Production technologies: Crop and horticultural production, grassland

WEED MANAGEMENT FOR DIRECT SEEDED RICE

Synopsis: Rice-wheat is the principal cropping system of the Indo-Gangetic Plains and increasingly due to labour and water constraints direct seeding of rice is being promoted and adopted. However, where weeds are not controlled the yield of direct seeded rice is well below that of transplanted rice. Technologies based around the use of herbicides, seed drills and hand weeding were analysed. The best tools vary with the environment and consideration of social issues and so a decision support framework for integrated weed management of direct seeded rice has been developed.

Detailed description of the technology

Introduction and Background

The rice–wheat system is critical to the food security of India and to the livelihoods of the rural communities across the Indo-Gangetic Plains. Rising costs of production and decreasing margins are forcing farmers to seek new production options to maintain profitability. With appropriate weed management options, direct seeding offers a number of advantages compared to transplanting. Direct seeding does not require the large quantities of water required for 'puddling the soil' prior to transplanting, but it is not known how great the saving will be over the duration of the crop. Labour requirements for direct seeded rice may also be lower as there is no longer the labour required for transplanting. A principal concern for the sustainability of the rice-wheat system is however the long term effect of alternate dry and wet cultivations for wheat and transplanted rice, respectively. Wet cultivation (puddling) largely destroys the natural soil structure in the surface layers (particularly in clay soils) and forms an impermeable layer in the soil. While this is suitable for water management in transplanted rice, it reduces the yield potential of the subsequent wheat crop. As dry direct seeding of rice avoids the need to 'puddle' the soil, soil structure is retained with potential long term yield benefits.

On-farm research into weeds and weeding

The on-farm research was conducted and validated in the states of Uttar Pradesh, Bihar and Uttaranchal. The sample villages were located in the plains, Terai and in the hills (**JOHNSON** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R7377_FTR.pdf)** 2003). There were large socio-economic differences e.g. farm size, sources of income, origins, castes, education levels, farm size, farming systems, water supply (canals, pumps and tube wells), access to seed/fertiliser drills, sources of labour (family or hired), most used hand weeding and herbicides although the poorer areas used just hand weeding and most relied upon fellow farmers and commercial distributors for agricultural knowledge. There was considerable variation in weed species across locations. Weed species identified in more than one location included: *Cyperus* sp.,*Echinochloa colona, Echinochloa colona, Caesulia axillaries, Cynodon dactylon, Fimbristylis miliacea, Commelina* sp., *Trianthema monogyna*, and *Oxalis latifolia*. The timing of weeding varied and was affected by the stage of the crop in the field and the labour supply. Farmers perceived the effectiveness of herbicides to be mixed.

The project has found that most farms are less than 2 ha in area and farmers use 25-50% of their land for cultivating rice/wheat and derive 30-50% of agricultural income from rice. Labour shortages at times of transplanting, manual weeding, and harvest occur on most farms. Family labour is supplemented by hiring migrant labourers from eastern Uttar Pradesh, Bihar, Bangladesh, or from the local area. Direct seeding instead of transplanting can address some of these labour shortages. The labour requirement for establishing a transplanted rice (nursery and transplanting) is approximately 50 person days ha^{-1} in comparison to 3 – 7 person days ha^{-1} for drill or wet seeded (broadcast and drum seeded) rice. Most farmers are familiar with herbicide use in wheat and are using herbicides (commonly butachlor) in transplanted rice. Farmers in different locations had a range of experience in direct seeding rice. In all but one of the sample villages in the plains and Terai a number of farmers had used direct seeding in the past. In every case, however, farmers had subsequently reverted to transplanting due to problems with weed management and poor

yields. The problems included:

- The labour requirement for establishing a transplanted rice (nursery and transplanting)
- Labour shortages at times of transplanting, manual weeding, and harvest occur on most farms. Family labour is supplemented by hiring of contract labour; migrant labourers travel either from eastern Uttar Pradesh, Bihar, Bangladesh, or the local area.
- Most farmers are familiar with herbicide use in wheat and are using herbicides (most commonly butachlor) in transplanted rice.

In on-station trials in weed free plots, a) equivalent yields were obtained from transplanted and wet-seeded (broadcast) rice; b) yields from drill (dry) seeded rice were lower (0.5 t ha^{-1} or more) than transplanted rice and in drill seeded rice, similar yields were obtained with reduced tillage. A single manual weeding was insufficient to prohibit yield loss in broadcast or drill seeded rice and highest yields were always achieved utilising a post-emergence herbicide (pendimethalin) and one subsequent hand weeding. There are however a range of registered herbicides that are effective for direct seeded rice.

For further information, including farmer perceptions and their assessment of the advantages and disadvantages of direct seeded rice, see (**RICHES (http://www.fao.org/docs/eims/upload/agrotech/1978/R8409_FTR.pdf)** 2006).

Farm trials for dry and wet seeding technologies
Farm trials, with extension support, have indicated that direct seeded rice can achieve equivalent yields to transplanted rice across a range of 13 rice cultivars in common use.

Sensitivity analysis of partial farm budgets has indicated that benefit-cost ratios for direct seeding with herbicides would be equal to transplanting and manual weeding even if rice yields fell (from 5.41 t/ha to 3.4 t/ha for wet-seeding and 2.64 t/ha for dry seeding)

SociaI cost-benefit analysis showed that, for the cost-benefit ratio from transplanting to equal that of direct-seeding, the opportunity cost of labour would have to be either zero or negative. This is implausible, since transplanting relies heavily on migrant male labour and real wages rates for peak-season activities like transplanting are near the market rate. Wage rates for farm labour in Uttar Pradesh have risen in real terms in the 1990s, reflecting opportunities for off-farm employment.

Direct seeding of rice is accompanied by a rapid shift in the weed flora with an increase in abundance of *Echinochloa crus-galli, E. colona, Ischaemum rugosum* and *Leptochloa chinensis* and on more freely draining soils, *Cyperus rotundus*.

In R8233, adaptive research and partnerships were extended under leadership from GBPUAT to NDUAT (Faizabad, Uttar Pradesh) and RAU (Patna, Bihar)

In the jurisdictions of the states of Uttar Pradesh and Bihar, diffusion of the DSR technologies has led to approximately 250 ha of direct seeded rice being grown by farmers in 2004 compared to all land being transplanted at the beginning of the project. An additional university of agriculture and technology (CSA Kanpur) is now independently initiating trials. Approximately 70 on-farm trials of DS rice are ongoing.

Farmer field days have been held at each of the partner sites (GBPUAT, NDUAT and RAU) and have been well attended by farmers and state officials. At Patna, 700 farmers and a Government Minister attended one meeting and 250 farmers at another; at Faizabad 250 farmers and at Pantnagar 53 farmers and 16 scientists attended other field days.

The technologies have been widely publicized through newspaper press-releases. Leaflets have been developed in English and Hindi on the technologies for direct seeding. (**RICHES (http://www.fao.org/docs/eims/upload/agrotech/1978/R8409_FTR.pdf)** 2006)

Local uptake
The local uptake of wet and dry direct seeding has been considerable in the project activity areas and among the institutions involved with the promotion. The project activities have

demonstrated opportunities with direct seeding in terms of labour saving, system productivity and the use of herbicides. These management options have however only been validated in a relatively small portion of area occupied by the rice wheat system that is in turn variable by nature. Farmers' response has, in general, been enthusiastic though the technologies have worked better in some locations than others and factors such has soil type, rainfall, farmers' knowledge and farm infrastructure are critical. In the Western areas of the Indo-Gangetic the technologies have been well tried and tested, this augurs well for significant impact at farm in the near future. Least information and greatest uncertainty with regard to the application of the technologies lies in the eastern areas of the Indo-Gangetic where farms tend to be smaller and with fewer resources that in the west. Validation and data collation over a wider area and in collaboration with farmers' groups will continue to be required in order to be able to further develop the technologies and to overcome constraints that arise. An initial decision support framework for the selection of options for integrated weed management has been developed (**JOHNSON et al.** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8233_FTR.pdf)** 2005); (**RICHES** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8409_FTR.pdf)** 2006).

The project has been actively linked with the Irrigated Rice Wheat Consortium at IRRI and also with the Rice Wheat Consortium. These consortia have adopted direct seeding as part of their program of activities and options and technologies form part of the suite of technologies being developed and promoted in south Asia.

References and further reading

JOHNSON, D.E., WHITE, J.L. and MORTIMER, M. **(http://www.fao.org/docs/eims/upload/agrotech/1978/R7377_FTR.pdf)** (2003) Development of sustainable weed management systems in direct seeded, irrigated rice. DFID Crop Protection Programme, Final Technical Report, Project R7377. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 52 pp.

JOHNSON, D.E., MORTIMER, A.M., and ORR, A.W. **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8233_FTR.pdf)** (2005) Promotion of integrated weed management for direct seeded rice in the Gangetic Plains of India. DFID Crop Protection Programme, Final Technical Report, Project R8233. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 28 pp. plus , **Annex 1** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8233_FTR_anx1.pdf)**, **Annex 2** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8233_FTR_anx2.pdf)**, **Annex 3** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8233_FTR_anx3.pdf)** and **Annex 4** **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8233_FTR_anx4.pdf)**.

RICHES, C. **(http://www.fao.org/docs/eims/upload/agrotech/1978/R8409_FTR.pdf)** (2006) Promotion and decision support for weed management in rice in India. DFID Crop Protection Programme, Final Technical Report, Project R8409. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 37 pp.

Contact details for DFID research project teams

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Evidence of validation

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e-Resources

IRRI, International Rice Research Institute:**http://www.irri.org/** **(http://www.irri.org/)**

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Global farming systems: **Irrigated** **(javascript:openPage('fs_descr.asp?fs_id=1',300,350))** | **Wetland Rice Based** **(javascript:openPage('fs_descr.asp?fs_id=2',300,350))** |

Technical, economic, financial, social and environmental attributes of the technology: Addresses farmers needs, priorities and management capabilities | Considers socio-cultural norms and practices | Improves efficient utilization of scarce resources | Increases efficiency of farm input use | Increases farm production | Reduces drudgery of work | Stabilizes farm production at higher output level | **JOHNSON, D.E., WHITE, J.L. and MORTIMER, M.** (2003) Development of sustainable weed management systems in direct seeded, irrigated rice. DFID Crop Protection Programme, Final Technical Report, Project R7377. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 52 pp. .**JOHNSON, D.E., MORTIMER, A.M., and ORR, A.W.** (2005) Promotion of integrated weed management for direct seeded rice in the Gangetic Plains of India. DFID Crop Protection Programme, Final Technical Report, Project R8233. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 28 pp. plus Annex 1 – 4.

Factors underlying success: Access to inputs and resources| Farmer's capacity | Incentives, credits and markets| Institutional support and outreach| Ownership by end users| **JOHNSON, D.E., WHITE, J.L. and MORTIMER, M.** (2003) Development of sustainable weed management systems in direct seeded, irrigated rice. DFID Crop Protection Programme, Final Technical Report, Project R7377. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 52 pp.
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Source(s): DFID Project R8409, R8233
See above for research project teams' contact details.

Additional external resources: JOHNSON, D.E., WHITE, J.L. and MORTIMER, M. (2003) Development of sustainable weed management systems in direct seeded, irrigated rice. DFID Crop Protection Programme, Final Technical Report, Project R7377. Natural Resources Institute (NRI), University of Greenwich, Chatham, Kent, UK. 52 pp.
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