Increasing crop productivity while reducing greenhouse gas emissions through resource conservation technologies in rice-wheat-mungbean cropping system

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Introduction

Resource conserving technologies (RCTs) enhance input use efficiency and provide immediate identifiable economic benefits like reduced production costs, savings in water, fuel and labor requirements and timely establishment of crops resulting in improved productivity. They can also reduce GHG emissions with less global warming impact (Aggarwal *et.al*. 2002). The CO_2 mitigation strategy for intensive rice-wheat-mungbean cropping systems has not been well studied. Crop residue management, tillage type and N fertilization strategies are likely factors to increase crop productivity and alter fuel consumption. The objective of this trial is to assess the potential productivity and reduction in GHG emissions by using RCT in rice-wheat system.

Materials and Methods

A 12-year trial was conducted at the RWRC, BARI Rajshahi (24^{0}3'N, 88^{0}41'E, 18 m above sea level). The site has a drought-prone environment and is located in AEZ 11. The area receives only 850 mm mean annual rainfall, about 97% of which occurs from June to September. Soil at the experimental site is a calcareous silty loam with slightly alkalinity (pH 7.5), low OM (0.8%) and low Total N (0.07% soil). The experiments consisted of four tillage/straw treatments (30% straw retention(SR)+permanent raised bed(PRB), 30% SR +conventional tillage (CTP), 0% SR + PRB and 0% SR + CTP) with three replications. Another five tillage options such as direct seeded rice (DSR) and non-puddled transplanted rice (TPR) in zero tillage, DSR and non-puddled TPR in raised bed and farmer practice (FP) were also used in rice-wheat systems on the farmer's fields for determination of diesel consumption and global warming potential (GWP).The total system productivity (TSP) for each treatment was calculated as the total annual productivity based on equivalent yields where TSP (rice-wheat-mungbean) = (rice grain yield*1.35) + (wheat grain yield*1.39) + (mungbean grain yield*1.54). The analysis of GWP is simply based on diesel consumption on different tillage options including farmers practice.

Results and Discussion

Total system productivity (TSP)

System yields on PRB consistently increased as SR increased from 0% to 30%, but the differences between 0 and 30% SR were always significant for all 12 crops cycle. The TSP increased by10-12% for all crops in 30% straw retention with PRB over conventional (Fig. 1). Annual TSP of rice, wheat and mungbean (R-W-M) was 12 t ha^{-1}. Yields tended to be lower in lower levels of straw retention for all crops. Lower system productivity also occurred from 0% SR with CTP due to reduced crop growth. Similar observations were made by Singh et al., (2003).

Irrigation water

Amount of irrigation water required at different growth stages of rice, wheat and mungbean varied remarkably between the conventional method and beds in all three years. The conventional method required higher amount of water at each irrigation time (Fig. 2). The total amount of irrigation water required for conventional method was 320, 350,155 liters in 15 m^2 in wheat, rice and mungbean, respectively. But in PRB the total amount of irrigation water was 240, 270 and 110 liters 15 m^{-2} in wheat, rice and mungbean, respectively. The total water saved by beds over conventional method was 25 %, 23% and 29% for three crops, respectively

Global warming potential

The diesel use varied between 2250 kg CO_2 equivalent ha^{-1} in direct seeded rice and wheat on beds and 3620 kg CO_2 equivalent ha^{-1} in conventional both puddle transplanted rice and wheat (Table 1)**.** Compared to the conventional practice all RCTs reduced the GWP by 13 to 37% (Figure 3). Kumar et al. (2006) found similar results from their experiments.

Environmental impact

Fuel used both conventional and reduced tillage system was showed in (Table 2). 54 litre/ha/year diesel used for PRB system where 96 litre/ha/year also used in conventional method. PRB tillage system saved 42 litre/ha/year of costly diesel fuel which 44% less emission of CO_2 into the atmosphere (Kataki. *et al*. (2001) reported same results from their experiment

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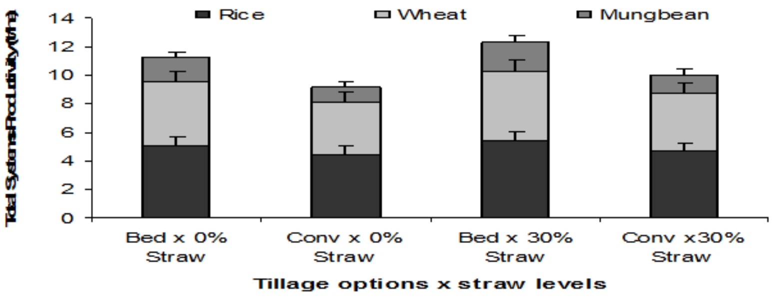

Figure 1. TSP under different tillage and residue management in R-W system

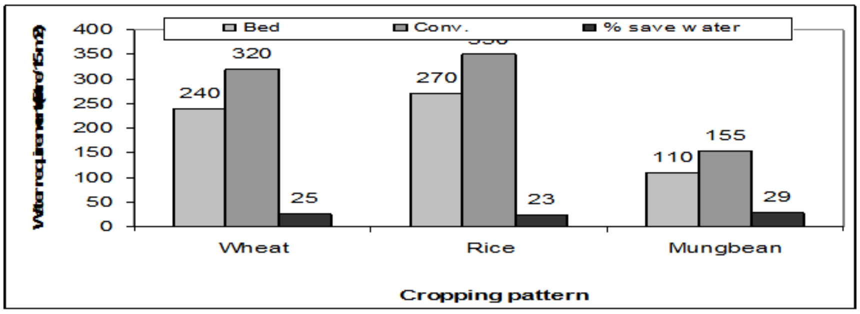

Figure 2. Irrigation water saved under beds and conventional method

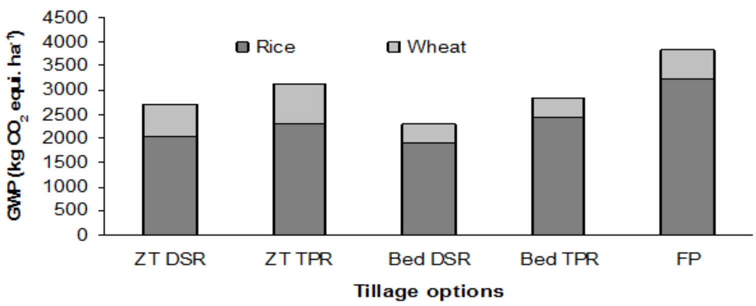

Figure 3. Global warming potential in R-W system under different tillage systems

Table 4. Comparative use of diesel fuel and CO_2 emission on raised bed & traditional method

Tillage options	Diesel used (L ha^{-1} yea^{-1})	CO_2 emission (L ha^{-1} yea^{-1})	Less CO_2 emission (%)	Fuel saved (L ha^{-1} year^{-1})
RB	54	140	44	42
Conv.	96	250	-	-