Improving soil and crop productivity through resource conservation technologies in drought prone area

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Introduction

Resource conserving technologies (RCTs) enhance input use efficiency and provide immediate identifiable and demonstrate economic benefits such as reduction of production costs, savings in water, fuel and labor requirements and timely establishment of crops resulting in improve yields. Rice is transplanted in flat fields that are typically ponded for long periods that negatively affect soil properties for the non-puddled crop (Kumar *et al*. 2000). Wheat is then planted in structurally disturbed soils, often after many tillage operations to prepare the seedbed. Growing crops on the raised beds offers more effective control of irrigation water and drainage management. Permanent raised beds might offer significant advantages for crop yields and be further increased by using residue retention (Sayre *et al*. 2005). Yields of rice and wheat in heat and water-stressed environments can be raised significantly by adopting RCTs, which minimize unfavorable environmental impacts, especially in small and medium-scale farms. Inclusion of grain legumes in rice-wheat cropping system may be another option for increasing cropping intensity, soil fertility and productivity. Limon-Ortega *et al*. (2000) observed that permanent beds with straw retention had the highest wheat grain yields with positive implications for soil health. Thus, crop residue management along raised bed strategies, are likely to be key components of increase crop productivity and soil fertility in rice-wheat system.

Materials and methods

A wheat-mungbean-rice cropping pattern was implemented over 12 years, starting with wheat sown in November 25, 2004 at the Regional Wheat Research Centre, Rajshahi, Bangladesh ($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 with course-textured soil (BARC 2007). The area receives only 850 mm mean annual rainfall, about 97% of which occurs from May to September is drought prone area. Soil at the experimental site is a calcareous silty loam with slightly alkalinity (pH 7.5), low organic matter (0.8%) and low N (35 µ/g soil). The experiments consisted of 12 subplots with 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. Total system productivity (TSP) for each treatment was calculated based on equivalent yields as follows: (rice grain yield*1.35) + (wheat grain yield*1.39) + (mungbean grain yield*1.54).

Results and Discussions

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 three crops. TSP increased about 10-12% for all crops in 30% straw retention with permanent bed planting system over conventional (Fig. 1). TSP of rice, wheat and mungbean (R-W-M) was 12 t ha^{-1} per year. 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) in Mexico.

Environmental impact

RCTs perform better with minimum disturbance of soil. Soil erosion was comparatively less compare to conventional method. Fuel used both conventional and reduced tillage system was showed in (Table 1). 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 (Witt *et al.* 2002) reported same results from their experiment

Soil organic matter (SOM)

After 12 years (2004 to 2015), increased organic matter by 0.78% (Table 2) from 30% SR both rice and wheat straw and full residue retention from mungbean crops with PRB system into the soil. Also, P, K, S, Zn, B availability increased from 30% SR both rice and wheat straw and full residue retention from mungbean crops. Increase in soil organic C with 30% SR at 50-150% N was almost double that with 0% N. Kumar and Goh (2000) reported that, in the longer term, residues and untilled roots from crops can contribute to the formation of SOM. It is clear that further increases in the productivity of the RW system will depend on proper management of residue.

Conclusions

30% straw retention from wheat & rice and full residue retained from mungbean crops under permanent beds were the best combination for getting higher productivity as well as improve soil fertility with increase microbial activities. Compared with all treatments, the raised bed system with residue retained appears to be a very promising technology for sustainable intensification of RW systems in Bangladesh

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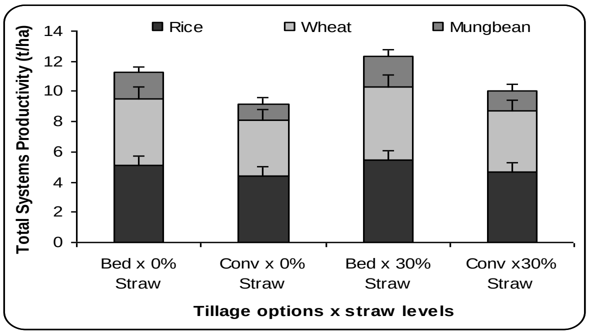

Figure 1: TSP under tillage options & straw levels

Table 1: Comparative use of diesel fuel and CO_2 emission on raised bed & traditional

Tillage options	Diesel used (litre/ha /year)	CO_2 emission (kg/ha /year)	Less CO_2 emission (%)	Fuel saved (litre/ ha/year)
PRB	54	140.4	44	42
Conv.	96	249.6	-	-

Table 2. Chemical properties changes after 12 years crop cycles

Characteristics	Initial	Final	Difference
Organic Matter (%)	0.90	1.62	+ 0.78
Total N (%)	0.12	0.19	+ 0.07
Exch. K (ml eq/100g soil)	0.26	0.48	+ 0.22
Avail. P (mg / g soil)	24.5	52.5	+ 38.0
Avail. S (mg / g soil)	25.6	38.9	+ 13.3
Avail. Zn (mg/g soil)	0.84	6.13	+ 5.29
Avail. B (mg /g soil)	0.19	0.37	+ 0.18

Table 3. Physical properties changes after 12 years crop cycles

Tillage options	Bulk density (mgm^{-3})			Infiltration rate	Total pore
	0-10 cm	10-20 cm	20-30 cm	(cmh^{-1})	space (vol.%)
Bed	1.37	1.59	1.74	0.85	53-59
Conv	1.57	1.79	1.95	0.59	43-48
LSD (0.05)	0.037	0.025	0.034	0.032	NS