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CROP YIELD TREND UNDER ZERO TILL PLANTERIN RICE-WHEAT-MUNGBEAN CROP ROTATION

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ABSTRACT

Zero till seeding is one of the key operations of conservation agriculture. Zero till planter has been developed in Bangladesh Agricultural Research Institute(BARI) and successfullyusing in the farmers' field. A long term experiment under zerotill condition has been established at Regional Wheat Research Centre ,BARI, Rajshahi and continuing in wheat-mungbean-rice rotation starting from 2009 to 2016.Wheat (BARI Gom24) sown after aman rice (BRRI Dhan 56) harvest, mungbean (BARI Mug 6)sown after wheat harvest,similarly rice (direct seeded after mungbean harvest through average crop residue level 30%. Every year three crops rotated same way under zero till condition. DAP fertilizers were applied during seeding operation. It maintained uniform seeding depth, uniform seed distribution and better seed soil contact which transfer soil moisture to seeds quickly for enhancing better plant establishment and yield. Long term trial (7 years), yields of wheat and mungbean show higher yield but non significant compare to conventional method.Aman rice yield shows lower than conventional transplanting method. In the long term trial (7 years), no yield reduction trend was observed over the years compare to conventional method. Zero till planter saved fuel 59.5 l/ha annually which was 60.4% less than conventional method. Effective field capacity of the zero till planter was 0.10 ha/h. Cost of wheat, mungbean, and rice seeding under zero till was Tk.2275/ha (1 US$=Tk. 78.0) which was 61.4%, 48.8%, and 73.3%less than that of conventional method of seeding.Zero till technique can be equally applied for other crops like maize, lentil, and oilseed crops avoiding delay planting operation.

Key words: conservation agriculture, crop rotation, fuel saving, long term trial, zero till

INTRODUCTION

Zero till seeding is one of the key operations of conservation agriculture. Small scale agricultural machinery and mechanization mobilize the large scale socio economic developments of the country. The demand of food production is increasing day by day along with the increasing of population. So, it is now require to increase the cropping intensity and food production from limited area of cultivable land.

Most of the traditionalseeding operations are accomplished by human labour which is slow, time consuming and costly. Farmers are facing trouble for agricultural operations due to labour shortage especially during planting, harvesting and threshing period. Most of the power tiller (two wheel tractor)operated resource conserving planting technology has been developed by

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BARI and promotional activities are being conducted in the farmer's fieldfor yield gap minimization, water saving, efficient input utilization, soil health improvement, sustainable crop production, and crops diversification (Hossain *et al*. 2015).Rice-wheat is the major cropping system in North West part of Bangladesh. Generally wheat is planted after T. aman harvest followed by 3-4 number of ploughing passes and traditional manual seed broadcasting. This process is slow and costly operation. If rice harvest is delayed, wheat planting is also delayed. In this situation, farmers always suffer from their potential yield. Wheat planting after 30 November cause yield decrease at the rate of 45 kg/ha/day (Saunders, 1988). Timely planting and timely harvesting are the key operations for increasing cropping intensity and achieving the desired yield. Reduced till seeding machinery such as power tiller operated seeder (PTOS) is the alternate ways to ensure timely planting, meet up labour shortage, keep crop production at economic level and enhance cropping intensity (Hossain *et al.* 2009). This seeding machinery is capable finish the seeding operation in a single pass without any extra tillage operation. The adoption of minimum tillage methods can offer significant environmental benefits while providing energy savings and other natural resources (Hatfield and Karlen. 1992). Zero till can allow soil less disturbance, facilitates beneficial organism to become more active and less emission of CO_2 into the atmosphere. Grace (2003) reported that tillage operation contribute CO_2 through the rapid organic matter decomposition due to exposure of large surface area to increase oxygen supply. Rapid tillage reduces soil organic carbon at double rate in the top 20cm surface. Reduced tillage technique accepts by the farmers for wheat, maize, pulses, oilseed crops, jute and onion field preparation. Moreover dry direct seeding rice (DSR) under minimum till condition is also practicing limited scale in Rajshahi area targeting water, labor, and cost saving. There is confusion about zero till technology among some agricultural personnel that crop yield to be reduced in successive crop cultivation under reduced till or zero till practice. Therefore, this long term trial has been established observing the yield trend and status under zero till technique in the rice-wheat-mungbean crop rotation.

The specific objectives of this study are- (i) to findout the crop yield and yield trend underzero till technique in long term trial (ii) to find out the fuel savings compare to conventional method, (iii) to compare the cost of planting between zero till and conventional method.

MATERIALS AND METHOD

Power tiller (Two wheel tractor) operated zero till planter whichworks as opening narrow slotthrough crop residue, apply seed and fertilizer side by side, and opening slot cover by a press wheel simultaneously in a single pass. No extra tillage operation required prior to seed sowing. Zero till planter is a pull type implement which hitch with the power tiller replacing the regular rotavator of power tiller. There are seed and fertilizer box separate and it regulates the seeds by the improved inclined plate seed metering device. It can handle wheat, maize, rice, pulses and other seeds. The experiment was set up on station for 7 years in Regional Wheat Research Centre, BARI, Rajshahi 2009 starting with mungbean seeding under wheat-mungbean-rice crop rotation. The experiment has been continuing.Every year, wheat planted after T aman rice harvest in last week of November, mungbean planted after wheat harvest at the end of March and similarly rice seeded directly third week of June. Wheat, mungbean, and rice varieties are BARI Gom 26, BARI Mung 6, and BRRI dhan49/BRRI dhan56, respectively. The seed rate of wheat, mungbean, and Aman rice were 120 kg ha^{-1}, 24 $kgha^{-1}$, 30$kgha^{-1}$ and line to line distance were 20cm, 30 cm, 20 cm, respectively. There are two treatments (i) Zero till by 2WT,and (ii) Conventional method; and replicated three times.Recommendedall basal doses of fertilizers were

broadcasted before seeding operation in conventional method, but Die Ammonium Phosphate (DAP) fertilizer applied during zero till seeding.Other fertilizers were applied as normal production practices. For weed control in zero till treatment plots, roundup herbicide was applied before rice seeding, after 20 days of seeding one time hand weeding were done. After rice and wheat harvest, plots were weed free, so wheat and mungbean planting was done without any herbicide application. Three irrigations were applied in wheat crop, no post planting irrigation was given in mungbean plot.One supplementary irrigation was applied in Aman rice after seeding 15 days as soil moisture available during that time. In zero till seeding, single pass required for completing the seeding operation for wheat, mung, and rice seeding, but in conventional method, wheat, mung, and rice required 3, 2, and 3 numbers of ploughing passes followed by laddering, respectively.

Fig.1: 2WT operated zero till planter

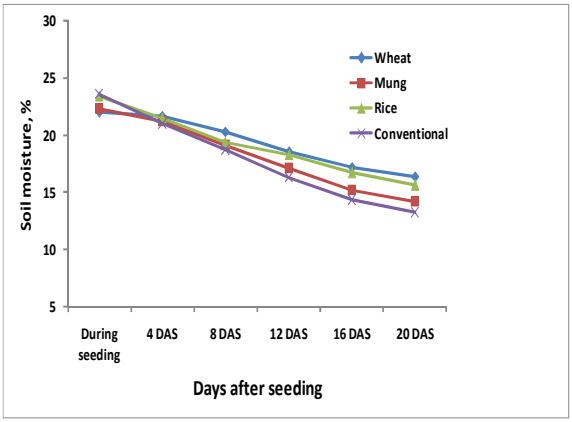

Figure 2: Soil moisture days after seeding

Data Collection

The following data were collected during the test: (i) Depth of seed placement,cm(ii) Travel speed, km/h (iii) Effective field capacity, ha/h (iv) Field efficiency, % (v) Fuel consumption, l/h (vi) No. of plant /m^2, (vii) Soil moisture , % (viii)Yield/m^2, (ix) Cost of planting . Cost was calculated according to the farm power and machinery management text book (Hunt, 1995).

RESULTS AND DISCUSSION

Two wheel tractor driven zero till planter is capable completing seeding operation through crop residue immediate after previous crops harvest by a single pass. It reduces turn around time between previous crop harvest and next crop planting. Field performances of the zero till planter were shown in Table 1.

Zero till planter maintains uniform seed distribution and uniform seeding depth 4 cm for wheat, mung and rice seeding. Press wheel of the planter cover seeds with minimum pressure and keep contact seeds with soil. Conventional seeding method, depth of seeding was uneven 0-5 cm, seed distribution was uneven which can not maintain standard spacing. During long term trial, some of the season, soil was dry, so pre sowing irrigation was applied for creating optimum soil moisture. Average soil moisture after seeding was shown in Figure 2. Average soil moisture during wheat, mung and rice seeding were 22.0%, 22.3%, 23.4%, respectively over the year. During direct rice seeding, soil moisture was 23.6%. Soil moisture in zero till plots showed higher moisture compare to conventional broadcasted plots before first irrigation of wheat and

mung cultivation. Soil moister in zero till plot was less evaporated compare to conventional plot, because residue acts as mulch over the surface.

Table 1. Seeding performance of zero till planter in long term trial

Sl No.	Particulars	Wheat, n=10 (CV%)	Mungbean, n=10 (CV%)	Aman rice, n=10, (CV%)	Remarks
1	Depth of seeding, cm	4.2 (8)	4.1(6)	4.2(5)	Conventional method:uneven distribution uneven depth of 0-5 cm; plant population wheat: 270/m^2 Mungbean: 22-32/m^2
2	Plant population/m^2	295(7)	27(8)	290 (8.2)	
3	Effective field capacity, ha/h	0.10	0.10	0.10	

The experimental plot is sandy loam soil. In zero till plot, water moves faster compare to conventional plot as water percolated more in ploughed soil. In the month of May- June there were monsoon rainfall in Rajshahi area (Figure 3). Only one irrigation was applied in Amanrice growing period, no post sowing irrigation in mungbean, but three irrigations were applied in wheat growing period. Dry direct seeding rice (DSR) under zerotill seeding, water can be saved average puddling operation. Zero till wheat seeding, irrigation water 17.6% can be saved compare to conventional method.

Table 2. Comparative irrigation water application in zero till plot and conventional plot

Sl No.	Name of crops	Average irrigation water applied, mm								Yearly average applied irrigation water, mm	
		Pre planting irrigation		1st irrigation		2nd irrigation		3rd irrigation			
		Zero till	Conv.	Zero till	Conv.	Zero till	Conv.	Zero till	Conv.	Zero till	Conv.
1	Wheat	50	75	80	95	150	175	80	92	360	437
2	Mungbean	42	53	-	-	-	-	-	-	42	53
3	Rice (Aman)	-	-	130	145	-	-	-	-	130	145

There are three crops cultivated yearly under long term trial in wheat-mungbean-rice rotation, and 23 numbers of crops completed so far. Zero till and conventional method of planting required average fuel consumption 39L $ha^{-1}$and 98.50L ha^{-1}, respectively (Table 3) for seed sowing yearly. So, zero till seeding method saved 60.4% fuel consumption annually compare to traditional method of seeding.

Table 3. Yearly average fuel used (L ha^{-1})for planting operation in zero till and conventional method

Sl No.	Tillage method	Wheat		Mungbean		Aman Rice		Yearly total fuel used for planting L ha^{-1}
		Average fuel consumption		Average fuel consumption		Average fuel consumption		
		L hr^{-1}	L ha^{-1}	L hr^{-1}	L ha^{-1}	L hr^{-1}	L ha^{-1}	
1	Zero till planting	1.3	13	1.3	13	1.3	13	39.0
2	Conventional method	1.5	35	1.5	22.5	1.5	41	98.50

Cost components of different operations of wheat, mung, and rice cultivation between conventional method and zero till were shown in Table 4. Seeding cost of zero till planting was much less than the conventional planting method. Planting cost of wheat, mungbean, rice under zero till were 61.4%, 48.8%, and 73.3% less than that of conventional method of planting cost, respectively. Both water and cost can be saved by zero till planting.

Table 4. Planting cost (Tkha^{-1}) comparison between zero till and conventional method

Cost items	Zero till, Tkha^{-1}			Conventional method, Tkha^{-1}		
	Wheat	mungbean	AmanRice	Wheat	Mungbean	AmanRice
Pre weed control (Glyphosat)	0	0	1500	0	0	0
Land preparation& laddering	0	0	0	5400	4000	5750
Seeding/transplanting	2275	2275	2275	495	450	8400
Total planting cost, Tk ha^{-1}	2275	2275	3775	5895	4450	14150

Long term trial results showed that wheat and mungbean yield underzero till higher than conventional method over the years (Table 5), but Aman rice under zero till direct seeding method showed lower yield than conventional transplanting method. Wheat, mungbean cultivation continuously underzero till did not affect the yield over conventional method. So far, rice yield under direct seeding underzero till showed always lower than conventional method. Weed management, right variety of rice for direct seeding method are the key issues for successfully for rice cultivation under direct seeding method. It was also observed that zero till wheat and rice less lodging compare to conventional planted plot due to more root anchor with soil.

Table 5. Long term yield (t/ha) comparison between zero till and conventional planting under wheat-mung-rice rotation

Year	Wheat		Mungbean		Aman Rice	
	Zero till	Conventional	Zero till	Conventional	Zero till	Conventional
2009	0	0	0.87	0.82	4.13	4.3
2010	3.45	3.2	0.89	0.81	3.85	4.3
2011	3.45	3.3	0.90	0.80	4.00	4.5
2012	3.50	3.3	0.90	0.80	4.10	4.6
2013	3.55	3.4	0.97	0.90	4.10	4.5
2014	3.70	3.5	1.07	0.90	4.25	4.7
2015	3.83	3.5	0.84	0.60	4.17	4.5
2016	3.10	2.9	0.97	0.70	4.18	4.4
LSD	NS	NS	NS	NS	NS	NS

CONCLUSION

Zero till technology is being considered viable for small farmers in terms of cost saving, time savings, soil conservation, and judicial usages of natural resources. Based on the experimental results of wheat-mungbean-rice crop rotation of zero till planting, it can be concluded as-

i. In long term trial, yields of wheat, mungbean under zero till seeding in wheat-mungbean-rice rotation showed no yield declination compare to conventional seeding method, but yield of Aman rice under this technique showed lower than that of conventional transplanting method.

ii. Zero till seeding saved fuel annually 60.4% and irrigation water for wheat saved 17.6% compare to conventional method of planting.

Cost of planting under zero till seeding method for wheat and rice were Tk.2275.0, Tk. 3750.0 which were 61.8%, 73.5% lower than conventional method, respectively.

iii. Zero till planter can be used for other crops like maize, lentil, groundnut, for avoiding delay planting as well as cost reduction.

REFERENCES

Grace PR. 2003. Rice-Wheat system and climate change. Addressing resource conservation issues in Rice-Wheat systems of South Asia. A resource book. pp:63-67.

Hatfield JL and DLKarlen.1992.Sustainable Agriculture Systems. CRC Press, Boca Raton.FL.

Hossain MI, MS Islam, CA Meisner, M Bodruzzaman and I Hossain. 2009. Minimum tillage one pass seeder for sustaining cropping intensity and profitability in rice-wheat system. Int. J. Sustain. Agril. Tech. 5(6):32-37

Hossain MI, MJU Sarker and MA Haque. 2015. Status of conservation agriculture based tillage technology for crop production in Bangladesh. Bangladesh J. Agril. Res. 40(2):235-248

HuntD. 1995. Farm Power and Machinery Management. Cost determination. 9th Edition, Iowa State University Press, America.

Saunders DA.1988. Crop management research: Summary of results, 1983-88. Monograph No.5: Wheat Research Centre, Dinajpur, Bangladesh.