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Research Article

Studies on Draft Bullock Power Utilization for Sustainable Rural Livelihood and Food Security

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Abstract: Bullocks are the main source of power in Indian agriculture. Use of bullocks for agricultural work is limited to tillage, sowing and transportation in the state of Odisha, India. The total annual use of bullocks is less than 300 hours. But the potential use of bullocks in a year is nearly 800 hours. To enhance the utilization of bullock in the state, there is the need of suitable matching implements and bullock power operated stationary machines requiring around 1 hp (0.8 kW) power for doing various post harvest operations like threshing, chaff cutting, sugarcane crushing, oil expelling, pulses milling and dehusking etc. This would ultimately reduce the economic burden of owning a pair of bullocks and also to decrease the use of non-renewable energies in agricultural post harvest operations. With this aim, a study was conducted for operating a paddy thresher with the help of a rotary gear complex driven by bullock power. The mechanical power is transmitted to the thresher with the help of belt pulley arrangement with the provision of stepping up or stepping down the speed ratio as per requirement. The experiment was conducted continuously for 3 hours with the measurement of physiological responses like respiration rate, heart rate, body temperature etc. of the medium sized non-descript breed of bullocks (pair weight of bullocks 620 kg) of Odisha at half an hour interval and calculation of fatigue score to know their comfortable working without inflicting any health hazards. The bullocks were loaded with 9.8 % of their body weight and their speed was measured. The paddy thresher was run with a pair of bullocks in rotary mode of operation and three persons were employed for threshing. The output capacity in rotary mode thresher was observed to be 200 kg of paddy grain/hour, where as 250 kg/hour in electrically operated thresher and 40 kg/hour in traditional bullock treading method. The cost of operation in rotary mode of operation through bullocks, in electrically operated thresher and with traditional practices was observed to be Rs. 33.28, Rs.21.71 and Rs.32.82 per 100 kg of grain respectively. The energy savings of electrical energy for threshing of paddy for 1 hectare of land is about 10 kWh.

Keywords: *Renewable energy, Bullock energy, Sustainable energy, Agricultural implements, rural livelihood.*

1. INTRODUCTION

Odisha is situated in the east cost of India extending over a geographical area of 15.17 mha (million hectares) with 6.55 mha under cultivation. In Odisha around 77 % of the farmers are under small and marginal categories and they possess about 43 % of the total cultivable land. The numbers of operational holdings are 333.30 lakhs with a cropping intensity of 145 %. The average size of holding is 1.5 ha. Due to small and scattered holding and low input capacity, the farmers mainly depend on bullock power for different agricultural operations. About 82 % of the total cultivable land is under the command of the draught animal power and the rest is under tractors and power tillers. Use of bullocks for agricultural work is limited to tillage, threshing and transportation in the state of Odisha (Kurup, M.P.G. 2003). The total annual use of bullock amounts to less than 300 hours. Cost of utilization is, therefore, very high as the bullocks are to be fed throughout the year whether they are in use or not (Anonymous. 2001). One way to reduce the economic burden of owning a pair of bullocks is to increase the utilization of bullocks which can be possible if the bullocks will be used to carry out operations like running a thresher, winnower, chaff cutter and other agro processing units with rotary gear system (Kurchania, A.K., & Mishra, D. 2003). This study aims at use of animal energy particularly during

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idle period so that their annual use will be increased and ultimately the cost benefit ratio will be improved besides providing useful information on the suitability of animals in rotary mode of operations.

2. Agricultural Implements Available For Draft Animals

Draught animals are generally used for various agricultural operations like ploughing, puddling, levelling, harrowing, bund forming and ridging, seeding, planting, weeding, threshing and carting, The different implements and tools presently available are plough, leveller, puddler, harrow, cultivator, bund former, ridger, seed drill, planter, interculture plough, weeder, tool carrier and cart (Table 1). These implements are mostly of indigenous designs and are being manufactured by local artisans and small-scale industries. Implements are generally made up of locally available materials.

Table.1 Bullock-drawn tools and implements available

Sl No	Operation	Tools and implements	Weight, kg	Field capacity, ha/h
1	Tillage	Wooden plough	6.5-8.0	0.10-0.18
		Mould board plough	6.0-8.5	0.24-0.03
		Harrow	25.0-28.0	0.053-0.06
		Cultivator	15.0-18.0	0.058-0.065
		Puddler	16.0-22.0	0.10-0.12
		Leveler (bamboo)	8.0-9.0	0.31-0.35
		Leveler (wooden)	10.0-12.0	0.31-0.35
2	Seeding and planting	Seed drill	18.0-22.0	0.09-0.12
		Seed-cum-fertiliser drill	20.0-25.0	0.07-0.10
		Zero-till drill	15.0-18.0	0.06-0.07
		Inclined plate planter	19.0-25.0	0.16-0.20
3	Interculture	Intercultural plough	4.5-5.5	0.035-0.040
		Weeder	20.0-22.0	0.08-0.10
4	Harvesting	Groundnut digger	10.0-12.0	0.035-0.047
		Potato digger	9.0-11.0	0.032-0.036
5	Transport	Bullock cart	-	-
6	Other	Tool carrier	18.0-20.0	-
		Bund former	15.0-18.0	0.032-0.036
		Ridger	15.0-18.0	0.035-0.040

3. Utilization of Bullock Power through Mechanical Rotary Gear System

The rotary gear unit was installed in the premises of College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, Odisha, India. The experiment was conducted during 2012-13 in the College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, Odisha, India.

3.1 Rotary gear Unit

Gear box: In the box different parts are assembled, it is made of 6 mm thick pressed mild steel plate. Shape of the box is rectangular having dimensions of 660 x 579 x 274 mm.

Spur gears: Set of spur gears transmits the power between two parallel shafts. The spur gears are made of heat treated alloy steel having module 4.0 mm. The spur gear has 77 teeth while the spur pinion has 16 teeth. The speed ratio of 1: 4.8 is obtained.

Bevel gears: Set of bevel gears transmits the power at 90^0, they are spiral tooth bevel gear having module 6.5 mm. The bevel gear has 43 teeth and bevel pinion has 7 teeth. The material of the bevel gear is heat treated alloy steel. The speed ratio is 1: 6.14. Combination of bevel and spur gear can produce the speed ratio of 1:29.56.

Shafts: The first shaft of bevel gear is held in vertical position having diameter 50 mm and 63 mm at bottom side and top side respectively. The second shaft for bevel pinion and spur gear has diameter of 50 mm. The third shaft used for bevel pinion has diameter of 30 mm.

Bearing: One ball bearing 90x50x24 size is fitted on the 50 mm shaft and another ball bearing of 72x30x20 mm size is fitted on top of the same. One thrust bearing 60x38x20 mm size is fitted at the outer end of the pinion shaft with two ball bearings of 72x30x20 mm and 88x45x22 mm size.

Bearing cover: One bearing cover n is used for thrust bearing 60x38x20 mm size. The cover is made of 45C8 steel.

Bushes: Two bushes are used for the input shaft. One is fixed at the bottom plate of the box and the other is fixed at the cover plate. Necessary lubrication arrangement has been provided.

Belt Pulley transmission unit: The two transmission shafts are mounted on two pillars each. The diameter of the shaft is 50 mm. The first drive shaft was connected to the output shaft of the gear box

through universal joint coupling. One pulley of 60 cm was mounted on the first drive shaft and the counter shaft is having a pulley of 35 cm thereby stepping up the speed in the ratio 1: 1.71 when connected with flat belt. For threshing operation, a 40 cm V-pulley is also mounted on the counter shaft which is connected through V-belt with the thresher shaft having a 10 cm pulley stepping up the speed in the ratio 1: 4. So for thresher, the final speed ratio is 1:202. The details of the rotary unit are given in Fig. 1 and the photograph of paddy thresher cum winnower is given in Fig. 2.

Fig.1 Gear box unit for mechanical power in rotary mode

Fig.2 Multi crop thresher cum winnower used in rotary mode

3.2 Evaluation of Thresher

A hold on type multi-crop thresher cum winnower capable of threshing paddy was used for the threshing operation (Fig. 2). The thresher was tested for paddy only. The thresher can otherwise be operated with a one hp (horse power) motor. The working width of the thresher drum was 1200 mm. The details specifications of thresher are given in Table 2.

Table 2 Salient specifications of the multi- crop thresher

Sl No.	Components	Dimension
1	Over all dimension (LxBxH), mm	1400 x 550x 800
2	Length of the threshing drum, mm	1200
3	Diameter of the threshing drum, mm	340
4	Height of the wire loop, mm	50
5	No of wire loops per slat	23
6	Arrangement of the wire loops	Staggered

The thresher was run with the bullocks in rotary mode of operation and three persons were employed for threshing. The following parameters were studied during the experiment. Standard techniques were used for measurement of the different parameters. The experiment was conducted for three hours and the observations were taken at half an hour interval. Rotary gear parameters; power requirement at load, bullock parameters at load condition; speed of bullocks, average draft, power output, physiological responses, fatigue score and machine parameters (Thresher); peripheral speed of thresher, threshing efficiency, out put capacity, cost of operation etc.

2.3 Cost economics

The cost of operation was calculated for thresher in rotary mode of operation through bullocks and compared with traditional practices. The following assumptions were taken for calculating the cost (Table 3)

Table 3 Assumptions for computing cost of operation

Units	Cost, Rs	Life span	Repair & maintenance	Annual use, h
Rotary unit	30,000	10	5 % of the cost	960
Thresher cum winnower	11,460	10	-do-	240
Thresher cum winnower with motor	16,960	10	-do-	240
Bullock pair	20,000	5	Rs5/h	1200

Variable cost:

Threshing: Three persons and one bullock operator

Local method of threshing (Bullock treading): 3 pairs of bullocks with three persons for 2 days (4 hours/day) for threshing of one acre of paddy (12quintals). Labor charge Rs. 100/ day (Rs. 12.5/h for 8 hours/day) and 1 quintal is equal to 100 kg.

4. RESULTS AND DISCUSSION

The thresher was operated and the data on evaluation of the thresher in rotary mode has been presented in Table. 4. The draft requirement varied 632 N in the beginning to 569 N at the end. The mean draft was 596 N which was 9.8 % of the bodyweight of the bullocks. The increase in pulse rate and respiration rate as usual decreased with duration and varied between 48 to 90 and 14 to 46 within three hours respectively. The corresponding mean values were 75 and 33. There was not much variation in the body temperature. Half hourly RPM of the bullocks were between 54 to 36 and gradually deceased with duration so also the linear speed. The mean linear speed of the bullocks was 2.23 km/h and the corresponding thresher drum peripheral velocity was 5.88 m/s. The mean RPM of the threshing drum was observed to be 330. Threshing efficiency varied between 92 to 94 % with a mean of 92.95 %. The output of the thresher gradually decreased with duration; may be due to decrease in the peripheral velocity of the threshing drum. The mean output was found to be 226 kg/h where as the threshed paddy output in electric motor operated thresher cum winnower was 250 kg/h. The power output was found to be 0.36 kW which indicated that the bullocks could easily do the threshing operation and their utilization could be enhanced. The bullocks could sustain the duration of threshing without getting fatigue as the average fatigue score was 16. The bullock becomes fatigue when it attains a fatigue score of 20 (Upadhyay, R.C., & Madan, M.L. 1985) and is required to relieve it from work.

Table 4 Physiological responses of bullocks and performance of paddy thresher in rotary mode of operation

Parameters	Duration, h							Mean
	In	0.5	1.0	1.5	2	2.5	3.0	
Pulse rate, bpm (beats per minute)	48	65	72	78	83	86	90	75
Respiration rate, bpm (blows per minute)	14	25	29	33	39	42	46	33
Body temp, ^{0}C	37.9	38	38.1	38.4	38.5	38.6	38.8	38.40
Amb. Temp., ^{0}C	23.3	25.8	26.5	27.4	28.9	29.5	30	27.34
Rh, %	23	21	20	20	18	18	17	19.57
Draft, N	-	632	612	603	586	574	569	596
RPM of bullocks/0.5h	-	54	50	48	44	44	36	46
Speed, km/h	-	2.62	2.48	2.40	2.24	2.00	1.68	2.23
RPM of thresher	-	380	360	345	320	300	280	330
Peripheral velocity, m/s	-	6.76	6.40	6.13	5.69	5.33	4.98	5.88
Threshing efficiency, %	-	94	93.2	93	93	92.5	92	92.95
Output, kg/h	-	243	234	212	187	168	155	200
Power output, kW	-	0.45	0.42	0.40	0.36	0.31	0.26	0.36
Fatigue score	-	11	13	16	17	17	18	16

The cost of operation of the thresher in rotary mode was Rs. 33.28 /100kg whereas it was Rs. 21.71 /100kg in case of thresher being operated by electric motor as mentioned in Table. 5. The cost of threshing in rotary mode is Rs. 33.29 /100kg than that incurred in traditional method of bullock treading (Rs. 32.82/100kg). It shows that threshing through rotary mode of operation is cheaper and economically viable than the traditional method of bullock treading. The above operation through rotary mode was found to be within the draftability of the bullock.

Table 5 Cost Economics of rotary mode of operation in threshing, winnowing and chaff cutting

Machine	Fixed cost, Rs/h	Variable cost, Rs/h	Total Cost, Rs./h	Total cost, Rs/100 kg
Rotary unit (mechanical gear unit)	7.0	-	7.00	-
Bullock pair	3.91	5.00	8.91	
Man-hr	-	12.50	12.50	
One pair Bullock + one laborer	3.91	12.50	16.41	
Thresher cum winnower	9.31	-	9.31	-
Threshing in rotary mode	20.22	55.00	75.22	33.28
Thresher cum winnower with 1 hp electric motor	13.78	3.00(electric cost)	16.78	
Threshing with 1 hp motor	13.78	40.50	54.28	21.71
Traditional method (bullock treading)	-	-	-	32.82

5. CONCLUSIONS

The following conclusions are made from the study:

i) The operation for draft requirements of the thresher was found to be 9.8 % in term of percentage of body weight. So the bullocks could sustain the draft for three hours of continuous operation.

ii) The operation of thresher through rotary mode was not economical compared to be operated with electric motor. However, threshing through rotary mode was marginally more than the bullock treading method of threshing.

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