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Short to medium term effects of tillage and residues on cool dry season crops in a rice-based system of Bangladesh

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Introduction
The densely-populated region of the Eastern Indo-Gangetic Plain relies on rice-based cropping systems. However, the sustainability of the system under conventional cultivation is jeopardized by soil and water resource degradation, and increasing scarcity and cost of inputs (Gathala et al., 2011). In rice-dryland crop systems, rice is grown in puddled and submerged soil while the dryland crop is grown after rice with intensive tillage and limited residue retention. Although puddling is beneficial for establishing rice by transplanting, it can be harmful for the next dryland crop (Gathala et al., 2011). Conservation agriculture (CA), comprising minimum soil disturbance along with increased residue retention and suitable crop rotation may hold the key to address these problems (Johansen et al., 2012). Conservation agriculture practices are emerging but there is still limited understanding on dryland crop performance in rice-based systems of Bangladesh. This paper focuses on the effects of CA on grain yields of cool dry season crops over three years in a rice-based system.

Material and methods
A field study was conducted from 2010 to 2013 on rice-based systems at two different agro-ecological zones and soil types (Alluvial area—24°28’ N, 88°46’ E and High Barind Tract—24°31’ N, 88°22’ E) in Northwest Bangladesh. The crop rotation was lentil (Lens culinaris Medik.) or wheat (Triticum aestivum L.)-mung bean (Vigna mungo L.)-transplanted rice (Oryza sativa L.). Cool dry season (rabi) crops in the rotation: lentil or wheat. Three types of tillage (strip tillage - ST, bed planting - BP and conventional tillage - CT) in the main plot and two residue levels — high residue (HR - 50 % of previous cereal crop residue and 100 % of legume residue); low residue (LR - 20 % of previous cereal crop residue and 0 % of legume residue but root dry matter was retained in soil) in the sub-plot, replicated four times in a split-plot design. The ST and BP (made by versatile multi-crop planter) were implemented for non-rice crops followed by unpuddled rice cultivation while conventional tillage (CT) was implemented for non-rice crops followed by puddled (wet tillage) rice cultivation. Experimental details and results for the mung bean in the early wet season and transplanted rice in the main wet season are presented elsewhere (Islam, 2016).

Results and discussion
Although yield of lentil at Alipur was lower in BP than CT in Year 1, by the third season it was higher by 23 % in ST and 18 % in BP, compared to CT (Figure 1a and c). The positive effect of HR over LR was apparent by Year 2 (Figure 1b). At Digram, no treatment effects were apparent for wheat yield in Year 1 and yield was lower with BP in Year 2 due to to poor crop establishment and a lower plant population as a result of lack of experience of the machine operator in seeding on beds with residue (Figure 1d, e). Marginal yield increases by 9 % in ST and 7 % in BP over CT, and of HR (3 %) over LR, could be detected by the Year 3 (Figure 1f).
Conclusion
Although there were some operational problems in implementing conservation agriculture techniques initially (e.g. improper seed placement in strip with residue impaired seed-soil contact), yields of both lentil and wheat were comparable between ST and CT in the first two years. By the third year, the yield advantage of both ST and BP over CT; and HR over LR, had become apparent, suggesting the feasibility of adopting CA practices in these rice-based cropping systems. However, further studies are required over a longer time period under different soil, climatic, and socio-economic conditions in the eastern Indo-Gangetic Plain.

Figure 1. Effects of tillage and residue retention on grain yield of lentil (Figure a–c) at Alipur and wheat (Figure d–f) at Digram over three growing seasons. ST — strip tillage, BP — bed planting, CT — conventional tillage; HR — high residue, LR — low residue. Values are means of four replicates ± standard error of mean and the floating error bar on each figure represents the least significant difference (LSD) for significant effects at P≤0.05.

References

Islam, M.A. 2016. Conservation Agriculture: Its effects on crop and soil in rice-based cropping systems in Bangladesh, PhD thesis. School of Veterinary and Life Sciences, Murdoch University, Australia.