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Improving rice-based cropping systems in north-west Bangladesh: diversification and weed management

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ABSTRACT

Improving total productivity in the rice-rabi cropping system in Bangladesh depends on elevating component yields whilst minimizing the risk of drought to both crops. Direct seeding of rice has the potential of advancing crop establishment with the onset of monsoon rains and allowing greater opportunities for subsequent rabi (chick-pea, mustard, linseed) crops on residual moisture as the dry season commences. Agronomic studies over three years indicated that rice yields could be increased over traditional transplanting by use of direct seeding with both Swarna (a traditional cv) and in BRRI dhan 39 (MV). Oxadiazon applied pre-emergence controlled major weeds but one additional manual weeding was necessary for yield protection from weed competition from Altenanthera sessilis, Cyperus iria and Paspalum distichum in particular. Up to 14 day gains in rice maturity improved the yield potential of following chick-pea. Socio-economic evaluation indicated that adoption of direct seeded rice was more likely to occur on large farms where competition for labour at times of peak demand was intense and where there was a greater proportion of land area favourable for rabi cropping.

INTRODUCTION

A single crop of transplanted rainfed rice (TPR), grown in the monsoon aman season from June to October provides a major component of rural livelihoods in the High Barind Tract, in NW Bangladesh. Aman rice is vulnerable to late-season drought during grain filling in October and in the dry rabi (winter) season much of the land lies fallow. Cultivation intensity in much of the Barind is below 175%, and considerably less than in districts where irrigation allows two or three rice crops to be grown each year (Nur-E-Elahi et al., 1999). Farmers’ land is typically distributed over a shallow sloping landscape or toposequence. Twin objectives facing agricultural improvement are to simultaneously improve the reliability and yield of aman rice while increasing the total system productivity. Mazid et al. (2002) have demonstrated that these objectives can be achieved through the introduction of dry seeded rice (DSR) and the planting of short duration rabi crops (e.g. mustard, linseed or chickpea) on residual moisture immediately after rice harvest. Late.
onset of the monsoon or low rainfall can delay rice transplanting as a minimum of 600 mm cumulative rainfall is needed to complete land preparation and transplanting. Dry seeding, on the other hand, can be completed after land preparation by a power tiller with only 150 mm cumulative rainfall (Saleh & Bhuiyan, 1995). The earlier planted DSR crop matures 1-2 weeks before TPR reducing the risk of terminal drought, and allows earlier planting of a following non-rice crop (Saleh et al., 2000).

In comparison to TPR, DSR reduces labour and draught power requirements for rice establishment by 16% and 30% respectively, but weeds are a major constraint to adoption of DSR as the inherent advantage of weed control in standing water of transplanted rice is lost (Mazid et al., 2002). Monitoring of farmer managed transplanted aman rice crops in the Barind revealed that labour availability constrains timeliness of first weeding for many households and with current practices 34% of farmers lose over 0.5 t/ha of the attainable yield due to weed competition (Mazid et al., 2001). This study also reported that the integration of a pre-emergence herbicide with hand weeding has the potential to protect yield in DSR. Farmers in the Barind have a strong preference for the late maturing, but high quality, rice cultivar Swarna (135-145 days duration). Use of this cultivar however reduces the opportunity for establishing chickpea or other rabi crops on residual moisture, whereas growing earlier maturing modern cultivars may contribute to an earlier harvest.

This paper summarises selected findings from a field trial designed to explore the contribution of rice establishment method, rice cultivar duration and weed control practice to aman rice performance and the likely long-term impact on the composition of the rice weed flora. Associated investigations of the socio-economic circumstances influencing future adoption of direct seeding and increased rabi cropping by Barind farmers are also summarised.

**METHODS**

From the 2000 planting season, rice establishment, nutrient management and weeding practices have been investigated in farmland at Rajabari, Rajshahi in N.W Bangladesh in an on-going long term trial (as described in Mazid et al. 2001). In this paper we report results for rice crops in 2000, 2001 and 2002, comparing rice crop establishment methods and weed management practices. Treatments were 1) Transplanted rice (TPR) - soil is puddled prior to transplanting which is hand weeded twice at 30 and 45 days after planting (DAT); 2) Direct seeded rice (DSR) - soil is ploughed prior to seeding in rows by hand with hand weeding at 21, 33 and 45 days after sowing (DAS); 3) Direct seeded rice with chemical weed control (DSRH) -as for DSR but with oxadiazon (375 g a.i./ha) applied 2-4 days after seeding with one hand weeding at 33 DAS. Plots of these treatments were sown to the cultivars Swarna (maturity 140 – 145 days) and BRRI dhan 39 (maturity 120 - 125 days). Rice was harvested in 5m². Biomass of individual weed species was recorded in two unweeded quadrats per plot at 28 days DAS/DAT and total weed biomass at 45 DAS/DAT and again at harvest.

Information on timeliness of weeding was collected as part of a questionnaire survey of 119 households in Rajshahi district (Orr and Jabbar, 2002). Socio-economic factors that were likely to influence crop intensification in the High Barind Tract then were investigated through a second survey, undertaken after the harvest of the 2001 rice crop, of 91 households in 12 villages of Rajshahi district. This focused on the availability of labour for weeding rice and the key determinants of rabi cropping that will influence the area planted in the post-rice season.
RESULTS

Crop establishment method
With the exception of BRRI dhan 39 in 2000, yields from direct seeding of this and cv. Swarna were as good or better than from transplanting, the usual method of rice culture in the district (Figure 1). Early season weed control, by pre-emergence application of herbicide resulted in the highest yields except for BRRI dhan 39 in 2000.

![Graph showing grain yield tons/ha for BRRI dhan 39 and Swarna across years 2000, 2001, 2002 for DSR, DSRH, TPR treatments]

Figure 1. Effect of establishment and weed control practices on the yield (mean ± s.e.m) of rice cultivars BRRI dhan 39 and Swarna. DSR = direct seeded, hand weeded; DSRH = direct seeded with herbicide; TPR = transplanted rice + hand weeded.

Weed species shifts
The weed flora of rainfed rice in the Barind is diverse and exhibits high inter-seasonal variability depending on water regimes at rice establishment and soil moisture status of toposequence position. Common weed species are *Alternanthera sessilis*, *Ammania baccifera*, *Cyanotis axillaris*, *Cynodon dactylon*, *Cyperus difformis*, *Cyperus iria*, *Cyperus rotundus*, *Cyperus tenuispica*, *Echinocloa colona*, *Eclipta prostrata*, *Eriocaulon cinereum*, *Fimbristylis dichotoma*, *Fimbristylis miliacea*, *Hedyotis corymbosa*, *Lindernia ciliata*, *Ludwigia octovalvis*, *Monochoria vaginalis*, *Paspalum distichum*, *Paspalum distichum*, *Pseudoraphis spinescens* and *Sphaeranthus indicus*. At harvest there were significantly higher densities of weeds in DSR (228 m⁻²) in comparison to TPR (75 m⁻², P ≤ 0.023). However as expected at 45 DAS/DAT, least weed density and biomass was recorded in DSRH. The range of responses by individual weed species over three consecutive seasons to crop establishment and weed management
practices is shown in Figure 2. Increase in abundance (biomass at 28 DAS/DAT) of the broadleaved species *Alternanthera sessilis*, *Eclipta prostrata*, *Lindernia ciliata* and *Ludwigia octovalvis* and the sedges *Cyperus difformis* and *Fimbrystilis miliacea* was noticeable in DSR. Conversely the biomass of *Monochoria vaginalis* was decreased by direct seeding. The most noticeable increase in abundance was seen in the perennial grass *Paspalum distichum*.

![Graphs showing biomass of various rice weeds](image)

Figure 2. Effect of establishment and weed control practices on the biomass of nine rice weeds at 28 days after planting in unweeded plots. See text for details.

**Socio-economics**

Survey analysis did not reveal a significant difference in household labour supply by farm size but there was a lower participation rate \(P \leq 0.05\) of male family members on larger holdings of over 2.7 ha. The area of transplanted aman (*T-aman*) per adult male worker was much higher in the upper tercile of large farms, averaging 2 ha per worker or four times greater than that of the smallest farms (below 0.6 ha in the lower tercile of the sample). Whilst larger farms faced a significant shortage of family labour for weeding, the survey revealed that virtually all rice was weeded with some additional hired labour irrespective of farm size. Results for the
Aman crop in 2000 revealed that farmers weeded rice at 28 and 45 DAT. Late first weeding was more common on large farms and where plots were weeded using hired labour. 92% of farmers planted rabi crops in the survey year. Whilst the proportion of farmers planting rabi crops did not vary by farm size, the share of land planted to rabi crops was significantly higher (45%) on small farms, although the land area planted to these crops was significantly higher (1.63 acres) on large farms. Overall, rabi crops occupied 32% of the area planted to T-aman, with the remaining 68% was fallowed. Rabi cropping was not significantly associated with land tenure and sharecropped or fixed rent plots were just as likely as owned plots to be planted with rabi crops.

Plotwise analysis (data not presented) revealed that the extent of rabi cropping varied significantly by land type and position on toposequence, access to irrigation and according to the maturity group of rice cultivar grown in the previous aman season. Therefore rabi crops were most likely to be found on lower lying fields with moisture retentive soils and to be planted after short duration rice cultivars. This implied that owners of large farms were able to choose plots for rabi cultivation in order to reduce risk from moisture stress. By contrast, on small farms rabi crops were planted on marginal areas where soils were less favourable, and after cultivation of Swarna. On large farms, Swarna was grown primarily on plots with unfavourable soils that were not planted with rabi crops. On small farms, Swarna was not restricted to unfavourable soils, and plots planted to Swarna were likely to be followed by rabi crops. This lack of choice was positively related to subsistence pressure on small farms. For the survey sample as a whole and for small farms, Swarna was more likely to be planted on sharecropped plots. Average yields from Swarna were currently higher under farmer management than from shorter-duration MVs, and tenants in consequence expected to retain a higher absolute yield after 50% sharing with the landlord. In the lower tercile of the sample there was 0.11 ha per consumer in each household compared to 0.54 ha in the upper tercile. Smaller farmers share-cropped an average 58% of their farm of which 43% was planted to rabi crops, compared to 35% rented with just 25% under rabi for the largest holdings.

DISCUSSION AND CONCLUSIONS

The long-term trial has demonstrated that while rice yield can be maintained with the switch from transplanting to direct seeding, farmers will face a greater weed problem early in the crop season. Not only is there an increased burden of weeds in direct seeded rice but the change in establishment practice also leads to a shift in the relative abundance of important species. Use of a herbicide can reverse this trend in some cases, e.g. for F. miliaceae one of the most important weeds in the Barind (Mazid et al., 2001a) but to prevent the build-up of other species it is clear that follow-up hand weeding will be needed, particularly for perennial grasses (P. disticum). Previous research (Mazid et al., 2002) has indicated that direct seeding was associated with higher labour inputs for first weeding than is the case for transplanting. With the labour constraint, late first weeding, and a significant yield gap due to weeds on many farms in transplanted rice with current weed control practices (Mazid et al., 2001) it is clear that the adoption of direct seeding will need to be associated with use of chemical weed control. At current prices one application of oxidiazon followed by one hand weeding results in a saving of 35% compared to weeding twice by hand with hired labour. Socio-economic analysis suggest that herbicides will find a ready market in Rajshahi district because a) weeding is done almost exclusively by hired labour, and b) the supply of hired labour is local, with very little weeding done by seasonal migrant labour. Together, these factors will create intense competition for labour, especially on larger farms which would be intensified by the adoption of direct seeding. This work also suggests that interventions to expand
rabi cropping in the High Barind may distinguish two broad target groups: (1) Larger farms with lower cropping intensity and the potential to grow rabi crops under relatively favourable conditions. Interventions for this group should focus on raising the area planted. This may be achieved by adopting direct seeding of lower yielding short duration rice cultivars and herbicides for weed control; (2) Smaller farms with higher cropping intensity and limited potential to grow rabi crops under favourable conditions. Interventions for this group should focus on raising yields. Farmers may wish to continue growing higher yielding Swarna rice through transplanting but increase yield by use of herbicides to achieve timely weed control.

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