The Pharma Innovation Journal 2022; SP-11(6): 2879-2882

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(6): 2879-2882

www.thepharmajournal.com
Received: 07-04-2022
Accepted: 10-05-2022

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Design and development of bund cutter for paddy cultivation

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Abstract
Paddy is one of the important cereals in Maharashtra. The mostly rice growing region in Maharashtra is at most all the districts of Konkan region and Bhandara, Gondia, Chandrapur and Gadchiroli and part of Nagpur district in Vidarbha. 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. A cutting disc which is cut the bund G.I. sheet which has a curve along its length at the top of cutting mechanism has been suggest to convey mud towards top of the cutting portion of bund the following ability of cutting soil is supposed to be utilized in this new concept. Mechanizing the bund cutting process would be an entirely a new innovative concept in India and lot of investigation are needed during the testing. Keeping the above point in view the present investigation could be very helpful for farmer to save time, energy and make the work easy.

Keywords: Introduction, theoretical design consideration, design consideration, development of bund cutting equipment, summary and conclusions, references

1. 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. For best paddy cultivation sufficient water available in the paddy field throughout its whole lifecycle, and the good bunds achieved this, with minimum seepage and percolation. High water loss and the weeds on the bunds are restrict aeration resulting weeds causes huge reduction in crop yield as well as increase cost of cultivation, decreases input efficiency, interfere with agricultural operations, damage quality, act as alternate hosts for several insect-pests, diseases, disturb aesthetic appearance of the ecosystem, native biodiversity, also affect human and cattle health. 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 ha with an average productivity of 3.0 t/ha.

1.1 Scope and Limitation
Farmers of Eastern Vidharbha region cut (trim) and pack the bund manually which is time, energy and money consuming, therefore there is a necessity of Mechanization of bund or ridge forming which is an important process in the preparation of the paddy field before transplanting. No such machine is commercially available to cut and shape the formed bund in the country. To ease the farming operation, an attempt was made to design and develop such machine which enables combined operations of bund cutting and packing in single pass for saving fuel and resources. Equipment is simple in design and fabricated by local manufacturer within reasonable coast.

2. Theoretical design consideration to develop bund cutting equipment
1. The machine should be of modular structure with provision for easy assembling and dismantling.
2. The mounting of cutting disc should be easy as well as rigid so that they are easy to shift when wearing occurred and on other hand, enough to bear vibration and shocks during operation.

3. Suitability for uniform cutting and strengthen of bund.
4. The total length and weight of bund cutting equipment should be such that stability may not be affected in operation.
5. The machine should be cheap and easy to operate.
6. The machine should be simple in design so that, local manufacturer can fabricate.

3. Design consideration and calculation

3.1 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) [4]

$$D = D_0 + KV^2$$

Where
D = Draft, N
D_0 =Basic draft, kg
V = Speed, km/h
K = Constant

We know that,

Drawbar power = Draft × Speed

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

3.2 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.

3.3 Calculating drawbar pull

Drawbar pull available for bund cutter is given by

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

$$\text{Drawbar pull} = \frac{\text{DBHP} \times 4500}{\text{Speed (m/min)}}$$

3.4 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)

Therefore,

$$\text{Width of implement (cm)} = \frac{\text{Total draft (Kg)}}{\text{Unit draft(kg/cm3)} \times \text{Depth of operation(cm)}}$$

$$\text{Unit draft} = \frac{\text{Total draft (Kg)}}{\text{Area of implemen(cm2)}}$$

3.5 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
= 0.008×350 + 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.

4. Development of bund cutting equipment

The machine fabricated at Gadchiroli by local fabricator. The development of bund cutting equipment consist of several steps and required basic information *viz.*, soil properties, power requirement, source of power etc. this equipment was easy to fabricate at local level and suitable for cutting the bund in paddy fields. Machine design in such a way that easy to operate and adjustment of machine and maintenance done by untrained operator.

4. 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 (Plate 3.1) 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. The whole assembly of cutting mechanism mounted on three Point hitch system of the equipment.

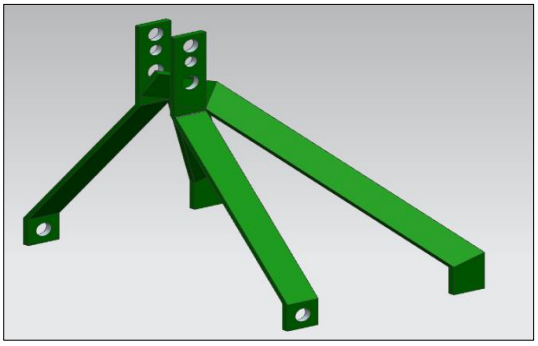

Fig 1: Hitching flat

4.1 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 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.

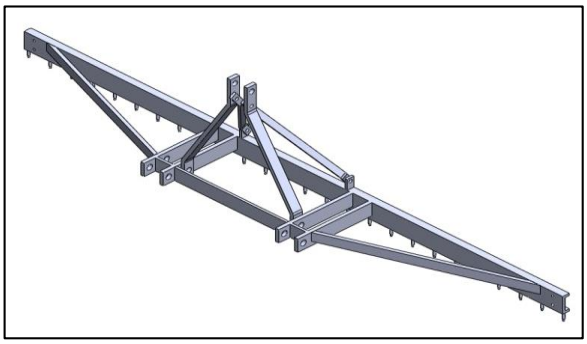

Fig 2: Isometric view of Main frame

4.2 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.

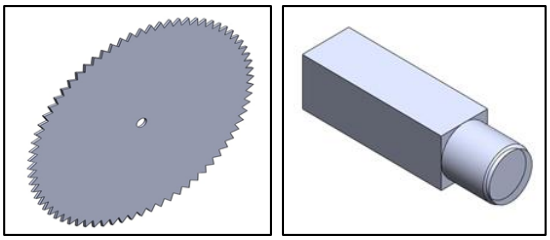

Fig 3: Isometric view of Cutting disc and Connecting rod

Fig 4: Cutting disc assembly

4.3 Bund cutting unit

The following fig.3.5 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.

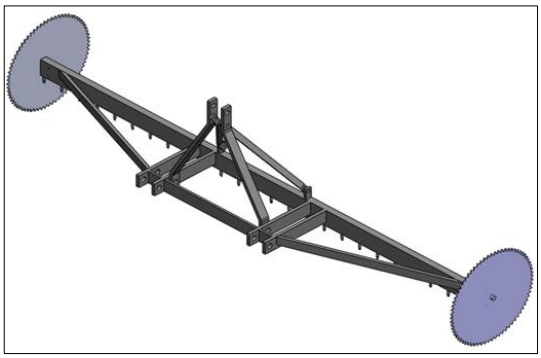

Fig 5: Isometric view of bund cutting equipment

5. Overall assembly

After completion of individual components fabrication all components were assembled. Lubrications to the components were given for smooth operation. Assembled view of the bund cutting equipment after modification was shown in plate 3.6 the overall dimensions and specifications of bund cutter equipment are presented in Table 1.

Fig 6: Actual model of fabricated bund cutting equipment

Table 1: Technical specification of bund cutting equipment

Sr. 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	_	280
	Width, cm		50
	Height, cm		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

6. Summary and Conclusions

The traditional method of bund cutting is done manually which is a time-consuming process. 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 is 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.

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