

**Report of a Trip to visit rice-on-beds and various establishment techniques in rice in Bangladesh and India
(18-31 August, 2001)**

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Objectives of visit:

1. To monitor and oversee the research activities under the ACIAR project #94/032, "Nutrient and irrigation management for sustainable rice-wheat cropping systems in Bangladesh and Australia"
2. To facilitate the further development and refinement of the new ACIAR Project #LWR2/2000/89, "Permanent raised-bed systems for sustainable rice-wheat and alternative cropping systems for NW India and SE Australia" at Punjab Agriculture University (PAU), Ludhiana. The project has been developed and finalised by PAU, CSIRO, and the UM.
3. To visit experiments on rice-on-beds and various establishment techniques in rice in the research stations and farmers' fields in Bangladesh and India

This Report includes my observations and experiences related to Objective #3 only.

Program:

Arrive Dhaka: 18 August

Visits to Nashipur, Rajshahi, Ishurdi, and Joydebpur: 19-23 August

Leave Dhaka and arrive Delhi: 24 August

Visit to Punjab (Ludhiana, Jalandhar): 25-27 August

Visit to Haryana (Karnal, Kathyal): 28-29 August

Visit to U.P. (Ghaziabad, Meerut): 30 August

Leave Delhi and arrive Melbourne: 31 August

Bangladesh (18-24 August)

I, together with Dr. M.A. Quayyum, PI (BARI Component) of ACIAR Project #94/032, left Joydebpur at 8:30 am on 19 August for north and NW parts of Bangladesh (Nashipur, Rajshahi, Ishwardi). We took the ACIAR Vehicle donated to BARI under that Project. With the encouragement and guidance of Craig Meisner and through initiatives of CIMMYT, RWC, and Cornell University, the BARI and BRRI researchers have started experiments on raised beds in rice-wheat-mungbean systems at Nashipur, Rajshahi, and Joydebpur since last year.

Nashipur:

Though Dr. Sakwat, Director, Wheat Research Centre (WRC), had a demonstration trial on wheat on raised beds formed by Chinese seed drill during the wheat season in 1999-2000, full-fledged replicated experiments on raised beds, made manually, were started from the wheat season in 2000-2001 only. The experiment is on a sandy loam soil, and was being conducted by Dr. Suphian and Mr. Talukdar, in wheat season 2000-2001, mungbean season 2001, and currently on transplanted rice (TPR). Suphian says both wheat and mungbean were pretty good, or even better, on beds than on flats. The experiment on wheat consisted of 2 cultivation methods (raised beds and conventional), 2 N placement methods (broadcast and between rows), and 3 N levels (50, 100, and 150 kg/ha) for Cv. Protiva. Mean yield of bed-planted treatments was 3.34 t/ha as compared to mean yield (2.85 t/ha) of conventional treatments, with greatest grain yield (3.5 t/ha) from wheat sown on beds with 150 kg N.

In the current experiment, two-week old rice seedlings were transplanted on 12 July in two rows per bed (8 rows per plot), made manually before the sowing of wheat in 2001, but those beds were reshaped before the planting of mungbean and rice crops. The conventional system of growing rice on puddled soil on flats had 15 rows of rice per plot, seven rows greater than on beds. This sandy soil has huge percolation rate, and hence, unsurprisingly, the plot required irrigation for rice almost every day, with more time required for irrigation on flats than on beds. I noted that the vegetative growth of rice on beds in this soil at this location was much poorer than on the flats (observed on 19th August), but later in the reproductive stage it could be otherwise.

Rajshahi:

At this site, work on raised beds was started from the rice season in 2000, with beds made manually. The experiment is on a clay loam soil, which can retain water more than the soil at Nashipur. Mr. Ilias Hossain (BARI, Rajshahi) is the In-charge of this experiment, jointly collaborating with Dr. Mazid (BRRI, Rajshahi). Ilias compared dry-seeded rice (DSR) vs. TPR and 2 rows vs. 3 rows on raised beds and on flats and found 2 rows better than 3 rows last year. In the first bed-planted wheat, he noted significant savings in irrigation water (he says incredible savings of 67% but needs to be confirmed). I saw photographs of rice-on-beds 2000 and mungbean-on-beds 2001, and both crops looked pretty good.

This year, the 35-day old seedlings of rice were transplanted on non-puddled soil on beds as well as on flats on 20 July, and as at Nashipur, there were 8 rows per plot (2 rows /bed; 30 cm between rows) on beds vs. 15 rows per plot on flats. By 20 August (the day I visited), the crop, since transplanting, was irrigated only 3 times compared to every day irrigation required for light (sandy) soils at Nashipur. The third irrigation was on the day I visited, and the fields were full of water over beds and furrows. Such over-irrigation could damage the beds, aggravate leaching and seepage between the sub-plots that had different N treatments, and would not have any more advantage in terms of water-use efficiency. I have explained this to Ilias. I noted the rice growth on beds at this soil on this location was better than in the sandy soil at Nashipur.

At the same location, across the street, Dr. Mazid (BRRI) has also started bed planting in rice-wheat-mungbean systems this year. He has now established TPR on beds formed using bed-former attached to power tiller (12 hp), but the experiment has been laid such that there will be DSR/TPR and N management treatments next year.

Joydebpur:

Dr. Rezaul Karim (Rice Farming Systems, BRRI) started work on raised beds from wheat season of 2000-2001 on a heavy clay soil. He compared 3 seed rates (60, 90, and 120 kg/ha) and 4 fertilizer rates (0, 50, 75, and 100 kg/ha) on wheat sown on beds and on flats, and found much greater yields on beds than flats. He also observed better growth and obtained greater yields of mungbean on beds than on flats.

The current rice was directly sown under cultivated unpuddled but moist soil on 16 July, with 80 kg/ha seed rate. The beds, as in other sites, were made manually, and 4 cultivars (BR30, BR31, BR32, and BR39) of rice were tested on both beds and flats. Rice seeds were sown at 20cm distance between rows, with 10 rows/plot on beds and 16 rows/plot on flats. Fertilizer was applied between rows. Weeds were fully controlled. Crop was rainfed, but the intermittent and frequent small rain at Joydebpur kept soil most of the time under saturation on both flats and beds. At this site, growth of rice on beds was much better (more vigorous, more tillers, more greenish) on beds than on flats. Overall, management of experiment was quite good at this site.

Clearly, performance of rice-on-beds depended on soil type, with better performance on heavier soils (Joydebpur) than on lighter soils (Nashipur).

Researchers at all sites were aware of high costs required for making beds manually, and Mr. Israil Hossain (Engineer) at WRC, Nashipur, has now modified a machine that can now form 2 beds/pass with 2 rows/bed.

There are two other experiments at BRRI (Mondal and Sattar, Water Management) aiming at saving water in rice. Both experiments, under rainfed, aim to conserve rainwater through dykes. One experiment compares boro-T.aman and Aus-T.aman-rabi (non-rice) cropping patterns, while the other compares 3 water management treatments (rainfed, one irrigation at PI, and two irrigations at maximum tillering and at PI) for wet-seeded rice

(WSR) and TPR. Both experiments were quite impressive and did not require any extra irrigation water due to maintenance of dykes, and rainfed treatment looked as good as the other two irrigated treatments, and WSR looked better than TPR due to timely sowing.

India (25-30 August):

Punjab:

In Punjab, I was accompanied by Dr. S.S. Dhillon, Senior Agronomist, and Dr. Y. Singh, Senior Soil Chemist at PAU. Drs. Dhillon and Singh, respectively, are the Project Leader (and PI) and the Co-PI of the new ACIAR Project at PAU. I visited the following sites/experiments in Punjab:

1. An experiment on rice-on-beds at PAU Farm conducted by Dr. Dhillon: The rice was sown by bed planter on a one-season old bed on a sandy loam soil where wheat was sown previously. The top soil at the site consisted of mainly sands until 2 years ago, but those sands from the top 1 ft soil were removed before the start of the experiment from wheat season in 2000. After harvest of wheat, the beds were reshaped. Two rice establishment techniques (DSR and TPR) were used each on non-puddled fresh beds (started from rice), non-puddled old beds (previously wheat-on-beds), and on flats and puddled soil. Since it was the first rice crop in this sandy soil, there was huge Fe deficiency at the initial stage of the crop, especially in the DSR, which was corrected by providing irrigation daily for first 20 days and by applying FeSO_4 . Afterwards, irrigation was applied every 3 or 4 days.

2. Another experiment, adjacent to the previous experiment, on maize-wheat on beds on a sandy loam soil. The experiment started from wheat season in 1999-2000 and hence there were 3 crops (2 wheat and one maize) prior to the current maize crop. The experiment compares 3 levels of N (120, 150, and 180 kg/ha) for wheat and maize planted with 3 soil management techniques (fresh beds made before each crop, permanent beds but reshaped before sowing, reduced tillage with little furrows open for sowing on flats, conventional tillage on flats). Grain yield and crop biomass have been collected over the seasons, which are yet to be summarised, but it is also important that, in addition to yield, such experiment monitors relevant soil physical and chemical properties in fresh beds as well as in permanent beds.

3. Dr. Dhillon also has a new experiment on cotton-wheat on raised beds at PAU FARM.

4. Dr. Yadvinder Singh's experiments: There is an experiment on a loamy sand and a sandy loam, sown to rice on 15 June, using latest rice Cv. PR 116 at PAU Farm. The treatments included: 1. TPR on puddled flat beds, 2. WSR on puddled flat beds, 3. DSR on flat beds, 4. TPR on raised beds (two rows per bed), and 5. DSR on raised beds. Polymer coated urea (obtained from Japan) applied at 90 kg N/ha (whole placed manually at sowing/transplanting) was also evaluated in rice on beds, and a no N control treatment was included under all the 5 methods of rice planting.

Heavy rain on 17 June flooded the field and reduced seed germination in direct seeded treatments. Observations on 26 August (the day I visited) indicated that rice transplanted on beds had as good stand and as good crop growth as that in conventional systems. However, rice on beds on the loamy sand had poorer growth than on the sandy loam. Polymer coated urea showed good promise in terms of crop stand. Iron deficiency appeared in two small patches on loamy sand only in DSR both on raised beds as well as on flats.

Yadvinder also has another experiment on nitrogen management in WSR, also on a sandy loam soil, also at PAU Farm. The treatments included: 4 levels of N as urea (0, 80, 120, 160 kg N/ha) and three levels of N as polymer coated urea and N using chlorophyll meter. DSR showed response to N up to 120 kg/ha. Rice under Polymer coated urea at 90 kg N/ha and urea at 120 kg N/ha looked similar.

In both sandy loam and loamy sands, the beds were a bit flattened, with more flattening on loamy sands than on the sand loamss. This indicates some difficulties in maintaining beds in the loamy sands, but if beds were made prior to wheat and were reshaped before rice sowing/transplanting, they would stabilize by then and would have less chances of flattening.

5. Visited a farmer's field (Farmer: Daler Singh) where rice was transplanted on new beds on non-puddled loam soil on 18 acres at Ladhawal Vilage (~10 km) near Ludhiana. I had visited this farmer and his farm during rice season last year and also during wheat season in early April this year. Last year, he had grown TPR on beds on 6 acres, followed by wheat on several acres. He did not transplant rice on old beds this year. The 18-acres of TPR on beds looked as good as those on the flats in the vicinity.

6. Visited a farmer's field (Farmer: S. Bahadur Singh) at Indrica Village in Jalandhar District (~30 km NW of Ludhiana). While I was there (27th August), there were also other 20 farmers, who were visiting this field together with Dr. S.K. Nagrath, Project Director, ATMA-NATP Project. With the encouragement of Dr. Nagrath, the farmer has started testing DSR on flats, and TPR on flats and on the lower parts of the shoulders of beds (Nagrath and the farmer prefer to call transplanting in furrows rather than transplanting in beds) on 1-acre field on a non-puddled sandy loam soil this year. These 3 treatments were sown/transplanted on the same day, and the fourth treatment (also TPR on flats) was transplanted after 25 days. The testing of these 4 treatments on non-puddled soil is also underway at 9 other locations in Jalandhar. At the Indrica Village, this farmer has also planted rice on shoulders of the beds (rather ridges in this case since they were much narrower) on another 15 acres field on a loam soil. Ridges were made by sugarcane transplanter, and both ridges as well as furrows were much narrower than the beds and furrows made by bed planters elsewhere in the region.

At this site also, after frequent irrigation, ridges/beds were almost flattened on the loamy sands but were less flattened on the sandy loams. While the yield measurements have still

to be made, both Nagrath and the farmer claim that, in terms of timing, there is huge savings of water on beds compared to those on flats.

This is the case that demonstrates variations among bed-planting systems, and how farmers adapt to new systems as per their soils and circumstances.

Haryana:

In Haryana, I was accompanied by Dr. S.S. Dhillon and Dr. Samar Singh (Agronomist, HAU, Uchani, Karnal). Dr. Samar Singh is very good field-level agronomist and recently returned from CIMMYT, Mexico, after spending 5 weeks with Ken Sayre. I had visited Dr. Singh's DSR on beds at Uchani Station last year also. In Haryana, I visited the following sites/experiments:

1. An experiment on "Demonstration on different crop establishment techniques in rice" at Uchani Station in Karnal. The soil is sandy loam and rice cultivar used was HKR-126. Treatments included: 1. Puddling and TPR, 2. Puddling and broadcasting of sprouted seeds (WSR), 3. DSR with seed drill, 4. DSR on permanent beds (one-yr. old) with bed planter, 5. TPR on non-puddled permanent beds (one-yr. old), 6. DSR on fresh beds, and 7. TPR on non-puddled soil on fresh beds.

2. Another experiment on "Evaluation of different crop establishment techniques and herbicides for weed control in rice" at Uchani. The rice cultivar was IR64, transplanted 33-d old seedlings on 7 July. The treatments included: Crop establishment techniques (1. zero tillage (ZT)-transplanting, 2. puddled-broadcasting of sprouted seeds (WSR), 3. ZT-broadcasting of sprouted seeds, and, 4. puddled-transplanting) in main plots, and 6 weed control treatments (1. weedy check, 2. weed free, 3. pretilachlor with Safener at 0.75 kg/ha as pre-emergence, 4. pretilachlor with Safener at 0.75 kg/ha as pre-emergence, fb hand weeding at 45 DAS, 5. Cyhalofop at 120 g/ha at 10 DAS, and 6. Cyhalofop at 120 g/ha at 10 DAS fb hand weeding at 45 DAS) in sub-plots.

Farmers' field demonstrations on crop establishment treatments (the four above treatments plus ZT-DSR) are also being conducted at six locations in Haryana (Teek and Ferozpur Villages in Kaithal District, and Nangla and Laloda Villages in Fatehabad District). I visited the demonstration plot at Teek Village (~65 km from Uchani) which is on clay loam soil.

3. Visited a 1-acre demonstration plot on DSR on loamy sand at Kulvehri Village (~10 km from Uchani) in Karnal (Farmer: Bhavneet Kalyana). The cultivar used was HKR-120 and seeds were sown on 3rd June. Sofit @0.75kg a.i./ha was used as pre-emergence herbicide and Almix was used to control broad-leaf weeds in DSR.

Surprisingly, in all of the above demonstrations, the WSR and ZT DSR treatments looked as good as the conventional puddled TPR treatment, but careful measurements of growth and water and nutrients in somewhat controlled replicated experiments, but still in the farmers' fields, needs to be done before making sound conclusions and recommendations.

4. Visited the farm of Sh. Jagvir Maan at Ghogaripur Village (~15 km from Uchani) in Karnal. I had visited this farmer last year also. He had TPR on beds on 1-acre land at the same site and harvested 8.3 t/ha on beds as compared to 7.0 t/ha on conventional puddled systems. He also had several acres of wheat on beds last season. This year, he has TPR grown to Cv. PA-6111 (hybrid) on 21 acres on beds on sandy loam to loam soils. The fields were previously grown to wheat-on-beds, and after harvest of wheat, he incorporated all wheat residues in the field. He also incorporated rice residues before sowing wheat last year. Weeds were controlled once manually and once by applying Oxadiargyl. He says both numbers and duration of irrigation in the current crop were more under conventional puddled conditions, and that about 48% of water (in terms of timing) was being saved on beds compared to that on flats. I visited about 25% of the total area, and rice on beds looked excellent. From the standing crops, it looked that it could yield as much as, or even more than, that on the flats, but definitely there was saving of water, and in long-run there would be improvement in soil structure and probably many other benefits. Certainly, this was an excellent site where TPR on raised beds has been successfully grown.

Delhi:

Visited the experiment of Dr. A.K. Singh, Director, Water Technology Centre (WTC), Indian Agriculture Research Institute (IARI). Dr. Singh is collaborating with Bas Bouman at IRRI. The experiment is being conducted on a sandy loam to loam soil, not a very typical rice soil. The experiment has 7 treatments: 1, DSR- flats (non-stressed); 2, WSR- flats (non-stressed); 3-5, DSR- raised beds- 2 rows, with 3 treatments (i. irrigation at 0.2 kPa or at alternate days; ii. irrigation at 0.4 kPa or every 3 days; and iii. non-stressed); 6, DSR (same geometry as for raised bed, i.e., 2 rows on flat, fb gaps, again 2 rows on flat, fb gaps, etc.)- non-stressed; 7, TPR-conventional. The unsaturated treatments (0.2 and 0.4 kPa) had severe Fe deficiency problems, but now after continuous application of FeSO_4 , it has started to recover. Amount of water inflow was measured using water meters. Access tubes and infiltrometers were installed to measure moisture content and percolation rates. Mercury tensiometers were installed at 3 depths to measure soil matric potential and to guide water application. DSR and WSR on flats were doing as good as TPR.

Dr. Singh plans to grow wheat after rice in the coming season, but next year, he will change the site, with typical rice soil.

Uttar Pradesh (UP):

In UP, I visited the sites/experiments in Meerut and Ghaziabad. In Meerut, Dr. P.K. Sharma, newly-recruited Research Scientist by CIMMYT under the ADB Project, briefed me about his experiment. Drs. R.K. Naresh and Vivek, Agronomists, SVBPUA&T, Meerut, were also with me. In Ghaziabad, I was accompanied by Drs. Naresh and Y. Singh, Senior Agronomist, Pantnagar University.

Meerut:

Dr. Sharma, who works closely with scientists of CIMMYT, IRRI, and the SVBPUA&T, has started a large experiment from this rice season with many sensible treatments comparing performance of rice on beds and flats, and associated soil physics and N dynamics. Two cultivars (inbred PR 106 and hybrid Pro-Agro 6111) have been tested on a silty loam soil. The treatments included: 1, Conventional puddled TPR fb wheat new and well-pulverised beds; 2, DSR on permanent beds, irrigation at -10kPa matric potential at 20 cm soil depth in middle of the bed (or irrigation every alternate day) fb wheat with minimum tillage; 3, Same as #2 above, but irrigation at -20kPa matric potential at 20 cm soil depth in middle of the bed (or irrigation almost every 3 days) fb wheat with minimum tillage; 4, DSR on flats, irrigation as on #2 above; 5, Same as #4, but irrigation at #3 above; and 6, DSR on flats, but spacing of 20*47*20cm, irrigation at -10 kPa matric potential. Permeameters have been installed for measuring permeability, water meters for water inflow, infiltrometers for percolation and for seepage and percolation, tensiometers for measuring soil matric potential and to guide water application, and gravimetric methods for measuring soil moisture contents. Iron deficiency was observed at this site too. Dr. Sharma imposed treatments immediately after sowing of DSR, so the seeds did not germinate in unsaturated treatments (-10 and -20 kPa), and those that germinated were water-stressed. He then continuously flooded all treatments, and now the plants started to recover even in the unsaturated treatments. Cracks were developed on the bed surface but not on the furrows and on flats. The initial observations reveal that under non-flooded aerobic-anaerobic conditions on beds, hybrid rice (Pro Agro 6111) appears to perform better than the inbred cultivar (PR 106), the difference between the two narrows when sown as TPR. Initial flooding of beds for few days (15-20 days) appears essential for obtaining proper crop stand of DSR on beds as well as on flats. As has also been observed elsewhere, weed infestation was the major problem in DSR on beds as well as on flats.

Ghaziabad:

Dr. Naresh, under the guidance of Dr. Raj Gupta, has been maintaining wheat and rice on beds over the past 2 years at several farmers' fields at Ghaziabad. I had visited the rice-on-beds last year and wheat-on-beds last season also.

Naresh says that there are 140 acres of rice-on-beds and 40 acres of DSR on flats at Ghaziabad this year. There were 4000 acres of wheat under ZT last season, which is expected to increase to 30,000 acres this coming season.

1. Visited a 1.5 acre rice (cv. PR106) on new beds on a sandy loam soil at Kazipura Village. The field was plowed once and ZT seed drill was used for sowing. There was also some area with controlled-traffic lanes maintained by blocking one row on each side of the Pantnagar seed drill, and also some area with paired rows of wheat on beds. Pendimethalene and Almix were used to control weeds. This demonstration is in many other locations in the District.
2. Visited another site at Bayani Village, where DSR (1 acre) was sown on 9 June on old beds previously sown to wheat on a silty loam soil. The site also has TPR on new beds on

one acre and also TPR after one plowing and without puddling on 0.5 acre (sowing on 9 June and transplanting on 9 July). Butachlor was used just after transplanting to control weeds on TPR. The plots were excellent, with no pests and diseases. This demonstration is also there in many other locations in the District.

3. Visited a DSR crop on new beds on 4 acres on a loamy soil. The cultivar was Pant 12 and seeds were sown on 10 June. Adjacent to that field was ZT DSR sown by seed drill on 1.5 acre on flats. An excellent crop. Also, there was a demonstration trial on TPR planted conventionally and on beds. Cracks were developed on furrows, but not on beds.

4. Visited another 1.5 acre rice-on-beds on a silty loam soil at Kallugari Village. The site had rice and wheat on beds in the last two seasons, and after the harvest of wheat, the land was laser-leveled, and rice was transplanted on 1 July on newly-formed beds. Butachlor was applied just after transplanting, and the crop was excellent, with full canopy cover on beds. Thus, though many researchers and farmers show concerns that there would be yield loss due to large spaces in furrows, it now becomes clear that there would be no such loss. It would, however, depend on soil type and crop management.

5. Visited the farm of Pradip Singh, who has been growing rice and wheat on beds over the past 2 years. I had visited his farm during rice season last year and also during wheat season this year. He has planted DSR on new as well as old beds. He has four cultivars of rice, sown directly, each with 22 rows, on new beds, on a clay loam soil, on one-acre area previously grown to zero-tilled wheat. There were cultivar differences on beds. Adjacent to that is sown to ZT DSR on 1 June, the previous crop being mustard. There is another 1-acre field on DSR on new beds. The field was previously sown to wheat-on-beds, but was laser-leveled before sowing rice on beds. There is 1-acre field where permanent beds have been maintained since rice season 2000. Farmer sprayed Roundup as the pre-emergence herbicide and the field was very clean. From my observations at this site as well as in some other farmers' fields, it seems that there are more earthworms and other biological activities on permanent beds than on the flats. During the last wheat season, I had observed long, continuous cracks on furrows and increased soil strength on the bed surface, but now there were no cracks on beds and furrows, and no increased soil strength on the bed surface. Adjacent to this site is a 2-acres land where rice is transplanted after one plowing on non-puddled soil.

6. Also visited a block of 1 acre with pigeonpea on beds, but Naresh says four other sites (1 acre each) also have pigeonpea on beds. There are also other crops (blackgram, cabbage, and radish) on beds at various locations in the district.

Conclusion:

Clearly, interest on research on rice-on-beds is increasing in Bangladesh and India, and quite a few farmers are already showing interest to grow rice-on-beds in India. While testing of rice and wheat and other crops on raised beds in both research stations and farmers' fields needs to be continued, understanding, measuring, and modelling the bio-physical and chemical processes becomes extremely important to identify the suitable

niches/soils and management practices and to extrapolate the raised-bed technologies for rice-wheat systems in the Indo-Gangetic Plains (IGP). Such work now has been started at least in WTC and Meerut. The new ACIAR Project, to be commenced from January 2002, aims to conduct experiments across 3 soil types (sandy loam to silty clay loam) in Punjab (both in PAU Farm and in farmers' fields). The Project will focus on measurements of crop physiological and soil physical and chemical aspects and modeling for rice-wheat systems on raised beds as well as on flats, and thus will complement the on-going research activities on raised beds in the IGP.

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