Boosting lowland rice yields and banishing weeds

RIU

Validated RNRRS Output.

New ways to control weeds and plant rice using direct-seeding have great potential to increase rice harvests in Bangladesh. At the moment, one-third of farmers lose half a tonne of rice per hectare because of weeds. Now, a range of cost-effective weed management practices have been validated, which include applying herbicides or using a manual rotary weeder. Yields are the same or better than with normal hand-weeding, but costs are 30-45% less. Direct-seeding has also proved valuable in drought-prone areas. It gives earlier rice harvests, allows farmers to grow a second crop, and reduces outlays on irrigation water and labour. Extensionists and NGOs are already spreading the word, and training manuals, leaflets and posters for pesticide-dealers' stores are available.

Project Ref: **CPP30:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **Natural Resources Institute (NRI), UK**
Source: **Crop Protection Programme**

Document Contents:

Description

CPP30

A. Description of the research output(s)

Research into Use
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

Bangladesh,

Target Audiences for this content:

Crop farmers,

1. Working title of output or cluster of outputs.
In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

Cost effective weed management packages for lowland rice in Bangladesh.

Suggested title:

Direct-seeded rice – securing the harvest and raising incomes

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

The Crop Protection Programme commissioned the core projects that generated the outputs described in this dossier. Activities in rain-fed rice in Rajshahi district were implemented in collaboration with the International Rice Research Institute (IRRI) co-ordinated regional *Rain-fed Lowland Rice Research Consortium*, and subsequently *Consortium of Unfavourable Rice Environments* (funded by Asian Development Bank). Salaries of the Bangladesh Rice Research Institute and the Department of Agricultural Extension partners were funded by Government of Bangladesh. One of the advantages for farmers who direct seed (a technology validated by these projects) is an increased opportunity to plant post-rice crops on residual moisture. Improved practices for post-rice cropping in Bangladesh were in turn investigated by the Plant Sciences Research Programme project R7438 led by University of Wales in partnership with Bangladesh Agricultural Research Institute and the NGO PROVA. CPP and PSRP therefore co-funded on-farm validation work in the rice-post-rice system.

Additional supporting work to validate the use of direct seeding in Rangpur district has subsequently been undertaken by Bangladesh Rice Research Institute in collaboration with the IRRI co-ordinated Irrigated Rice Research Consortium (funded by Swiss Development Corporation).

Herbicide promotion studies were undertaken by the CPP projects in Comilla District in partnership with the NGO SAFE Development Group, funded by the Poverty Elimination Through Rice Research Assistance programme (PETRRA – funded by DfID Bangladesh).

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities.

R7471 [1999-2002], R8234 [2003-2005], R8412 [2005-2006]

Partners:

Natural Resources Institute, University of Greenwich (Dr CR Riches – charlie@riches27.freeserve.co.uk; Dr AW Orr, aw.orr@virgin.net);
Bangladesh Rice Research Institute (Dr MA Mazid, [Rajshahi] activities in Barind Tract – brrirangpur@bdonline.

com); Dr GUJ Ahmed, [Gazipur] activities in Comilla District – gjuajmed@yahoo.co.in);
International Rice Research Institute (Dr D Johnson, [Philippines] d.johnson@cgiar.org);
University of Liverpool, School of Biological Sciences (Dr AM Mortimer – a.m.mortimer@liverpool.ac.uk);
Peoples Resource Oriented Voluntary Association - Rajshahi, (Mr MA Mussa; Dr C Johanson); ljohense@citecho.net
SAFE Development Group – Dhaka, (Mr G Chowhan); safedg@bangla.net
Syngenta Bangladesh (Mr M Rahman – mahbub.rahman@syngenta.com)

4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? ***(max. 400 words)***. *This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.*

Outputs were generated in 1999-2006 on two widely applicable approaches to improving the productivity of **rice-based lowland** systems in a range of seasons and at different levels of intensification (**rain-fed** and **irrigated**):

Ø Yield gaps and farm level constraints described: **Characterisation** studies determined **yield gaps** between rice yields with farmer's weed management and that attainable on-farm by clean weeding. Across a range of elevations on the toposequence in the transplanted ***aman*** (monsoon season) crop in the **Barind Tract** of **NW Bangladesh** (with a single rice crop per year typical of 1.2 million hectares in the country) or double cropping of transplanted *aman* followed by irrigated ***boro*** (dry season rice, system typical of 2 million ha accounting for 50% of the national crop) one third of farmers on average lose 0.5 t of rough rice per hectare to weeds. Identified that due to the emerging shortage of farm labour caused by the rapid growth of the rural non-farm economy rice producers, including poor share or rental croppers, are seeking to reduce input costs, increase production or both;

Ø A range of validated **cost-effective weed management practices** developed through **Participatory on-farm trials** and **demonstrations** validated a range of **cost-effective weed management practices** in both *aman* and *boro* seasons, including application of **herbicides** or use of a manual rotary weeder that result in similar or increased yields to the farmers existing practice of hand weeding while reducing input costs by 30-45% by reducing labour demand;

Ø Validated **dry** and **wet direct seeding** practices for **drought prone** low-land environments. For areas where farmers currently grow only a transplanted *aman* crop these technologies allow i) Timely rice harvest when late monsoons would otherwise delay transplanting; ii) Earlier rice harvest and fewer hungry months when the poor run short of food; iii) Cash income from an additional crop grown after earlier-harvested rice; iv) Reduced use of increasingly expensive irrigation water; and v) Reduced labour costs at peak season wages, as transplanting is not required. Wet seeding is also an advantage in irrigated *boro* rice allowing more timely crop establishment with reduced costs;

Ø A range of **decision support tools** for the promotion of the knowledge intensive technologies of direct seeding and herbicide use. These included a range of extension training materials (2 training of trainers manuals, 5 leaflets, a poster for pesticide dealers stores and fact sheets on the Bangladesh node of the IRRI managed web based Rice Knowledge Bank (www.knowledgebank-brri.org).

Ø A synthesis of the **policy implications** for extension service providers of promotion of direct seeding in Bangladesh and lessons from pilot promotion platforms.

5. What is the type of output(s) being described here?
Please tick one or more of the following options.

Product	Technology	Service	Process or Methodology	Policy	Other Please specify
	X		X	X	

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment

Rain-fed and irrigated lowland rice.

7. What production system(s) does/could the output(s) focus upon?
Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	High potential	Hillsides	Forest-Agriculture	Peri-urban	Land water	Tropical moist forest	Cross-cutting
					X		

8. What farming system(s) does the output(s) focus upon?
Please tick one or more of the following options (see Annex B for definitions).
Leave blank if not applicable

Smallholder rainfed humid	Irrigated	Wetland rice based	Smallholder rainfed highland	Smallholder rainfed dry/cold	Dualistic	Coastal artisanal fishing
		X				

*9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non RNRRS)? (**max. 300 words**).*

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

Crop establishment and timely weed management need to be used with other components of integrated crop management and crop diversification to increase yields, enhance system productivity, the quality of diets and farm household income. Bangladeshi rice growers rely heavily on inorganic fertiliser use but recent studies by PETRA sub-projects indicate that uneconomic over-use is common. Two approaches to nutrient management need to be promoted with direct seeding and effective weed control, the use of a leaf colour chart to guide fertiliser application decisions (validated by PETRRA programme) AND greater use of legumes in the rotation. Locally validated diversification options include use of chickpea as a post-rice crop in the *rabi* season in the High Barind Tract of NW Bangladesh. The best-bet practices for chickpea production, including suitable cultivars and establishment methods validated by Plant Science Research Programme project R7438, need to be promoted in tandem with direct seeding in the Barind and similar environments. Elsewhere there is the option to grow mung

bean in a rice/potato or wheat/mung bean rotation in much of Greater Rangpur region. Short duration cultivars of mung bean fitting this cropping pattern are available from the Bangladesh Agricultural Research Institute (BRRI).

Farmers are increasingly preparing rice land by hiring contractor operated power tillers (PT). A seeder suitable for wheat and rice can be attached to the PT and wider availability is likely to speed adoption of direct seeding. Validation and further modification of the tiller seeder has been undertaken in Bangladesh by CIMMYT working in collaboration with the Wheat Research Centre (funded by IFAD) and IRRI (funded by ADB).

Validation

B. Validation of the research output(s)

*10**. How** were the output(s) validated and **who** validated them?*

*Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the "who" component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation **(max. 500 words)**.*

In Comilla district farmer groups in three upazillas (see section 11) undertook on-farm trials of herbicides and mechanical weeding. Sites provided the replication for statistical analysis. Yield gains by applying herbicide or using a push-weeder over the usual farmer practice of hand weeding ranged from 200 to 600 kg ha^{-1}. These are of the order of previously recorded yield losses due to weeds with existing farmer management. Sets of farmer managed demonstrations were undertaken in four upazillas as detailed in section 11. Recorded yields indicated herbicide use to be a robust and reliable technology in both rain-fed and irrigated rice. Trials and demonstrations were co-ordinated by BRRI in partnership with village level extension workers from the Department of Agricultural Extension. Farmer perceptions of technical and economic performance of weed management options, were assessed by group and individual interview techniques. Extension and farmer training materials on safe and effective herbicide use, produced by BRRI and an NGO/private sector partnership, were tested with SAFE facilitated farmer field schools to which Syngenta contributed to lead farmer training. A poster covering these issues, was delivered by the Sygenta herbicide supply chain to village pesticide stores and has been well received by farmers and dealers who are often the farmer main source of information on pesticides.

A combination of field trials and socio-economic evaluations were used to validate direct seeding (DSR) with weed control by herbicides for improving the productivity of the fallow-*aman* system in Rajshahi region. A replicated research trial was run for 5 seasons comparing direct seeding and transplanting (TPR) in a rice-chickpea rotation. On-farm plot-scale trials compared dry or wet DSR with TPR for four rice cultivars with and without herbicide use. Sites provided replication for statistical analysis. Field-scale evaluations of dry DSR (sowing seed into moist soil) by using a hand pulled *lithao* (furrow opener) and wet DSR (sowing of pre-germinated seed using a hand pulled drum seeder) validated these technologies extensively under farmer management. The evaluation programme was co-ordinated in 2004 by the NGO PROVA with local facilitation by

staff of the upazilla Department of Agricultural Extension. In 2005 farmer groups were formed in six villages by BRRI for DSR evaluation. Rice yields under DSR were similar to TRP, but input costs were lower (no seedbed or transplanting) and harvest was 5 to 12 days earlier. Participants were not purposively selected for trials or field scale evaluation. Groups included both farmers from the Islamic majority communities and those from the *adivashi* (tribal) minority as well as both land-owners and those accessing land by *barga* (rental or share-crop contracts). For field scale evaluations of DSR, only equipment was loaned to participants who provided seed, fertiliser, pesticide and labour. Farmers perceived the use of DSR would allow them to plant a larger area of post-rice crops on land that would otherwise be fallow.

Technology was evaluated with farmers who had participated in on-farm trials. Participating farmers were not purposely selected. However, they were generally better educated and had higher levels of food security, who were able and willing to provide land for testing new technology. But they included sharecroppers and food-insecure households that allowed us to judge how the technology might benefit poorer households.

*11. **Where and when** have the output(s) been validated?*

*Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above **(max 300 words)**.*

-Validation occurred in wetland rice-based systems (land-water interface) in Bangladesh. Yield gaps due to weeds were determined in 2000 and 2001 in 18 farmer managed rice crops in Godagari upazilla, Rajshahi district, Tanore upazilla, Chapai Nawbgonj District and Nachole upazilla in Naogaon district (single rice crop system). For intensive rice systems (*aman*/*boro*) yield loss plots were monitored at 20 farms in Burichang, Comilla Sadar upazilla in Comilla District. An additional 10 farms were monitored in the *aus* season (rain-fed pre-monsoon rice) in Comilla Sadar in 2001.

Weed management practices for intensive rice systems were tested at the following sites:

Year/Season	Upazilla	Villages	Sites
2003 - *boro*	Burichang, Comilla Sadar	2	12 (3 good and 3 poor water management per village)
2004 - *boro*	Burichang, Comilla Sadar, Debidwar	3	22 (11 good and 11 poor water management per village)
2003 - *aman*	Burichang, Comilla Sadar, Debidwar	3	19
2004 - *aman*	Burichang, Comilla Sadar, Debidwar	3	20

Farmer-managed demonstrations of individual weed control options were undertaken as follows:

Year/Season	Upazilla	Sites
2003 - *boro*	Burichang, Comilla Sadar	20

2004 - *boro*	Burichang, Comilla Sadar, Debidwar, Baruara	80
2005 - *boro*	Burichang, Comilla Sadar, Debidwar, Hamna	40
2003 - *aman*	Burichang, Comilla Sadar, Debidwar, Baruara	80
2004 – *aman*	Burichang, Comilla Sadar, Debidwar	60
2005 - *aman*	Burichang, Comilla Sadar	22

The use of herbicide in transplanted *aman* rice was validated in rice/chickpea rotations on 100 farmers' fields in 2003 in 9 upazillas across Rajshahi, Chapai Nawabgonj and Naogaon districts. Detailed information on the long-term performance of direct seeding was collected between 2000 and 2005 on land rented from a farmer in Godagari upazilla. Dry-direct seeding with weed control by herbicide was tested in on-farm trials at 20 to 16 sites per year in 2002 and 2003 in Godagari, Tanore, and Nachole upazillas and in field-scale evaluations at 59 sites in 2004. Dry and wet direct seeding was evaluated further at 6 sites (one farmer group) in 2004 and at 54 sites (six groups) in 2005 in Godagari upazilla.

Current Situation

C. Current situation

12. ***How and by whom*** *are the outputs currently being used? Please give a brief description* ***(max. 250 words****).*

Herbicides are now being used widely in rice in Bangladesh, particularly in the *boro* season. Extension training information developed by this cluster of projects covering yield loss due to weeds and to support safe and effective use of herbicide is included in modules for extension worker training (for staff of DAE) delivered by BRRI. Copies have also been provided to all upazilla DAE offices in the country. Syngenta conducts regular training of pesticide form its retail network and includes information on safe and effective use of herbicides.

BRRI continues to research both dry and wet direct seeding, largely in a systems diversification context with trials at Rangur regional research station. On-farm trials using the farmer group methods and DSR practices validated in Rajshahi are being undertaken in Rangpur under projects of the Irrigated Rice Research Consortium, and Consortium for Unfavourable Rice Environments (funding through IRRI). Dry and wet DSR are being used in pilot promotion by the NGO RDRS programme in NW Bangladesh a through farmer field school approach.

13. ***Where*** *are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used* ***(max. 250 words).***

DAE extension officer training in integrated rice management is provided at BRRI HQ at Gazipur, Bangladesh. Syngenta and other companies undertake sales campaigns on herbicides around all rice growing areas of

Bangladesh. Use of the poster providing key messages on safe handling and effective use of herbicides is limited to extension offices and pesticide dealers stores in four upazillas of Comilla distict. 500 farmers benefited from training provided by BRRI in 2005 *boro* season in Barishal district. On-farm trials using the farmer group methods and DSR practices validated in Rajshahi are being used in on-farm trials in Rangpur District. Pilot promotion of DSR is being undertaken in Rangpur region, Bangladesh. BRRI is collaborating with CIMMYT and the Wheat Research Centre to validate the use of dry direct seeding by a power tiller operated seeder in Rangpur region. Use of pre-emergence herbicide, validated for dry DSR by the CPP projects is included in this work.

14. What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading ***(max 250 words).***

To date 4000 extension workers have received rice integrated crop management training (including in weed management) in 2005 and 2006 via BRRI training programmes. This is scheduled to continue until 10,000 village level extensionists have been trained. 1000 posters have been distributed to pesticide dealers and 500 to extension officers in Comilla District. According to data from the Crop Protection Association of Bangladesh herbicide use in Bangladesh increased from 838 to 3.463 metric tonnes product between 2001 and 2005. From a base of four products for use in rice in the market in 2000 there are now 35 registered for use. Use of the Syngenta product “Rifit” (active ingredient pretilachlor) alone has risen from 30 metric t in 2000 to 500 mt in 2005-06 *boro* and *aman* seasons (equivalent to treat 400,000 ha). Estimates from BRRI suggest that 10-15% of rice crops in Bangladesh are now treated with herbicides in *aman* and *boro* seasons. These figures indicate the importance of ensuring extension workers and farmers have access adequate training in safe handling and effective use of herbicides.

DSR is being used in trials during 2006 at 61 on-farm research sites in Rangur District facilitated by BRRI in collaboration with IRRI and IFAD (6 dry seeded by lithao, 17 dry seeded by power tiller seeder and 38 wet seeded). DSR is being promoted to four farmer groups with a combined membership of 170 in Rangpur region by three NGOs and one government co-operative (see section 16). The Ministry of Agriculture has provided 2,500 drum seeders for wet DSR, distributed across all upazillas of Bangladesh since 2003. Two local manufactures have now been established and recently a further 6000 units were imported for distribution.

15. In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? ***(max 350 words).***

Promotion of dry DSR to date, beyond work undertaken by the CPP projects, has been limited to the few farmer field schools and on farm trial sites described in this dossier. The co-ordinated multi-institution approach to focus on the issue of pre-harvest food insecurity in Greater Rangpur region taken by the North West Focal Area Forum is providing a useful model for co-operation. A number of local NGOs and government institutions are working together in a pilot programme in 2006 *aman* season to promote early planting by DSR and use of an early maturing rice cultivar. By coming together these partners are able to build upon each others strengths with technical training and backstopping from BRRI and, farmer field school and group facilitation by NGOs linking to their existing group network with extension support from DAE. Given the limited technical capacity that is available among the NGOs and the range of skills that will be needed for up-scaling promotion of DSR with herbicide use a partnership approach will be essential.

Environmental Impact

H. Environmental impact

24. What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? ***(max 300 words)***

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

Despite a four-fold increase in national fertiliser sales between 1980 and 2000, soil fertility in Bangladesh has become depleted as agriculture has intensified in the absence of proper replenishment by balanced fertilisation and organic recycling. Indeed average soil organic matter content in the top 15 cm of the soil declined by 11% in the period 1967-1995. One approach to prevent this trend compromising productivity gains is to incorporate more legumes into the rotation. As crops such as chickpea and mung bean are high value this diversification is a win win situation for farmers. As discussed in earlier sections the use of direct seeding can bring forward the harvest date to allow a greater opportunity to plant *rabi* crops, including legumes, in the post-*aman* period in areas such as the High Barind Tract where 80% of agricultural land lies fallow after harvest of *aman* rice. A further advantage of crop diversification and an expansion of *rabi* cropping will be the greater biomass on the land will result in longer periods of annual carbon sequestration from atmospheric CO_2 compared to where land is under bare fallows.

25. Are there any adverse environmental impacts related to the output(s) and their outcome(s)? ***(max 100 words)***

Use of herbicides carries with it a degree of environmental risk. However used at recommended doses the products entering the market in Bangladesh are very much less toxic than many registered insecticides that are classified by the world Health Organisation as “moderately” or “highly” harmful to human health. Herbicides also have favourable environmental toxicity profiles. But in rice systems they are use in the aquatic environment so it is essential that the rapidly growing number of users is made aware of the potential hazards, such as water contamination from inadvertent spills. The agro-chemical industry has a key role to play in disseminating information on safe use to the agriculture community.

26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? ***(max 200 words)***

“Drought” can delay or damage TPR. The optimum time for transplanting is mid-July. But once every two years erratic rainfall delays transplanting until after mid-July, and twice every 10 years transplanting is delayed until after mid-August. Furthermore, a two-week period without rain during the grain-filling stage occurs once every two years (see: Saleh et. al., 2000. In: *Characterizing and Understanding Rainfed Environments*. International Rice

Research Institute: Manila, Philippines). Access to knowledge and equipment to undertake both dry and wet direct seeding allows farmers to make appropriate choices on rice establishment methods as the pattern of the early period of monsoon unfolds. If the main monsoon is delayed dry seeding can be used in June or early July provided there are showers to stimulate germination. Dry seeding can be undertaken after 150 mm cumulative rainfall where as at least 450 mm is needed for transplanting. If sudden heavy rain falls early in the season and land can be drained, a drum seeder can be used to direct seed pre-germinated seed on to puddled land. The advantages of direct seeding, lower labour requirement and an earlier harvest are maintained. Increasing the establishment options available to farmers is likely to increase their resilience to the greater variability in climate and rainfall that is widely expected. This will allow farmers to adapt and reduce the risks inherent in late transplanting as were seen in NW Bangladesh for example in 2003 when insufficient water accumulation prevented transplanting until mid-August while showers allowed dry seeding by mid-June. The reduced costs associated with weed control by herbicides help farmers minimise the financial losses incurred when floods destroy crops before harvest.