ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 50(4): 365-375, December 2025

EFFECT OF TILLAGE AND PLANTING METHODS ON MAIZE

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Abstract

Timely tilling and seeding are major challenges in crop production specially after harvesting of Aman rice. The problem can be solved using power tiller operated seeder (PTOS). Different tillage and planting methods were implied in farmers' fields for maize in Patuakahli and Rajshahi during *rabi* seasons of 2018-19 and 2019-20. The experiment was laid out with RCBD design with four treatments and three replications. The treatments were power tiller operated seeder with full tillage (PTOS), strip tillage (ST), zero tillage (ZT) and conventional tillage cum manual planting method (CT). Farmers unit plot area of about 0.40 ha (One *Bigha*) land was selected for this experiment considering uniform land type, soil type and cropping pattern. PTOS was found effective in tilling and planting of maize in all locations. Significantly the highest grain yield was found from PTOS than ST, ZT and CT. The BCR (benefit cost ratio) of PTOS and CT methods were found 1.54 and 1.08, respectively. The PTOS saved time preventing late sowing and also reduced labour curtailing crop production cost. So, the BARI developed PTOS can be recommended for reduced tillage practices for planting of maize in Bangladesh.

Keywords: BARI Seeder, PTOS, Maize, Seeding, Strip tillage, Zero tillage, BCR.

Introduction

Among all the agricultural operations, tillage is one of the most power intensive operations. The present cropping intensity could not have been achieved without mechanized tillage operation. At present, about 80% of the cultivated land of the country is tilled by power tiller while the remaining 15% land is covered by tractors (Rahman *et al*., 2021). Only 5% upland crops are sown in line by seeder machine (Hossain, 2025). The government has a target to sow 10% upland crops by seeder within 2025 and 25% by the year 2030 (NAM, 2020). Power tiller is light duty agricultural equipment used for tilling operation in Bangladesh. The machine has been the part of farming system for many small and medium scale farmers in developing countries due to small farm and scattered field size combined with an affordable price compared with the tractors (Sarker *et al*., 2012). It is portable and

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can be used or taken to the interior farmlands where there is no access road for big tractors. The affordability of this equipment in terms of low price for local farmers can make agricultural crop production to increase considerably. Conventional tillage is commonly practiced in the country, tilling 4-5 times followed by laddering by power tiller or tractor and hand broadcasting of seeds (Wohab *et al*., 2007). Farmers usually adopt repeated or intensive tillage operations for crop cultivation for controlling weeds, minimizing the percolation rate of water, and preparing a soft bed for crop establishment. *Rabi* crops are cultivated after harvesting of Aman rice in most of the areas in Bangladesh. But, yield of crop is very low due to late planting. Generally, crop is planted after harvesting T. Aman in land prepared by 3-4 tillage operations followed by hand broadcasting seeds. This process is time consuming and costly operation and causes the delay in planting. As a result, yield loss of crops occurs in most of the cases. Farmers prepare the land by power tiller which takes more time, fuel, labour, as well as cost for crop production. One the other hand, land preparation, sowing of seeds in line and seed covering can be done by single pass using BARI seeder which is popularly known as PTOS (Hoque and Miah, 2015; Hoque *et al*., 2021a; Hoque *et al*., 2021b). Farmers can plant crops by seeder just after harvesting of Aman rice using residual soil moisture content. Seeder saves time, fuel and money for *rabi* crop production (Hoque and Gathala, 2018). There is abundant evidence that intensive tillage can cause the degradation of physical, chemical and biological soil properties, reduces soil organic carbon at double rate and decreases soil fertility (Grace, 2003), losses irrigation water and soils (Sayre and Hobbs, 2003). In addition, repetitive tillage requires significant amounts of fuel and energy and results in increased production cost and reduced profit (Gathala *et al*., 2016). Therefore, adoption of reduced or minimum tillage practices that can potentially reduce environmental impacts and improve agricultural outputs (Buckwell *et al*., 2014). BARI has developed power tiller operated seeder (PTOS) as resource conservation machine to address these problems. Resource conservation-based tillage technology permits direct seeding in untilled soil with moderate level of crop residue in different tillage techniques such as zero, strip, or reduced tillage, and raised and permanent beds (Gathala *et al*., 2011; Hoque *et al*., 2023). Research evidence illustrates that yields of wheat and maize from CA may be same or high, compared to conventional or traditional agriculture practices (Govaerts *et al*., 2006). Mafongoya *et al*. (2016) reported that the increases in grain yield under conventional tillage over zero tillage practice of maize were 17.8% and 28.2% during 2000-2001 and 2001-2002 seasons, respectively at Msekera in Zambia. Wang *et al*. (2024) conducted seven field experiments in high terrain and low terrain sites in the black soil belt of Northeast China. The methods of tillage practices were selected as ridge tillage (RT), strip tillage (ST) and no tillage (NT) method. They found that maize yields in the RT method and ST method were 6.12 % and 5.04 % higher than that in the NT method at the high terrain site and 6.28

% and 5.19 % higher than that in the NT method at the low terrain site, respectively. An appropriate power tiller-based seeder machine may be introduced so that minimum tillage cum seeding and resource conservation tillage method can be practiced for maize as well as other crops. Therefore, this research has been undertaken to evaluate the tilling and seeding performance of BARI seeder for maize cultivation in different soil conditions.

Materials and Methods

Field experiments were conducted in Godagari Upazila of Rajshahi district and Dumki and Kalapara upazila of Patukhali district during *rabi* season of 2018-19 and 2019-20. The Agro ecological zones (AEZs) and soil types in the project locations are given in Table 1. The soils and climates of two locations are quite different from each other. The existing common cropping patterns in the project locations were mainly based on two crops. T. Aman is the common crop in all locations. The improved seeder was used for land preparation and sowing of *Rabi* crops only.

Table 1. Agro ecological zones (AEZs) and soil types in the study locations

District	Soil Condition
Patuakhali	• AEZ: 13 (Ganges Tidal Floodplain) • Soil Type: Silty clay loam • Characteristics: Most of the top soils are acidic and subsoils are neutral to mildly alkaline. The soil remains wettywith poor drainage leading to late planting. The location experiences unusual rain fall and irrigation water scarcity.
Rajshahi	• AEZ: 26 (High Barind Tract) • Soil Type: Clay loam • Characteristics: The location is drought prone with low rainfall (annual 1200 mm). and it has terrace soil, high bulk density and declining groundwater table.

The experiments of all locations were laid out in randomized block design. Four treatments were imposed in each of Rajshahi and Patuakhali locations for planting maize using BARI seeder with three replications. Three methods were followed for seed planting by BARI Seeder, such as, whole land shallow tilling (5-6 cm) i.e. single pass full tillage (PTOS), strip tillage and zero tillage. The conventional method of seed sowing was also used i.e. full tillage by power tiller using 3-4 passes and then line sowing of seeds followed by seed covering by laddering. So, the treatments were PTOS, strip tillage (ST), zero tillage (ZT) and conventional tillage (CT). Each plot size was unit plot of farmers with 0.03-0.05 ha of land. Uniform plots were selected for conducting the experiment. Herbicides (Atrazine at 1.0 kg/ha and topramezone at 0.030 kg/ha in combination) were applied in the field with standing rice residue (25 cm) before strip and zero till seeding for controlling pre-emergence weeds. Locations, areas, crops and sowing methods under the experiments in Patuakhali and Rajshahi during *rabi* 2018-19 and 2019-20 are shown in Table 2. Fertilizer was applied as per FRG (2018). Seed rates of NK-40 hybrid maize in all locations were 20 kg/ha. Date of planting of maize in Rajshahi was 10-15 November and in Patuakhali it was 1-10 December both in the Rabi seasons of 2018-19 and 2019-20. Three irrigations were applied in Rajshahi at 20-30 days after sowing (DAS), 50-60 DAS (cob emergence) and at 80-89 DAS (grain formation) whereas two irrigations were applied in Patuakhali at 45-50 DAS (cob emergence), and at 80-89 DAS (grain formation).

Table 2. Experimental locations, crop areas and crops planted by BARI Seeder (PTOS) during *rabi* 2018-19 and 2019-20

District	Location	Maize variety	Land area (decimal)				
	Upazila		PTOS	ST	ZT	CT	Total area (ha)
Rajshahi	Godagari (Bijoynagar)	NK-40	25	35	27	33	120 (0.16)
	Tanore (Shampur)	NK-40	40	30	25	36	131(0.17)
Patuakhali	Kolapara (Tulatoli)	NK-40	40	34	26	10	110 (0.15)
	Dumki (Srirampur)	NK-40	45	26	25	33	129 (0.17)

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

The photographs of BARI seeder and its operation is shown in Fig. 1.

BARI Seeder (PTOS)

Operation of BARI seeder (PTOS) in farmer's field

Fig. 1. Pictorial views of BARI seeder (PTOS) and its operation in Rajshahi.

Economic analysis

A simple economic analysis was done based on total crop production. Production cost included input cost. The input cost was calculated by considering cost of land preparation, seed, fuel, fertilizers, herbicide, insecticide, irrigation and hiring charges of labour. The gross return and net return were calculated on the basis of local market price. The straight-line method was used for calculating of depreciation. The annual cost of operation of PTOS (BARI Seeder) was computed as the sum of fixed costs and variable costs Mottalib *et al*. (2019).

Data analysis

Data of different parameters of seeder was analyzed using Microsoft Excel worksheet. Yield and yield contributing parameters of crops under different tillage and sowing methods were analyzed using Statistix 10 software. Means differences among the treatments were compared least significant difference (LSD) ($P \leq 0.05$).

Results and Discussions

Yield comparison

Maize was sown by BARI seeder (PTOS) at Bijoynagar, Godagari, Rajshahi during 2018-19. Yield and yield contributing parameters of maize at Bijoynagar, Godagari and Shampur, Tanore Rajshahi for 2018-19 and 2019-20 are furnished in Tables 4 and 5, respectively. In both the years and locations, significantly the highest grain yield was found from PTOS and CT. There were no significant differences of plant height, grain per cob, straw yield and grain yield between PTOS and CT. Other parameters among the treatments were also found insignificant. Yield and yield parameters between ST and ZT were statistically alike but lower than those of PTOS and CT. Godagari, Rajshahi is located in high Barind Tract (AEZ-26). Here, *rabi* crops generally suffer in moisture stress. In strip and zero tillage system, maize roots could not penetrate the surrounding soils due to untilled hard soil. But, in PTOS and conventional tillage systems, the whole land was tilled and maize roots could easily penetrate the surrounding soils and received more moisture and nutrients than strip and zero tilled maize plants. Hence, yield parameters and grain yields of PTOS and conventional tillage became higher. These findings are supported by Islam *et al*. (2022).

Table 4. Yield and yield contributing characters of maize at Bijoynagar, Godagari, Rajshahi during 2018-19

Treatments	Plant population/ m^2	Plant height (cm)	Cob/ plant	Grain/ cob	TGW (g)	Straw yield (t/ha)	Grain yield (t/ha)
PTOS	8.77	178.33	1.33	418.67	365.33	10.58	8.36
ST	8.70	162.33	1.00	385.33	349.58	8.84	6.89
ZT	8.60	156.33	1.00	375.33	324.53	8.38	6.53
CT	8.50	170.00	1.00	396.00	346.88	10.52	8.25
LSD (0.05)	NS	12.08	NS	42.25	NS	1.50	1.21
CV (%)	3.9	2.56	26.65	3.79	5.86	5.53	5.71

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

Table 5. Yield and yield contributing parameters of maize at Shampur, Tanore, Rajshahi during in 2019-20

Treatments	Plant $/m^2$	Plant height (cm)	Grain/cob	1000-grain wt. (g)	Grain yield (t/ha)
PTOS	6.88	196.07	476.33	296.67	8.84
ST	6.28	186.40	445.67	273.60	6.89
ZT	5.90	179.00	409.33	265.33	6.53
CT	6.53	193.27	468.0	292.53	8.28
LSD (0.05)	0.78	7.12	50.82	20.45	0.98
CV (%)	6.09	1.89	5.66	3.63	6.92

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

Yield and yield contributing parameters of maize at Tulatoli, Kalapara, and Srirampur, Dumki, Patuakhali are shown in Table 6 and Table 7, respectively. It is revealed from the tables that significantly the highest plant height, grains per cob and straw yield and grains yield were found from PTOS and CT than ST and ZT treatments. Yield and yield contributing parameters of PTOS and CT were statistically similar. Significantly the lowest yields were obtained from ZT in all locations. ST gave the intermediate yield of maize than other treatments. Hence, maize cultivation by full tillage gave the significantly the highest yield. So, considering the time, fuel cost and yield, PTOS was found suitable for maize planting method in Patuakhali. Patuakahli also fresh water scared area due salinity (6-8 dS/m) during dry season. Clay soil becomes cracked due to water stress. Crop growth stunted in untilled soil (Mottalib *et al*., 2019). So, lower yields were found from strip tillage and zero tillage. Similar results were reported by Gathala *et al*. (2016) for maize.

Table 6. Yield and yield contributing characters of maize at Tulatali, Kolapara, Patuakhali during 2018-19

Treatments	Plant population /m^2	Plant height (cm)	Cob length (cm)	Grain/ cob	TGW (g)	Straw (t/ha)	Grain yield (t/ha)
PTOS	8.00	258.43	23.80	370.63	295.00	12.40	7.73
ST	7.67	223.97	18.13	350.13	286.67	11.51	6.47
ZT	7.00	189.50	14.60	296.47	273.33	9.55	6.20
CT	8.00	267.87	23.97	380.50	302.67	12.62	7.89
LSD	NS	26.19	5.06	51.48	23.68	1.59	1.05
CV (%)	7.53	3.94	8.90	5.21	2.89	4.87	4.73

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

Table 7. Yield and yield contributing characters of maize at Srirampur, Dumki, Patuakhali during 2018-19

Treatment	Plant /m^2	Plant height (cm)	Cob length (cm)	Cob weight (g)	Grain/ cob	TGW (g)	Straw yield (t/ha)	Grain yield (t/ha)
PTOS	8.77	265.53	28.33	243.00	513.33	285.57	11.55	7.51
ST	8.53	231.33	22.27	217.00	518.67	286.00	10.76	6.53
ZT	8.60	221.33	20.33	201.67	438.67	258.27	9.62	6.41
CT	8.53	248.87	22.00	225.00	516.67	292.93	11.24	7.38
LSD	NS	32.50	7.48	22.07	72.59	31.61	1.79	1.64
CV (%)	4.53	4.89	11.38	3.52	5.17	3.98	5.88	6.90

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

Yield and yield contributing parameters of maize at Srirampur, Dumki, Patuakhali are shown in Table 8. Significantly the highest grain yield was obtained from PTOS followed by CT and ST. Significantly the lowest grain yield and yield attributes were found from ZT. The reason might be that during dry season sufficient irrigation could not be applied in the maize field due to fresh water scarcity and soil became very hard and root could not be penetrated in the soil for moisture stress and hence crop growth became slower and yield became lower. Among CA practices PTOS performed the best followed by ST. ZT performed the lowest. It may be due to shortage of soil moisture in the field during sowing period. Usually, maize sowing started at Dumki in mid-February. In this period land become harder rapidly due to high evaporation loses of soil moisture that reduced germination of seed in ST and ZT.

Table 8. Yield and yield contributing characters of maize at Srirampur, Dumki, Patuakhali during 2019-20

Treatment	Plant/m^2	Plant height (cm)	Cob length (cm)	Grain/ cob	1000-grain wt. (g)	Grain yield (t/ha)
PTOS	8.80	262.07	23.00	528.00	235.00	7.31
ST	8.40	253.67	20.33	479.00	227.67	6.13
ZT	7.77	247.67	20.00	390	210.67	5.56
CT	9.47	258.67	21.67	505.67	231.67	6.48
LSD	1.19	NS	1.49	89.37	20.01	1.7
CV (%)	6.96	4.17	3.51	9.4	4.43	13.38

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

Yield and yield contributing parameters of maize at Tulatoli, Kalapara, Patuakhali are shown in Table 9. In case of maize, significantly the highest plant height, grains per cob and straw yield and grains yield were found from PTOS that was statistically similar with CT. Among the CA practices PTOS and ST produced the statistically similar and higher yield than ZT. In sufficient moisture during sowing hamper germination and plant stand in ZT field that reduced the crop yield. Hence, significantly the lowest yields were obtained from ZT. So, considering the time, fuel cost and yield, PTOS was found suitable for maize planting method in Patuakhali.

Table 9. Yield and yield contributing characters of maize at Tulatali, Kalapara, Patuakhali during 2019-20

Treatment	plant/m^2	Plant height (cm)	Cob length (cm)	Grain/cob	1000-grain wt. (g)	Grain yield (t/ha)
PTOS	8.20	271.48	17.74	479.46	242.60	7.71
ST	7.60	229.30	14.46	399.40	227.80	5.91
ZT	7.00	196.82	12.16	314.40	219.00	4.84
CT	8.00	270.18	16.66	483.40	244.40	7.35
LSD	0.96	12.24	1.04	25.44	10.04	0.80
CV (%)	9.03	3.67	4.97	4.4	3.12	8.69

Note: PTOS: Power tiller operated seeder, ST: Strip tillage, ZT: Zero tillage, CT = Conventional tillage

In both Rajshahi and Patuakhali locations similar grains yields were found between two Upazilas of each district during 2019-20. But, between two different agro-ecological zones (Rajshahi: 23 and Patuakhali: 13) different yield patterns were found in both the years, 2018-19 and 2019-20. Comparatively low grain yield was found in Patuakhali than Rajshahi. Patuakhali had soil salinity (8-10 DS/m) and late planting season (December), therefore, lower yields were obtained than Rajshahi. Similar results were reported by Gathala *et al*. (2016).

Economic analysis

The economic analysis was done from the viewpoint of machine owner as well as custom hire basis. Fixed cost and variable cost for seeder operation were estimated as Taka 2460 per hectare and Taka 1976 per hectare, whereas, those for power tiller were Taka 1886 per hectare and Taka 3254 per hectare, respectively (Table 10). The economic life of the machine was assumed five years. The area under land preparation by both PTOS and CT the machine operations per year was 26 and 13 ha, respectively. Again, the custom hiring charge for both the machines was estimated as Taka 7000 per hectare based on the field data. The revenue can be received by the owner of the seeder Taka 66664 per year and power tiller owner Taka 24180. Therefore, a LSP (local service provider) or a seeder machine, the owner can earn additional Taka 42484 per year than that of a only power tiller owner. The result also shows that BCR of a seeder was found 1.54 which is a profitable venture for an entrepreneur than that (1.08) of CT.

Table 10. Economic analysis of BARI seeder and power tiller

A. Items	PTOS (Power tiller with BARI Seeder)	CT (Power tiller without seeder)
A. Fixed cost		
Purchase price (Taka)	190000	120000
Salvage value (Taka)	19000	12000
Depreciation (Taka/year)	34200	21600
Replacement cost (Taka/year)	29520	16318
Interest (Taka/year)	10578	7298
Total fixed cost (Taka/ha)	2460	1886
B. Variable cost		
Fueland oil cost (Taka/ha)	709	1602
Repair and maintenance cost (Taka/ha)	252	313
Labour cost (Taka/ha)	909	1339
Total variable cost	1976	3254
Total annual operating cost (Taka/ha)	4436	5140
Annual use in area (ha/year)	26	13
Net return (Taka/year)	66664	24180
Benefit cost ratio (BCR)	1.54	1.08

Conclusion

The highest grain yields were found from the reduced tillage (PTOS) followed by conventional tillage, strip tillage (ST), and zero tillage (ZT) in both Rajshahi and Patuakhali. PTOS was found an effective tillage and maize planting method in moisture stressed condition. Significantly the highest crop yields were found from reduced tillage (PTOS) than ST, ZT and CT methods. The BCR of PTOS and CT method were found 1.54 and 1.08, respectively. The PTOS saved time to prevent late sowing and also reduced labour to curtail crop production cost. The PTOS is recommended for reduced tillage practices in Bangladesh. Future research may be undertaken on determination of seed rate, weed and fertilizer management for seeder for different soils and crops.

Acknowledgement

Authors are also thankful to R. K. Metal for providing technical supports for fabricating the seeder and providing training facilities. Special thanks are given to Krishi Gobeshona Foundation (KGF) for providing financial support.

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