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MECHANIZED BUND CUTTING OPERATION FOR PADDY CULTIVATION

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ABSTRACT

The paddy cultivation system in India almost fully mechanized at different level except bund reconditioning. Hence research was conducted and developed bund cutting equipment for transplanted rice field at Krishi Vighyan Kendra (KVK), Sonapur-Gadchiroli. In this study the machine parameters evaluated were the effective depth, width of operating area of cut, wheel slip, fuel consumption, energy requirement and bund cutting efficiency at different speed of tractor i.e. 1.5, 2.5 and 3.4 km/h were used to determine the performance of machine. The optimal operating forward speed was found to be 3.5 km/h, the equipment achieved maximum bund cutting efficiency as 84% with the fuel consumption of 2.712 l/h was found to the operation. In low speed of operation *i.e.*; 1.5 km/h the equipment achieved lowest bund cutting efficiency as 75.41%. The fuel consumption for this operation was noted as 3.974 L/h. The energy requirement for operation of bund cutting was maximum as 154.98 MJ/h at a speed of 1.5 km/h and minimum as 105.77 MJ/h at speed of 3.5 km/h, this is due to the high fuel consumption during operation. The average cost of operation was Rs 551.50 per hector, which was less than manually *i.e.*; Rs. 1661.38/ ha (wages of 5 labour). The developed bund cutter can successfully use for eliminating manual high physiological cost involved during bund cutting operation.

Key words : Bund cutting, Cutting efficiency, Mechanization, Physiological cost.

Introduction

In paddy cultivation, bunds are very important and play very significant role to store the water in basin made by using bunds, for cultivation of paddy required lots off water from seedling to maturity. Bunds store water in basin formation and all the practiced required for paddy cultivation done in the basin structure. In traditional method, bunds are usually done in two steps at the beginning of each crop season.

First the bund should be cleared from weeds and grass before initial ploughing. Then the bund should be plastered with a layer of mud after the second plough. Good bunds help to limit water losses by seepage and under bund flows. Bunds should be well compacted and any rat holes should be plastered with mud. Manually, an average skilled person can trim and plaster 90-120 m of bund per day. Therefore, there is need to mechanized this bund making process to strengthen the existing bund (ridge) without damaging the height of the ridge. In Eastern Vidharbha region, bunds of paddy field are used for Tur (*Cajanus cajan*) cultivation and therefore bunds are generally large in size, that's why it is uneconomical and time consuming to make that much large size bund year by year. Also, difficult to trimming and plastering the bund by using trimming and plastering machine. A new concept is proposed for a bund cutting, as a direct attachment to the tractor.

Materials and Methods

Traditionally, the untilled soil near the bunds and corners of the field are prepared manually for which required more time and energy. The traditional manual bund/ ridge forming work was characterized by low efficiency, low strength, high cost and directly affects the productivity and profitability of paddy farming. More

over manually made bunds not properly aligned and compacted not last for long and causing rodent problem. Now a days as there is labour scarcity and their wages is a big problem hence mechanical bund cutting equipment is the need of paddy cultivated area.

Design consideration and calculation

Power requirement

Selection of matching power for effective operation of bund cutter is very important. The properties of soil, the speed of operation was affected by the power. By considering the suitable physical and mechanical properties of various soil type in the region (Kepner *et al*., 2005), the power requirement of the machine was calculated using following formula

Draft requirement of bund cutter (kg) = total soil contact perimeter of pegs (cm) × Soil resistance(kg/cm^2)

We know that, 1kg = 9.81 N

The basic draft and speed of operation of the machine ensure the draft requirement of the machine in the field operation (Gill and Berg,1968)

$$D = D_0 + KV^2 \quad (1)$$

Where,

D = Draft, N

D_0 = Basic draft, kg

V = Speed, km/h

K = Constant

We know that,

Drawbar power = Draft × Speed (2)

As 1 hp = 746 watt

Drawbar horsepower available (DBHP) is equal to 60% of Brake horsepower (BHP) of the tractor (Sharma and Mukesh, 2008).

Drawbar horsepower is given by,

DBHP = 60% of BHP of tractor

Selection of power source

Any farm machine was intended for the particular task in the field. In the proposed investigation, bund cutter has been designed and developed for a medium range tractor (35 to 45 hp). The appropriate power source was selected according to the requirement and design specification.

Calculating drawbar pull

Drawbar pull available for bund cutter is given by

$$\text{DBHP} = \frac{\text{Pull}(\text{kg}) \times \text{Speed}\ (\text{m/min})}{4500} \quad (3)$$

$$\text{Drawbar pull} = \frac{\text{DBHP} \times 45000}{\text{Speed}\ (\text{m/min})} \quad (4)$$

Width of Implement

The width of bund cutter (W) can be calculated by,

Total draft (kg) = Unit draft (kg/cm^3) × Width of implement (cm) × Cutting depth (cm) (5)

Therefor,

Width of implement(cm) =

$$\frac{\text{Total draft}(\text{kg})}{\text{Unit draft}\ (\text{kg/cm}^3) \times \text{Depth of operation}\ (\text{cm})} \quad (6)$$

$$\text{Unit draft} = \frac{\text{Total draft}(\text{kg})}{\text{Area of implement}\ (\text{cm}^2)} \quad (7)$$

Calculation of thickness of cutting disc

The thickness of cutting disc was calculated by using empirical formula given by Bosai *et al.* (1990),

Thickness = 0.008D +1

= 0.008350 + 1 = 3.8 mm

Where, D= diameter in mm

Hence, the commercially available cutting disc of 4 mm in diameter were used here in bund cutting equipment.

Three Point hitch point

The equipment has standard three hitch points; two lower and one upper. The equipment was attached to tractor through these three-hitch point. The three Point hitching unit was fabricated by using hitching flats (Fig. 1) to hitch the bund cutter equipment to suit the orientation of the implement with respect to the tractor and the arm position of the hitch. Proper hitching of any kind of tractor operated equipment was necessary to maintained quality of work and eliminating the power losses. The hitching flats were made from mild steel flat of 50×10 mm with length of 600 mm. The whole assembly of cutting mechanism mounted on three Point hitch system of the equipment. The lower link pins were made from MS rod of dia. 25mm (Fig. 2) and length of about 150mm.

Main frame

Generally, puddling has been accomplished by dragging a weighted harrow across a flooded paddy field behind a buffalo or ox and is now accomplished using mechanized approaches, often using walking tractor and used cage wheel for this purpose. Puddling reduces the percolation rates of water by churning the clay particles and making them close many of the soil pores. The overall

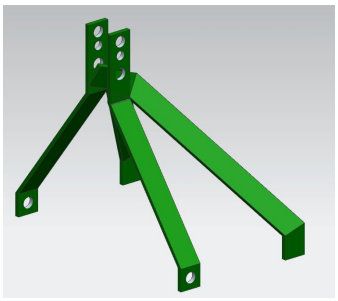

Fig. 1 : Hitching flat.

Fig. 2 : Isometric view of Main frame.

dimensions of main frame with cutting disc were 280 × 50 × 70 (l× b× h), two cutting discs with 4 mm thickness and no. of pegs 19 with 2 cm diameter and spacing between pegs was 7.5 cm.

Cutting disc

The cutting disc is made of mild steel plate having a diameter of 30 cm and thickness of 4 mm with a circular hole in the center for purpose of mounting a shaft. the cutting disc is attached to assembly in such way that it could rotated as implement moving forward and cut the bund.

Bund cutting unit

Fig. 4 shows the isometric view of the bund cutting equipment. The fabrication was done with the commonly available material (harden mild steel) the bund cutting unit consist of three Point hitching unit, harrow as a main frame and cutting disc.

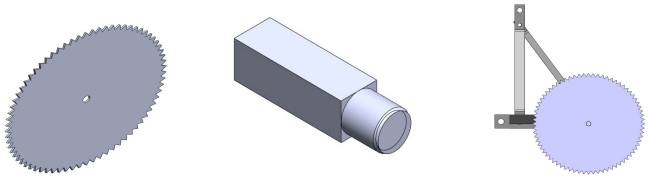

Fig. 3 : Isometric view of Cutting disc and Connecting rod.

Fig. 4 : Isometric view of bund cutting equipment.

Results and Discussion

Equipment performance parameters

Speed of operation

Three different speed of tractor *i.e.*, 1.5, 2.5 and 3.5 km/h were considered for calculation of wheel slip, fuel consumption, effective bund cut capacity and all other parameter.

The average operating width (14.27 cm) and depth (29.48cm) of operation was maximum at high speed of operation (3.5 km/h), while it was minimum at low speed of operation (1.5 km/h) compared to other treatments.

Table 1 : Technical specification of bund cutting equipment.

S. no.	Particular	Material	Specification
1	Source of power	_	Tractor 35 hp
2	Type of hitch system	Mild steel flats	3 Point
3	Type of implement	_	Mounted
4	Overall dimensions of implement Length, cm Width, cm Height, cm	_	280 50 71
5	3-point hitching Length, cm w × t, mm	Mild steel	60 50 × 10
6	Harrow Length, cm No. of pegs	Mild steel (Harden)	270 19
7	Cutting disc Diameter, cm Thickness, mm	Mild steel	35 4
8	Total weight of implement, kg		115

Table 2 : Depth of cutting and operating width at different speed of operations.

S. no.	Speed of operation, km/h					
	1.5		2.5		3.5	
	Operating width, cm	Cutting depth, cm	Operating width, cm	Cutting depth, cm	Operating width, cm	Cutting depth, cm
1	11.0	28.5	12.6	29.1	13.0	28.8
2	11.5	29.1	12.2	28.7	13.7	29.1
3	10.0	28.4	13.5	27.9	15.0	30.0
4	12.5	28.8	14.0	29.7	14.8	29.8
5	11.2	28.7	12.4	29.4	14.3	29.5
6	10.6	29.4	12.7	29.1	13.9	29.5
7	12.7	28.9	13.4	28.3	14.1	30.0
8	13.0	28.1	12.7	28.1	14.3	31.0
9	11.6	28.7	13.1	27.0	14.6	29.1
10	10.9	28.5	12.0	28.6	15.0	28.0
Avg.	**11.5**	**26.13**	**12.76**	**28.59**	**14.27**	**29.48**

Table 3 : Performance evaluation data for bund cutting at different speed of operation.

S. no.	Performance parameters	Speeds (km/h)		
		1.5	2.5	3.5
1	Soil moisture content, %	47.11	47.10	46.92
2	Bulk density, g/cm^3	1.90	1.87	1.70
3	Wheel slip, %	28.07	22.68	17.37
4	Depth of cut, cm	26.13	28.59	29.48
5	Operational width, cm	11.50	12.76	14.27
6	Theoretical bund cut capacity, m^2/h	450	750	1050
7	Effective bund cut capacity, m^2/h	339.39	609.38	882.19
8	Bund cut efficiency, %	75.41	81.13	84
9	Field capacity, ha/h	0.42	0.70	0.98
10	Fuel consumption, lit/h	3.974	3.453	2.712
11	Energy requirement, MJ/h	154.94	134.66	105.76
12	Wear, %	0.15	0.22	0.27
13	Cost, Rs/ h	689.062	633.18	540.692
14	Cost, Rs/ ha	1661.38	899.11	551.50

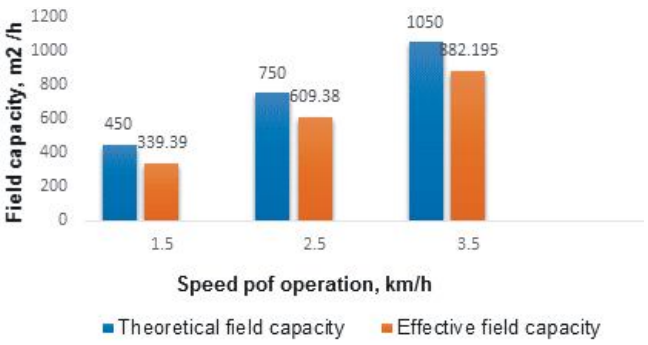

Fig. 5 : Effects of travel speed on bund cutting capacity.

Conclusion

The wheel slip decreased with increasing speed, measuring 28.07%, 22.68% and 17.37% at speeds of 1.5, 2.5, and 3.5 km/h, respectively, with the lowest slip observed at the highest speed (3.5 km/h). Fuel consumption for bund cutting was recorded as 3.973, 3.453, and 2.713 L/h at tractor speeds of 1.5, 2.5, and 3.5 km/h, respectively. The bund cutting efficiency was highest at the maximum speed (3.5 km/h) at 84% and lowest at the minimum speed (1.5 km/h) at 75.41%.

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