CROP PROTECTION PROGRAMME

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Contents

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Executive Summary

Project Purpose: This was the same as for work undertaken from 2002 to 2005 by project R8234 of which the current project was a 10 month extension. Activities were designed to develop and promote strategies for the management of weeds in lowland rice systems in Bangladesh.

Research outputs: A further set of on-farm demonstrations of improved weed management practices was implemented in the intensive *aus-aman-boro* system in Comilla district. A total of 332 demonstrations have now been undertaken in four upazillas (administrative areas) of the district since 2003. A set of on-farm trials showed that herbicide use is practical and effective in the rain-fed *aus* season (pre-monsoon) as well as in the *aman* (monsoon season) and irrigated *boro* season as had previously been shown. Findings from the project were compiled into a manual describing the major weeds and weed management options. Training courses were run for district and village level extension staff and lead farmers to increase the capability of the Department of Agricultural Extension and disseminate project findings in Comilla. Farmer groups evaluated rice dry direct-seeding (using a locally made *lithao*) and wet-seeding (using a drum seeder) as alternatives to transplanting in *aman-rabi* (post-rice crop) system in the High Barind Tract. Both options, with use of a pre-emergence herbicide, were found by farmers to be feasible on a field scale. Direct seeding was shown to be effective with the long duration cultivars that are widely grown. Yields were at least as good as when transplanting but direct seeding is labour-saving and therefore low-cost. An adaptation to the system was demonstrated. Broadcasting dry seed over planting “lines” (furrows) opened by the *lithao*, and subsequently covering seed with a ladder, reduces labour for crop establishment further. R8512 confirmed that farmers decide to use direct seeding in place of transplanting primarily because of the advantages it gives for rice. The main incentive for adoption was that direct seeding reduced costs for rice. Direct seeding reduced field duration of the rice crop and because it is conducted a month earlier than transplanting it advanced the harvest date so that terminal drought can be avoided in years when there is an abrupt end to the monsoon during the usual period of grain filling. A study of farmer decisions confirmed that the main reason why land was kept fallow in the *rabi* season was that there was insufficient soil moisture at rice harvest for *rabi* cropping. Hence, the decision-tree confirms the importance of direct seeding to allow earlier harvest of *aman* rice so that crops including chickpea can be planted on time. A series of leaflets summarising the knowledge that farmers need to undertake direct seeding were produced and a training course was run for extension officers and NGO staff in three districts of the High Barind Tract.

Contribution of Outputs to developmental impact

Previous research by the project team had highlighted the growing competition for and rising costs of labour for weeding in *aus-aman-boro* in Comilla district. When CPP funded work on weed management in rice began in Bangladesh in 2000 few farmers had knowledge of herbicide use in Comilla. Extension materials produced and training courses and demonstrations implemented by R7471, R8234 and R8512 have contributed to the increased acceptance in the farming community that herbicides allow a reduction in production costs, proving effective and profitable in rainfed aus, *aman* and irrigated *boro* rice. Yields may also be maintained by use of a push weeder but with higher labour inputs. Yield gains observed on-farm from improved weed management are of the order of previously recorded yield losses due to weeds with existing farmer management. Farmers in the two villages where the project team has been working since 2000 estimated that by 2005 herbicides had been adopted by 40-50% of rice growers in *boro*, and 30 to 35% in both *aus* and *aman*. There are now more than 30 products available on the rice herbicide market in Bangladesh, compared to four in 2000. Extension material produced by R8512 adds to the training tools previously prepared to ensure that both extension workers and farmers have access to the knowledge needed to handle and apply herbicides safely and profitably.

Farmer groups in Godagari upazilla in the High Barind tract moved direct seeding with appropriate herbicide use from small trial plots to field-scale implementation during 2005. These are the first steps in the evolution of dry direct seeding from being a “research

technology" to adoption as a "farmer practice". Dry and wet-seeding are low-cost, low labour input methods that resource poor households can use to optimise rice yield through timely planting and ensure a post-rice *rabi* crop is planted on time. The challenge identified by the CPP projects was to increase productivity of *aman* rice while at the same time enhancing system productivity by more reliable *rabi* cropping. Farmers are now showing that this can be achieved. Direct seeding with herbicide use is knowledge intensive. Extension leaflets produced, workshop presentations and training undertaken by R8512 provide the knowledge that farmers need to use the technology effectively.

Background

It has been projected that paddy production in Bangladesh will need to increase from the current level of 22 million to 50 million tons by 2020 (Hossain, 2002[1]). With 65% of the area planted to rice already under High Yielding Varieties, future increases in production will depend heavily on improvements in the efficiency of production, such as weed control, contributing to maintaining low rice prices that will remain vital for poor consumers.

The Bangladesh Rice Research Institute, International Rice Research Institute and Natural Resources Institute In collaboration with NGOs and the Department of Agricultural Extension as research partners in projects R7471 and R8234 (1999 to 2005), developed and promoted a range of sustainable weed management options for rice in Bangladesh. This work has improved understanding of the agronomic, technical and socio-economic opportunities for productivity gains in two widespread rice-based systems in Bangladesh. These are: a) labour-efficient weed management facilitating the introduction of direct seeding of rice in rain-fed *aman-fallow or aman-rabi* (monsoon and post-rice seasons found on 1.4 million ha) and, b) improved weed management practices for intensive transplanted *aman – boro* rice systems (monsoon and irrigated seasons found on 2 million ha).

Key findings of this research reported in the FTR for project R8234[2] were:

- The high cost of weeds and manual weed control. In *aman,* 30% of farmers lose at least 500 kg ha^{-1} rice at yield levels of 2.5 to 3.5 t ha^{-1} with current crop management practices. To reduce costs, farmers are adopting herbicides, particularly in intensive rice-rice systems.
- On-farm trials have shown herbicide use to be a robust, effective and profitable technology under various water management scenarios in both *aman* and *boro*. Herbicide use has been demonstrated in transplanted rice in collaboration with DAE in four upazillas (local government areas) in Comilla District (S.E Bangladesh) and at 100 sites across three districts in the Barind Tract (N.W Bangladesh).
- Pre-emergence application of herbicide resulted in *aman* rice yields under direct seeding as good as or better than from transplanting in four seasons of replicated trials in the Barind. In 2003, yields of one improved and one widely grown local cultivar from direct seeding were equivalent to those from transplanting in on-farm trials.
- Direct seeding can improve total productivity in the rice-*rabi* system by advancing the date of crop establishment and allowing earlier planting of *rabi* crops (chickpea, linseed etc) on residual moisture after rice harvest. Farmer evaluation of direct seeding across 70 sites is currently underway and results will be available after harvest in October 2004.
- Monitoring of weed responses over the past four years indicates likely shifts in species abundance with change in management practices, including increased abundance of difficult to control grasses and sedges. These changes and appropriate management responses need to be communicated to farmers.
- Herbicide promotion by the private sector in selected districts resulted in sales increasing by 43% between 2002 and 2003. Both farmers and extension workers need information about safe and profitable herbicide use and on the integration of herbicides with cultural practices.
- R8234 has collaborated with the NGO SAFE, funded by a PETRRA sub-project, to examine a partnership between the NGO and the herbicide manufacturer Syngenta, resulting in the preparation of a training manual on herbicide use to be distributed to all upazilla agricultural offices in Bangladesh. The project has also raised awareness of information issues in the private sector by a seminar and discussions with 9 companies selling herbicides.

[1] Hosssain, M. (2000) Recent Development and Structural Changes in Bangladesh Agriculture: Issues for Reviewing Strategies and Policies. *Dialogue on Bangladesh Agriculture at the Crossroads: Current Challenges.* July 15, Hotel Sonargaon, Dhaka. Mimeo, 18 pp

[2] Riches C. R (2005) Promotion of cost-effective weed management practices for lowland rice in Bangladesh. Final Technical Report, project R8234. Chatham, UK: Natural Resources Institute.

- A poster covering key issues on safe and efficient use of herbicides has been prepared for distribution and display in pesticide dealers stores throughout Comilla District.
- Socio-economic studies have revealed important differences in the Barind Tract between large (5 acres) and small farms (1acre) in (a) timeliness of weeding (b) availability of labour for weeding and, in the Barind (c) cultivation of *rabi* crops.

By the end of the 2004 monsoon season the advantages of direct seeding in the High Barind Tract had been demonstrated on a few field plots but questions remained as to the most effective method for implementing the technology on a farm-scale. A 10-month extension to the project was therefore agreed by CPP to evaluate the field-scale mechanisation of direct seeding. Work during this period would also bring together previous findings into decision support tools and media to inform policy makers, extension providers and farmers on choice of rice establishment and weeding options for *aman* rice-*rabi* and *boro* rice-*aman* rice cropping patterns.

Project Purpose

The project purpose addressed the CPP output "Promotion of Strategies to minimise impact of target pests in rice-based land-water interface systems, for benefit of poor people". This was the same purpose as for R8194 (2002-2005) for which the work described in this report was a 10-month extension. The activities were designed to continue the development and promotion of improved rice establishment and weed management practices, predominantly for rice farmers in the High Barind Tract (*aman* rice-*rabi*) and Comilla district (intensive *boro* rice-*aman* rice) cropping patterns.

Research Activities

Research partnerships: Collaboration continued between the Natural Resources Institute, International Rice Research Institute and the Bangladesh Rice Research Institute (BRRI), partners in the development and promotion of improved methods of rice crop establishment and weed management since 2000. Fieldwork in Bangladesh was co-ordinated by BRRI with trials, demonstrations and training courses implemented in collaboration with the Department of Agricultural Extension (DAE).

Research sites: Work continued to focus on rain-fed *aman* (monsoon season) rice in Rajshahi district of the drought-prone High Barind Tract of N.W. Bangladesh and in intensive rainfed rice grown in *aman*, and *aus* (pre-monsoon) and irrigated rice in Comilla district in eastern Bangladesh. Delayed transplanting due to low rainfall early in the monsoon and, drought spells during grain filling are common rice production constraints in the Barind Tract of NW Bangladesh, which covers about 0.16 million ha of which nearly 0.1 million is rain-fed. To improve the productivity of the area, where 80% of the land lies fallow in the post-rice season, research has focused on introducing direct-seeded rice (DSR) to replace transplanting (TPR) while promoting intensification through increased production of drought-tolerant crops, including chickpea grown on residual moisture after rice harvest. The widely grown rice cultivar Swarna, matures after 140 to 145 days and when transplanted may not be harvested until early to mid-November. In many years soil is drying rapidly at this time, reducing the likelihood of successfully establishing a chickpea crop. Direct seeding, can be completed after land preparation following 150 mm cumulative rainfall, compared to 600 mm needed for transplanting. DSR crops can therefore be planted earlier to mature 1-2 weeks before TPR reducing the risk of terminal drought, while allowing more reliable chickpea establishment. Weeds constrain adoption of DSR as the advantage of weed suppression through puddling and transplanting into standing water is lost. However, weed problems in DSR may be overcome by applying a pre-emergence herbicide.

Comilla district has long been recognised as being progressive in the adoption of modern agricultural practices. For example all *boro* irice s planted to modern high yielding cultivars as is 80% of the *aman* and 55% of the *aus* crop. With some 50% of land under irrigation, the cropping intensity (ratio of gross cropped area to net cropped) of Comilla is about 188%, compared to national average 134%. On-farm studies here indicated that in both rain-fed and irrigated rice the yield gap due to weeds between production under farmer management and the potential yield under weed free conditions can be as high as 1 t ha-1 with 30% of farmers loosing in excess of 500 kg ha^{-1}. With relatively stable rice market prices but escalating labour costs farmers have been searching for ways to reduce production costs. This is resulting in rapid adoption of herbicides in Comilla since the introduction of a new range of products to the market in 2000. Greater detail on the cropping systems and socio-economic circumstances of both the Barind and Comilla is presented in the final report for project R8234.

Work was undertaken during 2005 at an addition location in Gazipur district in central Bangladesh. Farmers in this area use direct seeding to produce rice in the *aus* season. Trials were planted in two villages to provide additional information on weed control in broadcast rice crops.

Activities by output

Output 1. Field-scale mechanisation of direct seeding evaluated

Farmer groups in the Barind: Fieldwork was concentrated with farmer groups in six villages in Godagari upazilla, in Rajshahi district. A total of 54 farmers planted a field by one of the two following methods of direct seeding:

- Sowing dry seed into moist soil by hand into rows opened by a locally fabricated furrow opener (*lithao*) . A total of 43 sites were planted by dry seeding between 6th and 29th June. Subsequent monsoon rain flooded fields preventing further use of this technique.
- A hand-pulled drum seeder was used to sow pre-germinated seed on wet soil at 11 sites. This method was used between 29th June and 10th July.

Previous work had demonstrated that direct seeding can be undertaken on what farmers clasify as either “highland” or “medium land” fields on the terraced toposequence of the area. Both land types were represented in each of the villages where groups planted direct seeded plots. The pre-emergence herbicide oxadiazon (375 g a.i. / ha) was applied 2–4 days after seeding by either *lithao* or drum seeder, and one hand weeding was undertaken by 30 DAS. A comparison plot of the same rice cultivar was established by the farmer’s usual method of transplanting at 45 sites. Transplanted plots were usually weeded twice. The majority of farmers choose to grow either *Lal Swarna* or *Sadar Swarna*, cultivars from India that are widely grown in the Barind. The farmer groups operated with in a “farmer-field school” framework coming together regularly to visit plots and discuss progress. The research team maintained detailed records of all operations and recorded yields. Farmer opinions were sought.

Additional plots were planted at 15 farms to examine optimum methods for establishing direct seeded crops by broadcasting, an adaptation of the *lithao* method and the performance of newly introduced herbicides in direct seeded rice. The following methods of establishment by direct seeding of dry seed into moist soil were compared:

- Broadcast seed @ 50 kg ha^{-1}, cover with a ladder;
- Broadcast seed @ 70 kg ha^{-1}, cover with a ladder;
- Planting furrows opened with a *lithao*, broadcast seed @ 50 kg ha^{-1}, cover with a ladder;
- Planting furrows opened with a *lithao*, broadcast seed @ 50 kg ha^{-1}, cover with a ladder;

Oxadiazon (375 g a.i. / ha) was applied 2–4 days after seeding and one hand weeding was undertaken at approx. 30 days. Broadcasting seed onto furrows made by *lithao* results in a “row” planted rice stand that makes weeding easier.

The following herbicides were compared in dry seeded rice planted by hand into rows made by *lithao*:

- Sun Rise (ethoxysulfuron 150 WG 100 g ha^{-1}) 3 DAS with hand weeding at 30 days;

- Arozin (anilophos EC 1.3 l ha^{-1}) 5 to 9 DAS with hand weeding at 30 days;
- Sun rice + arozin 5 DAS with hand weeding at 30 days;
- Hand weed at 15 and 30 days after sowing.

On-farm trials in Gazipur district: Although not included in the original research plan the opportunity was taken to evaluate weed control, options in dry-seeded broadcast *aus* (b *aus)* rice. B *aus* cultivars are sown into moist soil in the pre-monsoon season in April and are harvested in July/August. Unlike in the other major rice systems farmers largely rely on traditional landraces in the B *aus* season, with less than 25% of the area planted to modern high yielding cultivars[3]. BRRI recently released cultivar BRRI dhan 24 to improve the productivity of b*aus*. It was decided to implement on-farm trials with two communities that grow the crop in Gazipur district. Broadcasting had been demonstrated as a suitable method of direct seeding in the Baring by project R8234 during 2004. Work in Gaziour was designed to learn more about how to optimise yields under this system and particularly about alternative herbicide options. Until recently only oxadiazon (Trade name Ronstar) has been recommended for use on dry seeded rice but a number of other potentially useful products are now on the market. A weed management trial was therefore undertaken on six farms in Sripur village (planted 17th April) and five farms in Kapasia (all planted on 4th April). The following plots were established at each site by broadcasting 80 kg ha^{-1} seed following land preparation by bullock-drawn country plough:

1. Farmer practice – weeding at 35 days after emergence
2. No weeding
3. Hand weed twice at 20 and 35 days
4. Application of Corstar at 3 days after sowing (oxidiazon 25% EC 1 l ha^{-1}) with hand weeding at 30 days
5. Application of Fast Mix at 3 days after sowing (butachlor 50% EC 750 ml ha^{-1}) with hand weeding at 30 days
6. Application of Arozin at 3 days after sowing (anilophos EC 1.3 l ha^{-1}) with hand weeding at 30 days
7. Application of Sunrise at 3 days after sowing (ethoxysulfuron 100g ha^{-1}) with hand weeding at 30 days

Crop stand, weeds and yields were monitored at all sites.

Output 2: Decision support tool(s) that inform policy makers, extension providers and farmers on choice of rice establishment and weeding options for *aman* rice-*rabi* and *boro* rice-*aman* rice cropping patterns developed and evaluated.

Extension materials produced by the project team are based on evidence from fieldwork conducted since 2000. Activities needed to compile written outputs during the 10 month extension to the project included completion of field trial/demonstrations in Comilla, further analysis of previously collected data, development of our understanding of farmer decision making in the Barind and preparation of a series of training leaflets and brochures.

Activities for intensive rice systems in Comilla

Field trials and further demonstrations of weed management options: These were undertaken in *aman, boro* and *aus* seasons. Yield gap trials, reported by project R7471 demonstrated significant yield loss due to weed in transplanted *aus* rice on-fields in Paruara village in 2001. *Aus* yields were low and there was no significant difference between unweeded plots and those managed by farmers. Additional weeding gave a significant yield

[3] Nur-E-Elahi, A.H. Khan, M.R.Siddique, A,Saha, M. Nasim and S.M. Shahidullah, 1999. Existing cropping patterns of Bangladesh potential techniques and strategies for improving systems productivity. pp 107- 169 In: P*roceedings of the BRRI-DAE workshop*, held on Feb. 14-16, 1999, BRRI, Gazipour-1701, Bangladesh.

increase of 1.1 t/ha. From 2000, companies promoting chemical weed control in rice had emphasised the technology in irrigated rice in the *boro* season on the basis that farmers would have some degree of control over water at and immediately after herbicide application. Project R8234, in a series of field trials, showed that herbicide use is also an effective technology in rainfed *aman* rice. R8512 ran a trial with six farmers in Paruara in *aus* 2005 to generate information on weed management options for the third of the planting seasons in Comilla.

At each site the following plots were evaluated:

- Farmer practice – generally one weeding;
- Push weeder + one hand weeding;
- Rifit (pretilachlor 470 g a.i. ha^{-1})) aplied after transplanting + one hand weeding
- Machete (granular butachlor 1.25 kg a.i. ha^{-1}) applied after transplanting + one hand weeding;

Since 2003 a series of demonstrations of weed management options for transplanted rice has implemented in Comilla district collaboration with the Department of Agricultural Extension. During 2005 an additional 30 demonstrations were run in three villages in *boro* and 22 in two villages in *aman*. Weed control options were explained to farmers during pre-season training sessions by DAE with BRRI support. Participating farmers each choose one option for evaluation in their own rice crop in comparison with their own practice of hand weeding. New sites were selected in each season and year to ensure as great a demonstration effect as possible. This brings to 332 the total number of demonstrations implemented in Comilla district by the project since 2003. A minimum set of data including water depth at herbicide application, weed infestation at 45 DAT and yield was collected at demonstration site. Selected sites were used by DAE for field days so as to raise farmer awareness of the available weed control options. At least one field day was held each season in each upazilla attended by 30 to 35 farmers and local extension officers. Demonstration sites were all located adjacent to roads and large signboards indicated the weed control practice used. Village meetings prior to the season, the signboard and field days all contributed to raising awareness of improved weed management in target communities.

***Decision support materials and training*:** Previously project R8234 had distributed two leaflets covering weed management option and use of herbicides, a poster highlighting key messages in weed management in transplanted rice and a training manual focusing on use of herbicides produced in collaboration with Syngenta. During 2005 an additional colour brochure “Weed management in rice” was produced covering the major weeds found in Comilla, and weed management options. This has been produced in Bengali with a series of colour photographs for distribution to upazilla Agricultural Offices.

Basic information on the impact of weeds and use of herbicides, based on knowledge generated by the CPP funded weed management projects in Bangladesh has also been incorporated into two fact sheets (Appendix 2) now available as part of the Bangladesh Rice Knowledge Bank (RKB). Fact sheets are available as a loose leaf set and will also be placed on the Internet (See www.knowledgebank-brri.org).

Training courses were undertaken in Comilla Sadar, Burichang, Debidwar and Humna upazillas during late January and early February 2006. The courses, led by project collaborators from BRRI were aimed at block supervisors (village level extension officers), upazilla and district extension managers, selected lead farmers and herbicide dealers with stores in local bazaars. Depending on the number of blocks in each upazilla the number of participants at each training session varied from 50 to 80. The courses covered the following topics:

- An introduction to BRRI high yielding rice varieties;
- Modern rice production technologies – seedling age, spacing, nutrient management;
- An introduction to rice weeds (theory and practical);
- Weed management in rice;
- Safe use of herbicide in rice; storage, disposal human health and environmental considerations;
- Herbicide application, calibration etc (Theory and practical).

Activities in the Barind

Understanding farmer decision making

Direct-seeded rice (DSR) is promoted as an alternative to transplanted rice (TPR) in the Barind because it reduces production costs and facilitates intensified *rabi* cropping through the timelier harvest of rice. Recommendations for DSR are not straightforward, however. Rice establishment depends primarily on the nature of the monsoon. This makes decision-making a complex process, which requires the co-ordination of tillage, labour, and water management under changing conditions. This means that recommendations for DSR must be conditional, and take account of contingencies. To make such recommendations, therefore, we need a better understanding of how farmers make their decisions about rice establishment and subsequent choices about *rabi* production.

Socio-economic research in this phase, therefore, has focused on formalising the choices facing farmers into a decision-tree. This has included (1) developing a decision-tree for DSR and (2) validating the decision tree for rabi cropping that was developed under the previous phase of the project (See Working Paper # 8). The specific research objectives were to:

- Interview sample farmers about decisions for rice establishment and *rabi cropping*;
- Identify the main physical, climatic, and socio-economic factors involved in decision-making;
- Analyse the implications for adoption of DSR and increased intensification of the Barind cropping system.

***Decision-making for DSR*:** Research was conducted in two rounds. In Round One, a short structured questionnaire was administered to seven OFT farmers, in order to assist discussion of their decision-making. In Round Two, these farmer were re-interviewed following a checklist that covered various decisions needed for crop establishment. The checklist was developed in consultation with other members of the research team. In Rajshahi interviews were conducted between 16-18th August which corresponded to the period just after transplanting.

***Decision-making for rabi*:** A survey was made for a random sample of farmers in the project area during the 2005-06 cropping season to capture the most important variables influencing the timing of the *aman* and *rabi* crops. This was conducted in two rounds, one after weeding T. *aman* and two after planting *rabi* A sub-sample of 30 farmers from this survey was then interviewed to validate the decision-tree for *rabi* cropping developed in the previous phase of the project. Interviews were made using a structured questionnaire between 17-23rd January, after *rabi* crop establishment.

***Economics of DSR*:** The study on decision-making for DSR presented partial budgets for DSR and TPR based on interviews with OFT farmers (See Working Paper No. 8). The Agricultural Economics Division, BRRI, compared the economics of DSR and TPR for the T. *aman* season (2005) for a larger sample of OFT and non-OFT farmers. Results were presented at the BRRI Internal Review, 2004-2005.

***Farmer evaluation*:** The objective of the evaluation is to identify what farmers with exposure to the new technology consider to be the main advantages and disadvantages of DSR and to determine whether they have adopted DSR on any of their own fields. The evaluation was made using a structured questionnaire that asked farmers whether they agreed/disagreed/had no opinion on 11 possible advantages and 15 possible disadvantages of DSR, and asked them to rank the top three advantages and disadvantages. Twenty farmers who had participated in OFTs for two years or more were selected for this evaluation. The list included seven names from the farmer evaluation in 2003 who claimed they would adopt DSR in 2004. The evaluation was conducted in January after *aman* establishment using a pre-structured questionnaire that was developed and pre-tested in collaboration with project staff in Rajshahi.

Decision support materials and training

Knowledge generated by the project, including lessons learnt through farmer evaluation of direct seeding has been included into three extension leaflets (Annex 3.) These cover the main weeds found in the Barind (with pictures) and weed control options, safe and effective use of herbicides and, practical information on successful direct seeding. A workshop was run to train upazilla and village level extension officers, staff of the NGO CARE and lead farmers from the three districts of the High Barind Tract (Rajshahi, Chapai Nawabganj and Naogaon). The workshop focused on the practices for increasing productivity of the rice-*rabi* system by using direct seeding, improved weed management and increased planting of chickpea (Appendix 3.)

Dissemination to policy makers

Information on the technologies developed and evaluated by the project, the farmer group approach used and extension materials (decision support tools) produces have been communicated to senior extension and NGO staff working in the High Barind. Initially a workshop "Dissemination on Direct Seeded Rice, Weed Control Options in Rainfed Rice-Chickpea Cropping System in Drought Prone High Barind Soils of Bangladesh" was conducted in May 2005 (Appendix 4). A further presentation of highlights from the project, focusing on practical approaches to direct seeding, were presented to senior extension staff who attended a meeting on newly developed technologies for the Barind, organised by BRRI Rajshahi station in September 2005 (Annex 4). Two organisations are currently involved in promotion of improved rice production practices to farmers in the High Barind Tract. In addition to the Department of Agricultural Extension network of disrict and village extension workers the NGO CARE will be playing an increasing role. The European Union is funding CARE Bangladesh as a component of the Food Security for sustainable Household Livelihoods Programme. This aims to promote validated technologies to resource poor households. CARE can therefore play a key role, through collaboration with DAE, to promote project outputs in the High Barind. A presentation was made to the managers of the Rajshshi based CARE team in December 2005 to brief them on the knowledge that the project has generated (Annex 4.).

A major activity to communicate project outputs, particularly to policy makers, will take place in early March 2006. This will be a workshop held in Dhaka to disseminate a synthesis of the findings and implication of work completed by this project and also from work on improving *rabi* cropping implemented in the Baring by the DFID Plant Sciences Research Programme. The programme is shown in Appendix 5. The Bangladesh Minister of Agriculture will attend the meeting with Directors of Research and Extension and senior staff of Department of Agricultural Extension of all districts from the High Barind Tract, and Rangpur region where a similar marginal rain-fed rice based-system is the mainstay of rural livelihoods. The objectives of the meeting are:

- Present research highlights from Crop Protection and Plant Science programmes from 2000-2006 on crop establishment, weed management and intensification of *rabi* cropping;
- Scale out to strategically assess application of the technologies in other environments, with emphasis on direct seeding options and will
- Discuss opportunities and requirements for enhancing scaling-up of validated technologies.

The papers presented at the meeting will be published as a proceedings by IRRI.

Research Outputs

Output 1. Field-scale mechanisation of direct seeding evaluated

Field-scale evaluation of direct seeding by farmer groups

Dry direct seeding, wet seeding with the drum seeder or transplanting all produced significantly similar mean yields (p = 0.52) across field-scale evaluations conducted by six farmer groups in Godagari upazilla (Figure 1). The mean difference between transplanted and direct-seeded (dry and wet seeding pooled) rice yields was 0.04 $\pm$ 0.117 t ha^{-1}. There was also no significant effect of field location on the toposequence (p = 0.623) with high land fields producing 5.35 ± 0.136 and medium land fields 5.41 ± 0.076 t ha^{-1}. Project R8234 has previously reported poor performance of the earlier maturing cultivars such as BRRI dhan 39 under direct seeding. During 2005 farmers choose to plant one of two of the longer duration cultivar Swarna (Table 1). Across establishment methods Sadar swarna outyielded Lal swarna (p = 0.004) and there was no interaction of cultivar with planting method. Analysis of harvest dates (Table 2) provides good evidence that direct seeded crops have a shorter field duration (p = 0.002) and, most importantly for farmers wishing to establish *rabi* crops on residual moisture, they can be harvested earlier.

Table 1: Mean yields t ha^{-1} of two types of rice variety Swarna averaged across planting methods in field-scale evaluations, 2005.

Cultivar	Yield range	Mean	S.E.M	n
Lal swarna	2.9 - 6.6	5.23	0.093	51
Sadar swarna	4.8 - 7.3	5.62	0.086	36

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These results from farmer managed rice crops show clearly that the major advantages of direct seeding that had been identified by project R8234 in on-farm trials can also be achieved on a field scale using methods that are readily available to farmers. These are:

- Rice yield is at least equal to that achieved from transplanting;
- Direct seeding is an effective technology to use with widely grown long duration Swarna cultivars. Early maturing cultivars are not a prerequisite for advancing harvest date;
- The combination of earlier planting (from early June with dry seeding and from wet seeding with the drum seeder in 2005 compared to mid-July onwards with transplanting) and a shorter field duration brings forward the rice harvest date. An earlier harvest reduces the problem of terminal drought in rice when rains end abruptly in October This provides farmers with a longer window for planting a high value *rabi* crop such as chickpea on residual moisture. Evidence from trials reported in the final report of project R8234 had already indicated that farmers will take advantage of an earlier rice harvest to achieve timely chickpea planting and that timely planting results in significantly better chickpea plant populations.

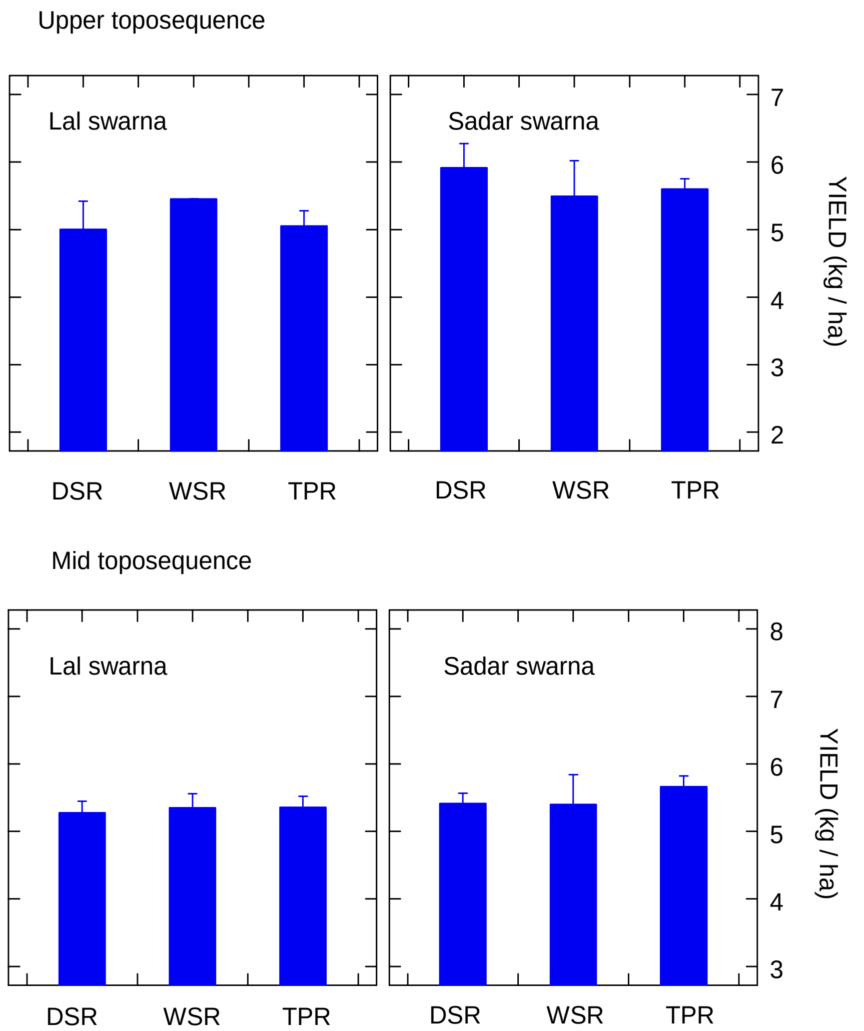


Figure 1: Mean yields of two cultivars of rice established by three methods in *aman* season 2005 in Godagari upazilla, Rajshahi district. Yields wee recorded from field-scale evaluation of methods by farmer groups. DSR = direct dry-seeded; WSR = pre-germinated seed planted by drum seeder; TPR = transplanted rice (seed beds established on day of direct seeding).

Table 2: Mean harvest dates and field duration for direct seeded and transplanted crops in *aman* 2005. Data taken from field-scale evaluations undertaken by farmer groups. The number of field days is calculated from initiation of seed bed in all cases i.e. includes days in nursery in TPR.

Cultivar	**Establishment method**	**Mean harvest date**	**Mean (± s.e.m) number of field days**
Lal swarna	Transplanting	14 November 2005	147 ± 2
Sadar swarna		8 November 2005	148 ± 1
Lal swarna	Wet seeding	12 November 2005	127 ± 1.5
Sadar swarna		9 November 2005	126 ± 0.9
Lal swarna	Dry seeding	6 November 2005	136 ± 1
Sadar swarna		30 October 2005	138 ± 1

The circumstances leading to a successful direct seeded rice crop were discussed with farmer groups. On the basis of their experiences they identified the following as key factors:

- Land preparation should be started early, on the first shower in early *baisak* (14th April). Plough again after 15 to 20 days and a third time when soil is sufficiently moist before planting early June. Make sure land is levelled and free of weeds before using the lithao. Field should be carefully levelled with a ladder to allow the *lithao* to make planting furrows of a consistent depth;
- Apply Ronstar (oxidiazon) within 2-3 days of sowing. Weed growth in direct seeded rice is often more than in transplanted rice, particularly when using dry seed with the *lithao* but this can be overcome by using herbicide. A follow up hand weeding will be needed but takes little labour compared to when farmers hand weed transplanted crops as direct seeded rice is established in rows. Farmers who direct seed and use Ronstar say they need only half the labour they would use for weeding transplanted.

Farmers have also commented on the need for flexible rice establishment decision making. As the monsoon intensifies fields become too wet for dry-seeding and then the hand-pulled drum seeder can be used effectively as demonstrated by the data. Farmers have therefor suggested that each group of farmers needs access to both a *lithao* and a drum seeder. Village blacksmith will make a 3 row *lithao* for about Taka 500 (approx. 50 kg rice at farm gate prices). All the drum seeders that are currently available in Bangladesh were imported byteh Ministry of Agriculture for evaluation. It is expected that a locally made version will soon be available for Taka 2000 to 2,500. Further information on the economics of direct seeding is provided under output 2.

Comparison of different methods of dry seeding and alternative herbicides

During 2004 similar yields were observed at a few sites in on farm trials from broadcasting dry seed as resulted from sowing seed into furrows opened with the *lithao*. Broadcasting is a low-labour input approach to direct seeding and so was evaluated further during 2005. The time consuming component of direct seeding with a *lithao* is hand sowing seed into the planting furrows. A possible way of overcoming this is to broadcast after *lithao* furrows have been made. It was hoped that if the land was laddered after broadcasting to cover the seed, most would fall into the *lithao* furrows so the crop would emerge in rows. This modification to dry seeding with the lithao and conventional broadcasting were compared at two seed rather on 15 farms.

Rice yields resulting from alternative establishment methods were significantly different ($p = 0.008$). Highest yield resulted from the modified *lithao* planting method. When broadcasting increasing the seed rate to 70 kg ha^{-1} also increased yield. This trial confirmed that the lithao planting method can be speeded up by broadcasting the seed over the planting furrows.

Table 3: Rice grain yields ($\pm$ S.E.M) following alternative establishment methods. Means of 15 sites in on-farm trials in 2005.

Establishment Method	Yield ha^{-1}
Lithao + Broadcast Seed 50 kg/ha	5.1 $\pm$ 0.58
Lithao + Broadcast Seed 60 kg/ha	5.3 $\pm$ 0.57
Broadcast Seed 50 kg/ha	4.9 $\pm$ 0.58
Broadcast Seed 70 kg/ha	5.1 $\pm$ 0.60

All direct seeding undertaken with farmers by the project to date has used Ronstar (oxadiazon) for weed control. Two other products recently introduced to the market in

Bangladesh were tested during 2005. There was no significant difference (0.507) between the yields resulting from use of these herbicides or when weeding the rice crop twice by hand (Table 4). Further analysis is needed of responses of important weed species.

Table 4: Yields of dry direct-seeded rice ± S.E.M. following use of different herbicides or hand weeding. Means from 15 sites in *aman* 2005.

Treatment	Yield kg ha^{-1}
Sunrise + hand weed	5.0 ± 0.31
Arozin + hand weed	4.6 ± 0.31
Sunrise/Arozin + hand weed	4.8 ± 0.31
Hand weed twice	4.8 ± 0.34

Further analysis of long term experiment

A core research activity of projects R7471 and R8234 was a long-term field trial that examined the effects of crop establishment method, weed and nutrient management in 5 cycles of a rice-chickpea rotation. Effects of establishment method (direct-seeding v transplanting) and weed control (hand weed v herbicide) were reported in the FTR for project R8234. Further work was undertaken during 2005. A final set of soil samples was recovered from each plot following the chickpea harvest and these have been analysed for major plant nutrient content. The data will be included in a series of journal papers to be prepared during 2006. An important output from the trial is an understanding of system effects on abundance of the major weed species found in the Barind tract. A summary of changes in species abundance was reported during the year in Mazid *et al*. 2005 (see Annex 2). Differential responses to crop establishment were observed for some important weed species (Figure 2). Densities of the perennial and annual grasses, *Cynodon dactylon* and *Echinochloa crus-galli*, and the annual sedge *Fimbrystilis miliacea* all increased under dry direct seeding while the broadleaf *Ludwigia octovalvis* and the sedge *Cyperus difformis* increased in transplanting. Density of *Monochoria vaginalis* declined in both cases. Larger changes appear to be associated with the standing water found early in the crop cycle with TPR.

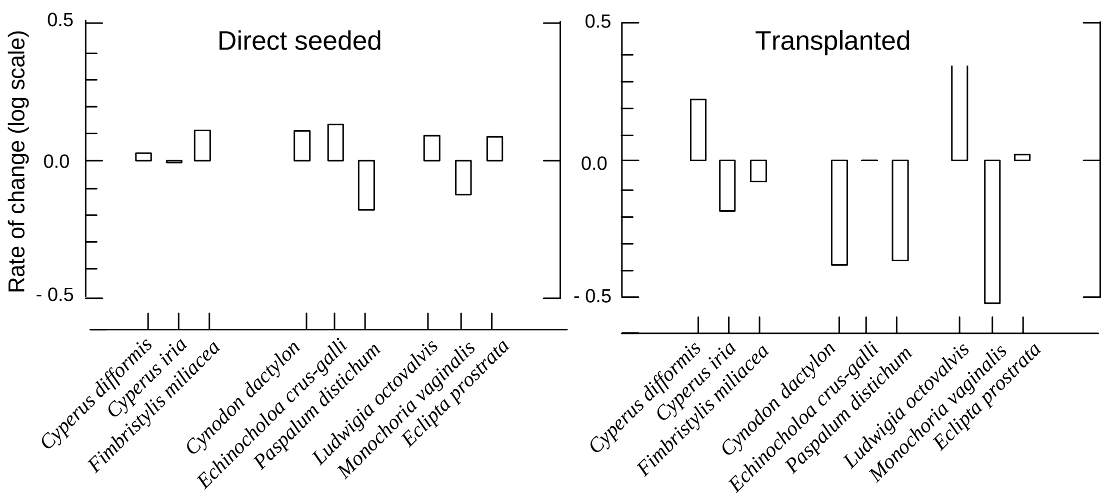


Figure 2. Trajectories (logarithm mean rate of change in density (plants m^{-2})) of selected individual weed species in response to crop establishment method. Census points 28 DAS/DAT in 2002 and 2004.

While herbicides reduce labour costs for weed control in direct seeding as previously reported by these projects, hand weeding is also needed to prevent survival of herbicide tolerant species including perennial grasses (e.g. *C. dactylon*) and a later flush of free-seeding annuals (e.g. *E. crus-galli and F. miliacea*). Alternating TPR with DSR every few years may be necessary to prevent an increase in the abundance of such species. The need for follow-up hand weeding after using herbicides in direct seeded rice is key message to include in farmer training.

Direct seeding and weed management in *aus*

Date from on-farm trials in Gazipur district demonstrate that farmers currently experience considerable loss in yield due to weeds in broadcast *aus* and as with other rice systems the yield gap can be addressed by introducing chemical weed control. The weed flora in fields of the two villages where trials were undertaken were somewhat different as shown by the following weed density data taken from unweded plots at 30 days after sowing:

	Village	
	Sripur	**Kapasia**
Weed density / m^2	31.1	31.4
Alternanthera philoxeroides		5.4
Commelina benghalensis	0.2	
Cyanotis axillaris	3.2	
Unidentified dicot. species	10.0	
Cyperus iria	15.0	2.4
Fimbristylis miliacea		22.0
Cynodon dactylon	2.0	1.6
Paspalum distichum	0.8	

Perennial grasses are a problem in Sripur while the annual sedge *F. miliacea* is dominant in Kapasia. Mean yields were significantly higher ($p = 0.0001$) in Kapasia (1.49 t ha^{-1} $\pm$ 0.065) than in Sripur (1.31 t ha^{-1} $\pm$ 0.041). Over both villages weed management had a significant effect on resulting rice yield ($p= 0.0015$), and there was a treatments x location interaction ($p= 0.0001$). The farmer practice of weeding once at approx. 35 days after sowing made no impact on weed competition in either village. Weeding at 25 and 35 DAS resulted in a

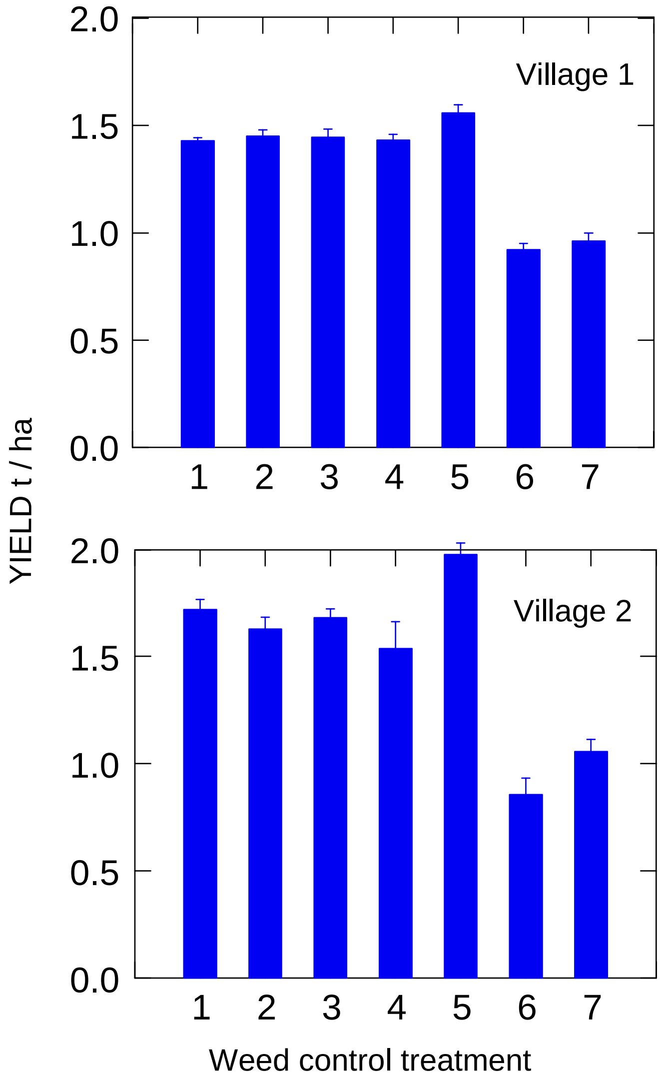


Figure 3: Comparative effects of weed control treatments on grain yield in Sripur (village 1) and Kapasia (villaage 2). Treatment codes: 1= Corostar + 1 hand weeding at 30 DAS; 2= Fast mix + 1HW, 3= Arozin + 1 HW, 4= Sunrise + 1HW, 5= 2 hand weedings, 6= Unweeded, 7 = Farmers practice. LSD = 0.21 t/ha.

significant reduction in the yield gap (Figure 3). Use of herbicides led to similar yields as hand weeding in Sripur but significantly lower yield than manual weeding in Kapasia. Weed management options had a significant effect (p = 0.001) on weed density (Figure 4). Ignoring the unweeded plots density was higher in Sripur (19 weeds m^2 $\pm$ 2.3 at 30 DAS) than in Kapasia (13.8 m^2 $\pm$ 2.9). Herbicide treatments were as effective as two manual weedings in reducing weed density in Kapasia, but a differential response was seen in Sripur, with lowest densities under manual weeding. The pattern of rainfall during 2005 was particularly unfavourable for *aus* rice with long dry spells. In Kapasia there was only 50 mm rain in the six weeks following sowing and 116 mm in the first three months of the crop. Despite these difficult conditions the trials demonstrated that farmers could increase yield substantially by investing in more intensive weed management either by timely manual weeding or by integrating herbicide with hand weeding.

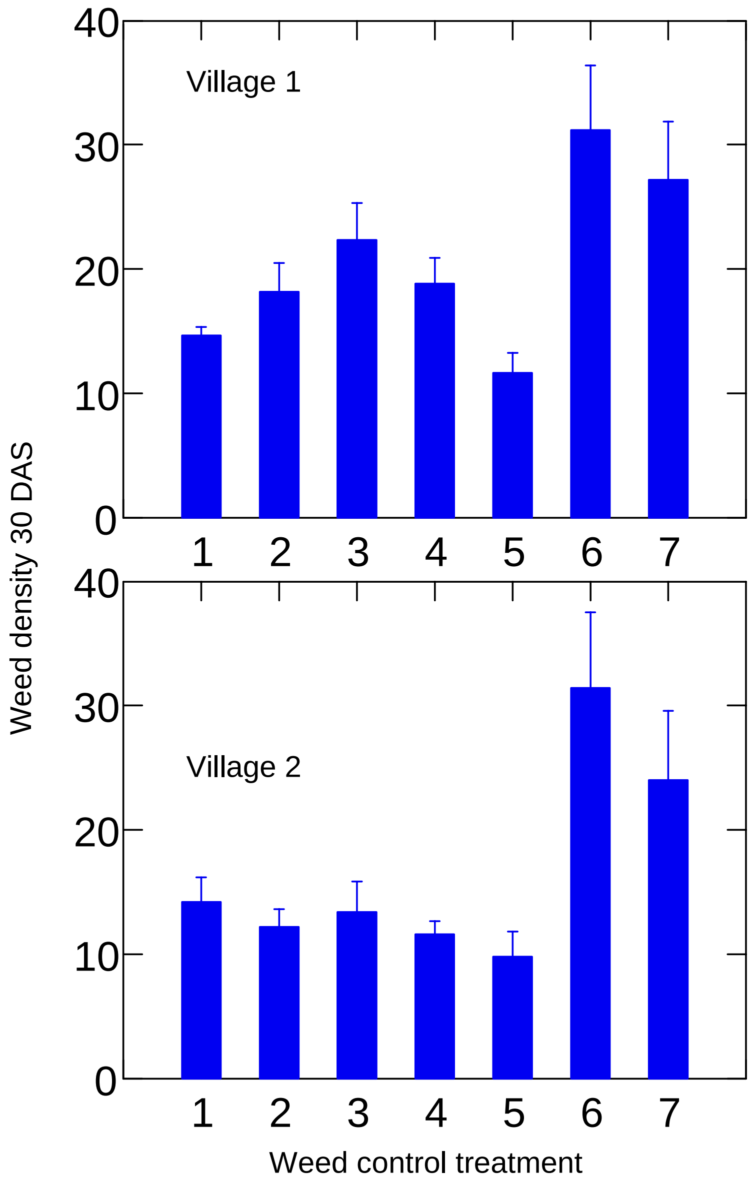


Figure 4: Comparative effects of weed control treatments on weed density at 30 DAS in broadcast *aus* in Sripur (village 1) and Kapasia (villaage 2). Treatment codes: 1= Corostar + 1 hand weeding at 30 DAS; 2= Fast mix + 1HW, 3= Arozin + 1 HW, 4= Sunrise + 1HW, 5= 2 hand weedings, 6= Unweeded, 7 = farmer practice.

Output 2: Decision support tool(s) that inform policy makers, extension providers and farmers on choice of rice establishment and weeding options for *aman* rice-*rabi* and *boro* rice-*aman* rice cropping patterns developed and evaluated.

Further results from intensive *aus-aman-boro* systems

Weed management in T-*aus*: Choice of weed management option had a significant effect on rice yield (p = 0.0151), weed density (p < 0.0001) and biomass (p < 0.0001) at 25 and 45 days after transplanting in rainfed *aus* rice (Table 5). Application of granular butachlor increased rice yield by more than 200 kg ha^{-1} (8%) compared to farmer practice of hand weeding twice at 16 to 19 and 31 to 34 days after transplanting. The annual weeds *Fimbrisytlis miliacea* and *Echinoichloa crus-galli* were both well controlled by herbicide treatments by 25 DAT with rice performance benefiting from reduced competition during this period.

The practicality of using herbicides the *aus* season was discussed with farmers in Paruara who planted from 0.5 to 1.5 acres to rice. They were particularly impressed that herbicide application reduced labour inputs to produce the rice crop in this season, as they have previously observed from trials in *boro* and *aman* rice. Following herbicide application it is only necessary to remove a few remaining weeds compared to the two or three intensive weeding needed where herbicide is not used. Farmers estimated that labour use for weeding was 75, 37 and 11 man days per ha for hand weeded, push weeded and herbicide treated crops respectively. Only one participant applied herbicide after irrigating his field. In general the temporary earth canals used to distribute water are not constructed for *aus* so this is a rainfed crop for the majority of growers. Farmers agreed that the push weeder can also work effectively in *aus* but is more costly in terms of labour than using herbicide. However shallow standing water is needed for the push weeder to work effectively. Only one participant applied herbicide after irrigating his field. In general the temporary earth canals used to distribute water are not constructed for *aus* so this is a rainfed crop for the majority of growers. All farmers who planted the trial reported sufficient depth of water when herbicide was applied from 2 to 4 days after transplanting. According to farmers interviewed in Paruara about 30 to 35% of households now use herbicides in *aus* having previously seen the benefits in other rice seasons.

Table 5: Effect of weed management practices on mean rice grain yield and weed infestation (number and g m^2 $\pm$ S.E.) in transplanted *aus* in 2005. Mean of six sites in Paruara village, Comilla.

Treatment	Yield kg ha^{-1}	s.e.m.
Rifit + I Hand weed	2589	68.2
Butachlor + I Hand weed	2635	67.2
Push weeder + I Hand weed	2546	72.5
Farmer practice	2415	85.2

Treatment	Weeds at 25 DAS		Weeds at 45 DAS	
	Density	Biomass	Density	Biomass
Rifit + Hand	30.0 $\pm$1.3	12.3 $\pm$ 3.3	24.5 $\pm$2.9	9.7 $\pm$ 1.2
Butachlor + Hand	30.3 $\pm$1.0	14.2 $\pm$4.0	25.5 $\pm$ 3.5	10.9 $\pm$ 1.6
Push weeder + Hand	31.9 $\pm$ 0.8	13.7 $\pm$2.8	31.7 $\pm$ 5.6	12.8 $\pm$ 1.7
Farmer practice	42.8 $\pm$ 1.1	19.8 $\pm$ 3.2	41.2 $\pm$ 7.1	18.7 $\pm$ 2.6

Weed management in T-aman

As had been observed in previous seasons the rice yieds achieved on demonstration plots managed by exuisting farmer practice (hand weeding were significantly higher (p = 0.0042) at sites in Chowara village (3263 kg ha^{-1} $\pm$ 170) than at those in Paruara (2717 kg ha^{-1} $\pm$ 118). None of the covariates tested (Seedling age, transplanting date, weeding date, weed biomass at 25 DAT, or dose of fertiliser applied) had a significant effect on yield. Yields harvested from herbicide treated plots (3535 kg ha^{-1} ± 188 in Chowara and 2778 ± 154 in Paruara) were not significantly different from hand weeded plots (p = 0.32). Mean time of first weeding was 15 days and of second weeding 38 days after transplanting indicatuing that in general farmers who hosted these demonstrations achieved timely weeding. Yield increases for each of the herbicides demonstrated were observed however (Figure 5).

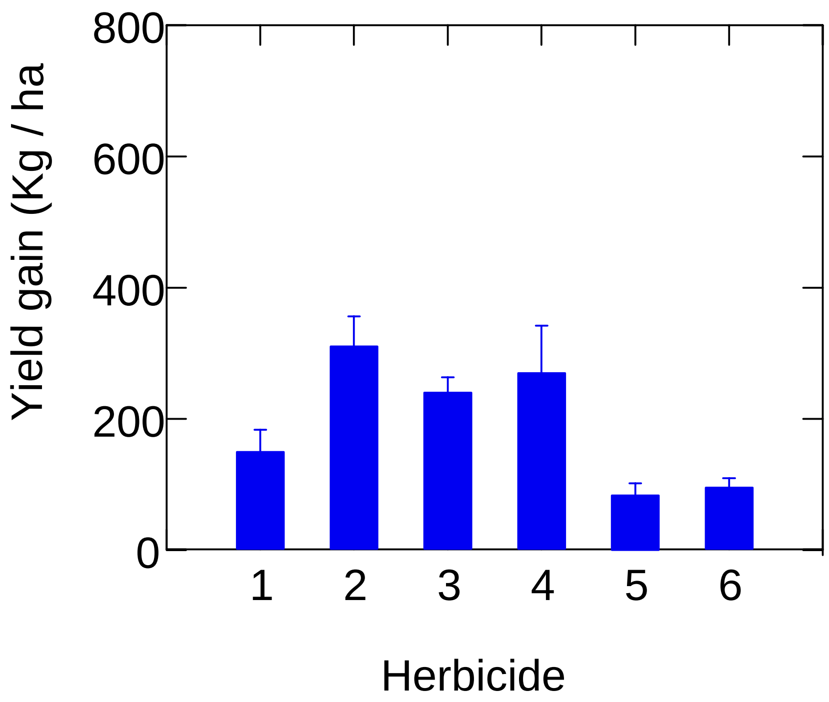


Figure 5: Yield gains by use of various herbicides in demonstrations during *aman* season 2005. Herbicide codes are 1 = Machete (butachlor); 2 = Emchlor (butachor); 3 = Rifit (pretilachlor); 4 = Argold (cinmethalin); 5 = Corstar (oxidiazon); 6 = Super Heat (pretilachlor)

Weed management in boro

Analysis of variance of data from demonstrations conducted during the *boro* season also indicated significant differences in yield according to area (Paruara, Zaforgang Chowara villages (p < 0.0001). Yield was effected by weeding method (herbicide application versus farmer practice (p = 0.004), and the dose of urea fertiliser applied (p= 0.004) with the response to weeding method, differing amongst areas, p = 0.56. Variation in yields in response to weeding method across areas, other than due to nitrogen level, was not significantly related to seedling age, transplanting date, weeding date, or P or K application. Across the three village areas the mean yields of herbicide treated plots was 4623 kg ha^{-1} $\pm$ 169 compared to 4154 kg ha^{-1} following farmer practice hand weeding. Improved weed management b y using a herbicide elevated yields by approx. 0.5 t/ha, the response being enhanced by N application (Figure 6). Yield gains due to herbicide application (Figure 7) differed significantly (p = 0.032), gains being similar with Machete, Argold and Ronstar and higher than that achieved with Rifit (each followed by 1 hand weeding). Ranking variance in performance (by CV) across trial sites indicated that Machete application was the most reliable. Ronstar was the most variable (150%) being greater than Rifit (121%) > Argold (77%) > Machete (62%). The mean yield gain from using Machete was 591 kg ha^{-1} $\pm$ 165. A number of granular products similar to Machete, containing butachlor, are now available on the market. This is a robust, reliable treatment across locations and is easy and to apply without the need for a sprayer.

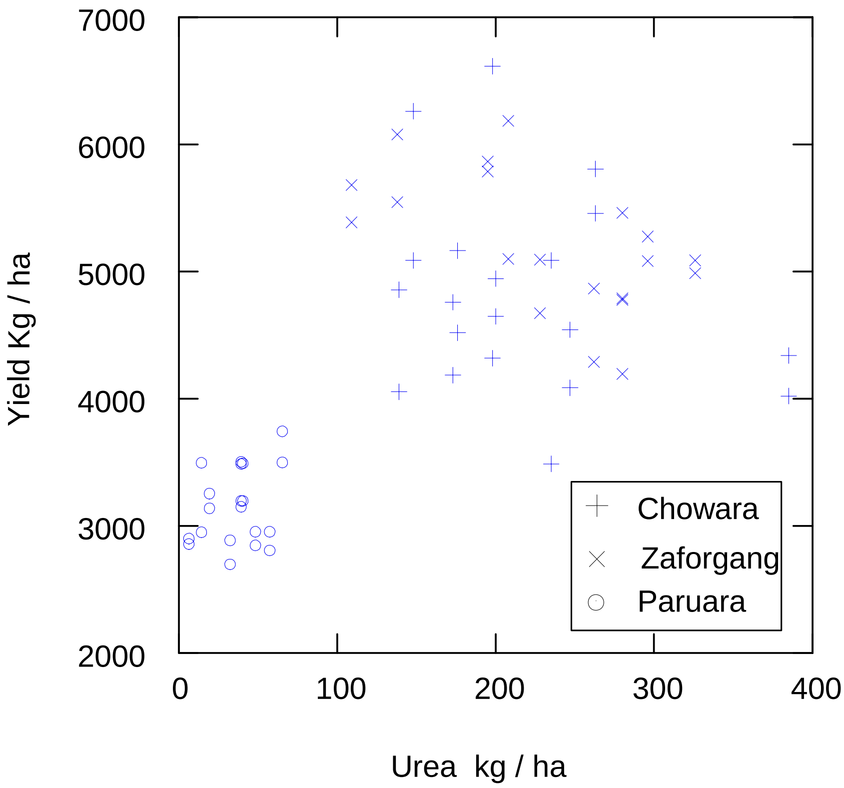


Figure 6: *Boro* rice yields in three villages in Comilla district during 2005 as effected by the dose of urea fertiliser applied by farmers.

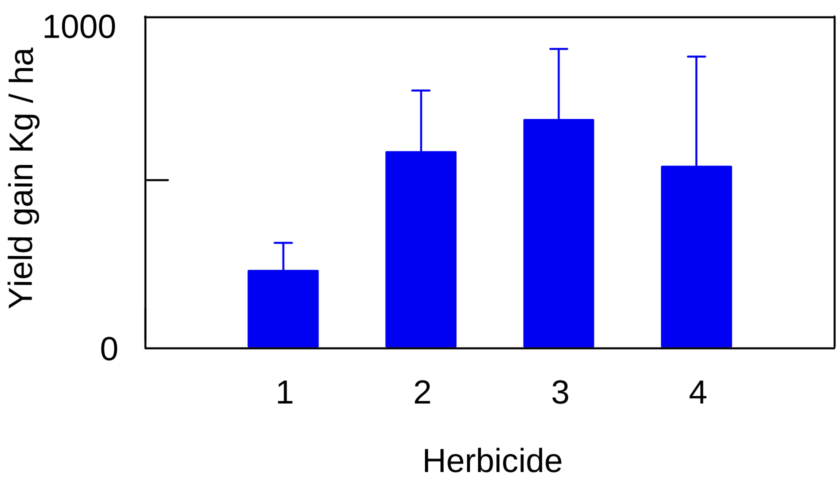


Figure 7: Yield gain in *boro* rice from herbicide application compared to farmer practice hand weeding in Comilla during 2005. Herbicide codes: 1 = Rifit + 1 hand weeding, 2 = Machete + 1 hand weeding, 3 = Argold + 1 hand weeding, 4 = Ronstar + 1 hand weeding

Farmer decision making in the Barind

DSR decision tree

The criteria identified by farmers included socio-economic, climatic, and physical constraints on rice establishment. Socio-economic variables included reliance on the markets for water and tillage for farmers who did not own these resources. Generally, tillage markets were competitive and few farmers complained about delays in rice establishment due to draught power constraints. Labour for transplanting was available, either locally or from migrants, but the transaction costs of hiring labour on separate occasions, feeding them, and supervision in the field added to farmers' costs. The opportunity cost of the farmer's labour, and of his family members, is usually omitted from partial budgets but these are evidently an important consideration for farmers.

The major climatic variable was the unpredictability of monsoon rainfall. Pre-monsoon showers determined the timing of tillage for dry-seeded DSR. Where no irrigation was normally available, as in Rajshahi, the choice of DSR method depended on rainfall and farmers could be forced to wet-seed if rainfall conditions were not favourable for dry-seeding. Rainfall also dictated the time of application for pre-emergence herbicide that required specific soil conditions. Physical decision-criteria included land type, with farmers choosing to sow DSR on medium land with good water control and where there was residual moisture available for an early *rabi* crop, and soil type, with farmers preferring to sow DSR on soils less prone to weeds.

DSR adoption

The decision-tree highlighted the major drivers of adoption for DSR. Farmers decided for DSR over TPR primarily because of the advantages it gave for rice. Increasing the time available for *rabi* cropping was sometimes mentioned but the main incentive for adoption was that DSR reduced costs for rice. In farmers eyes this saving consisted primarily in the saving of labour for transplanting, including the transaction costs of hiring and feeding more than one gang of contract labour, and the costs of personal supervision to ensure quality work. The farmers we interviewed did not specifically mention reduced cost of tillage as an incentive for DSR adoption. In fact, the budget we obtained show little difference in tillage costs between DSR and TPR. Another incentive for adoption was that earlier establishment of DSR allowed farmers to spread draught-power and family labour resources more evenly, which permitted more timely transplanting. This was an important secondary benefit, especially for farmers who rely on family labour.

Farmers wishing to direct-seed then faced choices over land type, soil type, and rice variety. Farmers' first choice for DSR was medium-level land because this tended to be less weedy than high land, and because water-control was easier than on low-lying land. An additional benefit was that residual soil moisture lasted longer on medium than on high land, which increased the chances of *rabi* cropping with chickpea after an earlier harvest of rice. As for soil type, farmers expressed a preference for DSR on sandy rather than clay soils, again because these were less prone to weeds. One disadvantage of sandier soils, however, was that they were more permeable and held water for a shorter time that clay soils. There is a trade-off here between the need to choose soils that harbour fewer weeds, and also ensure that it retains sufficient soil moisture after harvest to allow *rabi* cropping.

Finally, farmers must choose a rice variety. Since rice is the staple food crop, any yield penalty with DSR will discourage adoption. Farmers in the Barind have been advised to grow short-duration varieties in order to maximise the availability of residual soil moisture for sowing *rabi* crops. This recommendation created problems because short-duration varieties were vulnerable to pest-attack, matured during late-season rainfall, and incurred a yield penalty that reduced rice supply for food-insecure households and particularly for sharecroppers. As a result, the recommendation is now for early DSR using long-duration varieties.

Rabi decision-tree

Results from the survey conducted for *Aman-rabi* in 2005-06 and from the validation of the decision-tree will be analysed in a paper on “Farmer decision-making for *rabi* cropping in the Barind Tract” that will be presented at the Final Workshop in Dhaka between 4-5th March, 2006. Data from the survey and validation exercise have been entered but not yet analysed. Fieldwork impressions suggest that the decision-tree successfully captured the main constraints on *rabi* cropping. The main reason why land was kept fallow was that there was insufficient moisture (*batal*) at rice harvest for *rabi* cropping. Hence, the decision-tree confirms the importance of DSR in allowing earlier harvest of *aman* rice.

Interviews also showed several errors in prediction. These included:

(1) farmers’ unwillingness to relay-sow *rabi* crops when they realised that soil moisture would be inadequate if they waited until after harvest, because yields from relay-sown crops were too poor, partly because of moisture stress but also because of damage from grazing livestock
(2) farmers kept land fallow despite adequate soil moisture at harvest because of the risk of low yields in two years out of three did not justify the expense,
(3) farmers with larger holdings left some land fallow because they were simply too busy to supervise land preparation on all their plots.

Economics of DSR

The BRRI partial budget analysis that compared TPR + hand-weeding with DSR + herbicide gave the following results:

No.	Item	Debit (Tk/ha)	Credit (Tk/ha)
1	Additional cost of herbicide	2,472	
2	Revenue foregone from hand-weeding	24,476	
3	Profit/loss	3,494	
4.	Revenue earned from herbicide		26,479
5	Cost saved by not hand-weeding		3,963
6			30,442

Source: BRRI Internal Review, 204-05, XIII (Agricultural Economics)

Results showed that TPR + hand-weeding in T. *aman* was less profitable than DSR + herbicides, incurring a return of 3494 Tk/ha less.

Partial budget analysis based on farmer interviews during the study of DSR decision-making showed that net returns from dry-seeded DSR were higher than TPR in Rajshahi (see Working Paper No. 6, Table 3). Net returns from DS-DSR *aman* averaged 361 USD/ha (with subsidised inputs) and 379 USD/ha including the full cost of inputs. Net returns from TPR *aman* with hand-weeding averaged 320 USD/ha. The partial budget for Rajshahi included the cost of labour for the *lithao* but not cost of *lithao* hire, because we were unable to estimate this.

Farmer evaluation

Results from the farmer evaluation of DSR *aman* will be presented by Dr Jabbar in a paper at the Final Workshop in Dhaka between 4-5th March.

Contribution of Outputs to developmental impact

The 10-month extension to activities in Bangladesh built upon achievements of projects R7471 and R8234 to improve understanding of the agronomic, technical and socio-economic opportunities for productivity gains in two widespread rice-based systems in Bangladesh. These are: a) improved weed management practices for intensive transplanted *aman–boro* rice systems (monsoon and irrigated seasons found on 2 million ha) and, b) labour-efficient weed management facilitating the introduction of direct seeding of rice in rainfed *aman-fallow or aman-rabi* (monsoon and post-rice seasons found on 1.4 million ha).

Previous research by the research team had highlighted the growing competition for and rising costs of labour for weeding in *aus-aman-boro* in Comilla district. R8512 demonstrated that herbicide use is reliable in transplanted rainfed *aus* in addition to the other two seasons. Further demonstrations were completed of improved weed management options in *boro* and *aman.* When CPP funded work on weed management in rice began in Bangladesh in 2000 few farmers had knowledge of herbicide use in Comilla. Extension materials, training courses and demonstrations produced by R7471, R8234 and R8512 have contributed to the increased acceptance in the farming community that herbicides allow a reduction in production costs, and provide a robust approach to weed management, proving effective and profitable in rainfed aus, *aman* and irrigated *boro* rice. Yields may also be maintained by use of a push weeder but with higher labour inputs. Yield gains over use of the usual farmer practice of weeding by hand once or twice ranged from 200 to 600 kg ha^{-1} reflecting more timely and prolonged weed suppression. These yield gains are of the order of previously recorded yield losses due to weeds with existing farmer management – generally one third of farmers lose at least 500 kg ha^{-1} of the potential yield. Farmers in the two villages where the project team has been working since 2000 estimated that by 2005 herbicides had been adopted by 40-50% of rice growers in *boro*, and 30 to 35% in both *aus* and *aman*. There are now more than 30 products available on the rice herbicide market in Bangladesh, compared to four in 2000. Extension material produced by R8512 adds to the training tools previously prepared to ensure that both extension workers and farmers have access to the knowledge needed to handle and apply herbicides safely and profitably.

R8512 confirmed that farmers decide to use direct seeding in place of transplanting primarily because of the advantages it gives for rice. The main incentive for adoption was that direct seeding reduced costs for rice. In farmers eyes this saving consisted primarily in the saving of labour for transplanting, including the transaction costs of hiring and feeding more than one gang of contract labour, and the costs of personal supervision to ensure quality work. Farmer groups in Godagari upazilla in the High Barind tract moved direct seeding with appropriate herbicide use from small trial plots to field-scale implementation on a total of 6.5 ha across more than 50 farms during 2005. These are the first steps in the evolution of dry direct seeding with a *lithao* from being a “research” to adoption as a “farmer” technology. Farmers have identified the need to have access to both a *lithao* which can be made locally and a drum seeder for wet seeding. This allows them the flexibility to make appropriate crop establishment decisions as the season progresses. Dry and wet-seeding are low-cost, low labour input methods that resource poor households can use to optimise rice yield through timely planting and ensure a post-rice *rabi* crop is planted on time. The challenge identified by the CPP projects was to increase productivity of *aman* rice while at the same time enhancing system productivity by more reliable *rabi* cropping. Farmers are now showing that this can be achieved. A study if farmer decisions confirmed that the main reason why land was kept fallow was that there was insufficient moisture at rice harvest for *rabi* cropping. Hence, the decision-tree confirms the importance of direct seding to allow earlier harvest of *aman* rice. Direct seeding with herbicide use is knowledge intensive. Extension leaflets produced, workshop presentations and training undertaken by R8512 provide the knowledge that farmers need to use the technology effectively. The farmer groups already using direct seeding provide a nucleus for demonstration to others. To build on this resource the Department of Agricultural Extension is targeting the recruitment of 100 more farmers to begin using direct seeding in 2006 in Godagari upazilla.

Follow-up indicated/planned

Training has been provided to District and upazilla level extension staff in both Comilla and the High Barind. It will be desirable for BRRI staff to maintain contact with extension managers to continue supporting this capacity building. The project has demonstrated with farmers that direct seeding has a role to play in enhancing productivity of the Barind cropping system. Promotion of this technology now needs to be scaled up throughout Rajshshi, Chapai Nawabganj and Naogaon districts. Opportunities for accelerated promotion will be discussed with policy makers during the forth-coming workshop in Dhaka. Support for this process by CARE has already been identified. However, it is likely that further funds may be needed to support the training needed within Department of Agricultural Extension to ensure the new technology reaches farmers in all upazillas in the Barind.

PUBLICATIONS SUMMARISING RESULTS FROM R8512

Annex 1: Working Papers and workshop proceedings

Orr AW, Sushant Saxena, Sinha RK. Jabbar M A. and Mazid MA. 2005.Farmer Decision-Making for Rice Establishment in Eastern India and the High Barind Tract, Bangladesh Project Working Paper No. 6. Chatham, UK: Natural Resources Institute.

Orr. A. W (2006). Trip Report by Agricultural Economist, 15-27 January Orr report January.

ANNEX 2: Conference Papers

Ahmed GJU, Bhuiyan MKA, Riches CR, Mortimer M, Johnson D. 2005 Farmers, participatory studies of integrated weed management systems for intensified lowland rice in Bangladesh. 20th Asia Pacific Weed Science Society Conference, 7-11 November 2005, Agriculture Publishing House, Ho Chi Minh City, Vietnam, p 524-528.

Mazid MA, Jabber, MA, Karmaker, B., Mortimer, M., Wade, L., Riches, CR and Orr AW (2005) Increasing productivity of rainfed rice-based systems in NW Bangladesh: establishment, nutrient and weed management The BCPC International Congress – Crop Science and Technology, Congress Proceedings Volume 1: 539-544.

Mazid MA, Johnson D, Mortimer M, and Riches, CR. 2005 Direct seeding and weed control for rainfed and irrigated rice in northwest Bangladesh. 20th Asia Pacific Weed Science Society Conference, 7-11 November 2005, Agriculture Publishing House, Ho Chi Minh City, Vietnam. Poster summary volume.

Riches, C.R., Mbwaga, A.M., Mbapila, J., Ahmed, G.J. (2005). Improved weed management delivers increased productivity and farm incomes from rice in Bangladesh and Tanzania. *Aspects of Applied Biology 75: Pathways out of Poverty*. 127-138.

Conference Posters

Mazid *et al.* 2005 The BCPC International Congress – Crop Science and Technology.
Mazid *et al.* 2005 Asian Pacific Weed Science Society, Vietnam.

ANNEX 3: Extension materials

Fact sheet – Weed management in Rice (Bengali) – Bangladesh Rice Knowledge Bank – prepared by G Uddin Ahmed & Khairul Bhuiyan, BRRI, Gazipur

Fact sheet – Use of herbicides in Rice (Bengali) – Bangladesh Rice Knowledge Bank. G Uddin Ahmed & Khairul Bhuiyan, BRRI, Gazipur

Weed control of Rice in rainfed Barind Tract (Leaflet Bengali) – Prepared by Mazid MA, Biswajit Karmakar, Mazid MA Ansar Ali, Mortimer A M and Riches C. Bangladesh Rice Research Institute Publication No.151. – 5000 copies

Herbicide use in rice fields (Leaflet Bengali) – Prepared by Mazid MA, Biswajit Karmakar, Abdul Kader, Mortimer A M and Riches C. Bangladesh Rice Research Institute Publication N0. 148. – 5000 copies

Rainfed Direct Seeded Aman Rice in Rice-Rabi Cropping System in High Barind Soil (Leaflet Bengali) Mazid MA, Biswajit Karmakar, Ansar Ali, Mortimer A M and Riches C. Bangladesh Rice Research Institute Publication N0. 149. – 5000 copies

Weed Management in Rice (Bengali**)** Prepared by G Uddin Ahmed & Khairul Bhuiyan, BRRI, Gazipur. An illustrated training manual, including pictures of important weeds in various rice seasons in Comilla. Published by Bangladesh Rice Research Institute, Gazipur. – 2000 copies

ANNEX 4: Other dissemination of findings

Power point presentation made to CARE Bangladesh, in Rajshahi on 8th December 2005

Power point presentation made at Technology Dissemination Workshop (BRRI briefing DAE on Improved rice Production Practices for the Barind). BRRI Station, Rajshahi, 9th September 2005.

Power point presentation on Key messages made by A.M Mortimer (May 2005) Workshop: Dissemination on Direct Seeded Rice, Weed Control Options in Rain-fed Rice-Chickpea Cropping System in Drought Prone High Barind Soils of Bangladesh.

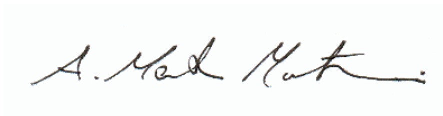
Annex 5: Media coverage

Experts call to use rice chickpea for more output (Bangladesh Observer, May 19th, English).
Workshop on direct seeded rice held in Rajshahi. (The New nation, May 21st, English).
Bright prospect for gram cultivation in Barind area (The Bangladesh Today, English)
Gram cultivation prospects bright in Barind land (Bangladesh Observer, May 21st English).
Workshop for weed control in rice chickpea systems (The Daily Mucta Sangbad, May 22nd Bengali).
BRRI, IRRI, NRI hold workshop (News Today, May 22nd, English).
Workshop for weed control in rice chickpea systems (Ajker Janata, May 22nd Bengali).
Workshop for weed control in rice chickpea systems (The Daily Gonomookli, May 24th Bengali).

Biometricians Signature

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:



Name (typed): Dr A. M. Mortimer
Position: Biometrician, School of Biological Sciences, University of Liverpool
Date: 30 January 2006

Logframe for Project R8512

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Goal			
Livelihoods of poor people improved through sustainably enhanced production and productivity of RNR systems.	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Purpose			
Promotion of strategies to minimise impact of target pests in rice-based Land-Water interface cropping systems, for benefit of poor people.	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Outputs			
1. Field-scale mechanisation of direct seeding evaluated	1.1 By 11/05 OFTs completed with 15 groups to test methods for direct seeding and appropriate herbicides.	1.1 Project reports and information incorporated in decision frameworks	Weather conditions allow completion of field trials and BRRI continue to allocate staff to fieldwork.
2. Decision support tool(s) that inform policy makers, extension providers and farmers on choice of rice establishment and weeding options for *aman* rice-*rabi* and *boro* rice-*aman* rice cropping patterns developed and evaluated	2.1 By 01/06 decision support tools for *aman* rice-*rabi* and *boro* rice-*aman* incorporated into training manuals for extension providers/pesticide dealers and placed on IRRI Rice Knowledge Bank. 2.2 By 01/06 training of extension workers undertaken in 3 districts in Barind and 5 upazillas in Comilla District 2.3 Decision tools and training modules placed on Rice Knowledge Bank by 01/06. 2.4 Policy brief on future use of decision support in promotion of improved weed management circulated to DAE management, NGOs and private sector	2.1 Project reports and IRRI web pages 2.2 Project reports 2.3 Publication of policy brief and journal paper describing process.	DAE remain committed to promotion of improved weed management; private sector partners remain committed to develop training materials.

Appendix 1. Fact sheets from Bangladesh Rice Knowledge Bank

ধান চাষে আগাছানাশকের ব্যবহার

আগাছানাশকের ব্যবহার
খরচ কমানোর হাতিয়ার

ভূমিকা:ধান ক্ষেতের আগাছা দমনে হাত নিড়ি এবং জাপানী উইডার ব্যবহারে শ্রমিক বেশি লাগায় বিঘা প্রতি ৫০০ থেকে ৮০০ টাকা ব্যয় হয়। আগাছানাশক ব্যবহার করে চাষি ভাইয়েরা কম খরচে আগাছা দমন করতে পারেন।যেহেতু আগাছানাশক একটি রাসায়নিক .পদার্থ, সেজন্য স্বাস্থ্য ও পরিবেশ সুরক্ষার জন্য প্রয়োগের সময় অবশ্যই সতর্কতা অবলম্বন করতে হবে।

আগাছানাশক কি ?

আগাছানাশক এক ধরনের রাসায়নিক দ্রব্য যা আগাছাকে মেরে ফেলে কিন্তু ফসলের কোন ক্ষতি হয় না। আউশ, আমন এবং বোরো ধান ক্ষেতে উহা ব্যবহার করা যায়।

আগাছানাশক জমিতে কিভাবে ব্যবহার করতে হ.য় ?

তরল আগাছানাশক

১।বিভিন্ন ধরনের আগাছানাশকের প্রয়োগবিধিও ভিন্ন ভিন্ন। উদাহরনস্বরুপঃ
তরল আগাছানাশকঃ যেমন- রনস্টার, রিফিট, করস্টার, সুপারহিট ইত্যাদি স্প্রে মেশিনের সাহায্যে মাঠে স্প্রে করা যায় ।
পাউডার জাতীয় আগাছানাশকঃযেমন-সেটঅফ, পরিস্কার পানির সাথে মিশিয়ে স্প্রে মেশিনের সাহায্যে মাঠে স্প্রে করা যায় ।
দানাদার আগাছানাশকঃযেমন- ম্যাচেটি বা এইমক্লোর, সরাসরি জমিতে ছিটিয়ে প্রয়োগ করা যায় ।

২। অঙ্কুরোদগমকালীন সময়ে কার্যকরী আগাছানাশক লাগানোর ৩-৫ দিনের মধ্যে এবং অঙ্কুরোদগমের পরে কার্যকরী আগাছানাশক ১০-১৫ দিনের মধ্যে জমিতে ২- ৩ সেঃমিঃ পানি থাকা অবস্থায় প্রয়োগ করতে হবে

৩। সরাসরি বা ড্রাম সিডার দ্বারা বপনকৃত জমিতে আগাছানাশক ব্যবহারের সময় জমিতে আগাছানাশক প্রয়োগের পরে জমিতে পানি বা কাদাময় অবস্থা ৫-৭ দিন থাকা আবশ্যক।রিফিট, ম্যাচেটি/এইমক্লোর এবং সানরাইস ব্যবহার করে ভাল ফল পাওয়া যায়। অঙ্কুরোদগমকালীন সময়ে কার্যকরী আগাছানাশক লাগানোর ৩-৫ দিনের মধ্যে এবং অঙ্কুরোদগমের পরে কার্যকরী আগাছানাশক ১০-১৫ দিনের মধ্যে প্রয়োগ করতে হবে।আগাছা ভালভাবে নিয়ন্এনে পরবর্তীতে ৩০-৩৫ দিন পর একবার হাত নিড়ানী দিতে হবে।

আগাছানাশক ব্যবহারের উপকার

- হাত বা হস্তচালিত নিড়ানী যন্এ দ্বারা আগাছা দমন করা কঠিন এবং ইহাতে অনেক লোকব অনেক সময় দরকার ।
- শ্রমিক দ্বারা আগাছা দমনের চেয়ে আগাছানাশক দ্বারা আগাছা দমন করলে অনেক খরচ কম লাগে ।

ভাড়া করা শ্রমিক দ্বারা আগাছা দমন করলে প্রতি বিঘায় আগাছা দমনের জন্য ৫০০/- টাকা থেকে ৮০০/- টাকা প্রয়োজন ।একই পরিমান জমিতে আগাছানাশক দ্বারা আগাছা দমন করলে ২০০/- টাকা হতে ৩০০/- টাকার প্রয়োজন হয়।

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ধান চাষে আগাছানাশকের ব্যবহার

বাংলাদেশে বহুল ব্যবহৃত কিছু আগাছানাশকের নাম ও মাত্রা:

আগাছানাশকের নাম	মাত্রা(বিঘা)
রনস্টার ২৫ ইসি	২৭০ মিলি
সেটঅফ ২০ ডব্লিও জি	১৩.৩৩ গ্রাম
অ্যারোজিন	১৮০মিলি
ম্যাচেটি ৫জি	৩.৩ কেজি
আরগোল্ড ১০ ইসি	১০০ মিলি
এইমক্লোর ৫জি	৩.৩ কেজি
রিফিট ৫০০ ইসি	১৩৩ মিলি
বুটাক্লোর ৫জি	৩.৩ কেজি
সিরিয়াস ১০ ডব্লিও পি	১৩.৩৩ গ্রাম
ভেচেটি ৫জি	৩.৩ কেজি
করস্টার ২৫ ইসি	২৭০ মিলি
সুপারহিট ৫০০ ইসি	১৩০ মিলি
এমকোস্টার ২৫ ইসি	২৭০ মিলি
*সানরাইজ ১৫০ ডব্লিওজি	১৩.৩৩ গ্রাম
*এম.সি.পি.এ ৫০০ ইসি	১৩০ মিলি
*সিরিয়াস ১০ ডব্লিউ পি	২০ গ্রাম

ব্যবহারের আগে আগাছানাশকের বোতল বা প্যাকেটের গায়ে লিখিত নির্দেশাবলী পড়া প্রয়োজন।

দানাদার আগাছানাশক

*আগাছা অঙ্কুরোদগমের পর কার্যকরী (পোষ্ট ইমারজেন্স হার্বিসাইড)
অন্যগুলো আগাছা অংকুরোদগমের সময় কার্যকরী (প্রি-ইমারজেন্স হার্বিসাইড)

আগাছানাশক কি মাটির ও ধানের পরিবেশ দুষন করে?

⦿আগাছানাশক জমিতে ব্যবহারের পর মাটির অনুজীবের কারনে ধ্বংসপ্রাপ্ত হয়ে নির্দোষ বস্তুতে পরিনত হয়। ফলে মাটির তেমন কোন ক্ষতি হয় না।

⦿বাংলাদেশে যে সব আগাছানাশক বিক্রি হয় সেগুলো পরীক্ষা করা হয়েছে এবং দেখা গিয়াছে যে সেগুলো পরিবেশের জন্য নিরাপদ।সরকার এভাবে শুধু পরীক্ষিত আগাছানাশকই বিক্রির জন্য অনুমোদন দিয়ে থাকে।

একই আগাছানাশক কি বার বার ব্যবহার করা উচিত ?

প্রতি মৌসুমে আগাছানাশক পরিবর্তন করলে ভাল। কারন প্রতি মৌসুমে একই রকম আগাছানাশক জমিতে ব্যবহার করলে কিছু আগাছা ঐ আগাছানাশক প্রতিরোধী হতে পারে। ফলে আগাছানাশক দিয়ে প্রতিরোধ ক্ষমতা সম্পন্ন আগাছা দমন সম্ভব হবে না। এ অবস্থা থেকে রেহাই পেতে মৌসুমে-মৌসুমে আগাছানাশক পরিবর্তন করে ব্যবহার করলে ভাল হয়।

আগাছানাশক ব্যবহারে কিছু লক্ষ্যনীয় বিষয়ঃ

⦿আগাছানাশক শিশুদের নাগালের বাইরে রাখা উচিত এবং খাদ্য হতে দুরে সংরক্ষন করা উচিত।

⦿আগাছানাশক বোতল হতে স্প্রেয়ারে ঢালার সময় যাতে চামড়ায় ছিটকে না পড়ে সেজন্য হাতে প্লাষ্টিকের ব্যাগ দিয়ে মুড়িয়ে নেয়া উচিত।

⦿ আগাছানাশক স্প্রে করার সময় বা ছিটানোর সময় ফুল হাতা জামা ব্যবহার করা উচিত যাতে আগাছানাশক শরীরে না পড়ে।

⦿স্প্রে করার পর খাওয়া অথবা ধুমপানের আগে সব সময় হাত ভাল করে ধোয়া উচিত।

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ধানক্ষেতে আগাছা ব্যবস্থাপনা

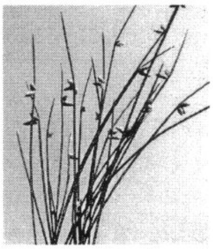
সময় মত আগাছা দমন
ক্ষেতে হবে অধিক ফলন

ভূমিকা: আগাছা ধান ফসলের একটি মারাত্মক শত্রু । ইহা ধানের সাথে খাদ্য, আলো, বাতাস ও পানিতে ভাগ বসায়, পোকামাকড় ও রোগ বালাইয়ের আক্রমন বাড়ায়, ফলে ধানের ফলন মারাত্মকভাবে কমে যায়। বর্তমানে হাত দ্বারা আগাছা দমনের খরচ খুব বেশী এবং অনেক সময় ভাল ফল পাওয়া যায় না। উন্নত আগাছা ব্যবস্থাপনার মাধ্যমে চাষি ভাইয়েরা ভাল ফলন পাবেন এবং আগাছা দমনের খরচ কমাতে পারবেন।

আগাছা দমনের উপকারিতা

- ✪আগাছা দমনের ফলে ধান গাছ পরিমাণ মত খাদ্য, পানি এবং আলো -বাতাস পায়।
- ✪এতে ধান গাছের বাড়-বাড়তি ভাল হয় এবং পরবর্তীতে ধানের ফলন বেড়ে যায়।

আগাছা পরিচিতি: যে সমস্ত আগাছা সবচেয়ে বেশী ক্ষতি করে তার কয়েকটি নাম ও ছবি দেয়া হলো।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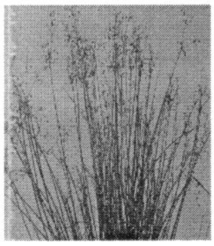
বড় জাভানী


ঝিল মরিচ


পানিকচু


বড় চুচা

আগাছা দমন পদ্ধতি

ক) প্রতিরোধমূলক ব্যবস্থাঃ

- আগাছার বীজ মুক্ত ফসলের বীজ ব্যবহার
- জমির আইল ও সেচনালা আগাছা মুক্ত রাখা
- কৃষি যন্ত্রপাতি পরিস্কার রাখা
- জমিতে গরু বাছুর যথাসম্ভব কম রাখা
- আগাছার অংগজ বংশ বৃদ্ধি ও বীজ উৎপাদন করতে না দেয়া

খ) উত্তম চাষ দ্বারা জমিতে আগাছার উপদ্রব কমানো যায় ।

গ) শস্য পর্যায় অবলম্বন করলে অনেক ক্ষতিকর আগাছার উপদ্রব কমানো যায় ।

ঘ) গাছের সংখ্যা হ্রাস/বৃদ্ধি বা স্পেসিং এর হ্রাস/বৃদ্ধির মাধ্যমে আগাছা দমন করা যায়।

ঙ) পানি ব্যবস্থাপনার মাধ্যমে জমিতে পরিমাণমত পানি ধরে রাখলে আগাছার উপদ্রব অনেক কম হয়।

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ধানক্ষেতে আগাছা ব্যবস্হাপনা

সময় মত আগাছা দমন
ক্ষেতে হবে অধিক ফলন

✪হাত দ্বারা আগাছা দমনঃ

বোরো ধানে ২-৩ বার আগাছা দমন করতে হয়। (বিঘা প্রতি ৫০০-৮০০ টাকা খররচ হয়) । এতে সময় ও শ্রমিক বেশী লাগে এবং আগাছা বড় না হলে ভালভাবে আগাছা দমন করা যায় না।

✪যন্এপাতির সাহায্যে আগাছা দমনঃ

লাইন করে রোপনকৃত অথবা বপনকৃত জমিতে জাপানী রাইস উইডার এবং ব্রি-উইডার দ্বারা আগাছা দমন করা যায়। জাপানী রাইস উইডার ও ব্রি-উইডারে অনেক সুবিধা আছে।

ক) ষ্টীলের সিট ও পাইপ দিয়ে কারখানায় সহজেই উইডার তৈরী করা যায় ও কাদাময় মাটিতে চালানো সুবিধাজনক ।

খ) একজন শ্রমিক অতি সহজে একটি উইডার দিয়ে ঘন্টায় ১০-১৫ শতাংশ জমির আগাছা দমন করতে পারে

গ) অনুমোদিত দুরত্বে লাগানো ধানের চারার ক্ষেতে (৮ ইঞ্চি×৮ ইঞ্চি অথবা ১০ ইঞ্চি ×৬ ইঞ্চি) এবং ৮-১০ ইঞ্চি দুরত্বে লাইনে বপনকৃত ধান ক্ষেতে উহা সহজে ব্যবহার করা যায়

ঘ) আগাছা দমনে খরচ কম ও কার্যকরী ভাবে দমন করে ।

✪আগাছানাশকের ব্যবহার:

•আগাছানাশক ব্যবহারে বিঘা প্রতি খরচ হাত দ্বারা আগাছা দমনের খরচের অর্ধেক এবং অনেক সময় এক তৃতীয়াংশ খরচ হয়।

•বর্তমানে বহুল ব্যবহৃত আগাছানাশকগুলোর মধ্যে রিফিট, ম্যাচেটি, রনস্টার, সেটঅফ, এইমক্লোর, এমসিপিএ, সিরিয়াস প্রভৃতি উল্লেখযোগ্য। এগুলো তরল, দানাদার ও পাউডার জাতীয় হয়ে থাকে।

•জমিতে আগাছানাশক ব্যবহারের পূর্বে বোতল বা প্যাকেটের গায়ে লেখা এর মাত্রা,সময় এবং সতর্কতা প্রভৃতি ভালভাবে বুঝে প্রয়োগ করতে হবে। মাঝে মাঝে আগাছানাশক প্রয়োগের পরেও একবাব হাত নিড়ানীর প্রয়োজন হয়।

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Appendix 2.

Training on Dissemination of Direct seeded rice, Weed control options in Rainfed Rice-Chickpea cropping system in Drought prone high Barind tract

BRRI-IRRI-NRI collaboration

Venue: Training complex, BRRI, Rajshahi Date: 25-26 January 2006

Time	Topics	Facilitator/Speaker
0900-0920	Major constraints to improve productivity in Barind tract and scope of improvement	Dr. MA Mazid PSO & Head, BRRI, Rangpur
0920-1000	Direct seeded rice using Lithao in Rainfed Rice-Chickpea cropping system in Drought prone high Barind tract	Dr. MA Mazid PSO & Head, BRRI, Rangpur
1000-1040	Direct wet seeded rice using Drum seeder in Barind tract	Biswajit Karmakar SO, BRRI Rajshahi
1040-1100	Emphasize of early crop establishment/DSR and/or shorter duration varieties to do advance harvest date	Dr. Md. Ansar Ali PSO & Head, BRRI Rajshahi
1100-1140	Tea Break	
1140-1220	Major weeds and weed control options in Rainfed drought prone high Barind tract	Biswajit Karmakar SO, BRRI Rajshahi
1220-1300	Major diseases of rice and control measures especially Sheath blight management	Dr. Md. Ansar Ali PSO & Head, BRRI Rajshahi
1300-1400	Lunch and Prayer	
1440-1520	Discussion on Farmer's opinion, responses and field experiences of DSR practiced in Barind tract	Dr. MA Mazid PSO & Head, BRRI, Rangpur
1520-1600	Economics of improved cropping pattern (DSR or TPR (SDV)-Chickpea Vs Traditional/ existing practices	Dr. MA Jabbar/Dr. MA Mazid CSO & Head, BRRI Gazipur PSO & Head, BRRI Rangpur
1600-1640	Formation of Farmer's Group-an effective technology dissemination/Extension approach and sustainability through Farmer's Field School (FFS) model	Additional Director, DAE, Rajshahi region, Rajshahi

Participants List:

Organization	Districts	Upozilla	AEO/UAO	BS/AASO	Farmer
DAE	Rajshahi	Godagari	1	3	6
		Tanore	1	3	6
	Chapai Nawabganj	Gomostapur	1	3	6
		Nachole	1	3	6
	Naogaon	Niamatpur	1	3	6
		Porsha	1	3	6
CARE, Rajshahi	Rajshahi	Godagari	1	1	2
		Tanore	1	1	2
	Chapai Nawabganj	Gomostapur	1	1	2
		Nachole	1	1	2
	Naogaon	Niamatpur	1	1	2
		Porsha	1	1	2
On farm participating **(Researcher's Managemnt)**	Rajshahi	Godagari	6	1	4
		Tanore			4
	Chapai Nawabganj	Gomostapur		1	4
		Nachole			4
	Naogaon	Niamatpur		1	4
		Porsha			4
On farm participating farmer **(Researcher's Managemnt**	Rajshahi	Godagari	6	Farmer group-1	10
				Farmer group-2	10
				Farmer group-3	10
				Farmer group-4	10
				Farmer group-5	10
				Farmer group-6	10
Total					

Appendix 3

Workshop : Dissemination on Direct Seeded Rice, Weed Control Options in Rainfed Rice- Chickpea Cropping System in Drought Prone High Barind Soils of Bangladesh

(BRRI-DAE-PROVA collaboration)
BRRI-IRRI-NRI

Venue: Training Center , Postal Academy, Rajshahi

Date: 16 May 2005 (Monday)

Schedule:

Time (hrs)	Topics	Facilitator/Speaker
0800-0900	Registration	E. Haque/Bablu (PROVA)/ B. Karmakar, SO, BRRI RS Rangpur.
0900-0915	Guest Take their seat	M. A. Salam, DD (HQ), DAE / A. Ali, SSO, BRRI RS Rangpur
Inaugural Session: Chairperson- BRRI/PROVA, Announcer: Dr. M. Ansar Ali/ B.Karmakar		
0915-0920	Recitation from Holy Quaran	Farmer's representative
0920-0925	Welcome address	Dr. Montazer Rahman, CSO & Head, BRRI Regional Station, Rajshahi
0925-0935	Workshop them and technology validation	Dr. M. A. Mazid Site Coordinator (BRRI-IRRI-NRI)
0935-0945	Speaks by Special Guest	Dr. Mrs. N. K. Kamal Director (Research), BRRI, Gazipur
0945-1000	**Speaks by Chief Guest**	Krishibid Md. Ibrahim Khalil, Director General, DAE, Khamarbari
1000-1015	Tea break	Dr. A. Ali/B. Karmakar / M.A. Salam/Abu Musa
Technical Session: Chair person: KBD Md. Ibrahim Khalil, Director General, DAE, Khamarbari Rapotears: DD , DAE, C.Nawabganj, Agril. Advisor, PROVA and Mr. B. Karmakar , BRRI		
1015-1045	Direct Seeded Rice (DSR), Weed Control Option and potential for DSR by lithao, broadcasting or drum seeder: Issues related to Technology validation and dissemination in Rainfed Rice – Chickpea Cropping System in High Barind soil through FFS Model	Dr. M. A. Mazid Site Coordinator, BRRI-IRRI-NRI and PSO & Head BRRI Regional Station, Rangpur
1045-1115	Emphasize DSR and/or shorter duration varieties do advance harvest date: Cover chickpea establishment (chickpea sowing date is earlier.), crop management and yields FTR - Chickpea data from PROVA sites in 2003/04 rabi.	Abu M. Musa, Agril. Advisor, PROVA, Rajshahi
1115-1145	Economics of Improved cropping pattern (DSR –Chickpea and SDV	Dr. M. A. Jabber CSO & Head

	(TPR) -Chickpea) Vs Traditional/existing cropping pattern, cost effective weed control methods and Farmer's feed back in Rainfed High Barind Tract of Bangladesh	Agril. Economics Divn., BRRI, Gazipur
1145-1215	Formation of Farmer's Group – an effective Technoligy Dissemination/Extension Approach and Sustainability through Farmer's Field School (FFS) model	Mr. M.L. Mahmud, ADAE, Rajshahi Region, Rajshahi
1215-1245	Highlight key messages for extension and farmers from our programme in the Barind. This will lead into need for decision support.	Dr. Martin Mortimer Professor of Liverpool University, UK and Weed Ecologist, NRI
1245-1315	Extension Materials: **Leaflet,** Booklet: Introduction of **early maturing variety and DSR** in Rainfed rice-chickpea system for wider adaptation of technology to the Target Environment	Dr. M. Ansar Ali, and Dr. M. A. Mazid
1315 -1400	Lunch /Prayer	Dr. A. Ali/B. Karmakar / M.A. Salam/Abu Musa
1400-1430	Extension Materials: **Leaflet**, Booklet: **Major weeds** in HBS, and **control measures and yield gaps** due to weeds for wider dissemination of technology to the Target Environment	Mr. Biswajit Karmakar and Dr. M. A. Mazid
1430-1530	Discussion	All participants
1530-1540	Vote of Thanks	Mr. M. A. Salam, DD (HQ), DAE, Rajshahi
1600	Close	

Appendix 4

Improving agricultural productivity in rice-based systems of the High Barind Tract, Bangladesh

BRAC Centre, Dhaka. 4-5th March, 2006

Inauguration (Chairman:		
09:00	**Introduction and Welcome**	*Dr Hamid Miah (BRRI Dhaka)*
09:05	Meeting Objectives	*Dr C Riches (NRI, UK)*
09:10	Summary of achievements of DFID work 2000-2006	Dr A M Mortimer (University of Liverpool, UK) & Dr D Harris (University of Wales, UK)
09:30	Speech by DG BRRI	
09:35	Speech by DG DAE	
09:45	Address by Chief Guest	Minister of Agriculture
09:55	Chairman's remarks	
10:00	Tea & snacks	
Session 1 – Setting the scene		
10:30	Contribution of rice-based agriculture to livelihoods in the Bangladesh: drivers of change	*Dr M Hossain (IRRI, Philippines)*
Session 2 – Development & Farmer evaluation of technologies 1.		
11:00	Improved weed management for transplanted *aman*	*Dr C Riches (NRI, UK), Dr A M Mortimer (University of Liverpool, UK) & Dr G Uddin Ahmed (BRRI, Gazipur)*
11:20	Developments in direct seeding of rain-fed rice in the High Barind	Dr M A Mazid (BRRI, Rangpur) & B. Khamarker (BRRI, Rajshahi)
11:40	Economic aspects of adopting direct-seeding: Lessons from farmer evaluation	Dr MA Jabber (BRRI, Gazipur) & Dr A Orr (NRI)
12:00	Direct seeding in rice-wheat systems in the Indo-Gangetic Plains	Dr Y Singh (GB Pant University, India)
12:20	Discussion	
!2:45	Lunch	
Session 2 – Development & Farmer evaluation of technologies 2.		
13:45	Breeding rice for stress prone rain-fed environments	Salam (BRRI, Gazipur) / Atlin
14:15	Shortening the duration of T. *aman* rice for more timely sowing of *rabi* crops	*Dr Joshi (Nepal) & Dr Johansen (PROVA, Bangaldesh)*
14:45	Opportunities for enhancing *rabi* cropping and introducing an improved chickpea production package in the High Barind.	Dr D Harris (University of Wales, UK) & Dr Johansen (PROVA, Bangladesh)
15:15	Farmer decision making for *rabi* production in the High Barind Tract	*Dr A Orr (NRI)*
15:45	Tea	
16:10	Extending *rabi* cropping in rice fallows of eastern India	*JVDK Kumar Rao (ICRISAT, India)*
16:30	Discussion	
Session 3 – Decision support		
16:45	Integration of chickpea and other *rabi*	A M Musa & C Johansen University of

	crops into rainfed rice-based systems of the High Barind Tract	Wales/PROVA team
17:05	Issues of long-term sustainability of direct seeding of rice and alternative rabi crops: rotations, weeds and nutrients	Dr A M Mortimer (University of Liverpool) with NRI/BRRI team + Chris Johansen, University of Wales/PROVA team
17:30	Discussion	
Day 2: 5th March		
Session 4 – Dissemination for impact		
09:00	Introductory paper on FoSHoL , BRKB and transferring complex technologies	Dr N Magor (IRRI Dhaka)
09:20	The farmer group approach in the High Barind: resources for trainers and farmers	*M. A. Mazid (BRRI, Rangpur)*
09:40	Bangladesh experiences with the drum seeder	*Dr. Musharref Hossain (BRRI, Gazipur)*
10:00	Formulation and dissemination of improved cropping system packages for the HBT	*MA Salam (DD Rajshahi Division, DAE)*
10:20	Developing seed systems for dissemination of chickpea and *aman* rice lines appropriate to the High Baring Tract.	A M Musa,University of Wales/PROVA team
10:40	Tea/snacks	
Session 5– Synthesis – opportunities for enhanced adoption		
11:00	Farm level opportunities for increasing productivity and income in the High Barind Tract	Dr A Orr +NRI/BRRI + Univ of Wales teams
11:30	'Whither' direct seeding –Regional commonalties and lessons learnt from other systems	*Dr D. Johnson (IRRI, Philippines)*
12:00	Discussion	
12:15	Lunch	
Session 6 Concluding discussions. Facilitator – Dr Hamid Miah (IRRI Dhaka)		
13:15	Agenda for future dissemination of technology in the High Barind	
14:15	Agenda for further research on rice and *rabi* systems for the High Barind and rice direct seeding systems	
15:30	Chairman's concluding remarks and close	

Direct seeding and weed control for rainfed and irrigated rice in northwest Bangladesh

The installation of shallow tube wells in many areas around Rangpur, in northwest Bangladesh, has allowed farmers to grow irrigated rice in the dry season, in addition to rainfed rice in the monsoon season.

While this raises land productivity, increasing costs are leading farmers to seek cheaper production methods and, in particular, to reduce the requirements for irrigation, water, and labor. Direct seeding rice (DSR) in place of transplanting (TPR) is a potential means to achieve such savings.

Objective

To assess the potential of DSR as an alternative to TPR, in the dry and monsoon seasons, through field experiments and participatory approaches.

Materials and methods

DSR was compared to the usual farmer practice of TPR in the dry and monsoon seasons. In DSR, wet, germinated seed was sown on puddled land with a light-weight hand-pulled drum seeder or by hand-broadcast (only in 2005).

Weed management options in rice were compared:

- hand weeding rice three times,
- BRRI push-weeder followed by two hand weedings,
- pre-emergence application of oxadiazon in drum seeder or pretilachlor in TPR, each followed by one hand weeding.

Establishment and weed control options were also assessed on-farm with five farmer groups in the 2005 dry season.

Results

Table 1. Rice grain yield (t ha^{-1}) in on-station trials.

	2004 Monsoon			2005 Dry season		
	Weed control					
Establishment method	Hand weed	Herbicide	Push weeder	Hand weed	Herbicide	Push weeder
Transplant	3.6	4.0	3.5	5.0	5.1	4.8
Drum seeder	3.8	4.6	3.8	5.9	6.4	5.8
Broadcast		-		5.8	6.3	-
S.E.M. ±		0.210			0.161	

- In the on-station experiments, highest rice yields were associated with direct seeding and herbicide use (Table 1).
- Increased weed infestation resulted in a 40% increase in hand weeding for drum seeder or hand-broadcast rice compared with TPR.
- Herbicide use, however, reduced weed control costs by 80% in DSR and by 60% in TPR.

Weeds

- The important weed species were similar among the different establishment treatments.
- *Marsilea minuta* accounted for the greatest biomass among the weeds followed by *Echinochloa crus-galli*, while *Cyperus difformis* was the most important sedge.
- There was substantially more weed biomass in the hand-broadcast and drum seeder plots than in the TPR plots.
- *Ischaemum rugosum, Echinochloa colona, Fimbristylis miliacea, Paspalum distichum,* and *Cynodon dactylon* were also found in the experiments, but were of minor relative importance.

Rice

- On-farm yields of irrigated rice established by the three methods were not significantly different, and across farms these averaged 4.9 t ha^{-1} for TPR, 4.9 t ha^{-1} for hand-broadcast, and 5.4 t ha^{-1} ($\pm$ 0.185) for drum seeder.
- Farmers reported lower labor requirements for drum seeder (3 person d ha^{-1}) compared with uprooting seedlings and TPR (77 days ha^{-1}).
- DSR required less water with lower pumping costs than TPR.

Transplanting

Drum seeder

Summary

- Yields of DSR were as good or better than those of TPR on farmers' fields and in station trials.
- Using direct seeding, farmers had labor savings of 74 person days ha^{-1}.
- Direct seeding by drum seeder or broadcasting resulted in increased weed growth compared with transplanting.
- Attention needs to be focused on any changes in abundance of important grass and sedge weeds that may occur with the adoption of different establishment methods.

M A Mazid[1], D E Johnson[2], A M Mortimer[3], C R Riches[4]

[1]Bangladesh Rice Research Institute Regional Station, Rangpur, Bangladesh; [2]International Rice Research Institute, Philippines; [3]University of Liverpool, UK; [4]Natural Resources Institute, UK

Natural Resources Institute

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