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Effects of Conservation Agriculture and Nitrogen Fertilization on Carbon Footprint in the Wheat-Mungbean-Rice Cropping System

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Introduction

Recent trends towards mechanization on small farms create an opportunity to develop conservation agriculture in Bangladesh. However, a range of soil processes under conservation agriculture in rice-based cropping systems will differ from those in dry land cropping systems. The emission of greenhouse gases for example may favour methane under flooded conditions rather than carbon dioxide. The effect of nitrous oxide emission under conservation agriculture in rice-based systems also needs to be determined. Thus, a study was undertaken to determine whether minimum tillage by strip tillage, different levels of N fertilizer and residue management altered the carbon footprint (CF) of wheat and mungbean and whether unpuddled transplanting affected CF of monsoonal rice relative to puddled soils.

Materials and Methods

The experiment was conducted at Bangladesh Agricultural University (BAU) Farm, Mymensingh on an Aeric Haplaquept during November 2012-March 2013 (wheat), April 2013-June 2013 (mungbean) and July 2013-November 2013 (rice). There were two tillage systems - conventional tillage and strip tillage, two residue retentions- low (20% of cereal residue retained) and high (60% of cereal residue retained) retention and five nitrogen rates as a % of the recommended fertilizer dose (RFD) - 60% RFD, 80% RFD, 100% RFD, 120% RFD and 140% RFD. The recommended N (RFD) dose for wheat was 100 kg ha-1, 20 kg ha-1 for mungbean and 75 kg ha-1 for rice. The experiment was designed in a split-plot design with tillage systems and residue retentions distributed to the main-plots and N application to the sub-plots. Carbon footprint was calculated using emission factors from the literature as default values following Hillier et al. (2009) as per guidelines of ISO14040-44 (ISO 2006) and IPCC (2006).

Results and Discussion

Fertilizers were among the highest sources of CF for all three crops. The contribution of fertilizers in the CF of wheat, mungbean and rice were 77%, 55% and 69%, respectively. On average the contribution of fertilizers in the CF over the year was 71%. Among the fertilizers, N fertilizer contributed 92% of the overall CF of the year. This large contribution of N fertilizer in CF is attributed to the fact that the manufacturing of N fertilizer requires high energy inputs (Yan, 2012) and it is the principal source of CO2 and NO2 emission (Lal, 2004). Mitigation of greenhouse gases emission from crop production should be focused on reducing N fertilizer use and N losses as N2O. The contribution of irrigation, machinery and labor inputs to the overall CF of the year was 19%, 4% and 6%, respectively in addition to 71% from fertilizers.

The grain yield of the crops did not differ significantly between the two tillage systems (except mungbean) as well as between two residue retention treatments. However, it varied significantly with different rates of N application. The grain yield increased with increase in N from 60 to 100% RFD for all the three crops then generally decreased with further increase in N rates it mostly. Comparatively higher yield was observed in strip tillage than
conventional tillage (mungbean and rice) and might have resulted from lesser decomposition of soil organic matter, better water conservation and increased biological activities in strip tillage.

There was no difference in CF for all the crops between two tillage systems (except mungbean) as well as between two residue retention treatments (except rice). Comparatively higher CF was observed in conventional tillage than strip tillage (mungbean and rice) due to higher soil disturbance and more carbon emission from fuel used by the tractor. In case of residue retention, higher CF was observed in 60% residue retention than 20% residue retention (wheat and mungbean). The CF varied significantly with different rates of N application in mungbean and rice but did not differ significantly in wheat. Comparatively higher CF was observed in mungbean followed by wheat and rice. However, when converted into rice equivalent CF, then the highest value was observed in wheat (207 kg t-1) followed by rice (99.5 kg t-1) and mungbean (85.6 kg t-1). The rice equivalent CF of wheat was almost double that of rice and mungbean. The rice equivalent total CF for wheat-mungbean-rice cropping system differed significantly between two tillage systems but did not differ significantly between two residue retention and different rates of N application (Fig.1). Comparatively higher rice equivalent total CF was observed in conventional tillage than strip tillage (mungbean and rice) due to higher soil disturbance and more carbon emission from fuel used by the tractor.

References

![Figure 1](image_url). Carbon footprints of wheat-mungbean-rice cropping system under different tillage, residue and N fertilizer management systems