

DEVELOPMENT AND EVALUATION OF AN ELECTRIC LAWN MOWER

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ABSTRACT

An electric operated lawn mower was developed and was evaluated in the Botanical garden of Bangladesh Agricultural University. The effective field capacity and the cutting efficiency of the mower using cutter with three blades were 0.02148 ha/hr and 99.4% respectively. While the effective field capacity of the mower using cutter with two blades and twisted steel wire were 0.01934 ha/hr and 0.0154 ha/hr, respectively. The cutting efficiency of the mower using cutter with two blades and twisted steel wire were 98.4% and 86.1%, respectively. The results indicated that the lawn mower using cutter with three blades could be used with high satisfaction.

INTRODUCTION

Bangladesh, the largest delta in the world is situated between 88°1' and 92°41' East longitudes and between 20°34' and 26°38' North Latitudes. The mean temperature varies from 29.4°C to 35°C. Due to the position of Lofty Himalayan Mountains and its branches. It enjoys monsoon climate from May to September. About 60% of the total precipitation of 2032 mm to 2082 mm (BBS, 94) occurs during June to August. The land is very fertile and the climate is very favourable for the growth of grass and vegetative crops. It is observed that the growth of grass is 4-5 mm/day in Bangladesh. The lawns, play grounds and gardens need to be cut grass least once a week. A lot of money and time has been spending to perform this tedious, labor intensive job.

Literature search indicated that numerous work on harvester and mower have been performed in the past, however almost all the machine developed were found to be of high capacity and costly. Vogl (1961) studied the fingerless cutter and found that knife with hollowed section had better performance when met with obstacles and was not easily damaged. Fomin (1962) investigates the cutting of grasses without a counter bar. He observed that the force required to cut lucerne at a cutting speed of 40 m/s is 0.008 kp and that less force was required to cut grass without counter edge. Harbage and Morr (1962) developed a

ten foot mower. He found that greater throughput could not be achieved by operating the reciprocating knife at higher speed. Shotmpel (1963) studied the technical process of cutting grasses with rotary mowers. Agarwal (1976) developed an experimental type trail mower. He used mild steel chains of different sizes, orientation of the trails, peripheral speed of chains and moisture content of plants of trails. The performance of the mower for cutting napier grass and common grass was stated to be satisfactory. Person (1993) developed a rotary mower and tested in the field. It consisted of sets of two concentric counter rotating discs, one with collecting counter shear finger and one with knives in close contact with the counter shears. Numerous modifications were made during the field test.

Diesel and petrol engine operated mowers have been using to cut the grass for a long time. Diesel or petrol engine operated mower is very costly, difficult to operate and maintain and sometimes proved to be very troubleshooting. Purchase price of the engine mower is very high.

Manually operated push type mower is very hard to push for a man of average weight. Initially, it works well finally it is very laborious, and time consuming and consequently become costly. The field capacity of the mower is also very small. Manual operation with sickle is very slow, time consuming, labour intensive and tedious job.

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GOB has already been taken a program to electrify all the villages of the country by 2005. All cities, towns and 16273 villages (BBS, 1994) have already been electrified. The lawns, play grounds and garden of various institutes are situated where electricity is available.

An attempt has been made to develop an electric lawn mower with a view to reduce cost. The specific objectives of the work were;

- 1) To develop an electrically operated lawn mower, and
- 2) To evaluate the mower in the field.

MATERIALS AND METHOD

Power Selection

The literature search indicated that the specific power requirement for cutting lawn grasses was about 1.6 kW/m of cutting width (Person, 1993). The specific power requirement of 1.82 kW/m has been considered for the development of the mower. The recommended peripheral velocity for cutting grass ranges from 27 m/s and 28.5 m/s (Brenner and Grimm, 1963). The rpm of the motor was chosen at 2900 which provide a peripheral velocity 30.82 m/s. To meet the power requirement and peripheral velocity and to cut the grass successfully, a single phase induction motor of 0.370 kW (0.5 hp) with 2900 rpm was selected.

Cutter Blade Selection

Mild steel plate of 203 mm length, 25 mm width and 1 mm thickness has been used to fabricate the cutting blade of the mower. This dimension was selected by considering the power and velocity requirement of the mower.

Three types of grass cutter were fabricated in the workshop of the Department of Farm Power and Machinery of Bangladesh Agricultural University. These include a cutter with three blades, a cutter with two blades and a twisted steel wire. Besides these, nylon rope (2 mm) was used as grass cutter. The frame of the lawn mower as shown in Fig. 1 was made of MS angle bar (25 mm X 25 mm). The shaft was made of MS rod of diameter of 25 mm and of

length of 300 mm. The wheel was made of MS plate (25 mm) and the diameter of the wheel was made 150 mm. The overall length of the frame was 310 mm and the width of the frame was 166 mm. The handle was made of wood and the length of handle was 1280 mm. A person of average weight could easily operate the mower.

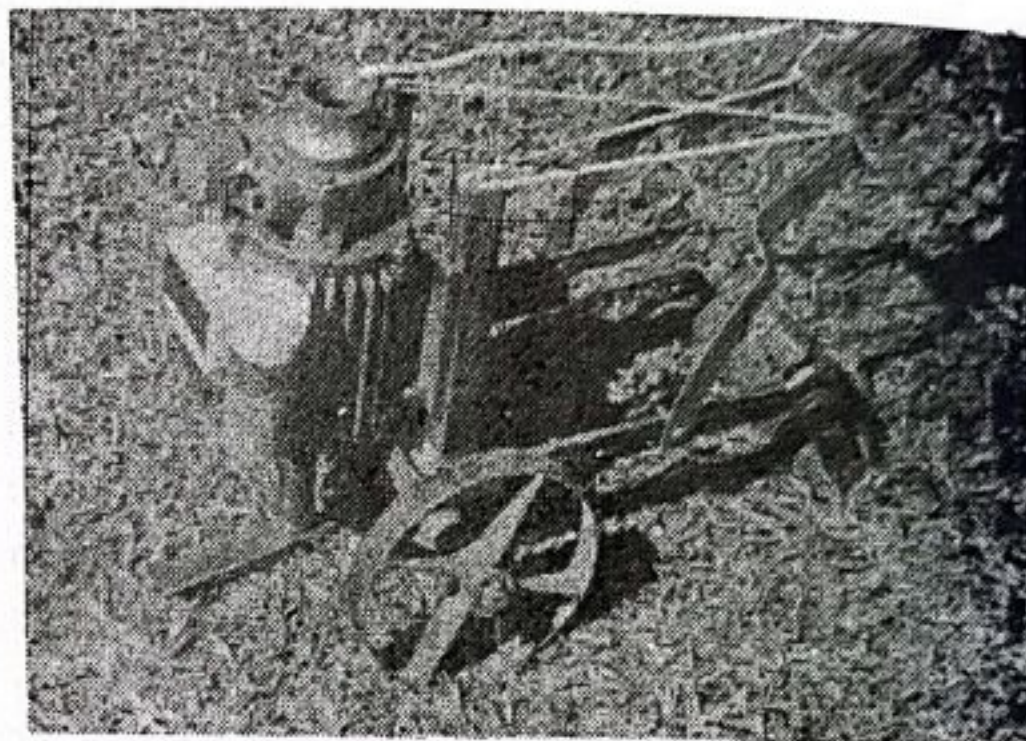


Fig 1 A Pictorial view of the electric lawn mower

Method of Evaluation

The lawn mower was tested and evaluated in the Botanical garden of Bangladesh Agricultural University, Mymensingh. Cutter with three blade and two blades; twisted steel wire of length 101.5 mm; and nylon rope of length 101.5 mm have been used during testing the mower.

An area of 6.096 m X 4.060 m was considered to conduct the experiment. The lawn grass was cut by the electrically operated mower and the mower was pushed by an operator at his normal walking speed.

The power consumed and the time taken was measured by a watt-meter and a stop watch, respectively. Five replication were taken for each type of cutter. The cutting efficiency, effective field capacity and cost of operation of the lawn mower were calculated. Besides, cost of operation for other available mower such as engine operated mower and manually operated push type mower were also calculated and compared.

Cutting Efficiency

The cutting efficiency of the lawn mower was determined as the ratio of the total number of cut grass to total number of grass present before cutting operation in the lawn. Randomly selected area of 6096 mm X 203 mm has been selected to count the grass.

The cutting efficiency is expressed as percentage.

$$\text{Cutting efficiency} = \frac{\text{Total no. of cut grass}}{\text{Total no. of grass present before cutting operation}} \times 100$$

Effective field capacity

The speed of the operator was calculated on the basis of the total length of the field travelled by the operator and time taken including turning time for each replication. The effective field capacity of the mower was calculated by the following formula :

$$\text{E.F.C.} = \frac{S \cdot W \cdot e}{10}$$

where,

E.F.C. = Effective field capacity, ha/hr

S = Forward speed, Km/hr

W = Width of cut, m

e = Field efficiency

10 = Constant

Cost Comparison

Cost calculation and comparison was made for the electrically operated mower (three blades, two blades and twisted steel wire); engine operated mower; and manually operated push type mower.

RESULTS AND DISCUSSION

Cutting efficiency and effective capacity were calculated. The cost comparison for the electric lawn mower (three blades, two blades, twisted steel wire), manually operated push type mower and engine operated mower was made in Taka per hectare. The

average cutting efficiency was calculated for five replications. Table 1 shows that the average cutting efficiency of the mower using cutter with three blades was 99.4%. Table 2 and Table 3 show that average efficiency of the mower using cutter with two blades and using cutter with twisted steel wire are 98.4% and 86.1%, respectively. The cutting efficiency of the mower using nylon rope as cutter is zero. Fig. 2 shows that the mower using cutter with three blades is the best in terms of cutting efficiency and nylon rope is invalid to cut grass.

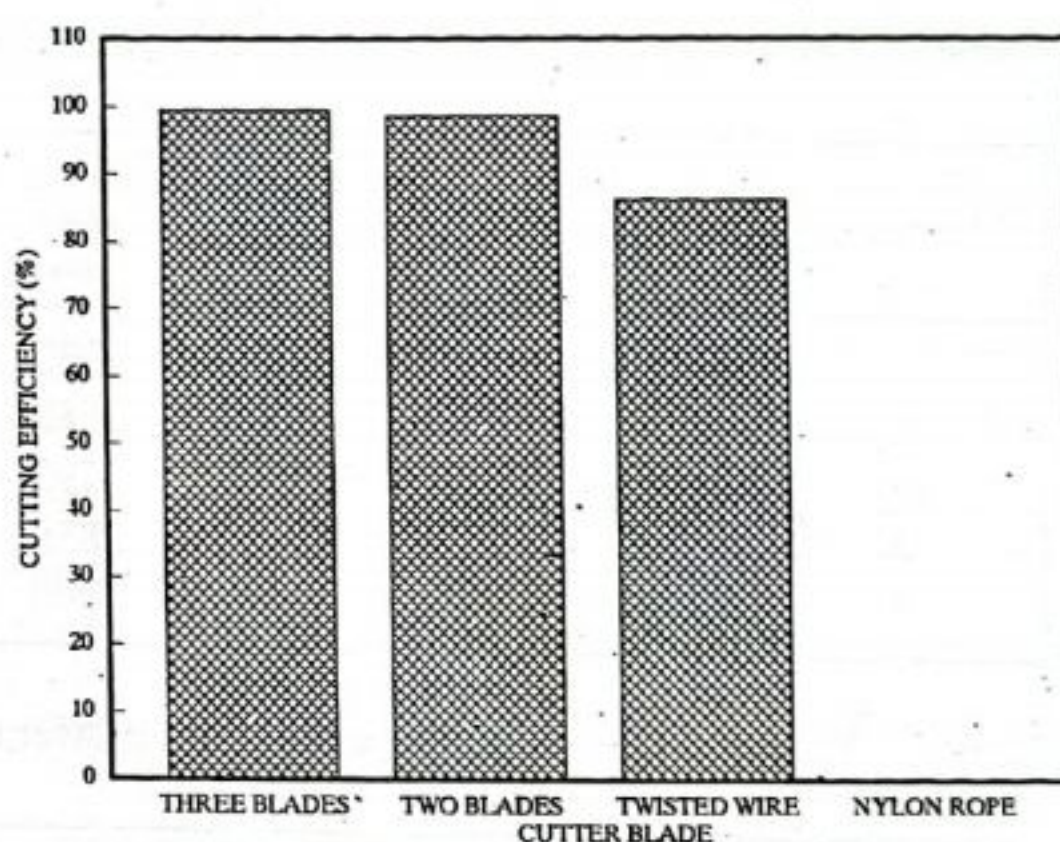


Fig. 2 The cutting efficiency of the mower for different types of cutter blades

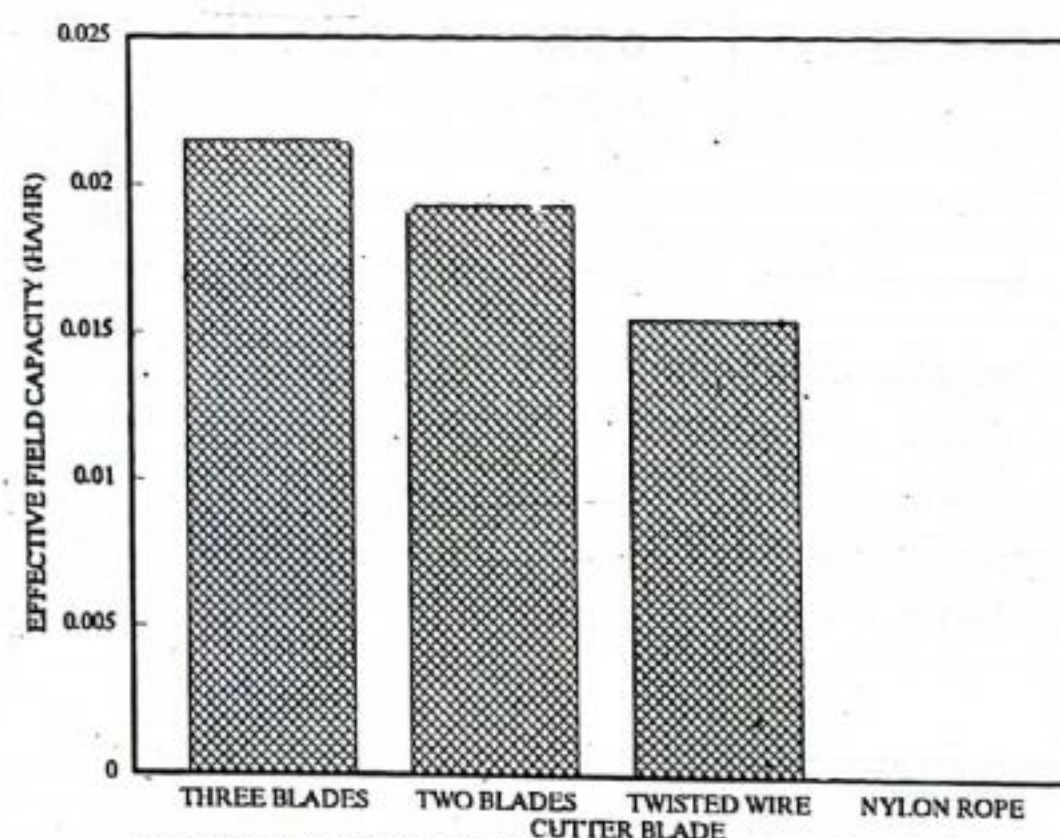


Fig. 3 The effective field capacity of the mower for different types of cutter blades

Table 1. The average cutting efficiency of the mower using cutter with three blades.

No. of Iteration	Length of the field (m)	Width of cut (m)	Total no. of grass (nos.)	Total no. of uncut grass (nos.)	Cutting efficiency	Average cutting efficieney (%)
1	6.096	0.203	2605	16	99.3	99.4
2	6.096	0.203	2650	15	99.4	
3	6.096	0.203	2705	12	99.5	
4	6.096	0.203	2680	10	99.6	
5	6.096	0.203	2700	19	99.2	

Table 2. The average cutting efficiency of the mower using cutter with two blades.

No. of Iteration	Length of the field (m)	Width of cut (m)	Total no. of grass (nos.)	Total no. of uncut grass (nos.)	Cutting efficiency	Average cutting efficieney (%)
1	6.096	0.203	2732	30	98.9	98.4
2	6.096	0.203	2680	25	99.0	
3	6.096	0.203	2792	45	98.3	
4	6.096	0.203	2830	62	97.8	
5	6.096	0.203	2790	55	98.0	

Table 3. The average cutting efficiency of the mower using twisted steel wire as cutter

No. of Iteration	Length of the field (m)	Width of cut (m)	Total no. of grass (nos.)	Total no. of uncut grass (nos.)	Cutting efficiency	Average cutting efficieney (%)
1	6.096	0.203	2852	352	87.6	86.1
2	6.096	0.203	2817	371	86.8	
3	6.096	0.203	2785	412	85.2	
4	6.096	0.203	2815	379	86.5	
5	6.096	0.203	2890	450	84.4	

The average effective field capacity was calculated for five replications. Table 4 shows that the average effective field capacity of the mower using cutter with three blades is 0.02148 ha/hr. Table 5 and Table 6 show that the average effective field capacity of the

mower using cutter with two blades and using cutter with twisted steel wire were 0.01934 ha/hr. and 0.01544 ha/hr, respectively. Fig. 3 also indicates that the mower using cutter with 3 blades is the best in terms of effective field capacity.

Table 4 The average effective field capacity of the mower for cutter with three blades

No. of iteration	Length of the field (m)	Width of cut (m)	Time taken including turning (sec)	Forward speed (km/hr)	Field efficiency	Power consumed (kw)	Average power consumed (kw)	Effective field capacity (ha/hr)	Average effective field capacity (ha/hr)
1	6.096	0.203	16.0	1.371	0.75	0.145		0.0208	
2	6.096	0.203	16.2	1.354	0.75	0.145		0.0206	
3	6.096	0.203	15.0	1.463	0.75	0.145	0.142	0.0222	0.02148
4	6.096	0.203	15.0	1.463	0.75	0.145		0.0222	
5	6.096	0.203	15.4	1.425	0.75	0.145		0.0216	

Table 5. The average effective field capacity of the mower for cutter with two blades

No. of iteration	Length of the field (m)	Width of cut (m)	Time taken including turning (sec)	Forward speed (km/hr)	Field efficiency	Power consumed (kw)	Average power consumed (kw)	Effective field capacity (ha/hr)	Average effective field capacity (ha/hr)
1	6.096	0.203	17.0	1.290	0.75	0.140		0.0196	
2	6.096	0.203	16.9	1.298	0.75	0.145		0.0197	
3	6.096	0.203	17.2	1.275	0.75	0.142	0.145	0.0194	0.01934
4	6.096	0.203	17.6	1.246	0.75	0.146		0.0189	
5	6.096	0.203	17.4	1.261	0.75	0.145		0.0191	

Table 6. The average effective field capacity of the mower for twisted steel wire as cutter

No. of iteration	Length of the field	Width of cut	Time taken including turning (sec)	Forward speed (km/hr)	Field efficiency	Power consumed (kw)	Average power consumed (kw)	Effective field capacity (ha/hr)	Average effective field capacity (ha/hr)
1	6.096	0.203	21.0	1.045	0.75	0.150		0.0159	
2	6.096	0.203	22.5	0.975	0.75	0.151		0.0148	
3	6.096	0.203	22.0	0.997	0.75	0.150	0.1506	0.0151	0.01544
4	6.096	0.203	20.9	1.050	0.75	0.152		0.0159	
5	6.096	0.203	21.5	1.020	0.75	0.150		0.0155	

Table 7. Cost of operation for different types mower

Engine operated mower (Tk./ha)	Mannually operated push type mower (Tk./ha)	Electrically operated mower		
		3 blades (Tk./ha)	2 blades (Tk./ha)	Twisted steel wire (Tk./ha)
1230.76	668.48	493.94	548.90	687.66

Cost comparison (Fig. 4) was made for the engine operated mower, manually operated push type mower and electric lawn mower (three blades, two blades, twisted steel wire). Table 7 indicates that the mower using cutter with three blades is the best in terms of cost of operation. It is economically more feasible than engine operated mower or manually operated push type mower. Therefore, the mower using cutter with three blade is the best in all respects.

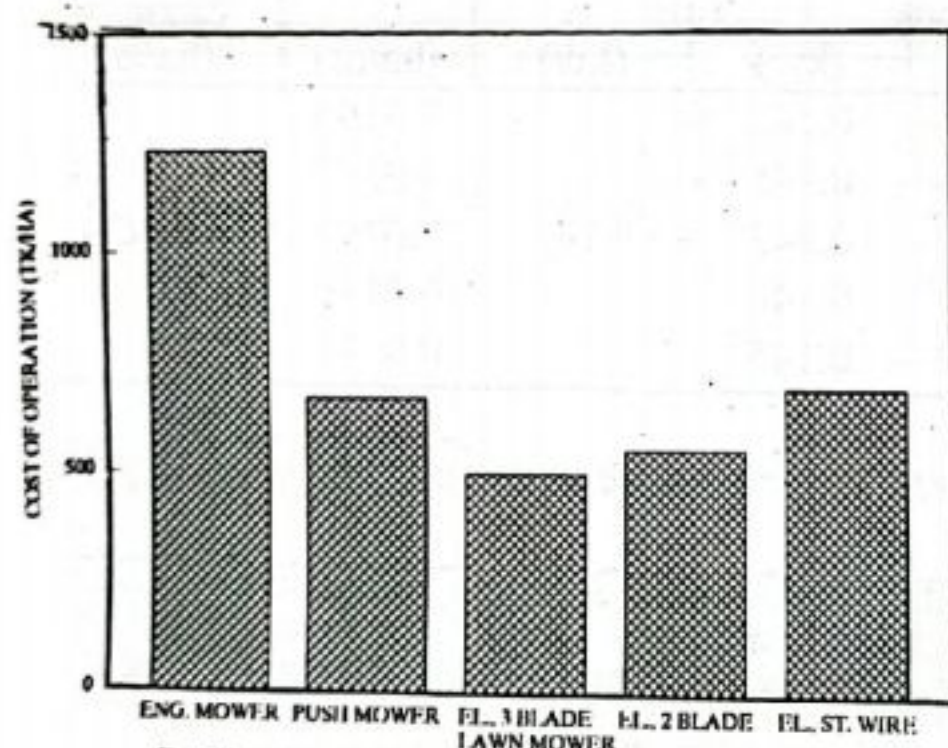


Fig. 4 The cost of operation for different types of lawn mower

The electric lawn mower with cutter blades might not work properly in undulated fields. In this case, the mower with twisted steel wire cutter might be suggested to cut the grass.

CONCLUSION

The efficiency of the electric lawn mower using cutter with three blades, two blades and twisted steel wire were 99.4%, 98.4% and 86.1%, respectively. The

mower using cutter with three blades was the best in terms of efficiency.

The effective field capacity of the mower using cutter with three blades was 0.02148 ha/hr. Among all the cutters tested, the cutter with three blades was the best in terms of cutting efficiency and effective field capacity.

The cost per hectare by the mower using cutter with three blades proved to be the minimum among the three types of cutter and even the operational cost was the minimum as compared with the available mower such as engine operated mower and manually operated push type mower.

The electric lawn mower is very cheap, easy to operate and the cutting efficiency is very high. This device could be used economically and efficiently to the lawns, play grounds and gardens of various institutes.

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