Evaluation of different tillage methods to assess BARI inclined plate planter

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Abstract: Engineering parameters of the bed planter and the inclined plate planter for bed planting, minimum tillage, strip tillage and conventional tillage cum hand planting methods were estimated at Gazipur. Field tests of the machinery for different tillage practices were conducted at Gazipur, Pabna, and Barisal in Bangladesh. Field tests were conducted with four treatments: bed planting with inclined plate seed metering, minimum tillage with inclined plate planter, strip tillage with inclined plate planter and conventional tillage. All the treatments were replicated thrice with randomize complete block design. The planter was tested for sowing maize, wheat and mungbean crops during 2012-2013. Energy requirement of bed planting, minimum tillage and strip till methods was 26%, 30% and 57% less and contributed 27%, 31% and 57% less CO2 in air than the conventional methods. The field efficiency for strip tillage and minimum tillage were 79% and 75% respectively, whereas it was 73% for bed planter. 27%, 53% and 60% time saving were found for bed planting, minimum tillage and strip till respectively than the conventional tillage method for maize production which required three passes of power tiller and one laddering operation. Inclined plate planter was suitable for small (mungbean) to large (maize) seed. Inclined plate metering device incorporated in bed planter showed better performance than others methods. But power tiller operated inclined plate planter reduced planting time as it covered double area than the bed planter. Significantly higher yield of maize and wheat were found in bed planting than minimum tillage, strip tillage and conventional tillage. The highest seed yield of mungbean was obtained from the bed planting which was statistically similar with minimum tillage and strip tillage but the lowest yield was obtained from the conventional tillage and broadcasting method. The cost for land preparation and planting for bed planting, minimum tillage and strip tillage were 89%, 86% and 81% less than the conventional maize planting method. The payback period of Bangladesh Agricultural Research Institute (BARI) developed planter for strip tillage and minimum tillage are 0.88 and 1.20 year and for bed planter it is 1.08 year.

Keywords: field efficiency, planter, bed planting, strip tillage, minimum tillage, energy requirement

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1 Introduction

Sowing of seed in the field needs to maintain optimum soil moisture. Residual moisture of the previous crop in the field is the target point of the farmers. Delay of sowing/planting reduces yield significantly. Timely sowing not only increases yield and cropping intensity but also reduces turnaround time. Conservation technologies have replaced the conventional frequent tillage operations. The major benefit of reduced tillage is the reduction of production cost. Land preparation is one of the major charges to grow crop. Additional benefit in income is obtained through higher yield (Hobbs, 2003). Broadcasting is the scattering of seeds on the fields' surface and soon after covered by manipulating the soil by hand tools (Micheal and Ojha, 1966). The method of mechanical drilling for seeds affects mainly the seeding depth, seed placement uniformity and leads to yield increase as compared with manual planting (Mona et al., 2009). Uniform seed pacing increases crop yield and non-uniform spacing reduces yield (Searle et al. 2008). Thus the sustainable solution is mechanical sowing. Mechanical sowing is a new method to the farmers of Bangladesh. It is becoming important to minimize the cost of land preparation, environmental pollution,

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maintain soil health and timeliness of operation. But the farmers of Bangladesh are still practicing broadcasting method of seed sowing by conventional tillage due to lack of appropriate seeding machinery. Fluted type seed metering devices are suitable for small seeds like wheat, pulses and oilseeds. But for large seeds like maize and groundnut are difficult to sow in hill at a certain distance. However, inclined plate type seed metering devices are suitable for large seed for planting as well as for sowing small seeds.

Power tiller operated inclined plate type planter was developed by Farm Machinery and Postharvest Process Engineering Division of Bangladesh Agricultural Research Institute (BARI) (Ahmed et al., 2005; Matin et al., 2008). The planter was tested and evaluated for planting different crops like maize, wheat, pulses and oilseeds in field condition. The field performances results were satisfactory. But the planter required prepared land before use which is costly and time consuming. The planter was developed for one pass tillage and seeding operation by placing inclined plate metering device on BARI high speed rotary tiller (Wohab et al., 2011).

The conventional tillage includes four-five passes ploughing followed by three-four times laddering. Power tiller operated seeder (PTOS) performs tillage operation, seeding in line and seed covering simultaneously which is named as the minimum tillage (Hossain et al., 2014). Strip tillage seeding system technique is a conservation agriculture based resource conserving technology which employs tilling the soil in strip just in front of furrow opener and place seed, and fertilizer in line at right depth (Hossain et al., 2014). Bed planting is a system where land is prepared conventionally and raised bed is prepared using bed planting machine. Crops are planted in row on the top of the bed and irrigation water is applied in the furrows between the beds (Islam, 2012).

These tillage forms could be accomplished by power tiller operated BARI inclined plate planter and BARI bed planter with inclined plate metering device for different crops. Thus the experiments were conducted with the following objectives

i) To assess performances of BARI inclined plate planter;

ii) To study the effect of different tillage methods on performance parameters, and

iii) To study the economics of machine use.

2 Material and methods

The experiment was conducted with BARI developed inclined plate planter (Figure 1) and BARI developed bed planter (Figure 2). BARI developed inclined planter accomplishes three operations in a single pass, including tillage (up to five cm), placement of seed in a furrow, and seed covering by post-furrow opener roller bar. This planter could be used as the minimum tillage planter by reducing the number of passes through 400-480 rotor speed results in considerable soil surface disturbance (Wohab et al., 2007). Strip tillage could be done by removing the rotary blades. In strip tillage the number of blades depends on the number of furrow opener where in front of every furrow opener, four blades were arranged for tillage (Hossain et al., 2005). The bed planter is described by Wohab (2010) which creates soil disturbance with 24 blades in 60 cm in width, place seed by fluted roller or inclined plate and finally shapes beds by a trapezoidal shapes, rolling by bed former. Dimensions of some important parts of BARI inclined plate planter and BARI Bed planter are shown in Table 1.

Table 1 Dimensions of some important parts of BARI inclined plate planter and BARI Bed planter

Sl.No.	Description	BARI inclined plate planter		BARI bed planter	
		Dimension, mm	Quantity	Dimension, mm	Quantity
01	Mud gaurd	1235×209.5	1	690×500	1
02	Seed box	1220×185×145	1	700×185×145	1
03	Furrow opener	255×75×35	6	255×75×35	3
04	Tine shaft	1180×Ø50	1	L=650,D=Ø50	1
05	Tine pocket	70×45×20	48	70×45×20	24
06	Roller	1220×Ø152	1	7000×Ø155	1
07	Bed shaper conical	-	-	ID=Ø155,OD=Ø395, L=150	2

Figure 1 BARI developed inclined plate planter

Figure 2 BARI developed bed planter

The initial moisture content of the samples was determined by oven drying at 103 ±1℃ for 72h. The length, width, thickness and mass of used seeds were measured on randomly selected 50 seeds. The length, width and thickness of materials were measured using a caliper with an accuracy of 0.01 mm. The arithmetic mean diameter (Da) of the seeds was calculated by using the following equations.

$$Da = \frac{L+W+T}{3}$$

Engineering parameters of the machines used for different tillage methods were estimated using following formulas:

Forward speed was measured by dividing the distance by time required to travel that distance. Three distances were taken with measuring tap and respective travelling times were recorded with stop watch. Average value was calculated. Forward speed was calculated by Equation (1) (Hunt, 1995):

$$S = \frac{3.6D}{t} \qquad (1)$$

Where, S=Forward speed (km/h), D=Distance (m), t=Time (s).

2.1 Effective field capacity

Effective field capacity was determined by equation (2) (Hunt, 1995)

$$EFC = \frac{A}{T} \qquad (2)$$

Where, EFC= Effective field capacity (ha/h), A= Actual operational area (ha), T= Total operating time (h)

2.2 Theoretical field capacity

Theoretical field capacity is the rate of harvesting that would be obtained if the machine was performing its function 100% of the time at rated forward speed and always covered 100% of its sowing width. It was calculated by Equation (3) (Hunt, 1995):

$$TFC = \frac{SW}{10} \qquad (3)$$

Where, TFC= Theoretical field capacity, ha/h, S= Rated forward speed, km/h, W = sowing width,m.

2.3 Field efficiency

The field efficiency was determined by Equation (4) (Hunt, 1995):

Field efficiency (%),

$$FE = \frac{EFC}{TFC} \times 100 \text{.............................}(4)$$

2.4 Fuel consumption

Fuel consumption was measured by Equation (5) (Hunt, 1995):

$$\text{Fuel consumption} = \frac{F}{A} \text{.....................................}(5)$$

Where, F= Amount of fuel (lit), A= Area Covered (ha)

2.5 Wheel slippage

Number of wheel revolution was counted for 10 m distance coverage for loading and unloading condition, wheel slippage percentage was calculated by Equation (6) (Hunt, 1995):

$$S = \frac{N_1 - N_u}{N_u} \times 100 \text{...}(6)$$

Where, S = Wheel slippage, %; N_1 = Number of revolution under loading condition; Nu = Number of revolution under unloading condition.

2.6 Coefficient of seed distribution uniformity

To calculate the coefficient of uniformity of seed distribution, prepared land strip with measurements of 20 ×1.2 m was filled with a layer of fine soil of 50 mm thickness. Planting was performed on the strip at the speed of 2 km/h. An area of two rows with a length of one meter was randomly selected using a wooden frame in each replication. The planted seeds in this area were separated from the soil using a sieve. The coefficient of uniformity of seed distribution was computed using Equation 7 (Afzalinia et al., 2012; Senapati et. al., 1992).

$$S_e = 100(1 - \frac{Y}{D}) \quad \text{………..} (7)$$

Where,

Se = coefficient of seed distribution uniformity, %;

Y = average numerical deviation of average number of plants per meter length of row from average desired number of plants per meter run, and

D = average number of plants per meter length of row.

2.7 Coefficient of planting depth uniformity

To measure plant depth uniformity, planted seeds were irrigated gently and adequate time was provided for seedling emergence. Once emerged, seedlings were cut at the soil surface. A part of the stem that was inside the soil (from soil surface to seed remnants on the root) was taken out and its length was measured. This length was considered as a criterion to compare the seeding depth of the plater. 20 samples were taken, and the coefficient of planting depth uniformity was calculated using Equation 8 (Afzalinia et al., 2012).

$$S_d = 100(1 - \frac{Y_d}{D_d}) \text{ ……………} \quad (8)$$

Where,

S_d = coefficient of planting depth uniformity, %;

Y_d = average numerical deviation of depth of seeds planted from pre-set planting depth and

D_d= average depth of seeds planted.

Tillage operations contribute CO_2 through rapid decomposition of organic matter. Experiments have shown that every liter of diesel fuel used by tillage machinery contributes 2.6 kg CO_2 to the atmosphere. Diesel use remains a great source of Green House Gases (GHG) (Groce, 2003).

2.8 Engine power

To calculate engine power, Equation 9 (Mona et al., 2009; Elmo, 1981) was used:

$$EP = \frac{FC}{3600} . \rho_f . LCV . 427 . \eta_{th} . \eta_m . \frac{1}{75} . \frac{1}{1.36} \text{...........}(9)$$

Where,

EP= Engine power, kW;

FC = the fuel consumption, l/h;

ρ_f = Density of fuel, kg/l (for diesel = 0.85 kg/l);

LCv = Lower calorific value of fuel, kcal/kg, (average LCV of diesel is 10000 kcal/kg);

427 = Thermo-mechanical equivalent, kg.m/kcal;

Please reedit the equation with equation editor. = Thermal efficiency of the engine, (considered to be about 40 % for diesel engine);

η_m = Mechanical efficiency of the engine, (considered to be about 80 % for diesel engine);

EP = 3.16 FC.

2.9 Energy requirement

Energy requirement (ER) in kW h ha^{-1}was calculated using the following equation:

$$ER = \frac{Enginepower(kW)}{Effectivefieldcapacity(hah^{-1})}$$

Field performance test: Field performance test of the planter was conducted in divisional experimental plot, BARI, Gazipur, Pabna and farmers field of Barisal. The inclined plate planter was tested for maize in Gazipur and Pabna, Bangladesh. The variety was BARI hybrid maize-7 and NK 40 in Gazipur and Pabna. The field performance of the planter was also conducted at Gazipur for wheat and at Barisal for mungbean. The experiment was conducted with four treatments: T_1= Bed planting with inclined plate; T_2= Inclined plate planter with minimum tillage; T_3= Inclined plate planters with strip tillage and T_4= Conventional hand planting. All the treatments were replicated thrice with RCB design. Date of planting of Maize at Gazipur and Pabna were 12 January 2013 and 20 February 2013 and the harvesting dates were 27 May 2013 and 03 June 2013, respectively. Spacing of maize seed was 60×20 cm. Wheat (BARI Gom-26) was sown with inclined plate planter at 29 November 2013 and harvested at 28 April 2014. In Barisal, the inclined plate planter was used in the farmer's field for sowing mungbean (BARI mung 6). The sowing and harvesting date of mungbean were 02 February 2013 and 10 April 2013. Irrigation, fertilizing, weeding and other intercultural operations were done timely. Some important soil physical properties in the experiment area are shown in table 2.

Table 2 Some important soil physical properties in the experiment area

Soil physical properties	Gazipur	Barisal	Pabna
Bulk density, Mg/m^3	1.50	1.35	1.42
Porosity, %	38.50	44.7	41.65
Field Capacity, %	23.00	29.25	27.00
Soil texture class	Clay loam	Clay loam	Sandy loam
Sand, %	35.30	36.00	53.00
Clay, %	27.41	27.00	13.00
Silt, %	37.29	37.00	34.00

3 Results and discussion

Performance parameters for bed planter, minimum tillage, strip till and conventional methods are given in Table 3. It was found that the field efficiency of the planter were 79% and 75% for strip tillage and minimum tillage, whereas it was 73% for bed planter. Similar results were also found from Hossain et al. (2014). During the test, forward speeds of the machines were 2.1, 2.0 and 2.3 km/h for bed planting, minimum tillage, strip till. If the operator is trained then the forward speed will be more which will ensure more field capacity of the planter. Field capacity of BARI planter both for strip tillage and minimum tillage were 82% and 55% higher than that of BARI bed planter due to higher working width and less drive wheel slippage. 14%, 31% and 57% less fuel consumption was found for bed planting, minimum tillage and strip till respectively than the conventional tillage method for maize production which required three passes of power tiller and one laddering operation. Conventional method planting was done manually. Thus 27%, 53%, and 60% time saving was reported for bed planting, minimum tillage and strip till respectively than conventional tillage only. Physical properties of used seed are shown in Table 4. Arithmetic diameter of wheat and mungbean is closer, thus the same seed plate could be used for those crops but different seed plates were required for maize since the arithmetic diameter is more than wheat and mungbean.

Table 3 Performance parameters for strip till, minimum tillage, bed planter and conventional methods

SI No.	Parameter	Bed planter	Minimum tillage	Strip tillage	Conventional
1	Travel speed, km/h	2.1	2.0	2.3	-
2	Effective working width, cm	60	120	120	-
3	Field Efficiency, %	73	75	79	-
4	Effective field capacity, ha/h	0.11	0.17	0.20	-
5	Drive Wheel slippage, %	9	8	5	-
6	Fuel consumption, l/ha	11.82	9.5	5.9	13.80
7	Total Time requirement, h/ha	9.10	5.9	5.02	12.50

Table 4 Physical properties of used seed

Used seed	Moisture content, %db	Length, mm	Width, mm	Thickness, mm	Arithmetic dia, mm	Mass of 1000 grains wt. g
Maize	14.5	10.48	8.72	4.97	8.05	254.40
Wheat	12	6.85	3.57	2.95	4.45	43.562
Mungbean	14	4.71	3.74	3.58	4.01	47.40

Coefficients of seed distribution uniformity (SDU) and planting depth uniformity (PDU) for the maize production under different tillage methods are shown in Figure 3. SDU was found significantly lower (91%) in minimum tillage method than strip tillage (97%), bed planting (96%) and conventional tillage (98%). PDU for minimum tillage was identical with the conventional tillage but those were significantly lower than strip tillage and bed planting methods. These might be due to huge soil through in minimum tillage and manual line making in conventional method.

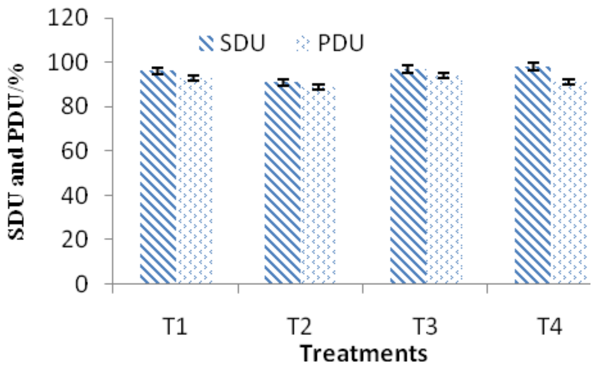

Figure 3 Coefficient of seed distribution uniformity (SDU) and planting depth uniformity (PDU) for the maize production under different tillage methods

Energy requirement and CO_2 emission for different tillage method are shown in Figure 4. Strip tillage required significantly lower energy requirement than other tillage methods. Minimum tillage and bed planting required 30% and 26% less energy than the conventional though they are statistically similar. Strip tillage required 57% less energy for maize planting than the conventional tillage only. Less energy requirement was recorded for the strip tillage methods due to less number of working blades and less soil movement which reduces the loads on the working engine. If energy requirement for manual planting is also taken into consideration then the amount will be more for the conventional method. CO_2 emission for different tillage methods is also found to follow similar trend of the energy requirements. Bed planting, minimum tillage and strip till methods contributed 27%, 31% and 57% less CO_2 in air than the conventional methods.

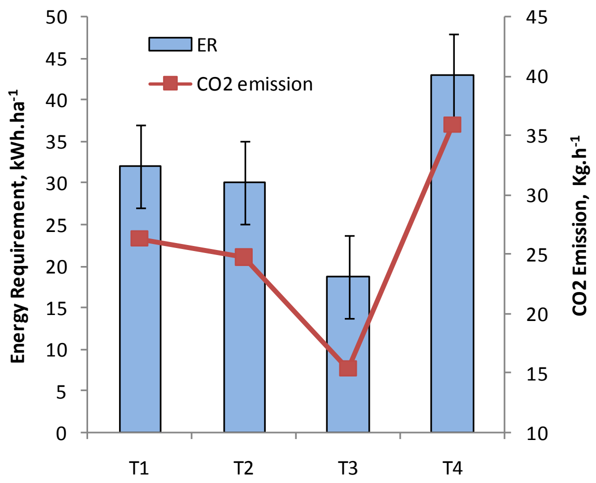

Figure 4 Energy requirement and CO_2 emission for different tillage method

Field performance evaluation of different tillage methods were done in three different locations and with different crops. Comparative performance of bed planter, minimum tillage, strip tillage and conventional tillage methods in laboratory test are shown in Table 5. In strip tillage and minimum tillage 23% and in bed planting 31% less amount of wheat seed was required than the conventional tillage and broadcasting. For mungbean, all mechanized tillage methods require 29% less seed than the conventional tillage and broadcasting. For maize, there was no significant variation in seed rate among the tillage methods. Seeding depth was more or less the same among the mechanically sown methods but there was variation in conventional broadcasting. In broadcasted wheat or mungbean, variable seeding depth was recorded since one pass tillage and laddering were done after the broadcast. In conventional maize planting method also the variability was found due to making the furrow and placing the seed was manual. Though the seed savings were recorded for the mechanical tillage methods, the plant population per meter square was more than the broadcasted wheat and mungbean. Plant population per square meter was the same for maize among the treatments since the coefficient of seed distribution uniformity of all methods were more than 90%.

Table 5 Comparative performance of bed planter, minimum tillage, strip tillage and conventional tillage methods

Parameters	Bed planter			Minimum tillage			Strip tillage planter			Conventional method		
	W	M	Mu	W	M	Mu	W	M	Mu	W	M	Mu
Seed rate, kg/ha or No./ha	105	83000	25	120	83000	25	120	83000	25	155	83333	35
Seeding depth, cm	3-4	4-5	2-3	3-4	4-5	2-3	3-4	4-5	3-4	0-7	2-8	0-6
Width of strip, cm	-	-	-	-	-	-	4-6	4-6	4-6	-	-	-
Plant population, no/m^2	282	10	24	271	10	24	284	10	23	252	10	20-25

Note: W=Wheat, M=Maize and Mu=Mungbean

Significantly higher yield (6.77 and 9.19 t/ha) was observed from bed planting (T_1) both in Gazipur and Pabna (Tables 6 and 7) due to highest grain per cob and 1000 grain weight. Conventional hand planting (T_4) in Gazipur also produced statistically similar yield (6.74 t/ha) with that of bed planting (6.77 t/ha) since earthing up was done and created similar effect like bed planting. Lowest yield (5.90 t/ha) was observed from strip till plot due its lowest grain per cob and 1000 grain weight. But in Pabna, earthing up was not done in conventional method for which inclined plate planter with full tillage produced statistically similar yield (8.75 t/ha) to conventional (7.27 t/ha). Yield of maize in bed planting (9.19 t/ha) at Pabna was statistically identical to power tiller operated inclined plate planter with full tillage and strip tillage.

Table 6 Effect of planting method on the yield of maize at Gazipur

Treat-ment	Plant Population, No/m^2	Plant height, cm	Cob length, cm	Cob dia., cm	No. of grain/cob	1000 grain weight, g	Yield, t/ha
T_1	7.76	149.83 b	15.36	12.66	358.20 a	247 a	6.77 a
T_2	7.53	158.76 ab	15.67	13.66	329.66 b	226.33 c	6.25 b
T_3	7.60	160.53 a	15.86	13.76	329.06 b	225.67 c	5.90 b
T_4	7.60	156.23 ab	15.40	13.23	347.46 a	232.00 b	6.74 a

Note: Common letter in the same column does not differ from each other by DMRT

Table 7 Effect of planting method on the yield of maize at Pabna

Treat-ment	Plant Population, No/m^2	Plant height, cm	Cob length, cm	Cob dia., cm	No. of grain/cob	1000 grain weight, g	Yield, t/ha
T_1	7.76	213.50	15.36	3.11	474 a	361.00	9.19 a
T_2	7.83	219.00	16.85	3.21	430 b	352.33	8.75 ab
T_3	7.60	209.16	15.55	3.09	463.33 a	371.33	8.40 ab
T_4	7.83	212.83	15.78	3.09	393.33 c	335.00	7.27 b

Note: Common letter in the same column does not differ from each other by DMRT

Yield and yield contributing characters of wheat under different tillage practices at Gazipur are given in Table 8. Highest yield (5.12 t/ha) was observed from bed planting due to highest number of filled grain per spike (39.16) and highest number of spikes per square meter. Yield of wheat sown by power tiller operated inclined plate planter was 4.69 t/ha which was statistically similar to that of strip till (4.84 t/ha) and conventional (4.70 t/ha). There was no significant difference in 1000 grain weight and number of unfilled grain among different tillage treatments.

Table 8 Yield and yield contributing character of wheat under different tillage practices at Gazipur

Treatments	Plant height, cm	No. of Spike, m^2	Length of spike, cm	No. of filled grain/ spike	No. of unfilled grain/ spike	1000 grain wt, g	Yield, t/ha
T_1	86.30 a	325.66 a	10.46 b	39.16 a	2.26	44.84	5.12 a
T_2	84.43 ab	300.66 b	11.44 a	35.80 b	3.27	44.89	4.69 b
T_3	81.80 ab	302.33 ab	10.74 ab	37.26 ab	3.86	44.73	4.84 ab
T_4	78.86	305.33 ab	10.06 b	36.03 b	2.86	44.66	4.70 b

Note: Common letter in the same column does not differ from each other by DMRT

Performance of different tillage methods in farmer's field in Barisal is shown in Table 9. Significant variations were observed for plant height, total plant/m^2, pod/plant, seed/pod, seed yield. The highest plant height (35.56 cm) was recorded in minimum tillage, which was statistically similar to the bed planting (33.43cm). The lowest plant height (28.56 cm) was recorded in the conventional tillage practice. The highest seed per plot (11.43) and 1000 grain weight (32 g) was found in treatment T_1. The highest seed yield (930.67 kg/ha) was obtained from the bed planting which was statistically similar with minimum tillage (908.33 kg/ha) and strip tillage (839.33 kg/ha). The lowest seed yield (765 kg/ha) was obtained from the conventional tillage and broadcasting method.

Table 9 Performance of different tillage methods for mungbean in farmer's field in Barisal

Treatments	Plant population, No/m^2	Plant height, cm	Pod/ plant	Seed/Pod	1000 grain,g	Yield, kg/ha
T_1	22.33 ab	33.43 a	34.90	11.43 a	32.00 a	930.67 a
T_2	21.33 ab	35.56 a	38.33	10.03 ab	29.66 b	908.33 a
T_3	24.33 a	31.60 ab	32.06	10.26 ab	28.33 bc	839.33 ab
T_4	19.00 b	28.56 b	32.30	9.73 b	26.66 c	765.00 b

Note: Common letter in the same column does not differ from each other by DMRT

Cost parameters for land preparation and planting of different tillage methods for maize production are shown in Table 10. It was observed that the cost for land preparation and planting for bed planting, minimum tillage and strip tillage were 81%, 86% and 89% less than the conventional maize planting method. If the planter used for custom hiring, net return was found to be Tk 129405, Tk 132420 and Tk 180948 per year for bed planting, minimum tillage and strip tillage respectively. Therefore, the payback period of the BARI planter for strip tillage and minimum tillage are 1.20 and 0.88 year and for bed planter it is 1.08 year.

Table 10 Cost parameters for land preparation and planting of different tillage methods for maize production

Sl. No	Parameters	Bed planting	Minimum tillage	Strip tillage	Conventional tillage
1	Price of the planter,Tk	140000	160000	160000	
2	Life of the planter, yr	8	8	8	
3	Annual use, h	340	340	340	
4	Annual fixed cost, Tk/yr				
	a) Depreciation	15750	18000	18000	
	b) Interest (12.5%)	9240	10560	10560	
	c) Repair , maintenance and shelter	4900	5600	5600	
	Total fixed cost, Tk/yr	29890	34160	34160	
	Total fixed cost, Tk/h	87.91	100.47	100.47	
5	Variable cost				
	a) Diesel, Tk/h	88	110	80	
	b) Operator (labour@ Tk 300/day) , Tk/h	37.50	37.50	37.50	
	c) Land preparation, Tk/ha			-	5400
	d) Labour for line sowing, Tk/ha			-	4800
	Total variable cost, Tk/h	125.50	147.50	117.50	
6	Grand total (FC+VC), Tk/h	213.41	247.97	217.97	
7	Cost for land preparation and planting , Tk/ha	1940	1459	1089	10200
8.	Income (considering custom hireing), Tk/ ha	5400	3750	3750	
9.	Net return, Tk/yr	129404	132420	180948	
10.	Pay back period, yr	1.08	1.2	0.88	

Note: 1 $ ≈ 77 Tk in 2013.

4 Conclusions

The field efficiency of the planter was 79% and 75% for strip tillage and minimum tillage, whereas it was 73% for bed planter. SDU was found significantly lower (91%) in minimum tillage method than strip tillage (97%), bed planting (96%) and conventional tillage (98%). PDU for minimum tillage was identical with the conventional tillage but those were significantly lower than strip tillage and bed planting methods. 14%, 31% and 57% less fuel consumption and 27%, 53%, and 60% time saving were found for bed planting, minimum tillage, strip till respectively than the conventional tillage method for maize production. Inclined plate planter was suitable for small (mungbean) to large (maize) seed. Inclined plate metering device incorporated in bed planter showed better performance than others methods. But power tiller operated inclined plate planter reduced planting time as it covered double areas than the bed planter. Significantly higher yield of maize and wheat were found in bed planting than minimum tillage, strip tillage and conventional tillage. The highest seed yield of mungbean was obtained from the bed planting which was statistically similar with minimum tillage and strip tillage but the lowest yield was obtained from the conventional tillage and broadcasting method. The cost for land preparation and planting for bed planting, minimum tillage and strip tillage were 81%, 86% and 89% less than the conventional maize planting method. The payback period of the BARI planter for strip tillage and minimum tillage are 1.20 and 0.88 year and for bed planter it is 1.08 year.

References

Afzalinia, S., A. Khosravani, A. Javadi, D. Mohammadi, and S. M. Alavimanesh. 2012. Effect of tillage and planting methods on the soil properties, grain drill performance, and wheat yield. *Journal of Agricultural Science and Technology* A2, 21(5): 537-543.

Ahmed. S., M. A. Matin, K. C. Roy, M. N. Amin, M. S. Islam, and M. S. Islam. 2005. Field performance test of power tiller operated planter for maize, wheat and pulses crop. Annual research report, BARI.

Ronel, E. 1981. Pedicting machine field capacity for specific field and operation conditions. Trans. of American Society of Agricultural Engineers (ASAE), paper No. 79-1029.

Groce, P. R. 2003. Rice-wheat system and climatic change. *In* Addressing Resource Conservation Issues in Rice-Wheat Systems of Sough Asia : A Resource Book, Rice-Wheat Consortium for the Indo-Gangetic Plains. Intl. Maize and Wheat Impr. Cent., New Delhi, India. pp 63-67.

Hobbs, R. P. 2003. Reduced and zero-tillage options. *In* Addressing resource conservation issues in rice-wheat systems of south Asia: a resource book. rice-wheat consortium for the indo- gangetic plains. Intl. Maize and Wheat Impr.Cent., New Delhi, India. pp 109-112.

Hossain, M. I., M. E. Haque, C. A. Meisner, M. A. Sufian, and M. M. Rahman. 2005. Strip tillage planting method for better wheat establishment. *Journal of Science and Technology*, 3:91-95.

Hossain, M. I., M. K. Gathala, T. P. Tiwari and M. S. Hossain. 2014. Strip tillage seeding technique: a better option for utilizing residual soil moisture in rainfed moisture stress environments of north-west Bangladesh. *International Journal of Recent Development in Engineering and Technology*, 2(4):132-136.

Donnell, H. 1995. Farm power and machinery management. Iowa state University Press America.

Islam, A. K. M. S. 2012. Development of multi-crop planter for conservation agriculture. PhD Thesis. Department of farm power and machinery. Bangladesh Agricultural University. Mymensingh. Pp 4-5

Matin, M. A., M. S. Islam, and M. Amin. 2008. Demonstration of BARI power tiller operated planter for Soybean and Maize, Annual research report, BARI.

Micheal, A. M., and T. P. Ojho. 1966. Principals of agricultural engineering. Jan Bros. Bombay Chronicle Press, Bombay, India.

Mona, M. A., H. Islam, M. M. Khater, and Y. Baran. 2009. Effect of field size on mechanical wheat seeder performance in reclaimed lands of Egypt. *Tanm Makinalari Bilimi Desrgis (Journal of Agricultural Machinery Science)*, 5(1): 45-51.

Searle, C. L., M. F. Kocher, J. A. Smith, and E. E. Blankenship. 2008. Field slope effects on uniformity of corn seed spacing for three precision planter metering systems. *Biological Systems Engineering:Papers and Publications.* Paper 151.

Senapati, P. C., P. K. Mohapatra, and U. N. Dikshit. 1992. Field evaluation of seeding devices for finger-millet. *Agricultural Mechanization in Asia, Africa, and Latin America*, 23(3): 21-24.

Wohab, M. A. 2010. Development of combined tillage bed former and seeder for upland conservation farming. PhD dissertation. Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh. 1-142.

Wohab, M. A., K. C. Roy, M. E. Haque, M. J. Abedin, and M. S. Islam. 2007. Field performance evaluation of BHT seeder for sowing and tilling. *Journal of Socioeconomic Research and Development*, 4(3): 116-119.

Wohab, M. A., M. A. Hoque, and M. S. Hassan. 2011. Development of seeding and planting machinery for conservation tillage. Proceedings of 10th conference on crop production under unfavorable ecosystems in Bangladesh. Organized by Bangladesh Society of Agronomy at Bangladesh Agricultural Research Institute, Gazipur-1701. 8 October 2011.