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Field performance of a tractor operated semi-automatic potato planter

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Abstract

The study was carried out to evaluate the performance of a 2-row tractor operated potato planter at the Bangladesh Agricultural University, Mymensingh farm during 26th December 2005 to 10th February 2006. Various technical and economic aspects of the planters' namely seed to seed spacing, percent of missing seed, depth of planting, and percent of injured seed, field capacity, field efficiency, fuel consumption, cost of operation and break-even analysis were evaluated on the basis of RNAM tests code. Considering recommended seed to seed spacing, percent of missing seed, depth of planting, percent of injured seed, and field efficiency; 1.1km/hr operational speed could be recommended for field operation of the planter for planting potato. At the recommended speed the effective field capacity and field efficiency of the planter was about 0.14 ha/hr and 70.70%, respectively. Costs and labour requirements of planting potatoes were reduced by 44% and 95%, respectively, compared with the traditional method.

Keywords: Tractor operated, Potato planter, Field performance, Break-even area, Operating cost

Introduction

Bangladesh has about 14.22 million hectares of land of which about 8.03 million hectares are cultivable, growing various food and cash crops. Among the various crops, area coverage by potato is 1.91% (BBS, 2004). At present about 0.27 million hectares are used for potato cultivation. Potato is very wholesome, rich in carbohydrate, fat and protein. The versatile use of potato has been increased in the country. Also potato plays an important role in the economy of Bangladesh. Total annual potato production increased from 1.384 million tons during 1992-93 to 3.908 million tons during 2003-04 (BBS, 2004). Also, the Department of Agricultural Extension (DAE) has targeted to produce 39 lakh tons of potato only in northern districts of the country (Practical famine relief, 2005).

All activities of potato cultivation in Bangladesh are still traditional and labour intensive. Among these activities planting is the first and the major pre-harvest operation of potato cultivation. Planting requires about 50% of the total labour requirements of potato cultivation (Singh et.al.,1981). At present potato planting is done manually which is not only time consuming and labour intensive but also costly. Traditional method requires 54.3 man-day/ha whose cost is Tk 3801 per ha (Hossain et. al., 2004). There is an acute shortage of labour during the planting season (rabi), which causes delay in sowing operation and occurs considerable losses of yield. In Bangladesh among the most important causes of low yield of potato, delay in optimum planting time, lack of practicing modern technologies and use of poor quality seed tubers are noticeable. To reduce delay in potato planting time and cost, and also to plant at appropriate spacing and depth, it is essential to introduce a suitable mechanical potato planter in Bangladesh. No significant study has been done related to a suitable mechanical potato planter. But recently a study was conducted on power tiller operated potato planter in Wheat Research Center (WRC), BARI with technical and financial assistance of CIMMYT. Similarly, the field performance test of a tractor-operated planter is of

immense importance. REFPI a component project of DFID, UK funded for importing a tractor operated semi-automatic potato planter made by AMAR of India, for academic purpose of the Department of Farm Power and Machinery. To introduce this, the field performance test of a mechanical potato planter under various potato variety and operating conditions is of immense importance. Based on the above discussion this study was undertaken to test the performance of AMAR brand tractor operated semi-automatic potato planter under field condition.

Materials and Methods

General description of AMAR potato planter

The AMAR potato planter is a semi-mounted 2-row planter with a hopper, base frame, potato metering device, furrow openers and soil covering device (three mould-boards), planter drive wheel and chain with sprocket for power transmission. The machine is mounted on a 3- point linkage of a tractor and two persons sitting on the machine feed the tubers. The potato planter was powered by a 40 hp diesel tractor at low 3rd gear speed. It can perform three functions simultaneously viz. making furrows, sowing seeds and making ridges. Also the planter is easy to operate and maintain. The power is transmitted from the planter drive wheel to the top transmission shaft through chain and sprocket. From the top transmission shaft the power is transmitted to the seed metering pulley axle by chain and sprocket. The power transmission system of the planter is shown in Fig. 1.

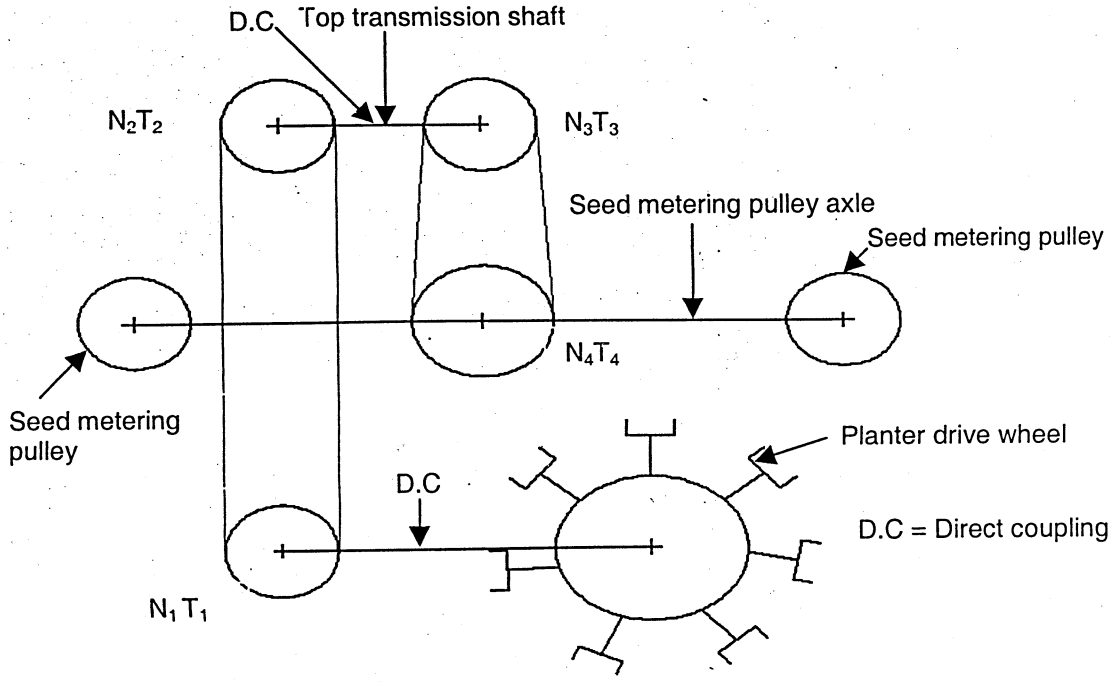

Fig. 1. Power transmission from planter drive wheel to seed metering pulley

Table A. Brief specification of AMAR potato planter

Model	Semi-automatic, Attachment and Without Fertilizer
No. of Furrows	2
Row to Row spacing range (cm)	60 – 66
Seed to seed spacing range (cm)	20 – 25
Seed hopper capacity (kg.)	120
Total length (cm)	140
Total width of machine (cm)	180
Total height (cm)	140
Total weight (kg.)	280
Compatible Tractor	30 hp and above

Planting mechanism

The seed metering mechanism of the potato planter is a cup type horizontal drive. As the tractor moved forward the seed-metering device was rotated by a chain-sprocket arrangement through drive wheels. Three operators were required to operate the machine; one to drive the tractor and the other two sitting on the frame placed the seed potatoes in seed metering cup by hand very quickly, if there were any missing. Just after the potato placement, a ridge is formed by the two consecutive mould-boards.

Seed to seed spacing in the field is regulated by the rate of rotation of the seed-metering pulley. The metering pulley rotation i.e. the seed spacing of potato is maintained by the planter drive wheel diameter and the size of sprockets attached to the planter drive wheel and axle of the seed-metering pulley (Fig. 1). That means if the drive wheel diameter and the sprocket size attached to the axle of the metering pulley is larger the seed spacing is increased i.e. the metering pulley rotation will be slower. Alternatively, if the sprocket size attached to the planter drive wheel is larger, the seed spacing is decreased i.e. the metering pulley rotation will be faster. The planter drive wheel diameter, sprocket size and seed spacing relationship is expressed by the following equation (Momin, 2006).

$$SP = \frac{\pi D T_4}{n T_1}$$

Where,

S_p = Seed to seed spacing of potato in the field (m)

D = Diameter of the planter drive wheel (m)

T_1 = Number of teeth of the sprocket attached to the planter drive wheel

T_4 = Number of teeth of the sprocket attached to the seed metering pulley axle

n = Number of cup per turn of seed-metering pulley

Collection of test data

According to the test code of the Regional Network for Agricultural Machinery (RNAM) following data were collected for every test run under this study.

1.Row to row spacing, 2. Seed to seed spacing, 3. Depth of planting, 4. Number of missing seed, 5. Number of injured seed, 6. Travel distance and time.

Calculation of technical parameters

1. Field capacity

Field capacity was determined using the following formula (Hunt, 1995)

Theoretical field capacity, $C_{th} = \frac{SW}{10}$, (ha/hr)

Where,

W = rated width of the planter (m)
S = rated forward speed of machine (km/hr)

Effective field capacity, $C_{eff} = \frac{A}{T}$, (ha/hr)

Where,

T = total time for the planting operation, hr
A = total area planted, ha

2. Field efficiency

Field efficiency, $e = \frac{C_{eff}}{C_{th}} x100$

3. Fuel consumption

The fuel tank of tractor was filled up to its top, before the start of planting operation. After completing the planting operation the fuel tank was again filled up to its top by a measuring cylinder to determine to fuel consumption.

4. Estimation of cost of operation

The cost of operation of the planter was calculated from test results and making the assumption for machine life, hours of operation (per day and per year), rate of interest and the cost of machine, etc as per standard procedure. The total cost of planter is divided into two components such as fixed cost and variable costs. Annual fixed cost including depreciation, interest on investment, tax, insurance and shelter where as the variable cost includes labour, fuel, oil and repair & maintenance costs. In Bangladesh there exists no tax and insurance for agricultural machinery. Annual depreciation was estimated using capital consumption method and interest was calculated on average investment on the machine over its full life.

The cost of operating the planter was computed using the following equations involving the fixed and variable cost items. The total cost per year for the planter can be expressed as (Hunt, 1995).

$$AC = \frac{FC\%xP}{100} + \frac{A}{C}.[(R\ \&\ M)xP + L + O + F + T]$$

Where,

AC = annual cost of operating the planter, Tk/year
FC% = annual fixed cost percentage
P = purchase price of the potato planter, Tk
A = annual planted area, ha
C = Effective field capacity of the planter, ha/hr
R&M = repair and maintenance cost decimal of purchase price, Tk/hr
L = labour cost, Tk/hr
O = oil costs, Tk/hr
F = fuel costs, Tk/hr
T = cost of tractor used by the potato planter, Tk/hr (for self-propelled machine it is zero)

Cost item		Value assumed
i)	Planter cost	Tk. 45,000
ii)	Bank interest rate, i	10%
iii)	Salvage value, S	10%
iv)	Tax and insurance cost	0 in Bangladesh condition
v)	Repair and maintenance cost	3.5% of purchase price (RNAM)

5. Break-even analysis:

The following formula was used to estimate the appropriate "break-even" point between mechanical planting and manual planting of potato.

$$Ha/yr = \frac{\text{Total annual cost for potato planting (Tk./yr.)}}{\text{Manual planting cost (Tk./ha.)}}$$

Planting uniformity

The inaccuracy of a planter that means the lack of uniformity of the distances between successive seeds at the particular operational speed is known to have an adverse effect on the yield. The parameter commonly used to express this inaccuracy is the coefficient of variation (CV = standard deviation/mean) of the distances between successive seeds at that particular operational speed.

Calculation procedure:

Mean, $\bar{x} = \frac{\Sigma f_i x_i}{n_i}$ Standard deviation, $S_d = \sqrt{\frac{1}{n}\Sigma f_i (x_i - \bar{x})^2}$

Coefficient of variance, $CV = \frac{S_d}{\bar{x}} x100$ Standard error, $SE = \frac{S_d}{\sqrt{n}}$.

Where,

f_i = Number of frequency;
x_i = Observation spacing (cm);
n = Total number of frequency

Results and Discussion

Seed to seed spacing

The average seed to seed spacing of potato with coefficient of variance at different operational speed such as, 2.0, 1.8, 1.5, 1.1 km/hr are shown in Table1. From Table 1 it is revealed that at 1.1 and 1.5 km/hr operational speed the average seed spacing of potato is 24.49 cm and 25.65 cm, respectively which is close to the recommended seed spacing 25 cm. But the planting uniformity or coefficient of variance of planting spacing is increasing with increased operational speed. Because, the higher operational speed means faster metering pulley rotation; thus spacing of potato is frequent and irregular. Also from Table 1, it is revealed that at 1.1 km/hr speed the range of average spacing of potato is between 24.06 and 24.92 cm i.e. the seed to seed spacing is maintained almost similar distance and closer to the recommended spacing of 25 cm. Considering the recommended seed to seed spacing of potato at 25 cm, 1.1 km/hr operational speed could be recommended for field operation of the planter.

Table 1. The effect of seed to seed spacing (cm) and operational speed (km/hr)

Operational speed (km/hr)	Seed to seed spacing (cm)			
	Mean	Standard deviation	CV (%)	SE (±)
1.1	24.49	2.14	8.74	0.22
1.5	25.65	4.10	15.98	0.43
1.8	19.96	7.39	37.0	0.70
2.0	15.04	8.33	55.39	0.71

Percent of missing seed

Percent of missing seeds at different operational speeds such as, 2.0, 1.8, 1.5, 1.1 km/hr are shown in Fig 2. From Fig 2, it is seen as a general trend that the percent of missing seed is increasing as operational speed is increasing, that indicates a great influence of speed on number of missing seed. This was due to the fact that at higher speed, the rotating cup on belt revolves at faster rate resulting in non-placement of potato tubers in its cup. Therefore maximum missing seed was observed at of maximum speed (Fig. 2). Apart from operational speed of the planter, the number of missing seed depends on many other factors, such as labour efficiency, feeding rate to the planter, size of hopper opening and type of potato seed, etc. Considering the number of missing seed, 1.1 km/hr operational speed could be recommended for field operation of the planter.

Depth of planting

It is observed that depth of planting is increasing with the increase of speed. At the higher speed the height of the ridge is become more, due to the throwing of more soil at higher speed. Depth of planting of the selected planter at different operational speeds such as, 2.0,

1.8, 1.5, 1.1 km/hr were observed around 14-18 cm (Table 2). The planting depth varied due to the uneven land surface and soil moisture content. Although the variation in depth of planting does not differ much, but 1.1 km/hr operational speed provide recommended depth (15cm) of planting.

Percent of injured seed

During performance test no injured seed was found at 1.8, 1.5, and 1.1 km/hr operational speed, but only at 2.0 km/hr speed 1% injured seed were found (Table 2). It means that the number of injured seed increases with the increase of speed higher than 2.0 km/hr.

Field capacity and field efficiency

The theoretical and effective field capacity and field efficiency at different operational speed such as, 1.1, 1.5, 1.8, 2.0 km/hr are shown in Table 2. The field efficiency was highest 70.70% at speed 1.1 km/hr. Though there was highest effective field capacity o.24 ha/hr at 2.0 km/hr operational speed but efficiency was low due to the higher proportion of turning loss. Therefore, considering the field efficiency, 1.1km/hr operational speed could be recommended for field operation of planter.

Table 2. Field performance of tractor operated AMAR brand potato planter

Sl No.	Parameters	Speed of operation (km/hr)			
		1.1	1.5	1.8	2.0
1	Row to row spacing, cm	1.1	1.5	1.8	2.0
2	Average seed to seed spacing, cm	60	60	60	60
2	Depth of planting, cm	24.49	25.65	19.96	15.04
3	Missing seed, %	14	17	17	18
4	Injured seed, %	3	6	10	13
5	Theoretical field capacity, ha/hr	0	0	0	1
6	Effective field capacity, ha/hr	0.20	0.27	0.32	0.37
7	Field efficiency, %	0.14	0.18	0.21	0.24
8	Fuel consumption, lit/hr	70.70	66.67	65.63	64.86
		1.5	1.5	1.5	1.5

Recommended speed of operation

The best performance of the planter is mainly depending on the speed of operation. Therefore, it is necessary to operate the planter at optimum operational speed to produce best result at farmers' level. From the experimental test results, considering seed to seed spacing, percent of missing seed, depth of planting, percent of injured seed, and field efficiency; 1.1km/hr operational speed could be recommended for field operation of the planter for planting potato.

Operating costs of planter

Estimated costs of the planter were determined with effective field capacity of 0.14 ha/hr obtained at speed of 1.1 km/hr. The estimated costs are shown in the Table 3.

Table 3. Estimated cost of planting for diamond variety of potato

Cost items	Semi-automatic potato planter	Manual planting
a) Fixed cost (As per Appendix-B)		
Depreciation	Tk.4566/yr	
Interest	Tk.2475/yr	
Taxes, insurance and shelter	Tk. 0/yr	
Sub total fixed cost	Tk. 7041/yr = Tk. 20/hr	
b) Variable cost		
Fuel cost	Tk. 45.5/hr	
Oil cost	Tk. 1.4/hr	
Labour cost	Tk. 26.25/hr	3801 Tk/ha
Repair & maintenance	Tk.4.74/hr	
Tractor hire cost	Tk.200/hr	
Sub total variable cost	Tk.278/hr	
Grand total planting cost	Tk. 298/hr or Tk. 2129/ha	3801 Tk/ha

The Table 4 shows that at the recommended speed of operation (1.1 km/hr), the cost of planting potatoes with the planter was Tk. 2129 with 3 man-days/ha but the conventional method it was Tk. 3801 with 54 man-days/ha. Therefore, the labour saved by the potato planter was about 95% and cost saved was 44%, over conventional method of planting.

Break-even analysis

Fig. 3 shows the cost of mechanical and manual planting per hectare. Break even level is found at 3 ha. This break even level can be used to select the machine for economic performance i.e. total cultivated land below 3 ha for potato is not economic to plant by the planter.

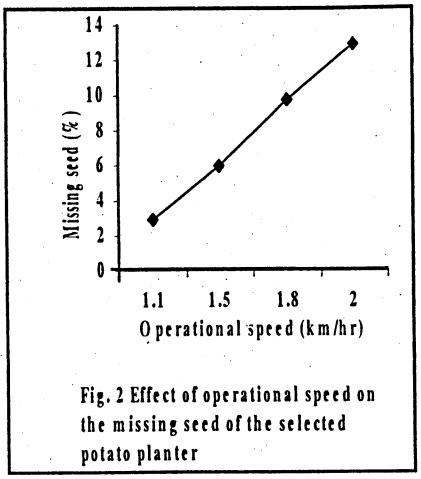

Fig. 2 Effect of operational speed on the missing seed of the selected potato planter

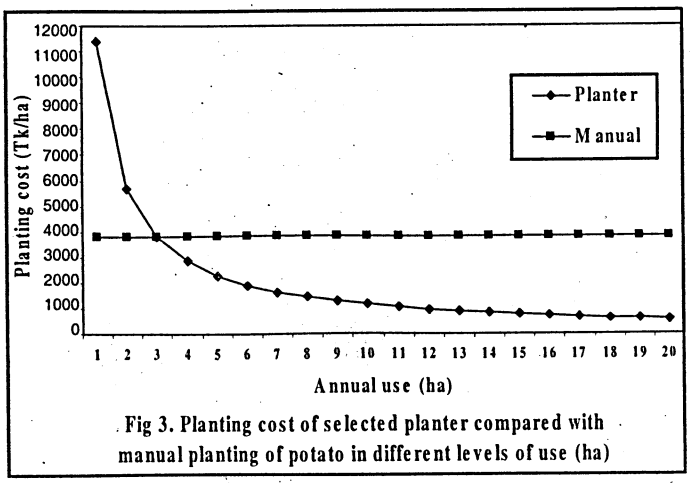

Fig 3. Planting cost of selected planter compared with manual planting of potato in different levels of use (ha)

Conclusions

Planting is one of the most important pre-harvest operations of potato. To improve timeliness of operation, minimize planting cost, overcome labour crisis at the peak planting period and reduce drudgery of manual planting, mechanical potato planters can substitute others methods of planting. Therefore, the performance of selected planter considering the various technical and economic parameters, the following conclusions are made in accordance with the objectives set out for this study:

1. Field performance test of the selected planter revealed that it can be used effectively for planting potato. The planter works well as seed placement at a regular interval consequently cover seed with earthing up in one pass. Three persons are necessary to carry out the sowing operation comfortably and about 95% labour saved by the planter, over traditional method. The effective field capacity of the planter is o.14 ha/hr. The cost of planting potatoes with the planter is lower than the traditional method and cost saved is about 44% over the traditional method of planting. At the current wage levels, the potato planter has break-even points of 3 ha/yr compared to that of the manual methods.

2. With respect to recommended seed to seed spacing, percent of missing seed, depth of planting, percent of injured seed and field efficiency of the selected planter, 1.1 km/hr operational speed was recommended for field operation for the selected variety of potato.

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