Promotion of integrated weed management for direct-seeded rice on the Gangetic Plains of India

R8233

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January 2003–March 2005

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Rice–wheat cropping is an effective use of land to maximise yields of vital cereal crops in India. However, the cropping system is facing constraints in part related to combining two crops with different growth habits and requirements. This project built on previous work to promote the adoption of direct-seeded rice, combined with appropriate weed management, to rice–wheat farmers on the Gangetic Plains of India. Field trials demonstrated that yields in direct-seeded rice can be comparable with those in transplanted systems. In the absence of weed control there is a significant reduction in yields under direct seeding, but this can be minimised with appropriate weed-management. The use of a herbicide followed by a single hand-weeding conferred a significant benefit in comparison with hand-weeding alone. The research has shown that changes in composition of the weed flora occurred under different direct-seeded crop establishment – information important to future weed-management strategies. Shortages of labour and water, coupled with the incentive for many farmers to reduce overall input costs, are likely to result in widespread adoption of direct seeding in many parts of the Gangetic Plains. The need to control weeds to protect yields will be paramount, and this project has laid a sound basis for the development and promotion of appropriate weed-management practices.

ISSUES

Rice–wheat is the principal cropping system of the Indo-Gangetic Plains, occupying some 13.5 million hectares and contributing 40% of India's grains. Its sustainability is vital to the livelihoods of farmers in the region, and to national food security. Traditionally, rice is transplanted at the end of the dry season (May/June) after the land has been flooded and puddled; wheat is planted in the rabi season (November/December). Constraints include an increasing shortage of agricultural labour; increasing labour costs; the relative cost of fertiliser and fuel; and late sowing of wheat (partly dependent on the date of rice harvest).

Rice is direct seeded either by dry or wet seeding, which relates to the physical condition of the seedbed and seed (pregerminated or dry). Dry drill-seeding of rice can be complementary to reduced or zero-tillage systems for wheat, as the same seed drills can be used. Direct seeding of rice is thought likely to reduce delays in sowing wheat, as it advances the start of the rice season by up to a month, resulting in an earlier harvest. A concern for the sustainability of the rice–wheat

Farmers in Bihar tend to use less mechanisation than in Uttaranchal

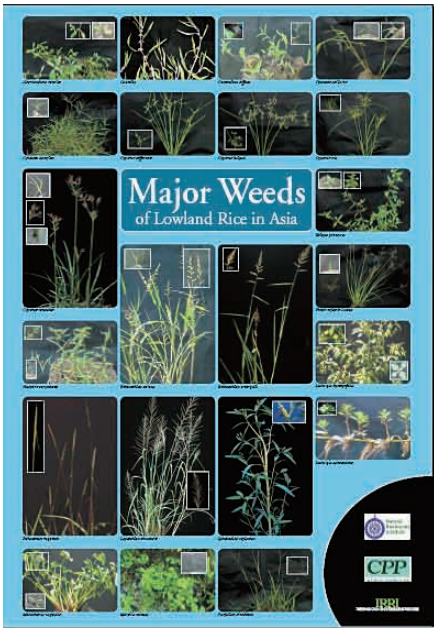
system is the long-term effect of alternate dry and wet cultivations for wheat and transplanted rice, respectively. Wet cultivation (puddling) largely destroys the natural soil structure in the surface layers. While this is good for water management in transplanted rice, it reduces the yield potential of the subsequent wheat crop. Dry direct seeding of rice avoids the need to puddle the soil, so the soil structure is retained with potential long-term yield benefits.

This project built on the development of direct seeding and associated weed-management options initiated under project R7377, which established that yields from direct-seeded rice can be comparable with those from transplanted rice if weed management is adequate. The role of the current project was to demonstrate the opportunities for direct seeding of rice to farmers across a wide geographical area on the Indo-Gangetic Plains.

ACHIEVEMENTS

On-station experiments in Uttaranchal, Uttar Pradesh and Bihar demonstrated that yields from wet direct-seeded rice are broadly comparable with transplanted rice provided that weed management is effective, while yields of direct-seeded rice tended to be about 0.5–1 t/ha less than from transplanted rice. If weeds were not controlled, yields in direct-seeded rice were a small fraction of those from transplanted rice. Highest yields were always achieved with a single herbicide application and at least one subsequent hand-weeding. These findings were validated in three states over 48 farmers' field trials in 2003 and 67 field trials in 2004.

In 2004, for the fourth successive year, at Pantnagar wet direct-seeded rice gave the greatest yield: 7.1 versus 6.8 t/ha for transplanted and 5.9 t/ha for dry direct-seeded. In Pantnagar District, on over 20 farms, mean yields from transplanted rice were greater than



Weed identification poster produced and disseminated by the project

from direct seeding (5.2 versus 4.8 t/ha). However, farm trials indicate that, with extension support, direct-seeded rice can achieve equivalent yields to transplanted rice across a range of rice cultivars in common use.

Direct-seeded rice was privately profitable for farmers, giving net returns of Rs13,350 per ha for dry direct-seeded and Rs11,592 per ha for wet direct-seeded rice, compared with Rs10,343 per ha for transplanted rice. Net labour savings with direct-seeded rice compared with transplanting averaged 27 days/ha.

Around Pantnagar, 46% of the cropped area belongs to farms larger than four hectares, and these holdings incur high variable costs for tractors and irrigation pumps in the rice–wheat system. With market liberalisation, spiralling costs are a powerful incentive for adoption of direct-seeded rice, which might not be justified solely in terms of labour costs. The incentives for adoption are likely to vary regionally, however. Direct seeding is usually seen as part of the solution to the 'yield problem' in the rice–wheat system. Larger-scale farmers around Pantnagar see the need to reduce unit costs, and recognise that this is possible by increasing wheat yields and adopting direct-seeded rice. These farmers see real and immediate benefits from direct-seeded rice and zero tillage by reducing cash outlay for mechanised tillage and labour for transplanting. Partial budgets for direct-seeded rice and transplanted rice were produced from data collected from 20 on-farm trials around Pantnagar in 2004. The data indicated that:

- total costs for direct-seeded rice (Rs13,816 per ha) were lower than for transplanted rice (Rs18,256 per ha) by Rs4440 per ha
- puddling (Rs2448 per ha) accounted for 55% of the difference in costs
- yields did not differ significantly, resulting in a higher cost:benefit ratio for direct-seeded rice (1.59) than for transplanted rice (0.96).

The species composition of the accompanying weed flora may also change with management practices. Direct seeding of rice is known to be accompanied by a rapid shift in the weed flora, with an increase in abundance of *Echinochloa crus-galli*, *Echinochloa colona*, *Ischaemum rugosum* and *Leptochloa chinensis* and, on more freely draining soils, *Cyperus rotundus.* The ingression of annual grasses and perennial sedges presents particular weed-management problems with continuous direct seeding. Data sets compiled have facilitated the development of decision frameworks and will underpin the widespread application of weed-management strategies.

Farmer groups in Uttaranchal, Uttar Pradesh and Bihar, who previously transplanted rice, were introduced to options for direct-seeded rice and the related weed-management practices. On-farm trials over several seasons at these sites demonstrated that direct-seeded rice can be successful. Many farmers have expressed considerable interest, and the systems are being adopted among lead farmers.

Transplanting is labour-intensive, costly and can cause delays

A total of 13 farmer field days were held, with events at each of the partner sites (GBPUAT, NDUAT and RAU), and were well attended by farmers and state officials. In 2004, at Patna, 700 farmers and a Government Minister attended one meeting and 250 farmers another; at Faizabad 250 farmers; and at Pantnagar 53 farmers and 16 scientists attended other field days. In Uttar Pradesh and Bihar, diffusion of the direct-seeded rice technologies has led to approximately 250 ha of direct-seeded rice being grown by farmers in 2004. Leaflets and posters on the technologies for direct seeding have been published in English and Hindi.

The project has established effective collaboration among three key agricultural universities in India, IRRI, the University of Liverpool and NRI. This enabled a multi-disciplinary team covering socio-economics, weed ecology and agronomy to link effectively with regional organisations, local administrative bodies, extension organisations and farmers' groups, in order to develop effective and appropriate weed-management options. The Chandra Shekhar Azad University of Agriculture and Technology (CSA Kanpur) joined the activities on direct-seeding technology with independent funding, and is keen to expand activities.

The prospects for adoption of direct-seeded rice in eastern India are brighter than previously thought, based on an analysis of existing crop-management practices for transplanted rice and farmer evaluations of on-farm trials. The results show no difference in average time of transplanting by farm size, suggesting that small as well as large farms would benefit from more timely crop establishment.

Livelihood diversification through seasonal migration has increased incentives for adoption of labour-saving technology, particularly in the light of the 'feminisation' of agriculture, where female family members substitute for men. Direct-seeded rice reduces the climatic risk caused by unpredictable monsoon rains. Reducing dependence on pump sets and tractors for timely crop establishment will benefit poorer farmers. Participatory evaluation shows that savings in labour costs were less important for large-scale farmers than savings in the costs of tillage and irrigation.

FURTHER APPLICATION

A follow-on promotional project with the main Indian partners (GBPUAT, RAU, NDUAT and CSA) will continue until January 2006 (R8409). This will address some of the information gaps identified during the research, and develop decision tools for improved weed management. There are additional researchable issues that could usefully be pursued in a future research programme: for example, management of weeds as species shifts occur; and issues concerning weedy rice and insecticide resistance.

The technology options for direct-seeded rice and the associated weed-management practices will be evaluated and promoted elsewhere in South Asia under the Irrigated Rice Research Consortium (IRRC) and the Consortium for Unfavorable Rice Environments (CURE) of IRRI.

Promotion of cost-effective weed-management practices for lowland rice in Bangladesh

R8234

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January 2003–March 2005

Closing the gap between the rice yields achieved by the best farmers and those with only average yields has now become a high priority in Bangladesh, and will largely depend on improvements in farmers' management practices. This project demonstrated that improved weed-management practices can reduce input costs and enhance productivity in intensive transplanted rice–rice systems in Comilla District, Bangladesh. Importantly, the use of herbicides can produce benefits in the Aman as well as the Boro season. The technology is knowledge-intensive, and the project developed innovative ways to work with the private sector and other organisations to disseminate relevant information more widely. Significant yield gains have also been shown in rice/rabi crop systems in the Barind Tract, through on-station and on-farm trials. A key feature of the work in this area is the focus on increasing overall system productivity. The use of direct seeding increases the opportunity for farmers to plant a rabi crop on residual moisture. Sustainable intensification of under-utilised agricultural production areas, such as those in the Barind Tract, is needed to increase national rice production and facilitate diversification into other crops. There is good potential for expanding production of rabi crops in this region. The crop-management systems promoted have good potential to ameliorate some of the key constraints to rice production in Bangladesh.

ISSUES

To keep pace with internal demand in Bangladesh, it has been estimated that paddy production will need to increase from the current level of 22 million to 50 million tonnes by 2020, an annual growth in yield of 1.5–2%. Widespread adoption of fertiliser-responsive modern varieties and expansion of the area under irrigation have driven the increase in rice production over the past 20 years in Bangladesh. In Comilla District, for example, which has long been at the forefront of adoption of modern rice-production practices, 80 and 100% of Aman and Boro crops, respectively (see Glossary, page vii), were planted to modern varieties by 1999. Future increases in rice production will therefore also depend on improvements in the efficiency with

Hand-weeding in Bangladesh

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Poster on 'Effective control of weeds in rice' displayed in pesticide stores in Paruara Bazaar, Comilla District

which inputs are used. Closing the gap between the rice yields achieved by the best farmers and those with only average yields has now become a high priority. Reducing this yield gap will largely depend on improvements in farmers' management practices. Characterisation work by the earlier project R7471 and needs assessments undertaken independently by the Dhaka based DFID-funded Poverty Elimination Through Rice Research Assistance (PETRRA) Project have confirmed that weed control is a major cost to farmers in the rice-production cycle in Bangladesh.

The High Barind Tract includes 12% of the drought-prone rainfed lowland rice grown in Bangladesh. Drought early in the season causes delays in transplanting, while an early cessation of the rains in October impacts on grain filling resulting in low yields. Due to the limited irrigation potential of the area, there is relatively little production of Boro (irrigated) rice in the dry rabi season. Thus much of the land lies fallow during the rabi season. Work undertaken by BRRI over the past 12 years has led to the development and testing of a system that can allow farmers to increase cropping intensity by more reliable establishment of a rabi chickpea crop. This can be achieved by direct seeding a short-duration rice variety to reduce crop duration to 125–130 days, thereby releasing land when there is still sufficient moisture for rabi crop establishment. However, weeds are a major constraint to adoption as the advantage of effective weed control prior to transplanting through puddling is lost when rice is established by direct seeding.

There are therefore two situations in which the promotion of improved weed control can contribute to increased rice productivity in the Barind – in the existing transplanted T-Aman, and in rice established by direct seeding.

Results from the previous project (R7471) provided a platform from which to scale up validation and promotion of weed-management options. This new work was designed to address the challenge of how to close the yield gap between the best on-farm yields and those of the majority of growers, through the promotion of a range of sustainable weed-management options.

ACHIEVEMENTS

On-farm trials at 20 sites over two years have shown herbicide use to be a robust, effective and profitable technology under various water-management scenarios in both Aman and Boro rice in Comilla. Herbicide use was demonstrated in transplanted rice in collaboration with the Department of Agricultural Extension (DAE) at 60 sites per season in four *upazillas* (local government areas) in Comilla District, south-eastern Bangladesh. Training of extension officers in the safe, efficient use of herbicides prior to each season, and farmer field days, were undertaken as components of the demonstration programme. Rice herbicide promotion by the private sector led to 43% increase in sales 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. In collaboration with the NGO SAFE, a partnership was developed between the NGO and the herbicide manufacturer Syngenta, resulting in a training manual on herbicide use that has been distributed to all *upazilla* agricultural offices in Bangladesh. The project also raised awareness of information issues in the private sector through a seminar and discussions with nine companies marketing herbicides. A poster covering key issues on safe and efficient use of herbicides was prepared and distributed for display in pesticide dealers' stores throughout Comilla District, making use of the Syngenta dealer network.

The challenge in the drought-prone, rainfed agriculture of the Barind Tract is simultaneously to improve the reliability and yield of Aman rice, and to increase the area planted to drought-tolerant post-rice crops. Research trials at 25 sites and field-scale evaluation by farmers at 30 sites demonstrated that dry direct seeding or wet seeding of pre-germinated seed reduces the labour requirement for crop establishment, resulting in rice yields similar to, or higher than, conventional transplanting. This system also advances harvest by a week to 10 days. Harvesting earlier reduces the risk of terminal drought in rice when the monsoon ends abruptly, and increases the opportunity for establishing a post-rice crop of chickpea on residual moisture.

Field work demonstrated that herbicide use is essential to facilitate direct seeding, and this further reduces rice-production costs. Herbicide use, to overcome late weeding due to labour constraints in transplanted rice, was demonstrated by DAE and the NGO People's Resources Oriented Voluntary Association (PROVA) at 100 sites across three districts in the Barind Tract, in collaboration with a DFID Plant Sciences Research Programme-funded project working on rabi crops. Herbicide use and the modified rice/rabi system using direct seeding are knowledge-intensive. A shift in weed species abundance was observed following the long-term use of direct seeding, and control needs to be factored into farmer training. Widespread sustained adoption will depend on farmers undertaking timely tillage, adequate land levelling and timely application of herbicides.

Field-scale evaluation of direct seeding by farmer group in Godagari upazilla*: transplanted rice variety Swarna surrounding maturing crop of BR31 direct-seeded with a hand-pulled furrow-opener (*lithao*)*

In collaboration with NGOs and the DAE, research partners have developed and promoted a range of sustainable weed-management options for rice. This has improved understanding of the agronomic, technical and socio-economic opportunities for productivity gains in two widespread rice-based systems in Bangladesh. Improved weed management will benefit poor rice farmers and sharecroppers directly by reducing unit costs for rice production and, in the Barind Tract, enhancing land productivity and income from rabi cropping. By helping to maintain rice productivity growth and lower rice prices, improved weed management will also benefit poor consumers. The social costs of labour displacement from herbicides and direct-seeded rice will be reduced by the rapid growth of non-farm rural employment (e.g. in construction, brick fields etc.). Adoption of labour-saving technology in rice reflects growing livelihood diversification and the diminishing importance of agricultural labour among the rural poor.

FURTHER APPLICATION

Access to knowledge is the key for farmers to take advantage of new rice-management opportunities. An extension to this project (R8412) will consolidate knowledge and make it accessible in a form that enhances understanding of the new technology, promotion by extension, and adoption by farmers. This will be achieved by developing a decision-support framework that will distil research findings into an interlinked set of decision tools for improved weed management of transplanted and direct-seeded rice, and for transition between both. There is scope for synergy between these activities and project R8233 (page 173) on direct-seeded rice in India.

To strengthen the knowledge base for decision-support frameworks in rice/rabi, trials will evaluate different methods of direct seeding on a field scale to gain more experience in field-scale mechanisation. This will broaden understanding of the options available to farmers. The IRRI Rice Knowledge Bank is being developed to provide a web-based resource on rice production, and will be the major route for dissemination of information through a recently initiated programme of rice-technology promotion funded by the EU. Outputs will be prepared in a format suitable for inclusion in the Rice Knowledge Bank to ensure they remain available for use beyond the end of the CPP project.