J. Agric. Mach. Bioresour. Eng. 5(1&2), 2009 : 85-90

ISSN 1993-4041

Performance Study of A Power Tiller Mounted Plate Sheet Leveler

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Abstract

The study was carried out to develop a power tiller mounted leveler and to evaluate the field performance of leveler at the Bangladesh Agricultural University Farm. Leveler was fabricated by locally available material. A 12-hp diesel engine was used to operate power tiller mounted leveler. Field capacity, field efficiency, leveling index, clod size, uniformity of field, fuel consumption, specific fuel consumption, cost of operation were determined on the basis of RNAM test code. The effective field capacity and field efficiency for leveler in the field were 0.09 ha/hr and 71.6%, for dry land and 0.08 ha/hr and 68.10% for wet land respectively. The fuel consumption for dry and wet land was 1.56 L/hr and 1.62 L/hr respectively. Leveling uniformity coefficient was 86.7% and leveling index in the different plots of field were 18.75%, 31.25%, 31.25% and 18.75% according to the range of average clod size 16-20mm, 20-23mm, 23-27mm and 27-30mm respectively.

Key words : Power tiller, Leveler, Performance

1. Introduction

Bangladesh is predominantly an agricultural country in which majority of the people earn their livelihood from farming activities related to agriculture. In Bangladesh the greatest contribution of Agricultural mechanization is in the field of land cultivation and irrigation, which has directly contributed to increase cropping intensity during the last decades. These can increase agricultural productivity, better yield, through improvement of timeliness of operation and quality of land preparation, minimization of production cost, better seed placement, better cultural and intercultural operations. Land leveling is one of the basic and costly phases in design and construction of irrigation and drainage projects.

Power tiller is being widely used all over the country. Though the power tiller is widely spreading but there are scarcities of tools and machines to increase its versatile use. The farmers are still using the bamboo made leveler with bullock for the land leveling. Power tiller mounted leveler can replace bullock driven leveler. Tractor mounted leveler are used at the field level, however the adoption of tractor is limited where power tiller is available. Power tiller mounted leveler can be used for improved cultivation, breaking clods, burying weeds and to improve leveling uniformity of the field. Gradually scarcity of draft animal is increasing and therefore farmers are facing problems of land preparation especially during the peak period. Power tiller mounted leveler may be a solution and can be used for the cultivation of Aus, Aman, Boro, HYV-Aman, Jute Tobacco, Potato, Wheat, Mustard, Pulse and vegetables. Wohab (2003) designed and developed a power tiller operated seeder which has a roller type leveler. This power tiller operated seeder simultaneously till the soil place the seed and compact and level the soil. Chaudhuri *et al.* (2007) evaluated the performance of laser guided land leveler for land leveling and grading operations to determine its effect on water requirements and yield of selected crops. Comparison was made with fields in which leveling/grading was done conventionally with drag scraper and also with unleveled fields. The standing deviation of reduced levels and leveling index values ranged from 0.43 to 0.50 cm and 0.29 to 0.34 cm. respectively. Khatib (2000) studied the effect of tillage systems on laser land leveling efficiency. The land leveler used was 3 meters in width, 770 kg in weight and 1.275 m3 in size, with a local plough (7 shares) and an offset disc harrow (US made). In India a power tiller front mounted leveler is developed for land leveling, terracing and bund forming. The unit consists of 1.0 m wide curved mild steel blade with a steel cutting edge at the bottom. It is attached to the front of the power tiller with the help of a mounting plate. No leveler is available for leveling the soil after tilling by power tiller. So attempt was taken to develop a power tiller mounted leveler with locally available materials with the following objectives:

1. To design and fabricate a power tiller mounted leveler.

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2. To test and evaluate the performance of the leveler in the field condition.
3. To identify the problems and constraints faced by the power tiller mounted leveler.

2. Materials and Methods

2.1 Fabrication of power tiller mounted leveler design consideration

The following factors were considered in the design of power tiller mounted leveler:

i. Simultaneous operation in tilling and leveling
ii. Made with locally available materials in local engineering shops
iii. Light in weight and easy to mount at the backside of the power tiller
iv. Convenient with the width of frame of power tiller
v. Low cost.

2.2 Fabrication of leveler and mounting with power tiller

The leveler was fabricated with locally available materials and was simple in construction. The specification of the leveler is shown in Table 1. The different materials used in the fabrication of the leveler were-M.S. angle bar, M. S. Plate Sheet, M. S. Shaft, Clamp, M. S. Rod etc. The different functional parts were assembled in the main frame of leveler. The leveler was attached to the rear main lever wheel shaft of the power tiller. The inclined angle bars were adjusted with some holes on the horizontal angle bar for operational ease while traveling on the road. The leveler adjustment condition was controlled by power tiller. The two dimensional AutoCAD drawing and field test of leveler are shown in Figure 1 and 2 respectively. The weight of plate sheet leveler was 20 kg.

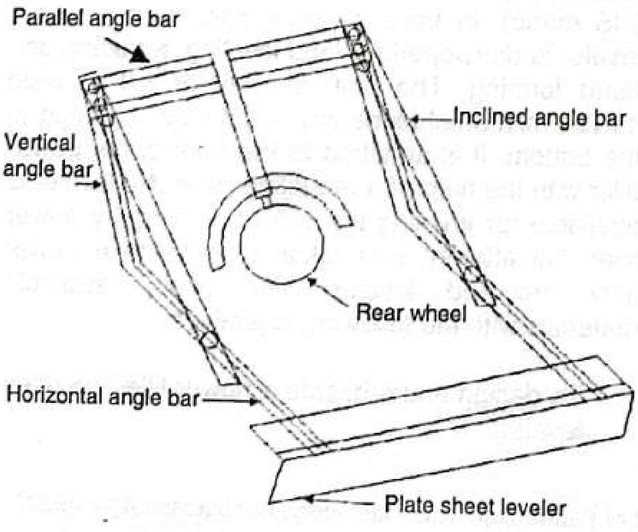

Fig. 1. Power tiller mounted plate sheet leveler

Table 1. Specification for power tiller mounted leveler

Items	Specification
Length, mm	1067
Width (thickness), mm	6
Height , mm	254
Weight of leveler, kg	25
Vertical angle bar, mm	609
Horizontal angle bar, mm	945
Inclined angle bar , mm	915
Parallel angle bar with clamp, mm	396
Number of clamp	1
Adjustment of leveler possible condition	Up and down
Nuts and bolts	16
Weight of leveler, kg	20

2.3 Procedure of field performance test of the power tiller mounted leveler

The plane method is used for land leveling. Field performance test of the power tiller mounted leveler was conducted at BAU Farm on 30 May to 13 September 2007. During testing of power tiller mounted leveler the following procedures were undertaken.

1. Engine fuel and oil were checked.
2. The plot was measured by measuring tape.
3. Power tiller mounted leveler sheet was properly attached with clamp , nuts and bolts etc.
4. The engine was started in releasing the belt tension by idler pulley and keeping the gear in neutral position.
5. Experiment was conducted at 2000 rpm of the engine.
6. Leveler was set up according to the field tillage condition and moisture.
7. Time losses were recorded.
8. The fuel consumption was recorded by the filling of fuel tank after completion of operation.
9. Total time was recorded after completion of leveling of plot.

2.4 Determination of performance parameters

The following parameters were determined for evaluating the performance of the leveler. Procedure and technology adopted for measurement, recording and computations of various parameters are as follows. a) Labour requirement of machine for leveling, b) Field Efficiency,

$e_f = \frac{C_e}{C_t} \times 100$, c) Fuel consumption, d) Specific fuel consumption, e) Uniformity of coefficient in the field, f) Leveling index and g) Cost of operations.

Fig. 2. Field test of power tiller mounted leveler

2.5 Uniformity coefficient of clod size

A measurable index of the degree of uniformity obtainable for any clod size of soil is known as the uniformity coefficient. This uniformity coefficient is indicated quantities of field condition. Uniformity coefficient depends on the power tiller tillage capacity, pressure of leveler on the soil, soil moisture, and depth of tillage, field pattern and shape.

The coefficient is computed from field observations of the leveling qualities of field at regular intervals within a field area. It is expressed by the equation developed by Christiansen (1942).

$$C_u = 100(1 - \frac{\sum X}{MN})$$

where,

C_u = Uniformity Coefficient

M = Average value of all observations (clod size of soil) mm.

N = Total number of observation points

X = Numerical deviation of individual observations from average clod size, mm.

A uniformity coefficient of 100% (obtained with overlapping leveling) is indicated of absolutely uniform leveling, as where the leveling is less uniform with a lower percentage. A uniformity coefficient of 85% or more is considered to be satisfactory.

2.6 Leveling Index

Leveling index indicates quantities of satisfying condition of field by the leveling. This index will depend on the size, shape, and number of clods and will be represented by different color.

2.7 Cost analysis

The cost of operation the power tiller mounted leveler was computed using the following equations involving the fixed and variable cost items

Fixed costs: Fixed cost is independent of use. Fixed costs items included are: depreciation (D), interest on the machinery investment (I), taxes (T), insurance (In) and shelters (S).

(i) **Depreciation:** Depreciation, often the largest cost of farm machinery, measures the amount by which the value of a machine decreases with the passage of time, whether in use or not. Rate of actual depreciation depends on the useful life of the machine. This depends on operating conditions, design and quality of materials used in machine manufacture, adjustment and repairs. Value declines, as a result of natural wear, obsolescence, damage, corrosion and weathering. In this study the following procedure was applied to calculate the yearly depreciation rate. In calculation of fixed cost a straight-line depreciation is assumed and the following equation was used:

Annual depreciation, $D = \frac{P-S}{L}$

where,

D = depreciation, Tk./yr.

P = purchase prices of leveler, Tk.

S = salvage value, Tk.

L = life of leveler, yr

(ii) Interest on investment cost:

Interest on investment, $I = \frac{P+S}{2} \times i$

where,

i = rate of interest

(iii) Tax and insurance: These are minor items in the total fixed cost but it should be included in farm machinery against losses. To simplify the calculation, an annual charge equal to 3% of the new cost is considered.

a) *Tax and insurance,* $T = P \times t$

Where,

T = annual taxes

t = taxes and insurance rate, decimal.

2.8 Variable cost

Operating cost of a power tiller mounted leveler is reflected by the cost of fuel, daily service and labor used by the power source.

(i) **Operator/ Labor cost:** Operations of the machine require one operator. The charge of the unskilled labor required to assist in the operation of the machine, is also included in the cost operation. The cost of labor varies from place to place. For owner labor operators labor cost should be determined from opportunity cost for the owner. For a hired operator a constant hourly rate prevailing in the country should be appropriate.

a) *Labor cost L, Tk/ man-hr*

(ii) Fuel and lubricant cost: Factors affecting fuel cost are (i) the prevailing market price, (ii) engine condition, (iii) load factor or ratio of used power to available power. Proper lubrication and the use of good quality lubricants are very important in reducing wear and repair costs of a leveler.

b) Fuel cost per hour, *F = liter/hr*

c) Lubricant/oil cost per hour, *0 = 3% of fuel cost.*

(iii) Repair and maintenance cost:

d) Repair and maintenance cost per year, RPM = 3.5% of purchase price.

(iv) Cost of leveler:

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

$$AC = \frac{FC\% \times p}{100} \times + A/C\,[(R\,\&\,M) \times P + L + O + F]$$

Where,

AC = Annual cost of operating the leveler Tk/year
FC% = Annual fixed cost percentage
P = Purchase price of the power tiller mounted leveler Tk
A = Annual leveling area, ha
C = Effective field capacity of the leveler ha/hr
R&M = Repair and maintenance cost, Tk/hr
L = Labor cost, Tk/hr
O = Oil costs, Tk/hr
F = Fuel costs, Tk/hr

3. Results and Discussion

The field performance data for both dry and wet land are presented below:

The power tiller mounted leveler was tested for both dry and wet land conditions. Table 2 listed the field performance parameter. The field capacity of power tiller mounted leveler in dry land was found to be 0.09 ha/hr and field efficiency of 71.6% when gear position was in two. The forward speed of the power tiller was 2.06 km/hr, fuel consumption was 1.56 L/hr and specific fuel consumption 174 ml/kw-hr. The field capacity and field efficiency of power tiller mounted leveler in wet land was found to be 0.08 ha/hr and 68.10% respectively. The forward speed and fuel consumption was 1.91 km/hr and 1.62 L/hr respectively. Leveling cost was found to be Tk. 19/hr (Table 3). Therefore cost of leveling per ha was Tk. 211 for dry land and Tk. 237 for wet land.

The field capacity and field efficiency of the power tiller mounted leveler was found different in dry and wet land. But the fuel consumption in wet land is higher than that of dry land. So, power requirement was higher in the wet land for both tilling and leveling operation.

3.1 Uniformity coefficient of clod size in the field

The uniformity coefficient was computed from field observation of the leveling abilities at regular intervals within a field area. The uniformity coefficient was found to be 86.7%. A uniformity coefficient of 85 percentages or more is considered to be satisfied (Michael 644). As the result was found higher than 85% it can be said that uniformity of leveling is found to be satisfactory. Table 4 shows the values of M (average value of all observations clod size of soil, mm) and X (numerical deviation of individual observations from average clod size, mm.

Leveling index of the field: The quality of satisfying condition of field by the leveler according to the clod size in the field is indicated by different color is shown in Fig.3 and uniformity of each plot is shown in Table 5.

3.2 Problems faced during operation

As there is no hydraulic system of lifting leveler, operator faced problem during turning at the end of the bout. Although there is mechanical system of lifting but it takes long time to lift leveler. So it is necessary to down the speed at too low during turning to avoid high frictional resistance with the soil. Mechanical lifting system is used to lift the leveler during road transport.

Another problem was faced during wet land tilling. Wet soil creates high resistance giving over load on the engine observed by black smoke in the exhaust. A roller type of leveler will be helpful to reduce this resistance and turning problem.

Table 2. The field performance parameter of power tiller mounted leveler at dry and wet land

No.	Item	Data(Dry land)	Data (wet land)
1.	Area of field (ha)	0.07	0.07
2.	Engine speed (rpm)	2000	2000
3.	Forward speed (km/hr)	2.06	1.91
4.	Total time (min)	62	70
5.	Time loss (min)	16	18
6.	Actual operating time (min)	46	52
7.	Total fuel required (liter)	1.2	1.4
8.	Theoretical field capacity (ha/hr)	0.13	0.12
9.	Effective field capacity (ha/hr)	0.09	0.08
10.	Field efficiency (%)	71.6	68.10
11.	Fuel consumption (L/hr)	1.56	1.62
12.	Fuel consumption (L/ha)	17.49	20.41

Table 3. Estimated total cost of power tiller mounted leveler in the field

Fixed cost	Tk
(i) Depreciation	Tk. 900/yr
(ii) Interest	Tk. 500/yr
(iii) Taxes, insurance & shelter	Tk. 0/yr
(v) Sub total fixed cost	Tk. 1400/yr = 3.86/hr
Variable cost (Tilling and leveling)	
(i) Fuel cost	Tk. 52/hr
(ii) Oil	Tk. 7/hr
(iii) Labor cost	Tk.30/hr
(iv) Repair & Maintenance	Tk. 7/hr
(v) Subtotal variable cost	Tk. 96/hr
Grand total leveler cost (I+II)	Tk. 99.86/hr
Variable cost (leveling)	
(i) Fuel cost	Tk. 17/hr
(ii) Oil	Tk. 2/hr
(iii) Leveling cost	Tk. 19/hr

Source: Hunt, (1995)

Fabrication cost of leveler is Tk. 5000 and machine life is 5 years.

Table 4. Uniformity coefficient of clod size in the field by power tiller mounted leveler

Plot	M (mm)	Average M (mm)	X (mm)
1	22-26	24	4
2	20-23	21.5	3
3	20.6-23.2	21.9	2.6
4	23-26.3	24.65	3.3
5	19-22	20.5	3
6	19.8-23.4	21.6	3.6
7	24-26.8	25.4	2.8
8	23.9-28.8	26.35	4.9
9	26-28	27	2
10	16.4 -16.8	16.6	0.4
11	16-21	18.50	5
12	27-31	29	4
13	29.2-32.4	30.8	3.2
14	23.2-27	25.1	3.8
15	283-31.4	29.85	3.1
16	26.4-29.8	28.1	3.4

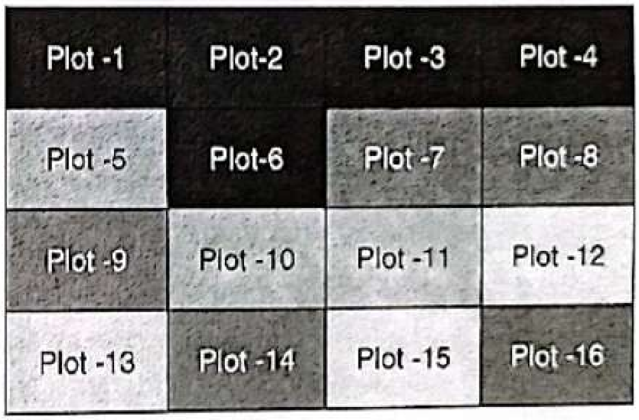

Fig. 3. Plots of the field showing the leveling index by color

Table 5. Leveling index in the field

Range of average clod size, mm	Colour	Items	Percentage (%)
16-20		3	18.75
20-23		5	31.25
23-27		5	31.25
27-30		3	18.75
Total	=	16	100

4. Conclusion

The study was undertaken to develop a leveler tools for the ease of agricultural operation, to improve timeliness, to minimize, energy and compaction of soil by performing the tilling and leveling in a single pass two individual field tests were undertaken for dry and wet land. Theoretical field capacity, Effective field capacity, Field efficiency and Fuel consumption were 0.13 ha/hr; 0.09 ha/hr, 71.6 % and 1.56L/hr respectively for dry land conditions. Again in the wet land conditions: Theoretical field capacity, Effective field capacity, Field efficiency and Fuel consumption were 0.12 ha/hr, 0.08 ha/hr, 68.10% and 1.62 L/hr respectively.

In the dry condition, the uniformity coefficient was 86.7% which indicate that satisfactory uniform leveling of clod size. The leveling index in the different plots of field were 18.75%, 31.25%, 31.25% and 18.75% according to the range of average clod size 16-20 mm, 20-23 mm, 23-27mm and 27-30 mm respectively. The fabrication cost of plate sheet leveler was low and reduces the operational time and save cost over traditional methods.

5. Recommendation and future study

From the findings of this study mechanical leveler was found suitable and recommended for the rural farmers. To extend the benefits of mechanical leveler among the farmer's appropriate adoption and dissemination programme must be carried out all over Bangladesh. A comparative study may be carried out with the cylindrical leveler. Field demonstration should be done for popularizing the leveler among the farmers.

References

Chaudrurl D, Mathankar S K, Singh, V V, Shirsat, N A, Dubey U C (2007). Performance evaluation of laser guided land leveler in versisols. Journal of Agricultural Engineering New-Delhi, 44(2), 1-7.

Christian J E (1942). Measuring the uniformity coefficient of water caught at regular interval within a sprinkled area. University of Califonia, Agri. Expt. Stn. Berkely. 91 p.

Hunt D (1995). Farm Power and Machinery Management, 9th edition, LOWA, State University, Press Ames, 67-77.

Khatib S I (2000). Effect of tillage systems on laser land leveling efficiency. Arab Universities Journal of Agricultural Sciences, 8(1), 31-40.

Wohab (2003), Designed and developed of a power tiller operated minimum tillage seeder by available materials. An ms thesis paper. Submitted to the department of FPM, BAU, Mymensingh, Bangladesh.