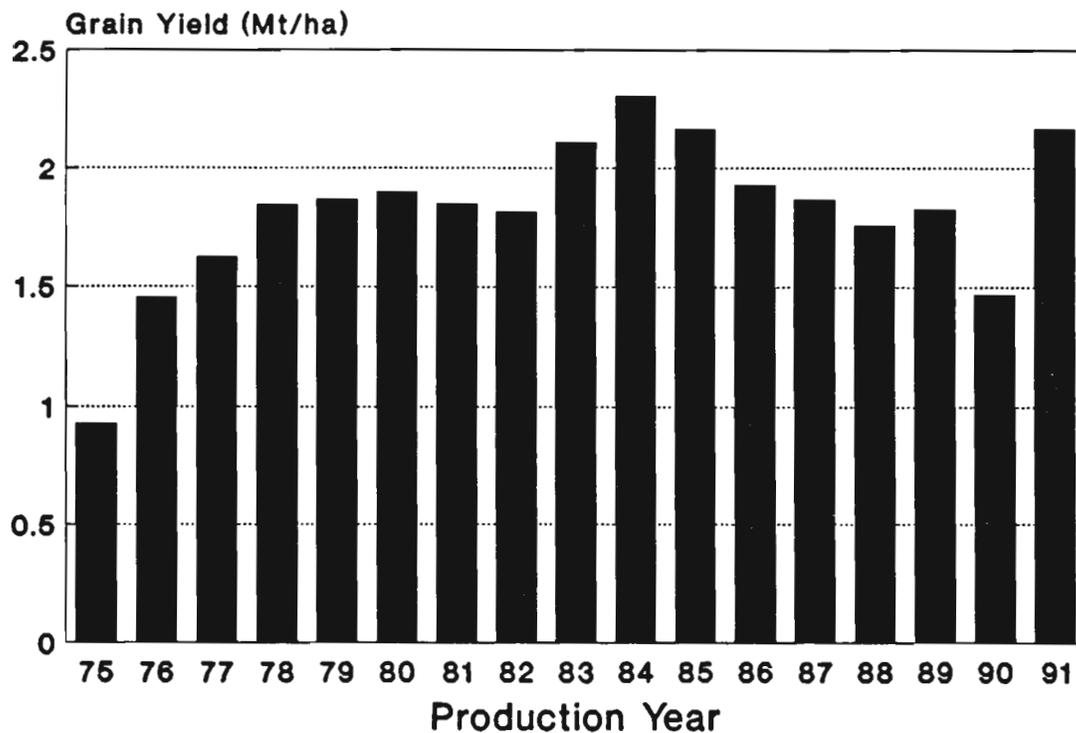


Figure 2. Average grain yields over the past 15 years (from FAO except 1991 data which are estimates).

- Land competition with other winter crops.
- Erratic rainfall in the 1980's.
- Lack of clear government policy.
- Import of PL-480 wheat from USA.
- Wheat threshing problems.
- Socio-economic problems.
- Lack of wheat price support.
- Good harvest of rice crop.
- Lack of strong winter crop production program.
- Late release of land after aman rice and salinity problem in coastal areas."

Nonetheless, increased wheat production remains biologically feasible, environmentally sound, and economically sensible for Bangladesh, which now imports over 1.5 million tons (mt) of wheat annually. A 4-year Phase II project beginning some time in 1992 will provide WRC further support to consolidate progress thus far. Without such support, the gains made under the Bangladesh Wheat Research program might not be able to be supported by BARI. Also during Phase II, Bangladesh wheat scientists will conduct further research on the constraints in wheat production to increase yields on a sustained basis (e.g. resistance to spot blotch, soil fertility within rice-wheat rotations, and boron deficiency). To address sustainability questions, long-term trials may be initiated to study the rice-wheat rotation more thoroughly in cooperation with BRRI (Bangladesh Rice Research Institute).

## RESEARCH HIGHLIGHTS OF PHASE I

### Varietal Gains

There is no doubt that the wheat varietal impact using CIMMYT's genetic material has been pivotal to the successful entry of new varieties in Bangladesh. These varietal pedigrees reflect some of CIMMYT genetic backgrounds. However, Kanchan, a variety released in 1983 and with no known CIMMYT genetic background, remains the major variety currently grown in Bangladesh, offering resistance/tolerance to leaf rust and *Helminthosporium* leaf blotch. Its quick replacement of Sonalika, the preferred but leaf rust susceptible variety, shows that growers can adopt new varieties well. Recent surveys have shown that 89% of the growers use the newest released varieties, Kanchan and Akbar, compared to only 7% who use Sonalika (Saunders, 1991a). Growers gave the following reasons for their new adoptions: higher yield potential (65%), could not find seed of the preferred variety (20%), and Kanchan seed was locally available (12%). This rapid change and the reasons given also point to the efforts of CIMMYT and the WRC in effecting shifts in government policy. The WRC has had excellent relations with other governmental institutions and thus has been successful with its constant pressure on the government seed producers to exclude Sonalika and to produce more of the new varieties.

Results from agronomic experiments on the newly released varieties showed that most of the recent genetic gains were attributed to disease resistance/tolerance alone (Saunders, 1991b). Experiments that eliminated foliar disease incidence with foliar fungicides showed no yield difference between Sonalika (improved, but rust-susceptible) and Kanchan, while Akbar and Aghrani both outyielded Kanchan (Figure 3). Since many field studies have shown Kanchan to outyield Akbar and Aghrani, the latter two varieties are thought to have less disease resistance/tolerance than Kanchan. Thus, the possibility of genetic gains due to yield potential remains a challenge to the breeders of Bangladesh.

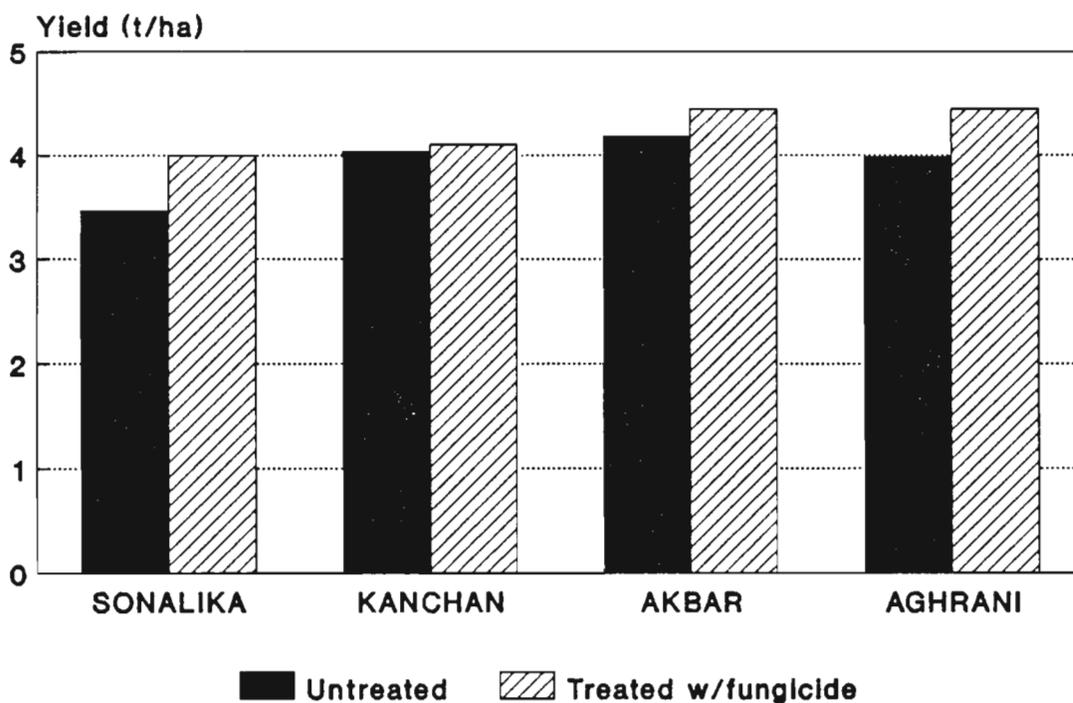


Figure 3. The response of the most common varieties to the control of foliar pathogens at optimum seeding date and management (Saunders, 1991b).

### Crop and Soil Management Research During Phase I

Over the years, crop management research has centered on:

- Determination of optimum planting time for newly released varieties.
- Obtaining proper plant stands.
- Identification of factors constraining yield.
- Fertilizer and management requirements for irrigated and nonirrigated areas under optimum and late planting conditions.
- Crop response to fertilizers.
- Improvement of tillage practices.
- Improvement of cropping patterns.

- Physiological approaches toward better crop management.
- Screening against stresses.
- Crop and soil management in relation to nutritional deficiency.
- Water and soil management in relation to crop growth.

Data reveal that seed rates higher than 120 kg/ha have no effect on yield, but that at lower rates, there are significant yield reductions. Previously, Bangladesh extension personnel routinely recommended higher seed rates to counter the effects of late planting. However, experiments conducted by WRC agronomists were able to discredit such recommendations, which has since saved some growers considerable money in useless extra seed costs for late planting. Unfortunately, some village extension officers still advise about a 150 kg ha<sup>-1</sup> seed rate. Experiments reveal that ideal seeding dates for the currently grown varieties to be Nov. 15 to Dec. 1 (Fig. 4). After the Dec. 1 seeding, the rate of potential yield loss is 1.3% per day.

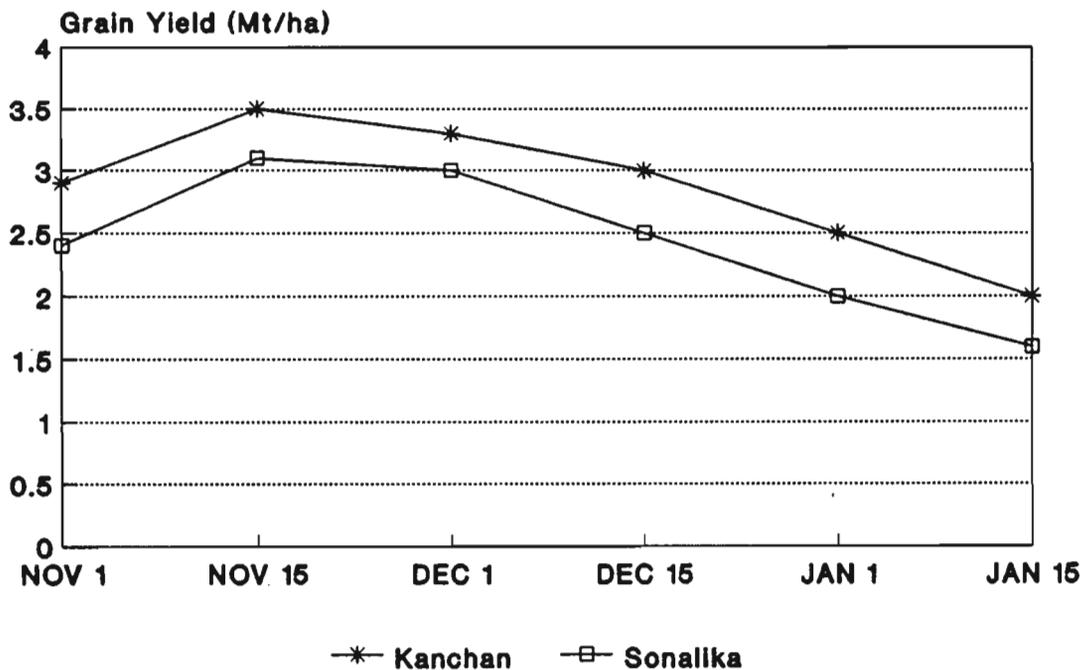


Figure 4. The effect of seeding date on wheat yields (t ha<sup>-1</sup>) in Bangladesh (means of 11 experiments over 4 sites and 3 years) (Saunders, 1988).

Yield constraints based on data collected during Phase I are summarized below:

- Foliar diseases reduce yield by 42% for Sonalika and 23% for Kanchan. The loss due to disease is highly variable between years (Saunders, 1990b, 1991b).
- Sub-optimal fertilizer use by growers results in yields 25 to 46% lower (depending on location and year than that possible utilizing the recommended fertilizer inputs) (Saunders, 1990b, 1991b).
- Late planted wheat yields are not affected by increasing the nitrogen application rate and did not have the same nitrogen response curves as optimum sown wheat. Thus growers are wasting money if they follow current recommendations which are not related to seeding date.
- Dependence on residual moisture alone reduces yield by 34% under low fertilizer inputs. Yet, yields under the same conditions with recommended inputs did not significantly differ from irrigated wheat with recommended inputs (Ahmed, et al., 1988).
- Irrigated wheat yields at growers' input levels were 37% higher than dryland wheat but at recommended fertilizer levels, yields did not significantly differ (Saunders, 1990b).
- Soil pathogens/soil insects reduce yields from 8 to 18% depending on the location and year of the experiment (Table 1). Research conducted on research stations showed that initial yield increases were as high as 18% but declined to 5.6% probably due to the stations' continued use of this treatment over all the farm.
- Seeding after the optimum date (Dec. 1) results in a potential yield loss of 1.3% day<sup>-1</sup> of delay of seeding, independent of fertility levels or seeding rates used (Fig. 4).
- Growers continue to plow their fields 5-8 times and ladder 8-9 times. These procedures require a great deal of time which causes growers in many years to plant after the optimum planting time. Numerous experiments have demonstrated that minimum tillage (one plow and one ladder) gives the same yield under low fertility conditions on all soil types. However, recent experiments provide evidence that at higher fertility, there is response to increased tillage (Saunders, 1988). Thus, minimum tillage will have to be weighed against attempting to plant during the optimum planting date.

## IMPACT OF CROP MANAGEMENT RESEARCH IN BANGLADESH

### Grower Demonstration Trials

In order to take experimental findings on research stations to the growers, up to 1,300 demonstration kits have been sown by growers each year throughout Bangladesh. These kits emphasize:

- Fertilizer usage (P, K, S, and B).
- Seed/soil treatment.
- Minimum tillage.
- Optimum management.
- Varietal trials for yield comparison.

The WRC provides these demonstration kits to the extension service which then identifies target growers in their respective districts. The kits contain all the necessary inputs to conduct on-farm demonstrative research. Once a management practice has been thoroughly investigated on research stations and found to be sound, the same, simplified experiment is applied through these demonstration kits to the growers, allowing the growers to decide for themselves. In 1989-90, average yields were 3.0 t ha<sup>-1</sup> for 760 on-farm demonstrations, all using the same recommended inputs (e.g. fertilizer, seed rates, fungicide seed treatment). However in the same year, growers with the optimum management demonstrations (using virtually the same inputs as other trials but in addition using recommended management such as tillage, planting date, irrigation dates, seeding depth, etc.) obtained yields of 5 to 6 t ha<sup>-1</sup> in their fields. The national average wheat yield in 1989-90 was 1.8 t ha<sup>-1</sup>.

Varietal demonstration trials have proven highly successful in the introduction of newly released varieties. For example, Kanchan, released in 1983 followed by Akbar and Aghrani were placed in these varietal demonstration kits each year. By 1991, surveys in Dinajpur showed that these varieties were adapted by 89% of the growers.

Experiments conducted in Phase I as demonstration trials revealed that soil fertility was a major yield constraint in growers' fields. In addition, various seed/soil treatment experiments showed that the use of Vitavax-200 or Furadan increased yield up to 12.7% in 1989 (Table 1) by sustaining high plant densities. Thus, the response of seed treatment in giving higher yields illustrates a complex of soil pest problems that will require further research. Results from 1990 and 1991 showed 5.2 and 5% increase, respectively. Phase II will emphasize more research into these and

other agronomic constraints affecting yields. Seed treatment, soil incorporated insecticide and minimum tillage were all introduced to farmers through these on-farm demonstrations.

**Table 1. The effect of seed treatment with Vitavax-200 on wheat yields in growers' field demonstrations, 1988-89 (means of 87 demonstrations) (Saunders, 1991a).**

	Sonalika		Kanchan	
	Irrigated	Nonirrigated	Irrigated	Nonirrigated
	kg ha <sup>-1</sup>			
Untreated	2880	2325	3300	2568
Treated	3245	2614	3666	2819
Yield Increase (%)	12.7	12.4	11.1	9.8

In the optimum management trials, the inputs were virtually the same as in the variety trials except cow dung was applied in the optimum management trial. Since all the trials were randomly selected by extension personnel, there was little bias between the selection of these trials. The addition of extra cow dung, based on previous studies, has been shown not to affect short-term wheat yields significantly, although its use is a recommended practice that growers generally follow. Thus, the yield differences between the variety Kanchan in the varietal trials and the optimum management demonstrations represent **recommended agronomic management practices alone** such as optimum planting date, seeding rates, seedbed preparation, irrigation, weeding and harvest time (Tables 2 and 3). Thus, the average 18% increase using the same inputs can be attributed to the use of recommended agronomic management. The research behind such recommended agronomic management requires experiments conducted over many years and over many locations. Thus, future research into constraints restricting higher yields in growers' fields appear to be concentrated around agronomic aspects of crop management.

**Table 2. The mean yield of Kanchan in optimum management demonstrations (1991) in 4 regions relative to its performance in varietal demonstrations (Saunders, 1991a).**

Region	Number of Demonstrations	Avg. Grain Yield (t ha <sup>-1</sup> ) for Optimum Management trials	Number of Demonstrations	Avg. Grain Yield (t ha <sup>-1</sup> ) for Varietal Demonstrations	% Yield Increase in Optimum Management trials compared to Variety Demonstrations
Rangpur	7	5.06	150	3.24	38
Rajshahi	5	3.88	180	3.65	6.3
Jessore	4	3.50	101	3.29	6.1
Dhaka	3	4.17	56	3.30	21.2

As seen in Tables 2 and 3, the possible agronomic impact through researched recommended practices clearly exists, although the impact over the 8-year presence of CIMMYT agronomists is not conclusive. Phase II research goals are to continue such demonstrations, work closely with extension personnel in order to transfer more of the research impacts to the growers' fields.

**Table 3. Highest yields obtained in the optimum management demonstrations by growers in their fields (Saunders, 1991a).**

Region	District	Upazila	Grain Yield (t ha <sup>-1</sup> )
Rangpur	Nilphamari	Sayedpur	6.60
Rangpur	Rangpur	Rangpur	6.29
Rangpur	Dinajpur	Birjol	6.25
Rajshahi	Rajshahi	Bagmara	5.50
Dhaka	Manikganj	Saturia	5.06
Rangpur	Dinajpur	Birgonj	5.00

### Grower Surveys in 1990 and 1991

CIMMYT has long been recognized for its on-farm diagnostic research and surveys and the development of such methodologies. Dr. David Saunders introduced such surveying techniques to the WRC and together, they have conducted surveys in 1990 and 1991. Results from these studies have clearly shown some advances in varietal adoption and growers' use of recommended agronomic practices in these survey areas. Table 4 summarizes these results. Although 2 years' data from two districts are not sufficient to determine any change over time in growers' adoption of recommended agronomic practices, it does provide comparative information. These two districts probably represent the two contrasting wheat environments within Bangladesh:

- Jessore which is heavily dependent on irrigation, but with slightly warmer temperatures during the wheat cycle and heavier soils.
- Dinajpur, which has less irrigation, but cooler temperatures, and lighter soils.

Virtually all growers sow seed at 150 kg ha<sup>-1</sup>, above the recommended rate of 100 to 120 kg ha<sup>-1</sup>, seed at the optimum time (or before) and apply close to the recommended quantities of phosphorus and potash. The exception was nitrogen-use strategies. Over 50% of the growers in the Jessore/Kushtia area appear to be applying more urea than necessary while about 30% are applying suboptimal rates. Furthermore, by the excessive splitting of urea (up to three top-dressings), growers are reducing the effectiveness of urea applications. In fact, the nitrogen use

efficiency (kilograms of grain per kilogram of additional nitrogen applied ) was only 75% of that obtained experimentally using the recommended nitrogen application strategy. Many growers (>25% in Dinajpur and 45% in Jessore/Kushtia) did not apply any nitrogen at seeding time. Research has shown this to be the worst possible strategy. Thus, more research is needed on the proper timing of N application to better utilize the amounts of fertilizer applied. Data collected from these surveys have introduced avenues of future WRC research and highlighted topics for further intensification of extension.

**Table 4. Comparison of some survey statistics in Dinajpur (1990) Jessore and Kushtia (1991) Districts (Saunders, 1990a, 1991a).**

Variables	Dinajpur (1990)	Jessore/Kushtia (1991)
Mean Wheat Yield (t ha <sup>-1</sup> )	2.45	3.04
Mean Farm Size (ha)	2.00	1.98
Mean Wheat Area Farm <sup>-1</sup> (ha)	0.37	0.36
Irrigation (% growers using on wheat)	67	90
Mean Rice Yield (t ha <sup>-1</sup> )(Spring-Planted)	2.39	2.27
Mean Rice Yield (t ha <sup>-1</sup> )(Summer-Trans.)	3.20	4.31
Percent growers using number of irrigations:		
-one time	28	9
-two times	43	34
-three times	28	38
-four times	1	8
Varieties (% growers usage):		
Kanchan	46	63
Akbar	2	26
Sonalika	50	7
Others	2	4
Mean Inputs for Wheat:		
Urea (kg ha <sup>-1</sup> )	139	222
TSP (kg ha <sup>-1</sup> )	118	133
MP (kg ha <sup>-1</sup> )	42	44
Cow dung (t ha <sup>-1</sup> )	5.3	10.5

Results from the 1991 survey illustrates the growing awareness of growers to utilize more fertilizer as well as more kinds of fertilizer to replenish the nutrients extracted by crop removal. The use of fertilizer has increased in the past decade although it has been difficult to ascertain how much is used for wheat compared to rice except over the past two years when surveys were completed (Figure 5).

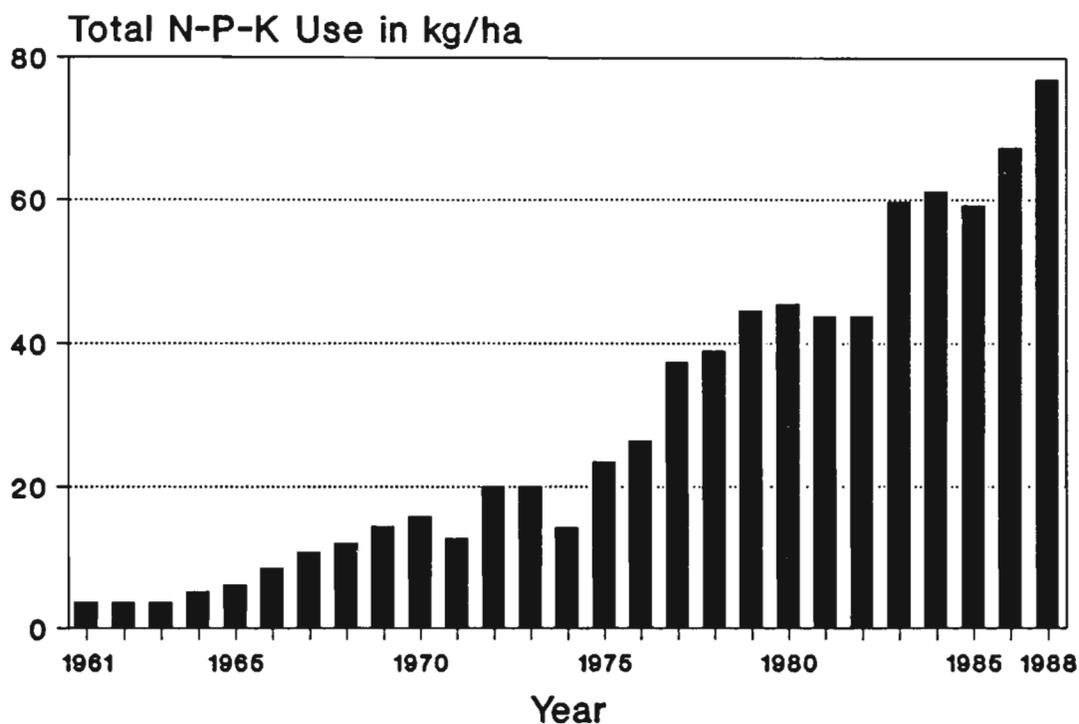


Figure 5. Fertilizer usage trends in Bangladesh (FAO Fertilizer Yearbook, 1989).

## CONCLUSION

There is no doubt that technology has been developed to substantially increase wheat yields in Bangladesh. From grower surveys, it has become apparent that growers do not perceive any substantial problems with wheat production apart from a shortage of cash or lack of credit facilities to purchase additional inputs. In recent years, the distribution of agricultural inputs has been opened to the private sector and these merchants will supply these inputs on credit (albeit at a high cost). Growers are utilizing this facility and are increasing their use of inputs. With increased attention to sensitizing the growers to technical advances, the research findings of wheat crop management should soon be reflected in the national wheat production.

## ACKNOWLEDGMENTS

This publication represents the data from many Bangladesh scientists who have worked many years, some all of their lives, to further wheat research as a tool to alleviate the poverty and hunger sometimes found in Bangladesh. Special thanks go to Dr. David Saunders for assembling the data into publications which will prove useful for many years.

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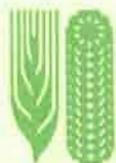
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