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Effect of tillage and residue retention on maize productivity

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Introduction

In Bangladesh, maize is generally sown after extensive tilth and minimum residue retention. Conservation agriculture (CA) systems reduce the input costs, machinery use, CO_2 emissions; and improve soil health (Raper et al., 1994). Crop residues are known to affect soil physical properties (Hulugalle et al., 1986), availability of nutrients (Wade and Sanchez, 1983; Asghar et al., 2006) and soil biological activity (Tian et al., 1993). Crop residue retention has been suggested to improve overall soil fertility and to support sustainable crop production. Crop residue retention under no tillage system reduce soil erosion, increase soil organic matter (SOM), and reduce requirement of labour and fuel under cereal grain and row crop culture (Salinas-Garcia et al., 1997). Kumar and Goh (2000) reported that incorporation of crop residues is essential for sustaining soil productivity through replenishing SOM that not only a key indicator of soil quality, but it also supplies essential nutrients upon mineralization (N, P, and S) and improves soil physical, chemical, and biological properties (Kumar et al., 2001). In our country, the crop residue is used mostly for cattle feed (Saadullah et al., 1991), fuel for stove and some cases burning. It is essential to estimate the amount of crop residue that should be retained in field to get the benefits. Therefore, the present research investigated to find out the minimum tillage with residue retention could be an effective element for maize production.

Materials and Methods

The experiment was set up at the Bangladesh Rice Research Institute (BRRI), Regional station, Rajshahi (24°69´latitude N, 88°30 longitude E) in the cool dry *Rabi* season of 2009. Land preparation was done with the Versatile Multi-crop planter (VMP). The main plot treatments were - conventional full tillage with four passes by the 2-wheel tractor (T_1); zero tillage by using hand tool '*naigla*' (T_2); bed formed by VMP (T_3), and strip tillage by VMP (T_4) and planted maize seed manually by hand. The subplot treatments were 100 % residue retention (C_1); 50% residue retention (C_2) and 0% residue retention (C_3) from the previous monsoon season rice. The maize seed of variety NK 40 was used. All recommended agronomic practices were maintained in the trial. Maize seed was sown with 20 cm distance from seed to seed on 19 December 2009. Recommended basal fertilizers were applied in the furrows. Rice straw was spread on the surface as per treatments. In 100 % straw retention plots, 4,582 kg ha^{-1} (on an oven-dry weight basis) rice straw was spread; and half that amount of straw was spread for the 50 % straw retention plots. The trial was laid out in a strip plot arrangement with three replications with tillage types in main plots and residue retention in sub-plots.

Results and Discussion

Fuel consumption was significantly higher (49.3 l ha $^{-1}$) in T_1 than other treatments (Table 1). Fuel consumption in T_3 and T_4 were 27.8 and 16.6 l ha^{-1}, respectively. Labour requirement in t T_2 was 500 % higher than for the treatments T_3 and T_4. There was no significant difference in labour requirements for land preparation between the treatments of T_3 and T_4. The greatest time was required for maize seed sowing in T_2 (161.3 person-hr ha^{-1}) and that was almost 300 % higher than the treatments, T_3 and T_4 (Table 1) for the placement of seed and fertilizer in untilled soil. Lowest time (49.4 person-hr ha^{-1}) requirement was recorded in T_3 due to broadcasting the basal fertilizers before bed formation and seeds were sown in tilled soil. The highest cost for land preparation was incurred in T_1 (Taka 3,774 ha^{-1}) and lowest (Taka 1,055 ha^{-1}) in T_3 because of minimal fuel and labour requirement. The maize seed sowing cost was highest in T_2 because of the need to place and cover the fertilizers in the furrow, then sow and cover the seed in the furrow (Table 2). The maize plant emergence rate was highest in bed planting and lowest in zero tillage plots. Rodent's damage was observed higher in zero tillage, strip tillage and conventional tillage plots than bed planting. Among the species, the weeds - *Chenopodium album* and *Cynodon dactylon* were dominant. Severe weed infestation was found in the zero tillage plots (T_2) followed by strip tillage plots (T_4) (Table 3). The highest time and maximum cost for weeding was incurred in the 0 % residue retention plots (Table 4). Tillage treatment had no significant effect on maize grain yield. Conventional tillage, zero tillage by *naigla*, bed formed by VMP, and the strip tillage by VMP plots yielded maize grain outputs of 7.75, 7.00, 8.48 and 7.19 t ha $^{-1}$, respectively. Residue retention did not significantly affect maize grain yield either. The 100 %, 50 % and 0 % residue retention plots yielded 7.31, 8.05 and 7.45 t ha^{-1}, respectively. The benefit cost ratio of conventional tillage, zero tillage by *naigla*, bed formed by VMP, and strip tillage by VMP was 2.95, 1.73, 3.26 and 2.10, respectively.

Table 1: Effect of tillage on fuel consumption, and on labour requirements for land preparation, basal fertilizer application and maize seed sowing.

Treatment	**Fuel consumption (l ha^{-1})**	**Labour requirement (person-hr ha^{-1})**	
		Land preparation	**Seed sowing and basal fertilizer application**
Conventional tillage (T_1)	49.3a	51.8a	73.0b
Zero tillage by '*naigla*' (T_2)	0.0c	40.6b	161.3a
Bed formed by VMP (T_3)	27.8b	11.8c	49.4c
Strip tillage by VMP (T_4)	16.6b	10.3c	59.7c

In a column, means followed by a common letter are not significantly different at 1 % level by Duncan's Multiple Range Test.

Table 2: Cost of land preparation and maize seed sowing under different tillage systems.

Parameter	Tillage treatment (Taka ha^{-1})			
	Conventional tillage (T_1)	Zero tillage by '*naigla*' (T_2)	Bed formed by VMP (T_3)	Strip tillage by VMP (T_4)
Land preparation	3,774a	1,219b	1,602b	1,055b
Seed sowing + basal fertilizer application	1,461b	3,226a	989d	1,194c
Total	**5,235a**	**4,445b**	**2,591c**	**2,249d**

In a row, means followed by a common letter(s) are not significantly different at 1% level by Duncan's Multiple Range Test.
Note: 70 Taka = 1 USD

Table 3: Effect of tillage on weed control

Parameter	Tillage treatment				Level of significance
	Conventional tillage (T_1)	Zero tillage by '*naigla*' (T_2)	Bed formed by VMP (T_3)	Strip tillage by VMP (T_4)	
Weeding (person-hr ha^{-1})	653b	1,903a	836b	1,444ab	*
Weeding cost (Taka ha^{-1})	13,050b	38,050a	16,740b	28,888ab	**

*, $P < 0.05$; **, $P < 0.01$

Table 4: Effect of residue retention on weed control

Parameter	Residue retention			Level of significance
	100 % residue retention (C_1)	50 % residue retention (C_2)	0 % residue retention (C_3)	
Weeding (person-hr ha^{-1})	884c	1,060b	1,682a	**
Weeding cost (Taka ha^{-1})	17,690c	21,210b	33,650a	**

** Significance at 1% level, * Significance at 5% level

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