Effect of minimum tillage systems on water balance for rice-based rotations in Northwest Bangladesh

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Introduction

Controlled traffic and minimum tillage are expected over time to alleviate degraded soil structure, particularly in rice –based cropping soils that experience annual soil puddling and intensive tillage. However, minimum tillage over time may weaken the plough pan and in turn alter water balance in the rice-based systems. This implication of a change of water balance may be detrimental for rice but beneficial for following crops and for groundwater recharge. The aim of the current study is to determine how soil structure changes over time under continuous minimum tillage system and how changes in soil structure, particularly in the plough pan, affects water balance in rice-based cropping system. This paper reports the magnitude of water balance components in different tillage practices for the Boro rice period of the crop sequence.

Materials and methods

Experiments were conducted in 2015 and 2016 on a silty loam soil (Alluvial soil) at Rajshahi, Bangladesh (24°29 N, 88°46 E). The experiments were completed on a long-term experiment site, which was established in 2010. The experiment had a split-plot design (plots 7 m × 15 m) with 4 replicates. The main plot was tillage treatment (Strip tillage (ST), Bed planting (BP) or Conventional Tillage (CT)) and the sub-plot was residue treatment (20% or 50% of straw retained). In 2015, all plots were irrigated by continuous flooding (CF). For the 2016 experiment the whole field was divided into two groups each consisting of two replications. Two replicate blocks were devoted to CF irrigation and the other two to Alternate Wetting and Drying (AWD) irrigation. In 2015, plastic sheets were installed in the centre of the bunds down to 15 cm. In 2016, no plastic sheets were installed. All the components of the water balance were measured daily, except for daily evapotranspiration which was calculated as the residual term in the water balance equation $PD_i=PD_{i-1}+R+I-ET-DP-S$ (cm), where *PD* is the ponding depth, *i* is the time index (days), *I* is the irrigation, *R* is the rainfall, *ET* is the evapotranspiration, *DP* is the percolation below root zone, and *S* is the seepage. Daily deep percolation was calculated from the daily decline of water level in the closed top lysimeters (PVC pipe 25 cm in diameter and 60 cm high) embedded into the hardpan to a depth of 30 cm. Seepage was calculated from the difference in the daily decline of water level in the plots and open lysimeters of the same dimensions as the closed top lysimeters. In 2016, as in the AWD irrigation the field is subjected to both wet and dry conditions, both ponded and unsaturated phases are taken into consideration to calculate the actual evapotranspiration and percolation from the rice field. The calculating procedure followed the method of Agrawal, Panda, and Panigrahi (2004), and Khepar, Yadav, Sondhi, and Siag (2000). Change in soil moisture storage (ΔSMC) was calculated by measuring soil moisture content to a depth of 30 cm prior to pre-irrigation and at harvest of each season of the Boro rice crops.

Results and Discussion

In 2015, there was no difference in the amount of water applied with tillage or residue treatments. In 2016, ST received 40-42 cm more water than CT with CF ($P<0.05$) (Table 1). BP-CF treatment received 30-45 cm more water compared to CT-CF treatment. Shifting from CF to AWD reduced the amount of irrigation water by an average of 19 % (20 cm) for all tillage treatments. In 2015 with plastic lining in the bunds to 15 cm below the soil surface, irrigation water was less than the 2016 CF plots, suggesting that the lining reduced seepage losses. High amount of under-bund seepage in 2016 might be attributed to the high hydraulic conductivity of the bunds. In addition, the fields surrounding the plots were not irrigated until 20 days later which may have exacerbated water movement under the bunds to these adjacent fields.

In 2016, higher amounts of irrigation water required for BP and ST were associated with increased deep percolation. Each year, there was a significant effect of Tillage treatment on percolation beyond 30 cm soil depth ($P<0.05$). Deep percolation in BP treatment was 32 cm in 2015 and 52 cm in 2016, and significantly higher than CT each year. In 2016, deep percolation of ST-CF was 19-27 cm higher than that of CT-CF treatment, and 30-35 cm higher than that of CT-AWD treatment. Higher amount of deep percolation was probably because of higher permeability of soil in the unpuddled soil of the strip tillage and furrows, and greater macropore development on the permanent beds in the BP. This study was conducted with groundwater level 10-12 m below ground level from transplanting to harvest of the season, which is also a determining factor in increasing percolation losses in the minimum tillage plots. Changes in water balance components for other cropping seasons should also be examined, particularly for Aman season.

References

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