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ORIGINAL RESEARCH ARTICLE

Use of high-speed rotary tiller and power tiller operated seeder for onion (*Allium cepa* L.) cultivation

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ABSTRACT

A field study was carried out to assess the performance of power tiller operated seeder (PTOS) and to compare the yield, quality, maturity and economic traits of onion under different planting methods at Spices Research Sub-Centre (SRSC), Bangladesh Agricultural Research Institute (BARI), Faridpur, Bangladesh with four planting methods as four treatments: T_1) ploughing the main field with high speed rotary tiller (HSRT) + direct seeding with power tiller operated seeder (PTOS), T_2) ploughing the main field with HSRT + transplanting of seedlings, T_3) ploughing the main field with HSRT + direct seeding in line and T_4) ploughing the main field with HSRT + direct seeding as broadcasting. Under the study the treatments were arranged in a randomized complete block design with three replications. The outcome of the study revealed that the treatments had a significant influence on the characteristics studied accept yield of onion. Different economic traits of onion were varied among the planting methods. The bulbs under direct seeding with the PTOS matured earlier (133.66days) as compared to the transplant (155.54days). All direct seeding methods showed insignificantly higher yields than that of transplants. The maximum yield (15.05t/ha) was recorded from broadcasting method. The yield performance under direct seeding with the PTOS and transplants were 15.08 and 14.92t/ha, respectively. The broadcasting method had very heterogeneous and under-sized bulbs due to uneven spacing and maximum plant population per unit area. In case of economic performance, transplanting method incurred the highest total cost of production. Maximum net return and benefit-cost ratio (2.95) were calculated from direct seeding with PTOS. So, it is concluded that in Bangladesh, direct seeding method with the PTOS may be a good option for getting early crop and maximum economic benefit.

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INTRODUCTION

Onion crop is raised by three different methods: a) by transplanting of seedlings, b) by direct seeding in line or broadcasting in the prepared field and c) by planting sets (small bulbs). Around 60-65% and 5-10% of total annual onion are produced using transplanting of seedlings and direct seeding, respectively while the rest by onion set (Rahim *et al*., 1992). In Bangladesh for growing and research work of onion seedling transplanting method is more common practice than direct sowing method. Labour shortage is being experienced in the country during peak period of onion cultivation. The labour force employed in on-farm agricultural activities would be reduced from about 43% in 2017 to about 36.1% by 2020, as predicted by Alam and Khan (2017). As a result, some labours are available at a higher cost and this situation leads to increase the demand for farm

mechanization. Nowadays farm mechanization has been steadily gaining importance in the country as labour saving technology. The labour cost of manual work is increased with each unit produced while use of machines reduces cost drastically by producing more units of output that ultimately increase farmer's profit (Ansarey, 2017). Farm mechanization directly saves seed (15-20%), time (20-30%), reduces labour (20-30%), drudgery (10-30%) and increases productivity (10-15%), as described by Tiwari *et al.* (2017). Most importantly, the farmers are getting the realization that to save time and cost of operation and to do profitable agriculture, there is no other better option than to go for mechanized agriculture (Ahmmed and Karim, 2017). Evidence suggests that mechanization has a major impact on demand and supply of farm labour, agricultural profitability and a change in rural landscape (Schmitz and Moss, 2015). In Bangladesh farmers of different district like Rajbari, Faridpur, Magura, Rajshahi and Dinajpur are using locally developed tilling machine namely high-speed rotary tiller (HSRT) and seeding machine namely power tiller operated seeder (PTOS) extensively (Ahmmed and Karim, 2017). A study conducted by Miah *et al.* (2009) revealed that conservation tillage (CT) through the PTOS has created significant impact on overall farming & farming activities, employment and household income of the farmers. Most of the crop seeds like wheat, paddy, maize, jute, pulses, oilseeds etc. are sown in line using the PTOS. The use of the PTOS is getting popularity throughout the country since its spare parts, repair and maintenance mechanics and workshops are available at the village level (Miah and Haque, 2015). The success of farming is judged by the amount of profit gained in it (Ozpinar and Cay, 2018). Information about comparative study on yield, quality, maturity and economic traits under different onion planting methods including PTOS is scanty in the country. Therefore, considering aforesaid senses a study on different planting methods of onion (var. BARI Piaz-1) was conducted to assess the performance of direct seeding of onion by the PTOS and compare the yield, quality, maturity and economics of onion among planting methods.

MATERIALS AND METHODS

Experimental site

A field trial was conducted at Spices Research Sub-Centre (SRSC), Bangladesh Agricultural Research Institute (BARI), Faridpur during winter season of 2019-2020 to evaluate the performance of power tiller operated seeder (PTOS) and to compare the yield, quality, maturity and economic traits of onion under different planting methods. The experimental site is belonging to Agro Ecological Zone (AEZ) no. 12 (Low Ganges River Floodplain). The geographic coordinates of the trial site are 23°11 N' and 89° 09' E. The elevation of Faridpur is about 12 meters above sea level. The trial field was texturally clay loam. The pH value and organic matter were 7.89 and 1.92%, respectively.

Experimental design

The study was designed in a randomized complete block design (RCBD) with four replications. Onion was grown in four planting methods as four treatments such as T_1) ploughing the main field with high-speed rotary tiller (HSRT) + direct seeding with power tiller operated seeder (PTOS), T_2) ploughing the main field with HSRT + transplanting of seedlings, T_3) ploughing the main field with HSRT + direct seeding in line and T_4) ploughing the main field with HSRT + direct seeding as broadcasting.

Descriptions of HSRT and PTOS

The high-speed rotary tiller (HSRT) is characterized by conservation tillage (CA) machine, 48 tines, rotating speed of 500-600 rpm while normal power tiller bears 18-20 tines and rotating speed of 300-400rpm. The HSRT enhances quick and smooth land preparation by reducing the number of ploughings from 4-5 (traditional tillage) to 2-3 (Ahmmed and Karim, 2017). On the other hand, the power tiller operated seeder (PTOS) is sketched by two wheels operated seed drill machine, 1200 mm width of operation, 6 rows sowing capacity at a time (Miah and Haque, 2015). The PTOS is widely used for various crop establishments through CA, sowing of seeds and laddering operations simultaneously in a single pass in many areas of Bangladesh.

Management practices

The seeds of onion were sown on 05 November 2019 for all the treatments. However, the seeds of the treatment T_2 were sown in the nursery beds @ 5kg/ha. For the treatment T_1, the seeds @ 6kg/ha mixing with saw dusts at the ratio of 1:2 was drilled in the prepared trial plots through PTOS keeping row spacing of 15cm. Hand sowing was done in the prepared experimental plots for the remaining two treatments: T_3 in line @ 10kg/ha and T_4 as broadcasting @ 15kg/ha. In addition, row spacing was also 15cm for the treatment T_3. Before sowing the seeds, one ploughing and another cross ploughing were done on the trial plots of the treatments T_1, T_3 and T_4. The 40-day old uniform/healthy seedlings were transplanted on 15 December 2020 in the main experimental plots and spaced at 15cm × 10cm. Before transplanting, roots of the seedlings were soaked in Rovral (Iprodione) solution for 5 minutes and about 5cm of seedling tops were trimmed out. The unit plot size was 10.00m × 5.00m for each treatment. The experimental field was fertilized with 3000kg well-decomposed cowdung, 220kg urea, 220kg triple super phosphate (TSP), 150kg muriate of potash (MOP), 110kg gypsum and 8kg B fertilizer (solubor) per hectare. The entire quantity of cowdung, TSP, MOP, gypsum, solubor and one third of urea were applied as basal dose during land preparation. The remaining urea was used as top dress in two equal splits on 04 January 2020 and 24 January 2020. The plants from the treatments involving T_1 and T_3 were thinned by uprooting excess seedlings 35 days after sowing at 8-10 cm from plant to plant. Nonetheless, the plants from the treatment T_2 were also thinned as and when needed. The fungicide mancozeb/iprodione @ 3g/1 litre of water was sprayed at fortnightly interval commencing from one month after transplanting of seedlings. All other recommended management practices were followed for each treatment.

Observation and data collection

The data recorded were: plant population (plants/m^2), plant height (cm), number of leaves per plant (no.), percent bolting (%), days to maturity (days), diameter of bulb (cm), individual bulb weight (g), percent split (multiplier) bulbs (%), dry matter content of bulbs (%), total soluble solid content (°brix), bulbs weight per plot (kg/ha) then calculated as yield per hectare (t). Ten plants were randomly selected from each plot for data recoding and averaging it. Simple randomization of each plot was done to select ten plants and aforementioned parameters were recorded. Plant height and number of leaves were recorded on 14 January 2020 and 14 February 2020. But average plant height and number of leaves were presented in the paper. The number of bolting plants was visually counted in each plot, recorded and expressed in percent in relation to the total number of plants. Bulbs were harvested at maturity when the pseudostem becomes flaccid and unable to support the leaf blades (Brewster, 1990[a]). Days to maturity were recorded considering days between the sowing of seeds and harvesting of bulbs. The leaves of harvested onion were removed at seven days after curing by cutting 8-10 cm above the bulb (Brewster, 1990[b]). After curing, the total bulb fresh weight was measured for each plot. The number of multiplier bulbs was visually counted in each plot, recorded and expressed in percent in relation to the total number of bulbs per plot. The percent dry matter content of bulbs was calculated by dry weight basis as per procedure of Walle *et al.* (2018). The total soluble solid (TSS) content of bulbs was recorded by hand refractometer (ATAGO, Master-53M, Japan) with a range of 0-53 °brix.

Statistical analysis

The Analysis of variance was done with the help of statistical package 'R', as suggested by Gomez and Gomez (1984) and the means were compared by the least significant difference (LSD).

RESULTS AND DISCUSSION

Effect of planting methods on the growth and maturity of onion

There was a significant difference among the planting choices on the characters of growth and maturity of onion (Table 1). The highest plant population (91.06 plants/m^2) was counted under direct seeding (broadcasting) method followed by the power tiller operated seeder method (PTOS), being (87.25 plants/m^2). Maximum plant population in broadcasting might happen due to application of maximum seed rate in broadcasting method. The transplanting method showed the lowest (66.61plants/m^2). Hoque and Wohab (2013) found significant difference on plant population among the planting methods. But they added that plant population was less in broadcasting method due to uneven distribution of seeds and uneven seed depth, which was contrasting with the present finding. The tallest plant height (53.80cm) had under transplanting of seeding followed by direct seeding in line (49.81cm). The minimum (46.93cm) was in direct seeding (broadcasting) method (46.93cm). The maximum number of leaves per plant (8.35) was recorded from transplant followed by direct seeding with the PTOS (7.62). The least (6.73) was under broadcasting of seeds. The shortest plant height from direct seeding method might be due to the increase in competition among the plants for space, nutrients, light and water. The present result is accordance with the finding of Bosekeng and Goetzer (2015) who stated that plant height decreased as plant population increased. Ketema *et al.* (2018) noted that direct seeding showed constantly lower plant height and minimum number of leaves/plant than those of transplant. Hoque and Wohab (2013) did not found significant difference among the planting methods on plant height. The highest incidence of bolting (21.55%) was observed at transplanting method followed by direct seeding in line (14.56%). Nonetheless, the lowest incidence (12.99%) is occurred under broadcasting of seed method. Comparatively transplant onions and direct-seeded onions developed in the soil and on the soil, respectively.

Besides the transplant method had the lowest number of plants per square meter. Henceforth, plants in the transplant method got more nutrients, space and water which might help the plants for vigorous growth then resulted in higher bolting. The finding agrees with the finding of Ketema *et al.* (2013). They opined that maximum incidence of bolting was found in transplants as compared to that of direct seeding. They further stated that bolters were responsible for the observed high unmarketable yield in transplanting method. On the contrary, Ahmed and Hassan (1978) stated that incidence of bolting was increased by direct

Table 1. Effect of planting methods on the growth of onion at SRSC, BARI, Faridpur during 2019-2020.

Planting methods	Plant population (plants/m^2)	Plant height (cm)	No. leaves/ plant	Bolting (%)	Days to maturity (days)
HSRT + PTOS	87.25	49.73	7.62	14.32	133.66
HSRT + Transplanting	66.61	53.80	8.35	21.55	155.54
HSRT + Direct sowing (line)	81.36	49.81	7.26	14.56	133.64
HSRT + Direct sowing (broadcast)	91.06	46.93	6.73	12.99	132.36
CV (%)	6.62	5.69	4.32	11.32	7.17
LSD at 0.05	7.53	3.69	0.65	2.61	8.80
Level of significant	**	*	**	**	**

** Significant at 1% level of probability, * Significant at 1% level of probability, HSRT-High speed rotary tiller and PTOS-Power tiller operated seeder.

seeding. The direct seeding method took minimum time to mature bulbs as compared to that of transplants. The broadcasting method of sowing onion hastened the maturity of bulbs (132.36 days) followed by the direct seeding in line (133.64 days). However, the transplanting of seedlings delayed the maturity of bulbs (155.54 days). Comparatively transplant onions and direct-seeded onions developed in the soil and on the soil, respectively. Hence, onions in the direct seeding method were more prone to be matured earlier which might be due to enjoying lower amount of nutrients, water, space and exposing of bulbs in the sun by the direct seeding method as well. Transplants are set deeper in the soil while direct seeded onions develop at or near the soil surface (Boyhan *et al*., 2008). For these aforesaid reasons, transplants are better able to survive compared with direct seeded onions, also describes by Boyhan *et al*. (2008). Macias-Duarte *et al*. (2004) and Abdalla *et al*. (1980) observed earlier maturity in direct seeding in comparing to the transplant method. Ahmed and Hassan (1978) reported that transplanting method delayed the maturity of bulbs. Ketema *et al*. (2013) and Motallebi *et al*. (2001) disagree with the present result. They stated that maturity was significantly more delayed in direct seeding method than that of transplant.

Effect of planting methods on the yield and quality onion

The planting methods significantly affected the yield and quality contributing characters of onion except yield trait (Table 2). The maximum split bulb (19.99%) was obtained from the seedling transplanting significantly followed by direct seeding with the PTOS (16.10%). In addition, the minimum percent of split bulb (15.02%) was under broadcasting method. Transplants showed higher percent of multiplier bulb as compared to that of direct seeded one (Ketema *et al*., 2013). They further noticed that multiplier bulbs were responsible for the observed high unmarketable yield in transplanting method. In contrast, direct seeding significantly increased percentage doubles (Ahmed and Hassan, 1978). The transplants possessed the highest dry mater content (18.45%) followed by direct seeding with the PTOS (16.32%). The lowest (15.02%) was observed under broadcasting method. The findings of Ketema *et al*. (2018) and Izadkhan *et al*. (2009) opined that mean dry weight of onion bulb was higher with transplanting seedlings than that of direct seeding. Plants in transplanting method were attributed to stronger photosynthetic efficiency and vigorous vegetative growth due to better establishment (Ketema *et al*., 2013) which resulted in maximum dry matter content in the bulb of transplant. The dry matter accumulation is a product of net photosynthesis reflected in terms of growth components (Gauder *et al*., 1988).

The maximum TSS content (17.53°brix) was found under transplants significantly followed by direct seeding with the PTOS (14.69°brix). The minimum TSS content was under the broadcasting (14.56°brix). The current results are in consent with the findings of Izadkhan *et al*. (2009) and Abdalla *et al*. (1980). They claimed that transplanting method had total soluble solid content as compared to direct seeding method. The maximum diameter of bulb (3.58cm) was registered from the transplanting followed by direct seeding in line (3.02cm) and direct seeding with the PTOS (3.01cm). Nevertheless, the least diameter of bulb (2.69cm) was under broadcasting of seeds. Bulb diameter increased as plant population decreased (Bosekeng and Goetzer, 2015). Direct seeding resulted in significantly lower bulb diameter than transplanted seedling (Ketema *et al*., 2013 and Motallebi *et al*., 2001). On the contrary, direct seeding increased amount of large bulb as compared to transplanting method (Ahmed and Hassan, 1978). Hoque and Wohab (2013) recorded no significant influence on bulb diameter by planting choices. In addition, very heterogeneous and under-sized bulbs were recorded with broadcasting method due to uneven spacing and maximum plant population per unit area. The similar results were also disclosed by Motallebi *et al*. (2001) and Khokhar *et al*. (1990). They reported that transplanting method produced more homogenous bulbs than that of direct seeding. The transplanting method gave the maximum bulb weight (24.01g) followed by direct seeding with the PTOS (19.54g). The broadcasting method had the minimum bulb weight (17.28g). Ketema *et al*. (2013), Motallebi *et al*. (2001) and Izadkhan *et al*. (2009) also published a supportive result as transplanting method produced maximum average bulb weight than direct sowing. Hoque and Wohab (2013) opined that broadcasting had significantly the lowest bulb weight but bulb weight in the seed sowing by drum seeder was at par with that of direct line sowing. Ketema *et al*. (2013) offered supplementary information as due

Table 2. Effect of planting methods on the yield contributing characters, yield and quality of onion at SRSC, BARI, Faridpur during 2019-2020.

Planting methods	Split bulb (%)	Bulb dry matter (%)	TSS (° brix)	Bulb diameter (cm)	Bulb weight (g)	Yield (t/ha)
HSRT + PTOS	16.10	16.32	14.69	3.01	19.54	16.08
HSRT + Transplanting	19.99	18.45	17.53	3.58	24.01	14.42
HSRT + Direct sowing (line)	15.45	16.11	15.01	3.02	18.43	15.11
HSRT + Direct sowing (broadcast)	15.02	15.02	14.56	2.69	17.28	16.15
CV (%)	10.09	8.11	11.75	8.37	6.02	9.35
LSD at 0.05	2.06	1.89	2.29	0.51	2.38	2.09
Level of significant	**	**	*	*	**	NS

** Significant at 1% level of probability, * Significant at 1% level of probability, NS-Non significant, HSRT-High speed rotary tiller and PTOS-Power tiller operated seeder.

Table 3. Effect of planting methods on the cost of production growing onion at SRSC, BARI, Faridpur during 2019-2020 (Tk./ha).

Types of expenditure	Planting methods			
	HSRT + PTOS	HSRT + Trans.	HSRT + DS (line)	HSRT + DS (broadcasting)
A) Variable cost				
Cost of seeds				
a) By trans. methods (5 kg)	-	4000	-	-
b) By direct seeding with PTOS (6 kg)	4800	-	-	-
c) By direct seeding in line with hand (10 kg)	-	-	8000	-
d) By direct seeding (broadcast) (15 kg)	-	-	-	12000
Land preparation with HSRT (hiring @ 30.00/decimal)	7410	7410	7410	7410
Seed sowing				
a) Direct seeding by PTOS (hiring @ 12.00/decimal)and watering	5964	-	-	-
b) Making lines/direct seeding in lines with hand/ laddering/watering	-	-	30000	-
c) Direct seeding (broadcasting) with hand/laddering/ watering	-	-	-	12000
Seed bed preparation/raising seedlings for trans. method (25 labour)	-	12500	-	-
Labour for making lines with tine and lifting/trimming/ treating//trans. of seedlings (80 labour)	-	40000	-	-
Manures and fertilizers				
a) Cowdung (3000 kg @ 8.00)	24000	24000	24000	24000
b) Urea (220 kg @ 16.00)	3520	3520	3520	3520
c) TSP (220 kg @ 22.00)	4840	4840	4840	4840
d) MOP (150 kg @ 15.00)	2250	2250	2250	2250
e) Gypsum (110 kg @ 6.00)	660	660	660	660
f) B fertilizer- Solubor (8 kg @ 400.00)	3200	3200	3200	3200
Labour for weeding/thinning (as and when needed)	12000	8000	12000	20000
Labour for irrigation (6 labours)	3000	3000	3000	3000
Plant protection	2500	2500	2500	2500
Labour for harvesting	10000	8000	10000	12000
Labour for curing, cleaning etc.	5000	3500	5000	7500
Interest on investment @ 14% per year for 6 months	6240	8916	7796	8111
Sub-total (A)	95384	136296	119176	123991
B) Fixed cost				
Land rent (1 ha=7.5 bigha @4000.00/bigha/year)	15000	15000	15000	15000
Land management charge for 6 months (LS)	2000	2000	2000	2000
Sub-total (B)	17000	17000	17000	17000
Total cost of production (A + B)	112384	153296	136176	140991

HSRT-High speed rotary tiller, PTOS-Power tiller operated seeder, Trans.-Transplanting of seedlings, DS-Direct seeding and price of seeds- Tk. 800.00/kg.

to better establishment plants in transplanting method were attributed to stronger photosynthetic efficiency and vigorous vegetative growth than that of direct sowing method resulted in maximum bulb weight in transplant. Khokhar *et al*. (1990) also noted that the transplanting method improved bulb weight compared with direct sowing. Macias-Duarte *et al*. (2004) also observed that the system of direct seed obtained better bulb weight in comparing to the transplant method. Moreover, the bulbs had wide variation in weight under the broadcasting due to uneven spacing. The broadcasting method yielded maximum onion bulb (16.15t/ha) followed by direct seeding with the PTOS (16.08t/ha). The lowest yield (14.42t/ha) was recorded from the transplants. The maximum bulb yield in broadcasting was associated due to maximum plant population per unit area in broadcasting method, though their bulb size was very much smaller. A survey report published by Miah *et al.* (2009) claimed that direct seeding with the PTOS ensured higher yield for onion as compared to traditional tillage through the power tiller. Hoque and Wohab (2013) found no significant variation between the yield of drum seeder and manual line sowing method but they found significant variation between the yield of drum seeder and broadcasting method. The direct seeding gave significantly higher yield as compared to transplanting method (Gauder *et al*., 1988). In contrast, the transplanting method increased bulb yield compared with direct sowing (Ketema *et al*., 2013; Motallebi *et al*., 2001 and Khokhar *et al*., 1990). Direct seeding was superior over transplanting method in respect of yield (Macias-Duarte *et al*., 2004 and Ahmed and Hassan, 1978).

Table 4. Effect of planting methods on the cost and return analysis of onion at SRSC, BARI, Faridpur during 2019-2020.

Planting methods	Yield (kg/ ha)	Total cost of production (Tk./ha)	Gross return (Tk./ha)	Gross margin (Tk./ha)	Net return (Tk./ha)	Benefit-cost ratio
		A + B = C	D	D - A	D - C	D / C
HSRT + PTOS	16080	112384	331760	236376	219376	2.95
HSRT + Trans.	14420	153296	313320	177024	160024	2.04
HSRT + DS (line)	15110	136176	329340	210164	193164	2.42
HSRT + DS (broadcast)	16150	140991	270900	146909	129909	1.92

HSRT-High speed rotary tiller, PTOS-Power tiller operated seeder, Trans.-Transplanting of seedlings, DS-Direct seeding and wholesale price of onion: Tk.22.00/kg, Tk..21.00/kg, Tk.22.00/kg and Tk.18.00/kg for PTOS, Transplanting, direct seeding (line) and direct seeding (broadcasting), respectively.

Economic analysis

The Table 3 revealed that the transplanting method incurred the highest total cost of bulb production (Tk.153296) followed by broadcasting method (Tk.140991). While the lowest (Tk.112384) was under the direct seeding with power tiller operated seeder (PTOS). The reasons for the highest cost incurred with transplanting method were due to involving a large number of labours for seed bed preparation, raising seedlings, lifting/ trimming/treating and transplanting of seedlings. The present results are at par with the results of Boyhan *et al.* (2008) and Brewster (2008). They explained the transplants as higher cost involving method due to requiring a large labour force and the direct seeding as cost saving method. The Table 4 depicted that the highest gross return (Tk.331760/ $3888), gross margin (Tk.236376/ $2770), net return (Tk.219376/ $2571) and benefit -cost ratio (2.95) were recorded from direct seeding with PTOS followed by manual direct seeding in line (Tk.329340/ $3860), Tk.210164/ $2463, Tk.193164/ $2264 and 2.42) and transplanting method (Tk.313320/ $3672, Tk.177024/ $2075, Tk.160024/ $1875 and 2.04), respectively. However, the broadcasting method had the lowest gross return (Tk.270900/ $7175), gross margin (Tk.146909/ $1722), net return (Tk.129909/ $1522) and benefit-cost ratio (1.92). The net return from the PTOS was 37% higher than that of the transplanting method. The present finding is in line with the finding of Macias-Leon and Leskovar (2019) who computed the maximum total cost of production from seedling transplanting method. On the contrary, minimum number of labours was engaged in the PTOS method. The maximum gross return from the PTOS followed by manual direct line seeding was mainly due to higher bulb price in earlier season. The reason for minimum gross return from broadcasting was due to lower bulb price of very heterogeneous and under-sized bulbs. The reasons for maximum economic benefits from direct seeding with the PTOS were due to less use of labour in the PTOS method. A survey report from the districts of Rajbari and Dinajpur, Bangladesh unveiled that direct seeding with the PTOS increased farmers' net income 30, 23, 46 and 45% in wheat, jute, onion and Mungbam, respectively (Miah *et al*., 2009). The current finding corroborates the finding of Macias-Leon and Leskovar (2019). The use of onion transplant is not a widespread commercial practice because of the higher production cost (Macias-Leon and Leskovar, 2019).

Conclusion

Based on the results, it could be concluded that, the transplanting method incurred the maximum total cost of production due to involving lot of labors for raising and transplanting of seedlings as well. At the same time, broadcasting method had very heterogeneous and under sized bulbs due to uneven spacing and maximum plant population per unit area and the bulbs under direct seeding with the power tiller operated seeder (PTOS) matured about 22days earlier as compared to transplants which is most important character to catch the early market. The maximum economic benefits were recorded under direct seeding with the PTOS due to less labor involving onion growing method and higher bulb price from early crop. Now a day, in addition to transplants, more adopted method so far in Bangladesh, direct seeding method with the PTOS may also be a good option for getting early crop and maximum economic benefit in the areas where there will be seen scarcity of labour or higher labour cost in transplanting of seedlings.

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