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DEVELOPMENT AND TEST OF POWER TILLER OPERATED BED PLANTER FOR UPLAND CROP ESTABLISHMENT

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Abstract

A power tiller operated bed planter was developed with locally available materials at Wheat Research Centre, Dinajpur with financial assistance of CIMMYT Bangladesh. The machine enables to make trapezoidal raised bed and can perform seeding operations on the top of the bed simultaneously at one operation. The machine comprises of four major components, namely toolbar frame, furrow opener, seeding unit and bed shaper. Performance of the machine was tested for wheat, maize and mungbean cultivation. The effective field capacities of the machine for wehat, maize and mungbean seeding were 0.10, 0.11 and 0.14 ha/hr, respectively.

Introduction

Agricultural machinery plays an important role to reduce drudgery of farm work as well as to sustain crop production at economic level. In the recent years, the number of power tillers is increasing day by day due to its versatile use in tilling, pumping, threshing, husking and transporting. Studies indicate that there is no alternate way to minimize labour shortage at peak crop season without using farm machinery.

Crop establishment using bed planting system is a new technique in the farming system of Bangladesh. Generally farmers grow potato and some vegetables in beds. Bed planting system was originally developed in Mexico's Yaqui Velly, where more than 90% of farmers had adopted the practice. In the northwest of Mexico, where high yielding irrigated wheat is commonly rotated with soybean and the farmers increased crop yield dramatically by using this practice in the last decade (Meisner *et al.*, 1992). Raised bed cultivation facilitates more optimum planting time provided by more timely field access because of better drainage and through new opportunities to reduce crop turn-around time by re-use of the same bed (Sayre, 2003). This system has many advantages, such as it reduces seed rate,

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increases crop yield, requires less water, imparts higher nitrogen use efficiency, reduces problem of crop lodging, etc over the conventional system (Hobbs *et al.*, 1997). The research findings showed that the benefits of the raised bed planting systems with furrow irrigation compared with conventional flat planting with flood irrigation were saving water 30% by changing from flood to furrow irrigation and also eliminated the formation of crust problem on soil surface (Fahong *et al.*, 2003). The permanent raised bed irrigated planting system for wheat and other crops that is being develoed in Mexico and elsewhere may finally provide a coherent technology to extend marked tillage reductions with appropriate management of crop residues for surface irrigated production system including those where wheat is a major crop (Sayre and Hobbs, 2003). Manually bed forming is a laborious and time consuming operation. So, it will be very helpful for the farmers, if they are provided with a mechanical device which can perform bed making and seeding operations at a time. Therefore, this programme was undertaken to develop and evaluate the performance of a shovel type bed former with seeding arrangement on a toolbar frame. The whole unit will be attached to a power tiller for wheat, mungbean and maize cultivation.

Terefore, the objectives of this study were :

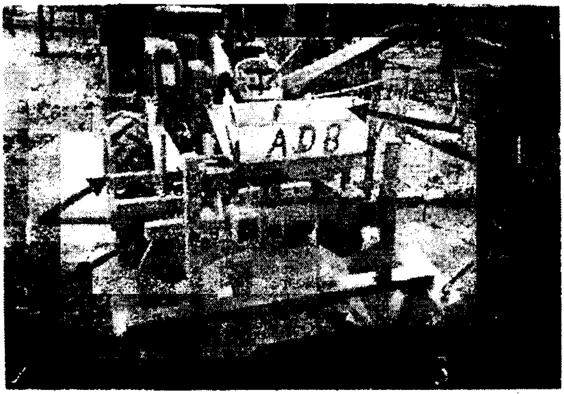
i. to develop and fabricate a shovel type bed former with seeding arrangement,

ii. to make necessary arrangements for hitching the toolbar frame to a power tiller,

iii. to test the performance of the bed planter for wheat, maize and mungbean cultivation.

Materials and Methods

A toolbar frame was constructed with locally available mild steel materials. A pair of shovel type furrow opener was made and fitted to the toolbar frme. A bed shaper was also constructed and attached behind the furrow opener. A seed box with a metering device was also attached to the frame. The seed metering device was operated by a chain sprocket mechanism, which transmitted power from the tiller wheelbase. The bed planter was hitched to the power tiller. Detailed specifications are given in Table 1. The bed planter was tested at the experimental farm of Wheat Research Centre, Dinajpur for wheat, mungbean and maize cultivation in the year 2002. The bed planter was operated in the tilled soil. There could be two lines for wheat, two lines for mungbean and one line for maize per bed. Power tiller operated bed planter is shown in Fig. 1.



1. Toolbar frame
2. Furrow opener
3. Bed shaper
4. Seed box

Fig. 1. Power tiller operated bed planter.

Data collection: The following data were collected during the test. Regional Network of Agricultural Machinery (RNAM) test code was followed to collect the data.

i) Depth of seed placement (cm), ii) Travel speed (km/hr), iii) Effective field capacity (ha/hr), iv) Field efficiency (%), v) Fuel consumption (1/hr), vi) No. of plants/m^2, vii) Yield/m^2.

Table 1. Specification of the power tiller operated bed planter.

Name of different parts	Quantity	Dimension (cm)	Material
Toolbar frame	2	66 x 45 108 x 5	M. S. square
Furrow opener	2	size: 66 x 19 Shape: 18 x 22 x 0.50	M. S. sheet
Hiching Plate	1	26x24x2	M. S. plate
Seed box	1	90 x 25	Plain sheet
Seed tube	2	53 x 2.5	G. I. pipe and plastic tube
Shaper	1	120 x 36 **Bed size** Trapezoidal Top width: 33 Bottom width: 70	M. S. sheet
Clamp/holder	8	-	M. S. square
Chain sprocket	2	-	Aluminum
Toolbar frame nut bolt	8	15 x 1.25	High carbon steel

A. Seed rate calibration: Transparent polythene bags were tagged with each of the six seed delivery tubes. The seeder was operated on a pre-measured 20m run, seeds collected through tubes were weighed separately and the total seed weight was also noted. This method was repeated by acceleration and decelaration of the lever of seed meter until the desired seed rate obtained. The seed rate was determined through calculation by using the following equation (Michael and Ojah, 1978).

$$S_d = 10\ W_s/A_m$$

Where, S_d = Seed rate (kg/ha)

W_s = total wt. of seed (g)

A_m = measured experimental area, m^2

B. Travel speed: Two standing sticks fixed pre-measured distance. At the time of sowing, fixed distance passing time was recorded by stopwatch and simple calculation was done. RNAM test code was followed to collect data.

$$S = 3.6\ d/t$$

Where, S = travel speed (km/hr)

d = pre-measured distance, m

t = recorded time (sec)

C. Theoretical field capacity: Theoretical field capacity was calculated as follows (Kepner *et al.*, 1987).

$$TFC = \frac{W \times S}{10}$$

Where, TFC = theoretical field capacity (ha/hr)

W = width of the seeder (m)

S = travel speed (km/hr)

D. Effective field capacity: It is the actual field coverage of the seeder per unit time. Effective field capacity was calculated as follows (Kepner *et al.* 1987).

$$EFC = A/T$$

Where, EFC = effective field capacity (ha/hr)

A = total area sown by the machine (ha)

T = Total recorded time (hr)

E. Field efficiency: It is the percentage of the ratio of effective field capacity and theoretical field capacity (Kepner *et al.*, 1987).

$$\text{Field efficiency, Fe} = \frac{EFC}{TFC} \text{ x } 100$$

Where, Fe = Field efficiency (%)

F. Fuel consumption: The fuel tank was filled and re-filled before and after the sowing operation, respectively. Re-filled quantity was taken as the fuel consumption.

$$F_c = Fr/t$$

Where, F_c = fuel consumption (1/hr)

Fr = re-filled quantity of fuel (1)

t = seeding time (hr)

Cost calculation: Cost analysis was done on the basis of fixed cost and variable cost. The cost items were i) Purchase price of the machine, ii) Salvage value of the machine, iii) Machine life, year, iv) Bank interest rate, %, v) Yearly repair and maintenance cost, vi) Fuel & oil cost, vii) Operator charge.

A. Fixed cost:

i. Depreciation = (P – S)/L

Where, P = purchase price, Tk.

S = salvage value, L = life, year

ii. Interest on investment = $\frac{(P+S)}{2}$ xi

Where, i = bank interest rate, %

B. Variable cost: Variable cost was calculated on the basis of (i) repair & maintenance cost. (ii) fuel, oil cost, (iii) operator charge, Tk./day

Results and Discussion

Bed making and seeding operations were performed in one operation. The performances of bed planter are presented in Table 2. Furrow opener angle and shaper position play the main task of the planter. To maintain equal shape, size and straight bed, furrow opener angle and wing radius of curvature need to be accurate for both the furrow opener. The radius of curvature of the furrow opener wing was 58cm. The operational view of the bed planter and wheat field are shown in Fig. 2 and Fig. 3, respectively.

Fig. 2. Bed planter in operation.

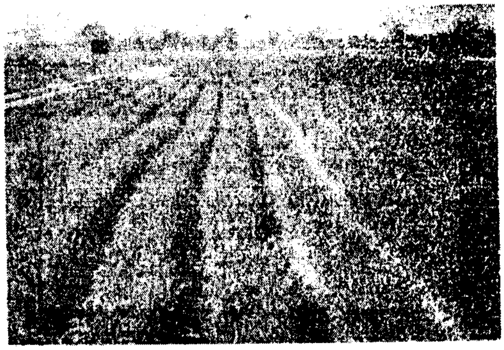


Fig. 3. Wheat field planted by bed.

The effective field capacity (0.10 ha/hr) of the planter was comparatively low for wheat sowing due to the lower travel speed compared to that of mungbean and maize sowing. Similarly the field efficiency of the machine was also higher (83.0%) during mungbean and maize seeding. This may be due to the use of the bed planter after modification in mungbean and maize sowing. It was observed from the field monitoring that growth of mungbean and maize on the bed were not hampered by excess rainfall. During the whole growing period, maize plants were not lodging in bed system. Fuel consumption of the machine was the same, at 1.2 lit./hr as normal tilling operation of the power tiller.

Table 2. Test performance of power tiller operated bed planter.

Parameters	Crop cultivation		
	Wheat	Mungbean	Maize
Bed shape and size (Top and bottom width), cm	Trapezoidal 40 x 70	Trapezoidal 33 x 70	Trapezoidal 33 x 70
Travel speed (Km/hr)	2.0	2.2	3.0
Effective field capacity (ha/hr)	0.10	0.11	0.14
Field efficiency (%)	70.0	83.0	83.0
Fuel consumption (l/hr)	1.2	1.2	1.2

Applied seed rates of wheat, mungbean and maize cultivation were 100, 30 and 20 kg/ha, respectively (Table 3), which were less than the recommended rate in conventional method. Depth of seed placement and line to line distance can be adjusted according to the agronomic requirement.

Plant establishment in the machine sown plots were same as the conventional one. Yield of wheat, maize and mungbean on beds were comparatively high than that of conventional once.

Table 3. Performance of crop cultivated by power tiller operated bed planter.

Parameter	Crop cultivation		
	Wheat	Mungbean	Maize
Seed rate (kg/ha)	100.0	30.0	20.0
Depth of seed placement (cm)	3.0-4.0	2.0-3.0	3.0-4.0
Plant population (m^2)	231.0	30.0	7.0
Yield (t/ha)	4.7	0.60	8.0

Cost curve was drawn according to the farm mechanization planning (Anonymous, 1991). Cost curve of yearly use of the machine is shown in Fig. 4. Cost per hectare utilization of the machine decreased as the cultivated land increased. It was estimated that 13 ha of land utilization is the break even point of the machine.

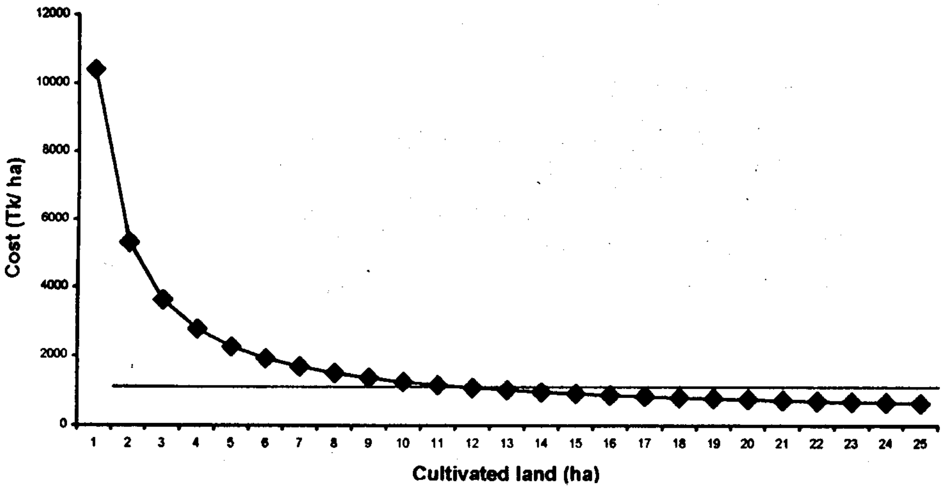


Fig. 4. Cost curve of the machine use.

Conclusion

Based on the results obtained in the field tests, following conclusions may be drawn:

i) An efficient low cost toolbar frame with multicrop seed metering mechanism can be assembled with the frame.

ii) Bed formation and seeding operation can be done in one operation by bed planter.

iii) The bed planter can be used for wheat, mungbean, maize cultivation successfully.

iv) The toolbar can easily be hitched with power tiller.

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