Bangladesh J. Sugarcane, **24-27** : *112-120* *July, 2005*

Development and Evaluation of a Power tiller Mounted Trencher for Sugarcane

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Received on 15.01.2006

ABSTRACT

A power tiller mounted trencher was designed and developed in Agricultural Engineering Workshop of Bangladesh Sugarcane Research Institute (BSRI), Ishurdi and its performance was investigated in the sugarcane field. The trencher is suitable to mount at the rear of the power tiller at the place of attaching trolley. The operator can run the power tiller sitting on the rear seat of the power tiller and can make trenches comfortably with the trencher. The trencher is suitable for making single trench at each run at a depth of 13-15 cm which is quite adequate for planting sugarcane setts. The operator can control the depth of trenches while running the power tiller and can also lift up the trencher bottom while making turn at the end of the field. The trencher can be used for making trenches as close as 0.75 m apart and the average field capacity is about 0.32 acre per day. The average cost of trenching is about Tk.2232.50 per acre which is about half of the cost incurred by spade with human labour.

Key words : Sugarcane, trencher, power tiller.

INTRODUCTION

Deep planting in rows is the most common planting practices for sugarcane all over the world. In Bangladesh, sugarcane is planted in deep trenches or furrows made by tractor drawn trencher only in some specific area such as Bangladesh Sugarcane Research Institute (BSRI) farm and in some sugar mills farms. In farmers' fields it is done by spade or by country plough drawn by bullocks or buffaloes. In the past, sugar mill authorities provided helps to the farmers with tractors, plows, harrows and trenchers, under mechanized sugarcane cultivation program of Bangladesh Sugar and Food Industries Corporation (BSFIC). Under this programme, about 10 to 12% sugarcane fields were prepared mechanically in mill zone area in the past (Hossain, 1992 and Hossain *et al.*, 1996). Presently there is no existence of the mechanized cultivation programme in sugar mill zone. The mill authorities were unable to continue the program due to some unavoidable mismanagement problems although the program was very helpful and encouraging for the sugarcane growers.

At present both in mill zone and non-mill zone areas many farmers have power tiller which they use for plowing their land with rotavator or for transporting their goods and farm products from field to home or from home to field or market. However, for making trenches they still use country plough or spade in order to plant sugarcane setts or settlings. Trenches made by country plough are usually very shallow and not suitable for planting setts or settlings. On the other hand, trenches made by spade are quite deep but

the task is very labour intensive, time consuming and consequently costly. Similarly tractor is also very costly and farmers cannot afford it. Therefore, there exists a need for the farmer to look for an alternative device of tractor, country plough or spade.

Presently power tillers are relatively cheaper than four wheeled tractor. There are about 20 thousand tractor and 300 thousand power tiller in Bangladesh that are being used for tilling 60-70% of the agricultural land (Satter *et al.*, 2005). However, farmers cannot use their power tillers for the purpose of trenching because they do not have any small trenchers suitable for power tiller. With this field level need of the sugarcane growers a power tiller mounted trencher was designed and fabricated to facilitate farmer to place their sugarcane setts or settlings in deep trenches for increasing sugarcane yield in the country.

MATERIALS AND METHODS

Design and Functional Consideration

The following considerations were taken up during the design of the power tiller mounted trencher.

1. Ease of attachment with the power tiller;
2. Ease of operation;
3. Ease of depth adjustment;
4. Ease of width adjustment;
5. Ease of trailing from home to field or field to home;
6. Locally available materials for manufacturing;
7. Cheaper and durable;

Considering the above design considerations, the following functional components were incorporated with the trencher:

1. One trencher bottom /Furrow opener was incorporated to make furrows;
2. A Space adjustment mechanism was included to adjust the distance between two furrows;
3. A depth control mechanism was incorporated to control the depth of furrows;
4. A trencher bottom lifting mechanism was incorporated to lift the trencher bottom during turning at the end of the field and trailing to or from the field;
5. A frame was fabricated to attach the above components with the trencher.

The functional components were designed and drawn by computer using AUTOCAD programme. For the fabrication of the trencher locally available material viz. mild steel (M.S.) angle bar, M.S. flat bar and M.S. sheet of different sizes were used. Galvanized iron (G.I.) pipes of different sizes, MS rod, rear wheel of power tiller, clutch cable of motor cycle and nut-bolt of different sizes were also used for the fabrication and attachment of the machine with a power tiller.

Performance Test of the Machine

The machine was tested in 3 fields of different sizes: 38 m x 23 m, 60 m x 41 m and 39 m x 35 m respectively. It was observed that the machine was not suitable for making trenches in the untilled field as well as in the field prepared/ tilled by tractor with disk plow or disk harrow. In the untilled field, engine of the power tiller became overloaded while in the deeply tilled field, excessive wheel slippage occurred. The machine was

performing well in the field tilled by power tiller with rotavator. Therefore, the selected fields were tilled using power tiller with rotavator. Observation and test data were recorded to enumerate the following test parameters.

Field capacity of the machine

Actual capacity and theoretical field capacity of the machine were calculated from the data obtained from the test. The theoretical field capacity of the trencher was calculated using the following formula (Kepner *et al.*, 1978)

$$Ctf = \frac{WS}{10} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, W is the width of cut (m) and S is the forward speed of the power tiller (Km/hr).

The actual field capacity of the trencher was calculated dividing the total area cut by the total time required. The field efficiency was also calculated dividing the actual field capacity by theoretical field capacity of the machine.

Depth of trenches : For measuring the depth of trenches, 5 trenches were randomly selected and the depth at two ends (leaving 1 m from side) and at the middle of the furrows were measured and the average depth was calculated.

Fuel Consumption : The developed trencher was mounted with a Dong Feng Power tiller powered by a 8.8 kW (12 ps) diesel engine. The fuel consumption of the machine was measured using top filling method and expressed in liter per hour (l/hr).

Ease of operation, depth and width control of the machine : Ease of operation of the power tiller with the machine as well as depth and width control of the machine were enumerated from the field observations and operators' opinions. For this purpose three (3) operators were selected and allowed to operate the power tiller with trencher in the fields and their opinions were recorded, discussed and considered.

Ease of turning of power tiller at the end of the field : For making easy turn at the end of the field a trencher bottom lifting mechanism was incorporated with the trencher. Ease of the power tiller operation was evaluated from the observations and operators' opinions.

Cost of trenching: Cost of trenching for unit area was estimated adding operational cost with the overhead cost (fixed cost) of both the power tiller and the trencher. Purchase price of power tiller and trencher was taken as Tk.50,000.00 and Tk.10,000.00 respectively. Depreciation was calculated following straight line method assuming salvage values and economic life of both the power tiller and the trencher were 10% of the purchase price and 10 years respectively. Fifty percent (50%) of the total usages of the power tiller and cent percent (100%) of the total usages of the trencher were considered for trenching operation. Considering one month (30 days) as plantation period of sugarcane annual trenching area was assumed to be 8 hectare (20 acres). Annual depreciation of both power tiller and trencher calculated by straight line method are given in the Table 1.

RESULTS AND DISCUSSION

Mechanical details of the machine :

A schematic view of the trencher and views of the major components /parts of the trencher are shown in Figure 1 and Figure 2 respectively. The machine consists of a frame, one furrow openers, and two guide and depth control wheels at the back. Original driver's seat of the power tiller is incorporated with the machine with little modification. The main frame of the machine is made of mild steel (M.S.) angle bar of different sizes. The trencher bottom or furrow opener is made of M.S. sheet of 3 mm thick. The details of the materials together with the cost involved are given in the Table 2.

The fabrication cost of the machine was about Tk. 10,000.00 which seems to be little higher. This is due to higher price of M.S. angle and M.S. flat bar in the present market. The cost of the machine might be reduced to some extent with the fabrication of a large number on commercial basis.

Performance Test of the Machine :

The developed power tiller mounted trencher was run in the fields to evaluate its performance in the fields. The trencher attached with the power tiller and in operation are shown in Figure 3 and Figure 4 respectively. The field capacity, field efficiency and depth of cut of the machine obtained from the test are given in the Table 3.

Theoretical Field Capacity : Theoretical field capacity (TFC) of the trencher was found to be 0.71 ha per day of 8 hours (0.09 ha/hr) (Table 3). TFC is dependent on width of cut of the machine and forward speed of power tiller. So, it is always same in all field sizes for a particular width of cut and forward speed.

Actual Field Capacity : Actual field capacity (AFC) is the actual rate of field coverage per unit of time and is expressed as ha/day. Average AFC of the developed trencher was found to be 0.32 ha/day which ranged from 0.29 to 0.36 ha/day (Table 3). AFC largely depends on the field sizes unlike TFC. Running the machine along the longer direction of the field requires less turn to complete the field. Thus the AFC is more when the machine is run along the longer direction of the field than when it is run along the shorter direction.

Field Efficiency: The field efficiency of the trencher was calculated as 45% which ranged from 41% to 50% (Table 3). The lower field efficiency of the trencher indicates excessive time loss during operation. Time loss occurred during turning at the ends or due to some troubles occurred during operation.

Depth of trench : Depth of trench is the depth of the trench bottom from the field surface. Average depth of trench was found to be 13-15 cm in clay soil (Table 3). In light soil (loamy or sandy loam) the depth of trench might be increased.

Fuel consumption: The trencher was mounted with a Chinamade power tiller during test which was powered by a 8.8 kW diesel engine. The average fuel consumption of the engine as measured during test was found to be 1.5 liter per hour (Table 3).

Ease of operation, Depth control and width control of the machine : During operation it was very important to run the power tiller so as to make the trench straight along the side of the field. Out of the three operators one was very experienced in driving tractor and power tiller and could make the trench very straight as shown in the Figure 4. Two other operators who had little experience in power tiller driving could make straight trench but not as good as the first one. However all of the operators expressed their opinions such as that after few days of operation they would be able to make very accurate straight trench in the field.

Depth control of the trencher was made by downing or raising the trencher bottom and fixing it with the frame. Depth could also be controlled by lowering or raising the guide wheel of the trencher. All the operators opined that depth control mechanism of the trencher was very good and they could operate it with comfort.

Distance of the trench could be varied from 0.75 m to 1.00 m or more. Usually sugarcane is planted in trenches at a distance of 0.75m in the farmers' fields and 1.00 m in the experimental fields. Therefore, the trencher would be suitable for the farmers as well as researchers for planting sugarcane in the field.

Ease of turning of power tiller at the end of the field : For making trench it was not necessary to make any direct turn of the power tiller. At the end of the field the power tiller was stopped and backed, and then taking a turn, the power tiller was placed for making next trench. During this process, the trencher bottom was lifted up by using a trencher bottom lifting mechanism. All the operators experienced little difficulty to operate the trencher bottom lifting mechanism at the beginning. However, after running few turns they were used to operate the mechanism with comfort.

Cost of trenching : Cost of trenching by the power tiller mounted trencher as given in Table 4 is about Tk.2232.50 per hectare. Trenching by spade using human labour requires about 60 labours per hectare which costs about Tk.4500.00. Therefore, cost of trenching by power tiller mounted trencher is almost half of the cost incurred by human labour with spade.

CONCLUSION

From the design and functional considerations undertaken in the fabrication of the trencher together with the performance test and opinions of the operators it was assured that the developed power tiller mounted trencher performed well to achieve the desired objectives to provide better service to the sugarcane growers. In conclusion, the salient features and effectiveness of the developed trencher can be briefly outlined as follows:

1. The trencher can be mounted with nut-bolt at the back of the power tiller, where trolley is attached, without any modification of the power tiller;
2. Driver or operator can run the power tiller sitting on the rear seat and can make trenches;
3. The trencher can make single trench /furrow at each run;
4. The operator can control the depth of trench while running the power tiller. The trenches can be made at a depth of 13-15cm.
5. Distance between two trenches can be made as close as 0.75 cm or more as required;
6. Either rubber wheels or iron wheels can be used with the power tiller while trenching;
7. The capacity of the trencher is 0.32-0.36 ha per day;
8. Manufacturing cost of the trencher is about Tk.10000.00 (taka ten thousand);
9. Cost of trenching is about Tk.2232.50 per ha;

Hence, the developed power tiller mounted trencher can be profitably used by the farmers for planting sugarcane setts or settlings in the fields.

Table 1. Calculation of annual depreciation of power tiller and trencher.

Item	Purchase Price	Economic Life	Salvage value	Percent considered	Annual Depreciation (Tk.)
Power tiller	50,000	10	10%	50%	2250
Trencher	10,000	10	10%	100%	900
Total					3150

Table 2. Materials required for the fabrication of the power tiller mounted trencher, 2004-05.

Sl. No	Name with Specification	Quantity	Rate (Tk.)	Total (Tk.)
1	Angle bar (76 mm x 76 mm x 5 mm)	1900 mm (15.58 kg)	40.00	623.00
2	Angle bar (38 mm x 38 mm x 4 mm)	5340 mm (26.28 kg)	40.00	1051.00
3	Flat bar (38 mm x 4 mm)	3588 mm (4.70 kg)	38.00	179.00
4	Flat bar (51 mm x 4 mm) (for raiser grip)	380 mm (0.62 kg)	38.00	25.00
5	Flat bar (51 mm x 25 mm) (for trencher bottom)	800 mm (6.56kg)	40.00	265.00
6	MS Sheet (10 mm thick) (for attachment box)	160 mm x 130 mm	-	200.00
7	MS Sheet (3 mm thick) (for trencher bottom)	480 mm x 350 mm	-	215.00
8	GI Pipe (51 mm dia)	1350 mm (1.35m)	290.00	392.00
9	GI Pipe for handle (25mm dia)	150 mm (0.15m)	150.00	20.00
10	MS Rod (12.7 mm dia)	320 mm (0.32 kg)	100.00	30.00
11	Wheel (Rear wheel of power tiller)	2 No.	1000.00	2000.00
12	Wheel fork for rear wheel of power tiller	2 No.	900.00	1800.00
13	Clutch cable of Motor cycle	1 meter	100.00	100.00
14	Nut Bolt (9.4 mm dia x 51 mm long)	20 No.	20.00	400.00
15	Workshop cost (cutting, welding, finishing etc.)		2700.00	27000
16	Total cost of fabrication of power tiller mounted trencher			10000.00

Table 3. Field capacity, field efficiency and depth of cut of power tiller mounted trencher, 2004-2005.

Sl. No.	Field size	Theoretical field capacity (ha/day)	Actual field capacity (ha/day)	Field efficiency (%)	Depth of cut (cm)	Fuel consumption (l/hr)	Soil type
1	38 m x 23 m	0.71	0.29	41	13-15	1.4	clay
2	60 m x 41 m	0.71	0.36	50	13-15	1.6	clay
3	39 m x 35 m	0.71	0.32	45	13-15	1.5	clay
	Average	0.71	0.32	45	13-15	1.5	

Table 4. Cost of trenching by power tiller mounted trencher, 2004-2005.

Item	Calculation	Total annual cost (Tk.)	Cost per hectare (Tk.)
Depreciation	From Table 1.	3150	393.75
Interest (@5%)	0.05 x (60,000 + 6000)	3300	412.50
Repair, maintenance & lubrication (@3%)	(0.03 x 50,000)/2 + (0.03 x 10,000)	1050	132.25
Fuel (@ Tk.25.00/l)	((1.5 x 8) / 0.32) x 25		937.50
Oil (@ Tk.40.00/l)	((1.5 x 8) / 0.32) x 0.03 x 40		45.00
Operator @Tk.100.00/day)	100 /0.32		312.5
Cost / hectare			2232.50

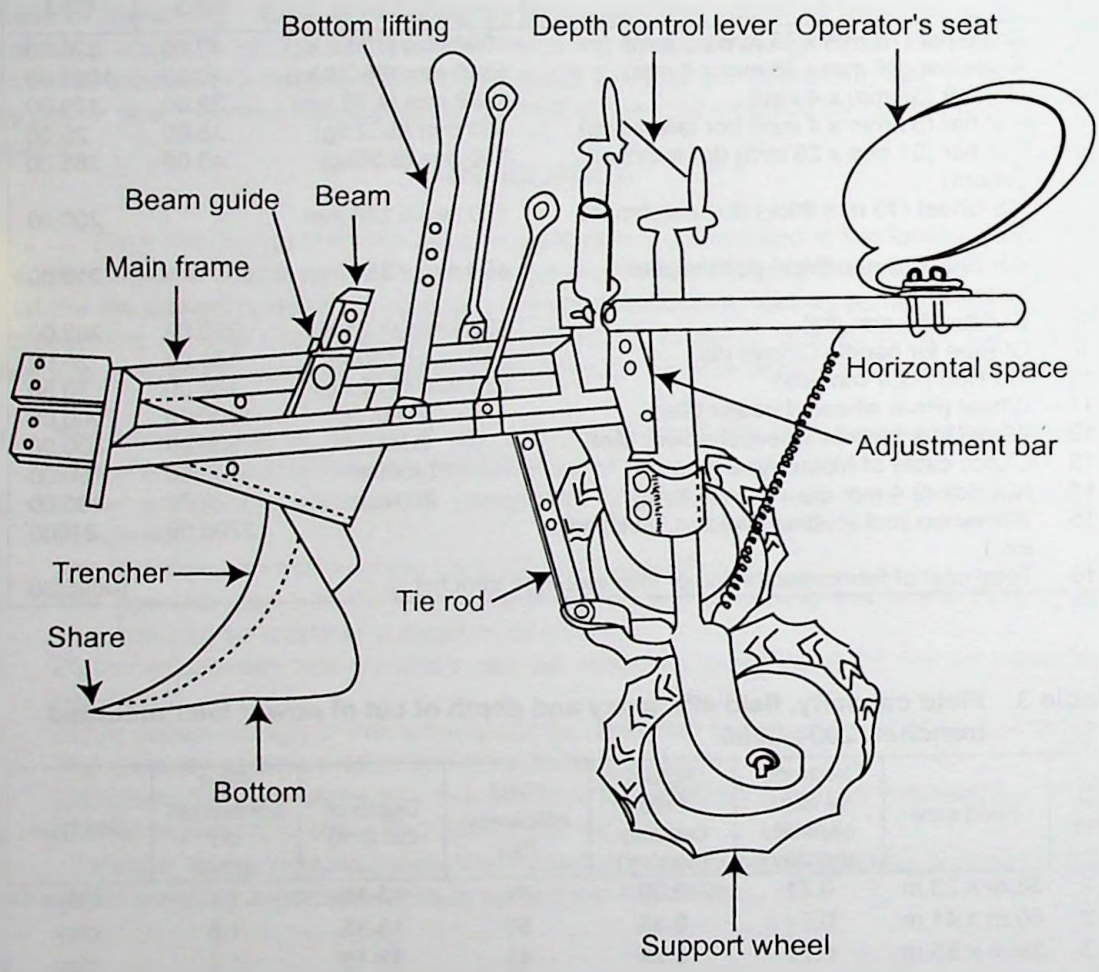
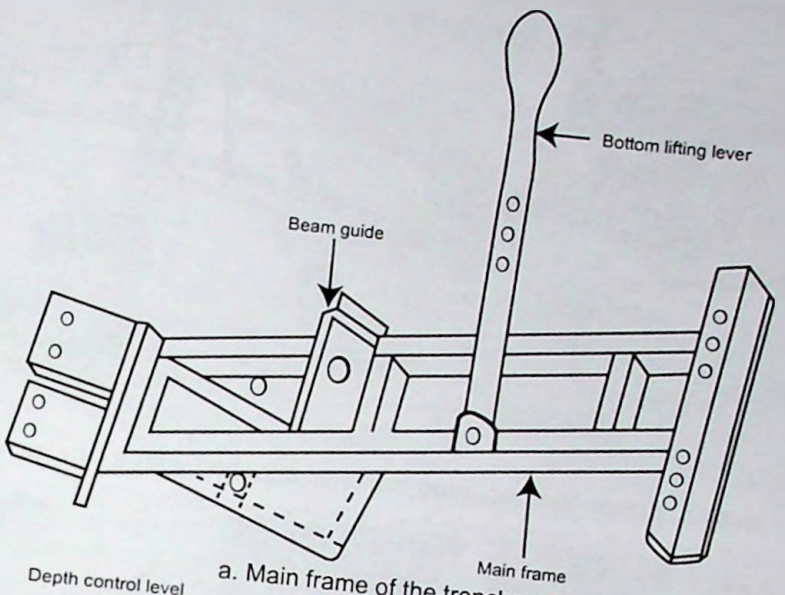
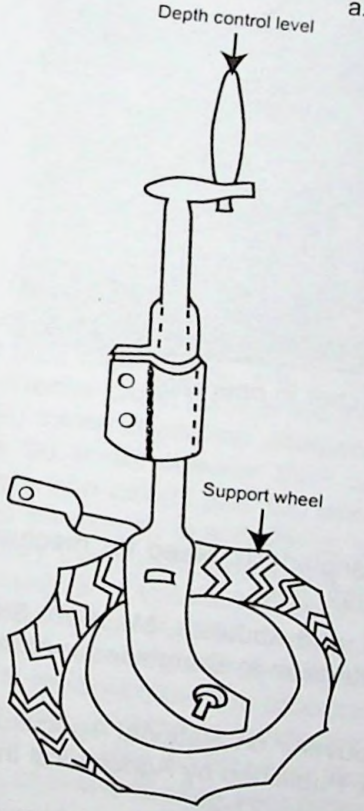


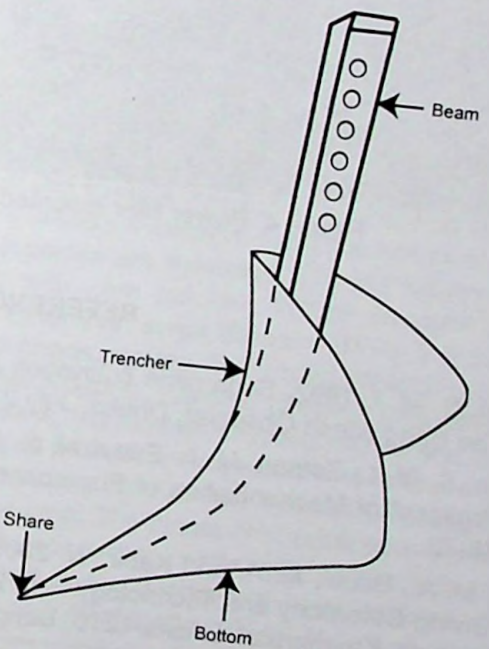
Figure 1. Schematic view of the power tiller mounted trencher



a. Main frame of the trencher



b. Depth control mechanism



c. Trencher bottom

Figure 2. Major components/parts of the power tiler mounted trencher

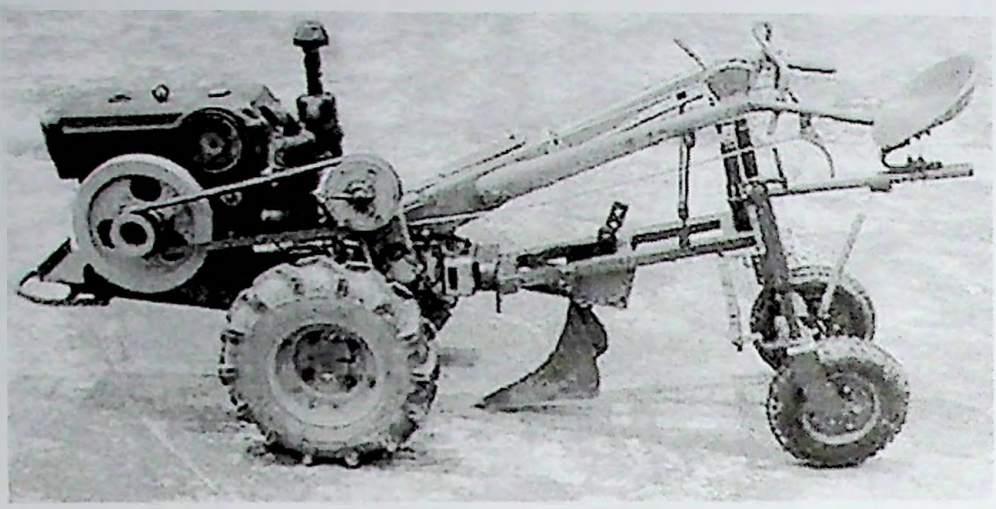


Figure 3. Power tiller mounted trencher attached with a power tiller

Figure 4. Power tiller mounted trencher in operation

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