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DEVELOPMENT OF ANIMAL DRAWN ROTARY TILLER

S. M. Nage[1], B. P. Mishra[2], A. K. Dave[2] and J. S. Nikhade[2]
[1]Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Jalgaon (Ja), India
[2]Faculty of Agricultural Engineering, IGKV Raipur, India
E-Mail: nagesandip91@gmail.com

ABSTRACT
Rotary tiller generally refers to breaking down soil aggregates into ultimate soil particles. The degree of clod breaking depends on moisture content, tillage implements and intensity of clod breaking. One unit of animal drawn rotary tiller with L-shaped blades was developed and fabricated at the workshop of Faculty of Agricultural Engineering, Raipur. The effective field capacity of animal drawn rotary tiller (18 blades) was found to be 0.12 ha/h at a forward speed of 2.5 km/h. The field efficiency of 62.85% was observed during the field performance. The draft requirement of the developed animal drawn rotary tiller is 378 N. Mean Mass Diameter (MMD) of soil clod size was found 28.42 mm. The operational cost was found 384 Rs / ha.

Keyword: animal drawn rotary tiller, MMD, draft, bulk density.

INTRODUCTION
During the last two decades or so the growth of mechanization of Indian agriculture has been comparatively rapid. However draft animals, particularly bullocks; still continue to be a predominant source of energy for traction and rural transport in India because in India livestock population is 4, 85,002 thousand Livestock census (2003). Today draft cattle provide about 50 million hp or about 35 million kW of energy in a year. More than 65 percent of this energy is used for agriculture and the rest for transport. Over 150 Mha of land, farming about 65 per cent of the area sown, is cultivated through the use of draft animals every year. The average operational land holding in India has declined from 2-7 ha in 1960-61 to just half today. Most of farmers have smallholdings and can hardly opt for complete mechanization. Therefore the use of draft animal power is going to be continued in India for many more years, especially in a state like Chhattisgarh (Mishra and Tripathi, 2006).

Devnani (1981) reported the work of Mason Vough (1947) who found that the bullocks developed draft equivalent to 1/5 to 1/6 of their body weight and maximum draft which the bullocks could exert varied from 49.5 to 60.5 % of the body weight. Yadav (1990) concluded that on the basis of average energy output of the whole day, working a load equivalent to 10 % of body weight with a rest pause of one hour in two session of working was found better.

Looking to the versatility and utility of rotary tiller, and the large command area under animal farming system, an animal operated rotary tiller needs to be developed as at present only power operated rotary tillers are available. As rotary type implements have good scope for seedbed preparation and intercultural operations in most of the timely crops.

In rotary tiller the power requirement and quality of tilth depend on the shape of tines, spacing, number of tines, cutting angle and rotational speed. Therefore in order to introduce a good animal drawn rotavator in the region, a study will be carried out with different parameters in which L- types of rotavator tine will be developed, tested and evaluated in laboratory and in actual field condition.

MATERIALS AND METHODS
The materials and methods adopted for development, fabrication and testing of animal drawn rotary tiller as multipurpose tool attachment have been described below.

The machine was developed using standard formula from text books (Khurmi and Gupta) and later fabricated in the workshop of Faculty of Agricultural Engineering, IGKVV, Raipur (C.G.) during year, 2009. The selection of material was generally made as per IS: 68, 13/1973 and was brought from local market of Raipur, capital of Chhattisgarh state. The laboratory and field-testing were conducted in the research field of FAE, IGKVV, Raipur (C.G.).

DEVELOPMENT CONSIDERATION FOR ANIMAL DRAWN ROTARY TILLER
The development of an animal drawn rotary tiller was adopted considering environment, soil type, cultural practices, type of animals, farmer's general attitudes towards improved implements, and cost.

The general design considerations for the following components, controlling arrangements and attachments are discussed under following heads.

Animal drawn rotary tiller
The designing of animal drawn rotary tiller was done to obtain good clod breaking with different shapes of blades in previously tilled field to reduce the loss of soil water by leaching and percolation. Due to being very less speed of operation chances of cutting the grass and stubble is little but by turning the soil it would be buried the weed within the soil and consequently will be beneficial for plant growth. The power is given from the ground wheel. For power transmission pulley and V- belt is used. Two big pulleys are fitted on the ground wheel of diameter 270 mm and two small pulleys on the rotor of the rotary unit of diameter 88 mm. The V- belt is of B- grade of length 1770 mm. The speed ratio is 1: 3.

Designing of animal drawn rotary tiller

During designing of the rotary tiller the following points were considered:

- Size of pulley
- Length of v-belt
- Velocity ratio
- Slip of the belt
- Speed of operation
- Power required for the operation.

Size of pulley

The sizes of pulleys were decided, considering the weight and arc of contact of driven belt on the driving pulley and velocity ratio between driven and driving pulley. For good power transmission it was calculated that arc of contact should not be less than 180° and velocity ratio 1:3.

Length of V-Belt

The length of v belt was calculated by using the following formula.

$$L = \pi(R + r) + \frac{(R - r)^2}{C} + 2C \qquad \text{…………… (1)}$$

Where,

L = Length of belt for open belt drive
R = Radius of larger pulley
r = Radius of smaller pulley
C = Centre to centre distance between pulleys.

Given that

$$R = \frac{25.4}{2} = 12.7$$

$$r = \frac{7.62}{2} = 3.61$$

$$C = 44cm$$

Putting the value, we get

$$L = 3.14(12.7 + 3.81)\frac{(12.7 - 3.81)^2}{44} + 2\times 44$$

$$= 3.14\times 16.51 + \frac{(8.89)^2}{44} + 88$$

$$= 51.84 + \frac{79.032}{44} + 88$$

$$= 51.84 + 1.796 + 88$$

$$= 141.64cm$$

Velocity ratio

Velocity ratio is the ratio of the driving speed of driven pulley to that of the driving pulley. Velocity ratio was calculated by using the following formula.

$$VR = \frac{N_2}{N_1} = \left(\frac{D_1 + t}{D_2 + t}\right) \qquad \text{…………… (2)}$$

Where,

N_1 = Rotational speed of the driving pulley
N_2 = Rotational speed of the driven pulley
D_1 = Diameter of the driving pulley
D_2 = Diameter of the driven pulley
t = Thickness of the belt

Slip

The effect of slip is to decrease the speed of belt on the driving shaft and to decrease the speed of the driven shaft. The combined slip was calculated by using the following formula.

$$S = s_1 + s_2 - 0.01s_1s_2 \qquad \text{…………… (3)}$$

Where,

s_1 = Percentage slip between driving pulley and the belt
s_2 = Percentage slip between the pulley and belt
S = Total percentage of slip.
Thus the effect of slip on velocity ratio is expressed as following expression.

$$VR = \frac{N_2}{N_1} = \left(\frac{D_1 + t}{D_2 + t}\right)\left(\frac{100 - S}{100}\right) \qquad \text{…………… (4)}$$

Calculation of rotational speed of animal drawn rotary tiller

Speed of bullock= X km/h = $= \frac{100\chi}{6}$ m/min
Diameter of ground wheel = D, m
Distance covered by ground wheel in one revolution = π D, m
No of rev. of G W/min = Bullock speed / distance covered by G W

$$= \frac{100\chi}{6\pi D}$$

$$V_R = \frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \text{or} \quad N_2 = N_1\frac{D_1}{D_2}$$

$$\text{or } N_2 = \frac{100\chi}{6\pi D}\times\frac{D_1}{D_2} \text{ rev / min}$$

Where,

N_2 =speed of driven pulley
N_1 = speed of driving pulley fitted at shaft
D_1 = diameter of driving pulley

D_2 = diameter of driven pulley

Given that
D = 80 cm = 0.80 m

X = 2.5 km / h $= \dfrac{2.5 \times 1000}{60}$ m / min = 41.66 m / min

Distance covered by ground wheel / rev. = π D
= 3.14 × 0.80 m
= 2.50 m

No. of revolution in one minute = $\dfrac{41.66}{2.5}$ = 16.66

Speed of rotavator shaft $N_1 = N_2 \dfrac{D_1}{D_2}$ = 16.66 × $\dfrac{11.5}{2.5}$
= 61.318 rpm

Table-1. Specification of multipurpose tool frame.

Overall dimension (L x W x H), mm	1350 x 1800 x 1500
Wheel tread, mm	1100
Axel (pipe) dia, mm	80 (O.D.)
Main Shaft (split type): Number	2, one for each L and R wheel.
Ground wheel (G W) Diameter, mm	800
Rim width, mm	50
Thickness, mm	6
Spokes: size, ø, mm	10
Length mm	370
No. of spokes	10
Operators seat : base (L x W), mm	450 x 280
Base heights (adjustable) mm	260-360
Beam : m. s. pipe mm ø	40
Length, mm	2300
Beam Joint shape	V- Type
Total weight of cart, kg	45

Table-2. Specification of rotary tiller unit.

Overall dimension (L x W x h), mm	650 x 1200 x 370
Types of blades	L- shaped
Total no. of blades	18
No. Of blades per junction	3
Set of junction on rotor shaft	6
Setting of blades	Arranged on pipe frame at apart: 120°
Distance between blades junction, mm	120
Overlapping of blades mm	50
Velocity ratio between G. W. to rotor shaft	1: 3
Diameter of rotor, mm	360
Power transmission	V - Belt and pulley
Pulley: (i) Large pulley dia., mm	254 (2)
(ii) Small pulley dia., mm	88 (2)
V - Belt (2 Nos.)	B - grade
Weight, kg	12

RESULTS AND DISCUSSIONS

Main components of animal drawn rotary tiller were developed, to carryout detailed study. L -shapes of tines, two- telescopic arms for tightening of belts, and a shaft positioning lever cum tiller -depth adjuster, were developed which worked successfully. This rotary tiller was developed as a attachment for already developed a tillage cart /MPT carrier (Verma and Mishra, 2006). It is an animal drawn MPT, like a cart which can be used for tillage and intercultural operation in wider spacing crops. It has two large ground wheels (dia. 800 mm) which were used to drive the developed rotary tiller through two sets of V-belt pulleys in 1:3 speed ratios. A tool frame was developed to carry out the developed rotary tiller. All these developmental and testing works carried out in the Faculty of Agricultural Engineering IGKV, Raipur. A rotary tiller of length 1200 mm and diameter 650 mm was developed.

- **Development of experimental unit**

An experimental unit was developed to carry out the study. The study was carried out to see the effect of different spacing of tines, and number of tines (1-3) per flanges on draft requirement and quality of tilth. The experimental unit to carry out above study was developed with provision of mounting different types of tines and in the desired number and spacing. This unit could be rotated at desired depth and speed. A rotary shaft of dimension (L x dia.) 1200 x 650 mm was fabricated.

Rotary tines

L- Shapes of tines were got fabricated. The L-shaped tines were made with blade angle 90^0 and length of cut of 100 mm. All these are made of Mild Steel flat of 5 mm thick.

Width of cut and field capacity

Width of cut was (100 mm) with L shaped blade. Field capacity of experimental unit varied with the number of flanges on the rotary shaft. There were four level of number of flanges on the shaft (2, 3, 4 and 6 flanges). Initially an effort was made to develop an animal drawn rotary tiller. After development of animal drawn rotary tiller in the Faculty of Agricultural Engineering workshop, its performance was observed in the experimental field of Faculty of Agricultural Engineering, Raipur. The field performances of rotary unit with L- shape of tines are given in Table-3.

- **Effect of blade on draft and tilth quality**

Effect of L - shape at different spacing (S_1 = 12 cm, S_2 = 24 cm), found on the tilth quality and draft requirement as given below.

Effect of L-shape of tines on draft

The effect of L-shape of tines on draft requirement and tilth quality is shown in Table-3.

i). Effect of Flange spacing

In L - shape of tines the draft requirement increased in wider spacing, S_2 (423.66 N) than that of S_1 (316.27 N).

ii). Effect of number of blade per flange

Draft increased as number of tines per flange increased. Maximum draft was recorded with B_3 (395.81 N) whereas minimum draft was recorded with B_1 (370.41N).

iii). Effect of number of flange on the shaft

It is revealed from the Table-3 that draft requirement was increased with increased in number of flange on the shaft. Maximum draft (479.56 N) was recorded with F_4, having 6 flanges followed by F_3 (386.69 N). Minimum draft was recorded with F_1 (301.56 N). It was due to less number of cutting tines and soil resistance.

Effect of L-shape of blade on tilth quality

The tilth quality was observed in terms of MMD and bulk density. Smaller MMD and lower bulk density indicated better and finer tilth quality.

i). Effect of spacing on tilth quality

It is clear from the Table-3 that closer flange spacing (S_1:12 cm) gave better tilth with smaller MMD (29.18 mm) and least Bulk density (1.21 gm/cc), than that of wider spacing S2 (MMD = 30.15 mm, BD = 1.23 gm/cc).

ii). Effect of number of blade per flange on tilth quality

We got finer tilth with smaller MMD and reduction in bulk density as we increased the number of tines per flange (Table-3). Minimum bulk density (1.22 gm/cc) and minimum MMD (28.27 mm) was recorded with B_3 (3 tines /flange) and larger MMD (31.46 mm) and greater BD (1.23gm/cc) was recorded with B_1 (1-blade/flange). It was due to size of soil slice cut by the number of tines per flange.

iii). Effect of number of flange on tilth quality

The number of flanges on the shaft-hub affected the actual cutting width and intensive tilling. Table-3 indicates minimum MMD (22.32 mm) and minimum bulk density (1.20 gm / cc) with F_4 (6 flanges) $_{and}$ maximum MMD (34.62 mm) and maximum bulk density (1.24 gm / cc) with F_1 (2 flange). It was happen due to intensive soil tilling with closer and more number of flanges than with less number of flanges.

Effect of rotational speed on tilth quality and draft

The experiment was carried out with speed ratio 1: 3. The rotational speed was calculated at laboratory test. Rotational speed varied with number of tines per flange and shape of tines. The rotary action of the tines, cutting width and depth of operation these factors affects the rotational speed of the rotary tiller. As rotational speed increases draft and tilth quality was increase. However it was observed when speed was increase then power requirement was increase.

Table-3. Performance of L-shape of rotary blade at different spacing (S), number of tines per flange (B) and number of flange in the shaft (F) on draft and tilth quality., at 2 cm depth.

Flange spacing	Av. Draft, N	Av. MMD, mm	Bulk density, gm /cc
S_1:12 cm	316.27 (--)	29.18*	1.21*
S_2:24 cm	423.66 (+ 33)	30.15	1.23
Tines / flange			
B_1: 1	370.41	31.46	1.23
B_2: 2	380.41	29.27	1.22
B_3: 3	395.81	28.27*	1.22*
CD 5 %	38.34	2.66	
Nos. of flange			
F_1:2	301.56	34.62	1.24
F_2:3	342.36	32.12	1.22
F_3:4	386.69	24.62	1.21
F_4:6	479.56	22.32	1.20
CD 5%	38.34	2.66	

CONCLUSIONS

Most of the review found with tractor drawn rotary tiller, mostly tractor operated rotary tiller were developed no one reported about animal drawn rotary tiller. In India draught animals was easily available, for experimental purpose research work was done on development of animal drawn rotary tiller.

REFERENCES

Deshpande S.D. and Ojha T.P. 1988. Testing and evaluation of improved yatra Ox cart. AMA. 19(4).

Devanani R.S. 1981. Design considerations for harnesses and yokes for drought animals. Technical Bulletin No. CIAE/81/30. CIAE, Bhopal, India. pp. 18-21.

Livestock census. 2003. Ministry of Agriculture, government of India.

Mishra B.P. and Tripathi R.S. 2006. Availability of farm power and mechanization planning for India and Chhattisgarh. National Symposium on conservation and management of agro-resources in accelerating the food production for 21st century, 14-15th December, IGKV, Raipur(C.G.), India. pp. 341-349.

Vaugh M. 1947. Method of yoking bullocks for Agricultural works. Indian Journal of Vet. Sci. and AH. 5: 180.

Verma B.B. and Mishra B.P. 2006. Design, development and testing of tillage cart with cultivator and hook patella attachment. 40th ISAE, Annual Convention and Symposium, TNAU, Coimbatore, India. January.

Yadav G.C. 1990. Study of draught capacity of malavi and local breeds of bullocks using Allahabad harness and local yoke in sustained working. Annual report on UAE, Bhopal Center, India. pp. 10-42.